COMPUTER DESIGN

THE MAGAZINE OF MODERN DIGITAL ELECTRONICS

MAY 1967

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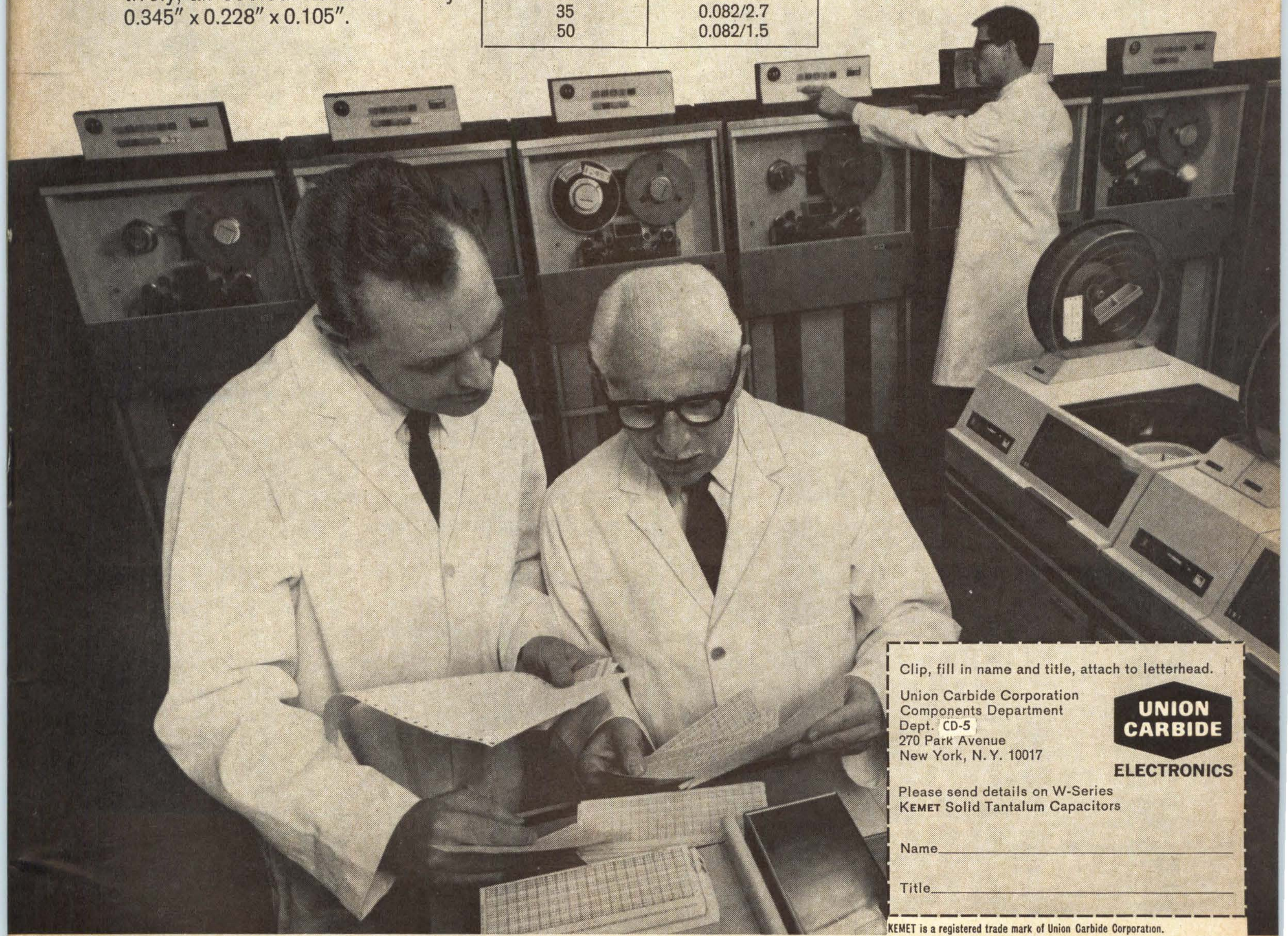

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CIRCLE NO. 2 ON INQUIRY CARD

MAY 1967 • VOLUME 6 • NUMBER 5

FOR ENGINEERING PERSONNEL RESPONSIBLE FOR THE DESIGN & APPLICATION OF DIGITAL CIRCUITS, EQUIPMENT, AND SYSTEMS IN COMPUTING, DATA PROCESSING, CONTROL AND COMMUNICATIONS.

Editorial & Executive Offices
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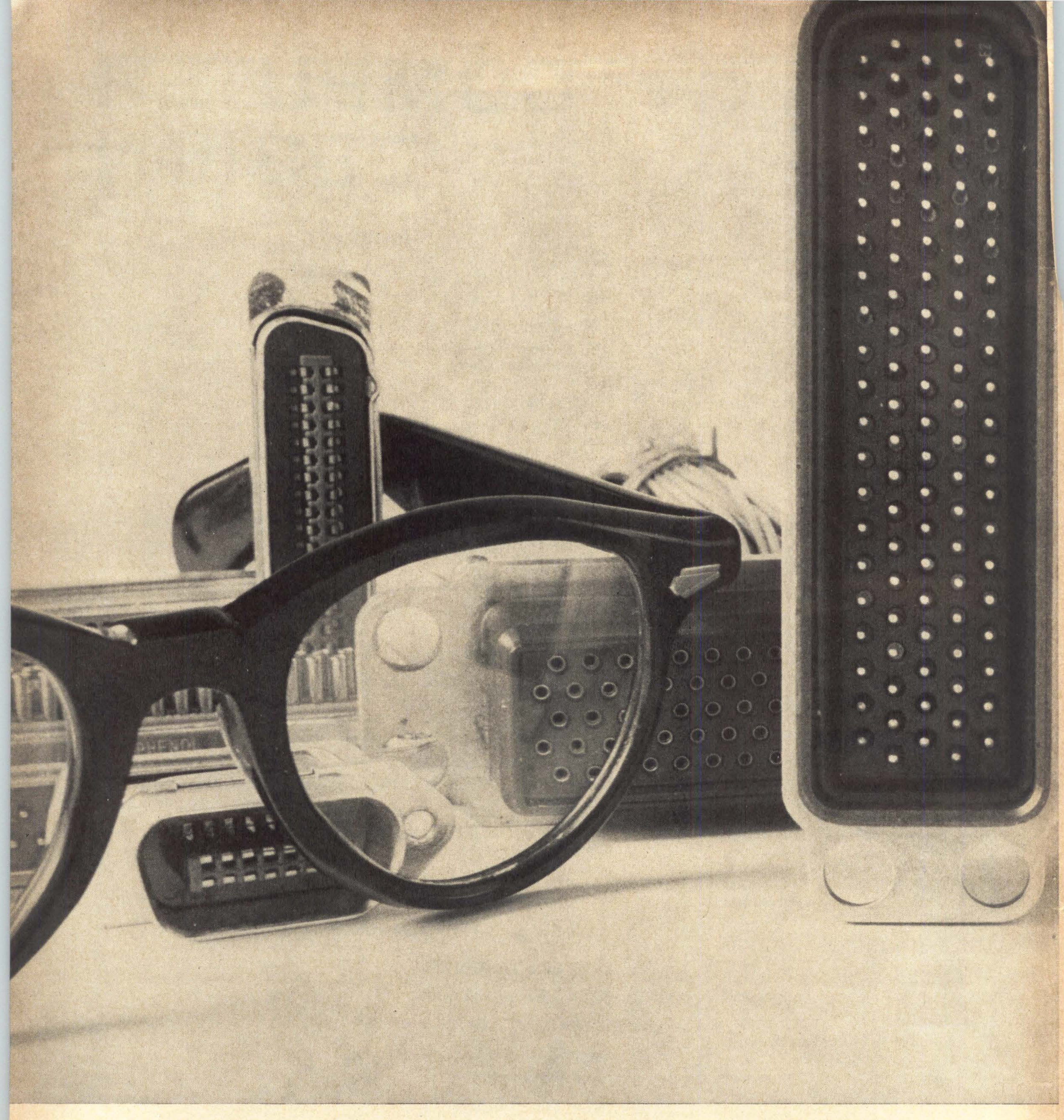
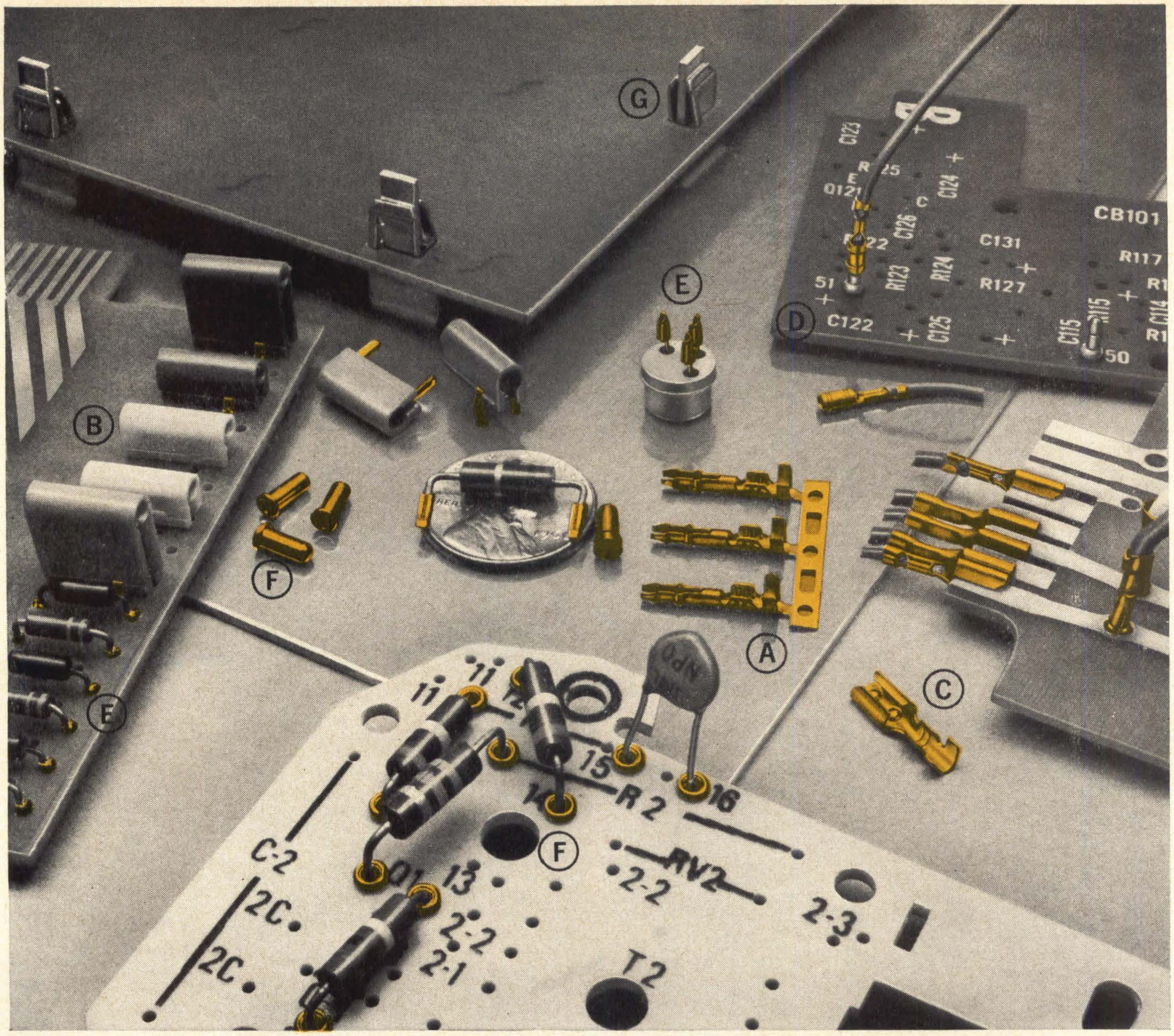
COMPUTER DESIGN

FEATURES

DEPARTMENTS



What to look for in a good miniature rack and panel connector.



Small size. Small price. Big printed circuit convenience.

These little time-savers can help simplify, economize, and automate your printed circuit board production. Specifically designed for users of printed circuit boards, they each incorporate AMP's quarter century of development and experience in precision solderless techniques. One or more can benefit you if you use printed circuit boards.

For example, AMP-IN* Printed Circuit Pins (A) may be attached at rates up to 4,000 an hour; snap-in design holds leads in position for easy solder dipping. With AMP's handy Test Probe Receptacles (B), test points may be provided anywhere on printed circuit boards. Color coded for quick location; double-ended probe entry. The AMP-EDGE* Single Circuit Edge Connector (C) is a quick disconnect contact that fits an edge slot in printed circuit boards from .040″ to .093″ thick. Its wiping action pre-cleans board contacts. AMP's Printed Circuit Board Disconnect (D) comprises a staked pin and a receptacle which is crimped to the lead. This enables you to bring a variety of wires to a printed circuit board and to disconnect them at will.

Components are held in place during assembly with CIRCUITIP* Terminals (E), which also promote uniform solder fillets; machine-applied at rates of 7,200 an hour. The many ways to use AMP's Reusable Component Test Receptacles (F) include testing, breadboarding, and modular connector design. One size accepts leads from .018″ to .040″ in diameter; eliminates soldering. The newest product for printed circuit boards is AMP's Printed Circuit Board Fastener (G), which speeds up the process of assembling a printed circuit board to a chassis and greatly aids servicing. Includes types which facilitate component mounting and power input connections radio, TV, Hi-Fi, vending, and commercial control products. Write today for full information about any of these useful printed circuit board aids. Or, let us help solve your special printed circuit problem.

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CIRCLE NO. 5 ON INQUIRY CARD

If you want the best connectors money can buy

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This booklet gives capsule reviews of specifications and general information on Continental's precision electronic connectors. Check your requirements against the most complete and reliable product lines for printed circuitry and rack and panel interconnection applications. Each connector series meets the critical standards of design and application engineers in both commercial and military systems including computers, electronic data processing, communications, aerospace, telephone and other intricate electronic equipment.

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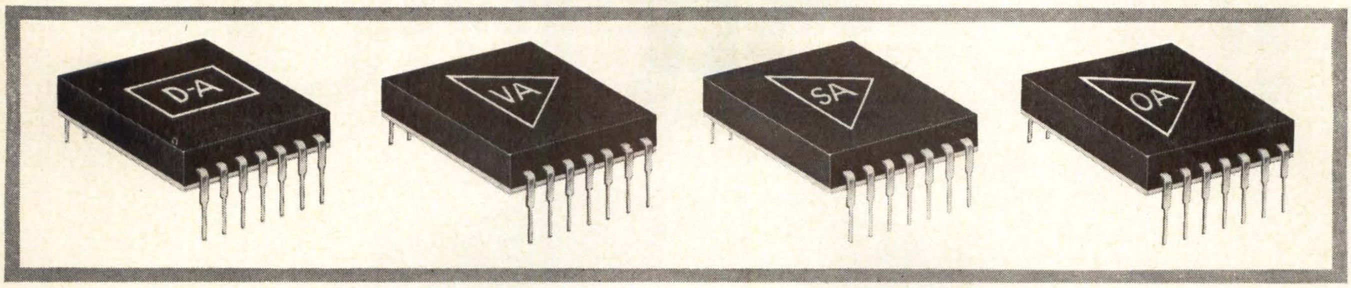
CIRCLE NO. 8 ON INQUIRY CARD

A new concept...optimum-technology integration



MODULINE® microcircuits have solved the problems of technology trade-offs.

Silicon integrated circuits, thick and thin films, tantalum nitride or nickel-chromium on silicon, discrete semiconductor devices active or passive—each has its own technology advantages for the circuit designer.

Until today, the designer lived with the limitations of each technique as well. Circuit design and component selection finally ended after the battle with technology trade-offs.

MODULINE® MICROCIRCUITS

Now Sprague introduces Moduline microcircuits. Simply put, Sprague selects the optimum technologies for you, integrates these various techniques into functional or multi-functional circuits, then packages them into dual in-line packages with 100 mil pin spacing.

Moduline microcircuits are complete! No additional "add-on" components are needed. Four standard circuits are available today. More will follow.

D to A CONVERTER

The Moduline UM1000 4-bit D to A converter combines ladder network, ladder switch, and buffer amplifier in one package.

The ladder network is a monolithic silicon chip with 9 deposited tantalum nitride precision resistors. Only this technology could give the UM1000 the ability to be expanded to 12 bits with less than ½ bit error.

The ladder switch is constructed from 8 complementary "low off-set" transistors mounted on a thin film circuit. Each transistor is discrete, to permit superior matching.

Lastly, the buffer amplifier consists of 4 NPN transistors and 12 nickel-chromium resistors, again on a thin film. This type of resistor construction is chosen because of its very low temperature coefficient which provides precision tracking through a broad temperature range.

The Moduline UM1000 D to A converter is in a dual in-line package 0.72″ long by 1.35″ wide, with 14 pins on 100 mil centers, 1.4″ between rows. It is specified over the full military temperature range of —55 to +125 C. Also available is the UM1200, specified for 0 to +70 C commercial applications.

VIDEO AMPLIFIER

Complete, ultra-flexible self-contained circuitry is provided by the Moduline UC1518 video amplifier.

The heart of the circuit is the monolithic amplification section. This is where old integrated amplifiers stopped. The UC1518 adds screen-deposited planar noble metal resistors inside the package, allowing gain from 5 to 50 volts and bandwidth from 40 Hz to 40 MHz to be chosen by nothing more than package pin selection.

Further technology integration adds discrete multi-layer Monolythic® micro capacitors to the ceramic substrate for A-C de-coupling of input and output. The single dual in-line package needs only the board space equal to two conventional single-chip DIP packages.

SENSE AMPLIFIER

The UC1519 combines 3 silicon monolithic integrated circuits and 8 deposited resistors on a ceramic substrate.

The resistors form a tappable voltage divider to allow selection of sensing voltage threshold level.

Two identical monolithic analog comparators receive the signal, then feed to a monolithic Exclusive OR gate.

The result is sensitivity and speed—12mV maximum differential input voltage for "1" output, strobe turn-on 30 nsec.—all produced by combining proven, high-volume integrated circuit chips. The UC1519 dual inline package measures 1.3 inches between rows.

OPERATIONAL AMPLIFIER

The UC1522 operational amplifier answers the need to combine the advantages of discrete and integrated designs.

The discrete input Darlington-connected transistors are closely matched for low off-set. The single-chip amplifier is a "no compromise" design. Then all chips are close-proximity mounted on the same substrate. The result is exceptionally low V_{BE} differential and close tracking over the full temperature range.

Six planar resistors are then bonded onto the substrate. They provide stability and high impedance for the input and output.

The UC1522 is in the same package as the video amplifier.

For further information write to:
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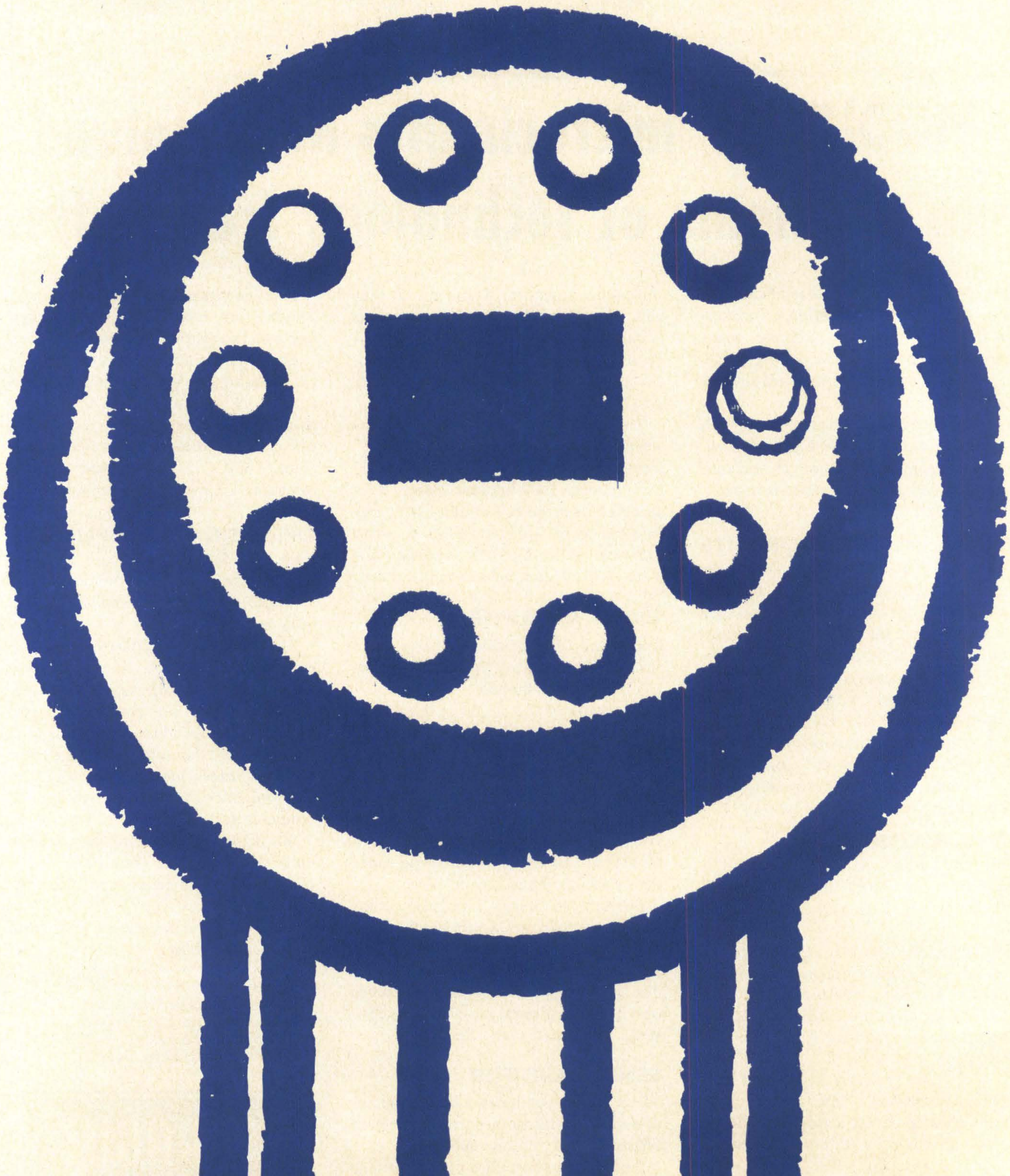
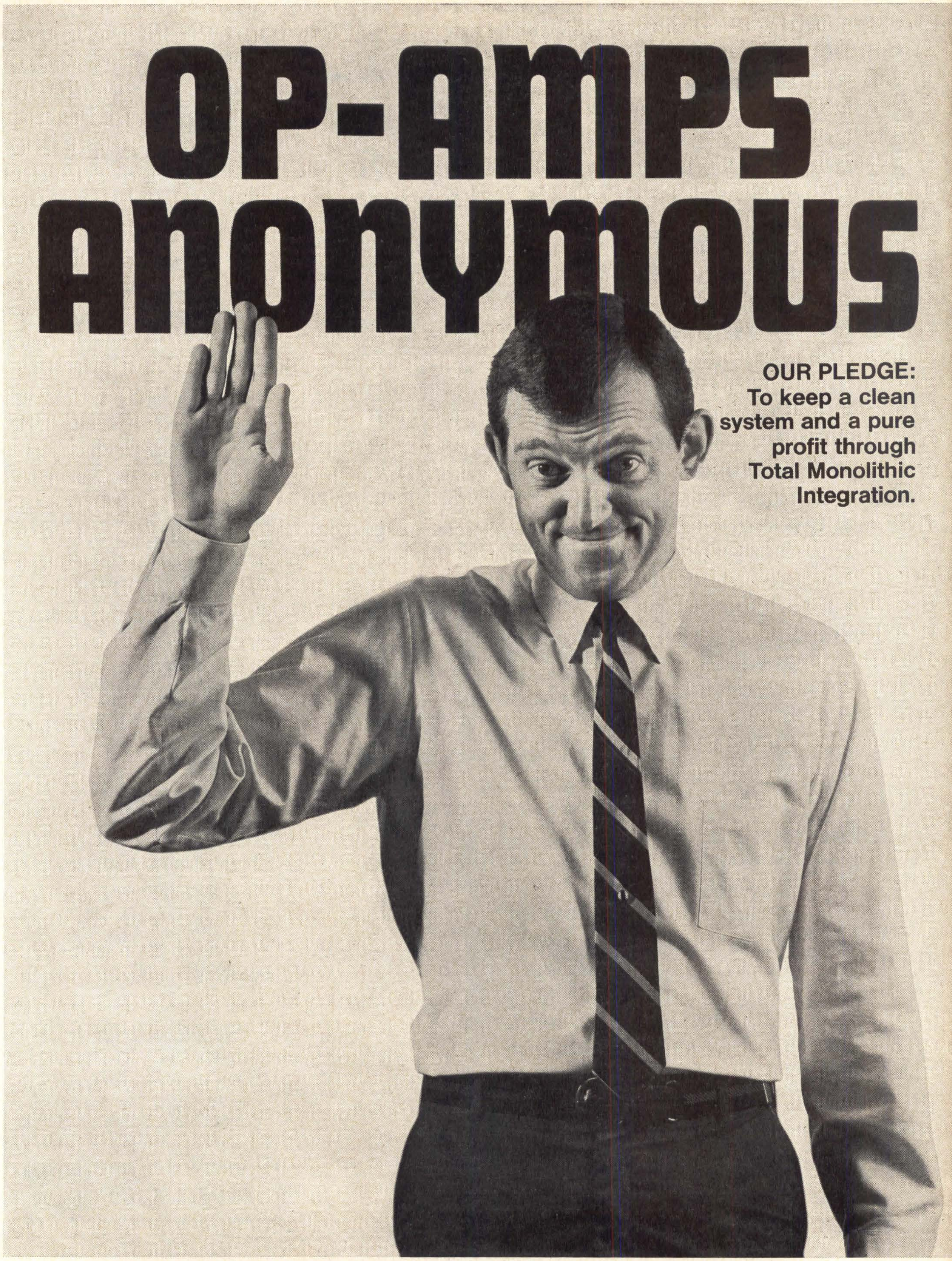
CIRCLE NO. 10 ON INQUIRY CARD

100-bit MOS





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Read how T. H. Pfahlert changed his entire life through Op-Amps Anonymous:

"It started when I was a junior designer using only an occasional amplifier module or two. As the years went by it just seemed the normal thing to do. Almost before I knew it, every analog job I designed was loaded with $60 modules. Oh, I knew better, all right: I.C. prices were coming down, performance characteristics had become equivalent, customers were pressing for monolithics. But I still clung to the old way. Specifying op-amp modules had become a conditioned reflex.

Then I met a man from OAA. He proved conclusively that a $60 module could be replaced by a $5.50 integrated circuit and about $8 worth of discrete devices. Could my company make a profit assembling a dozen or so components for $46.50? You bet!

Now I'm a monolithic man. A little bit of non-recurring design work, Fairchild linear circuits, and a few discrete devices are all I need to regularly turn out high performance, low cost systems. No more embarrassing customer questions. The sales guys don't complain anymore. And because I qualify for the special OAA Member price discount from Fairchild, even the company accountants smile at me.

Since joining Op-Amps Anonymous, I've had three raises and my mother-in-law has moved out of the State."

Who's behind Op-Amps Anonymous?

OAA is a free service of Fairchild Semiconductor. It is clear evidence that Fairchild takes full responsibility for causing the current stampede to monolithic integrated amplifiers (Fairchild introduced the first commercially available linear integrated circuits... has been the leader in reducing LIC prices by over 80% ... offers the broadest product line and speediest delivery of all... and today sells more off-the-shelf linear integrated circuits than all other manufacturers combined).

OAA is dedicated to helping farsighted technical men help themselves to break the op-amp module habit. It offers complete information and counseling services on new scientific discoveries that can help anyone achieve Total Monolithic Integration, regardless of age, sex or working experience.

Order your Op-Amps Anonymous Poster & Membership Kit today

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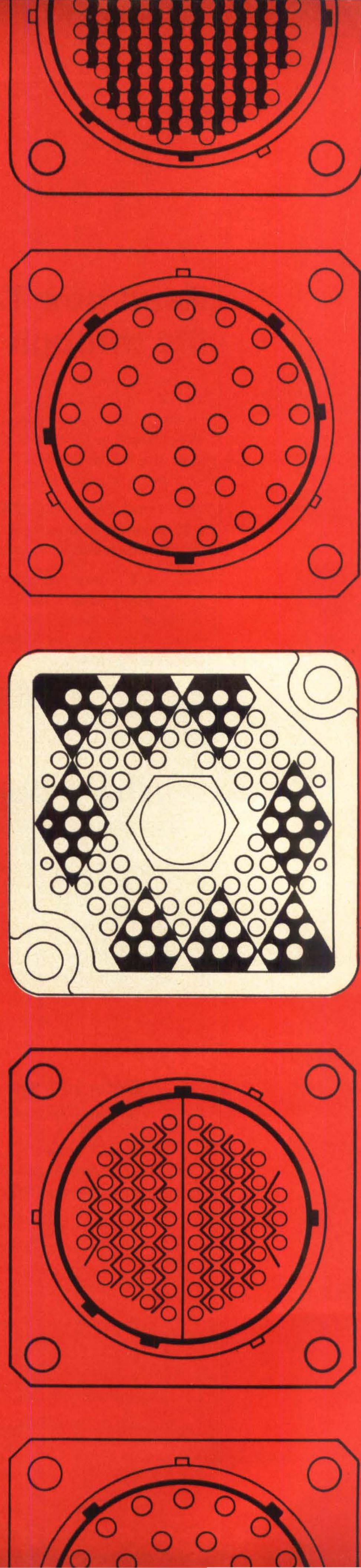
CIRCLE NO. 12 ON INQUIRY CARD

Winchester Electronics just changed the shape of the high density connector market.



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Could be YOU: with Mosaic Fiber Optics!

EDP systems design engineers are only beginning to tap the potential of fiber optics. Yet, after a brief acquaintance with this broad, new technology, they have made breakthroughs already . . . obsolescing "standard" EDP design solutions. Advances like greater speeds. Design freedom. New capabilities. Reliability and lower costs.

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Do you know the story on Mosaic Fiber Optic systems? In new EDP readers, printers, punched tape and card verifiers . . . in keypunch and teletype equipment, they're more dependable, less complicated, less costly and over 4 times faster than heat, wear and friction-prone mechanical systems!

Mosaic fiber optics can help you make breakthroughs to advance the EDP state-of-the-art, too. Give those specific design problems of yours a hard look now. Then get going with the solution. Start by contacting Mosaic Fabrications, the people who know fiber optics inside-out . . . the largest single source of fiber optics technology, capability and productivity on earth!

Mosaic will work with you to solve your EDP design problems *now* . . . will help you design and develop,

from prototype to production, the specific EDP fiber optic hardware to put you way ahead!

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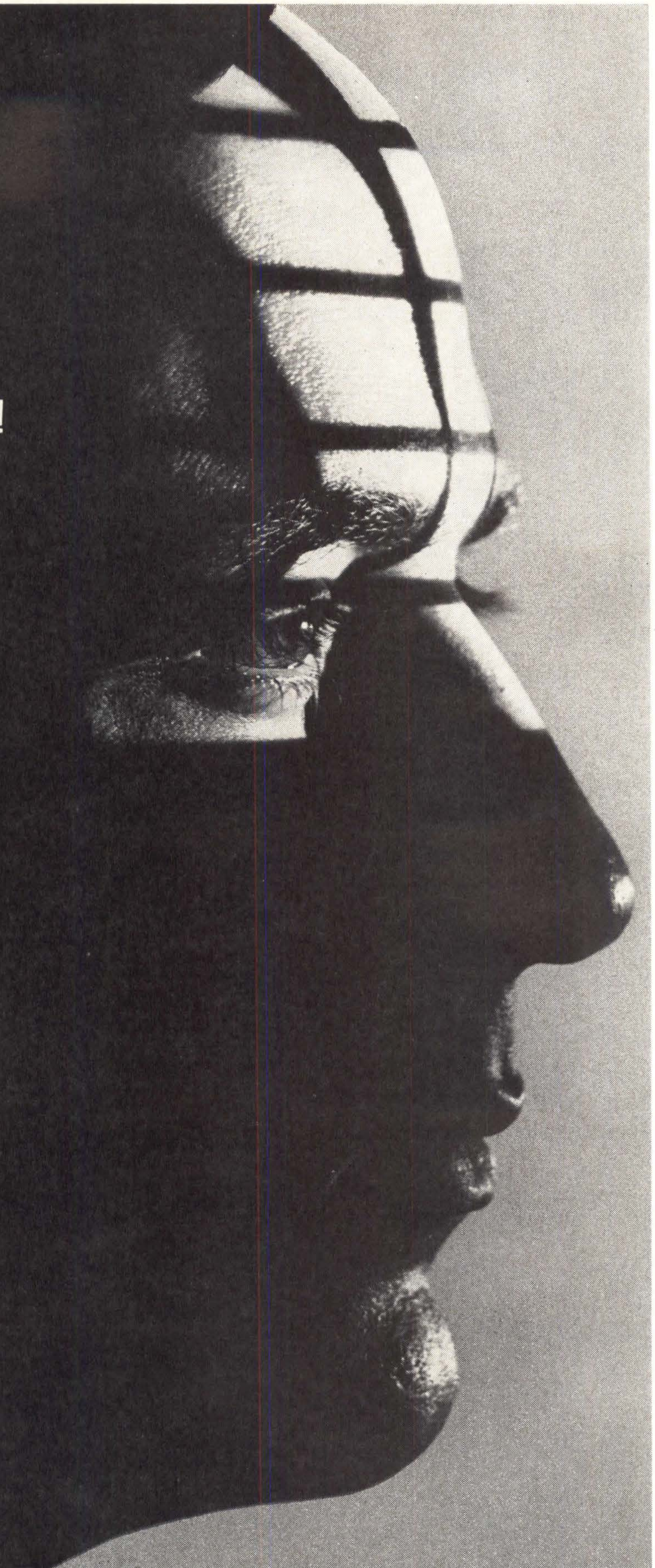

Bendix **Mosaic Fabrications, Inc**

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CIRCLE NO. 14 ON INQUIRY CARD

Talk's cheap at Applied Logic.

Over twenty users can talk at once to Applied Logic Corporation's PDP-6 computer with its Bryant Memory System at their time-shared computation center in Princeton, N.J. They can listen, too. All because of the low cost and easy access of time-sharing. Scientists, mathematicians and businessmen call in from teletype units night and day, 144 hours a week. Their man-machine dialogue may take only a few seconds. But it saves them hundreds of man-hours of work. And to help the PDP-6 do its work, Applied Logic chose a 6-million character Bryant Auto-Lift Drum. They say it expands the core memory economically and gives ideal swapping and storage for the system. And interfaces with no trouble at all. They must like it! Now they're expanding with a 60-million character Bryant Model 2A Disc File. Write Bryant Computer Products, 850 Ladd Rd., Walled Lake, Mich. 48008. Ask for On-Line Application Note #3. We'll make a Bryant believer out of you, too.

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CIRCLE NO. 16 ON INQUIRY CARD

DATA COMMUNICATIONS

equipment for on-line, real-time processing

traveling fast with a host of characters

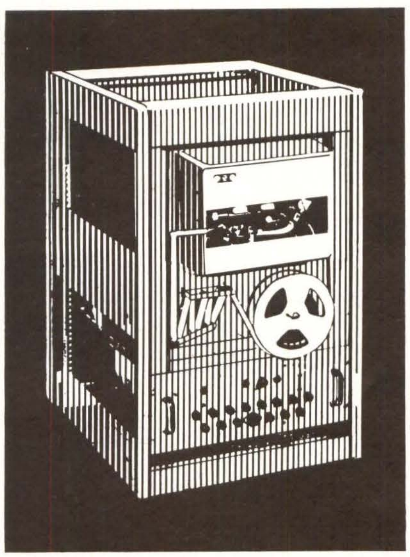
Modern data communications and processing systems require high-speed operations to be most effective. However, they must also be versatile to meet speed and code level requirements of various data equipment. The Teletype DRPE high-speed paper tape punch meets this very need.

The DRPE is an asynchronous, electromechanical, parallel-wire punching unit. It is capable of receiving and punching characters in paper tape at any speed up to 240 characters per second (2400 words per minute)—without any internal changes or readjustments. In addition, the DRPE can perforate most 5, 6, 7, or 8-level codes in 11/16, 7/8, or 1 inch wide tape.

VERSATILE DATA USES

The DRPE can be used as the receiving terminal in high-speed tape-to-tape equipment or as a high-speed output device for computers and other business machines. The punched tape produced by the DRPE can be relayed by Teletype high-speed or standard-speed paper tape readers.

The circuitry of the DRPE converts low-level signals to controlled power signals that are capable of operating the punch magnets at the required high speeds.



DRPE WITH ELECTRONICS AND TAPE HANDLING GEAR IN 19 INCH RELAY RACK

OPERATION OF THE DRPE

Basically, the DRPE punch consists of cantilevered armatures attracted to magnets—one for each code level and the feed hole. Here's how it operates...

When a character code combination is received, appropriate armatures, linked to corresponding punch pins, perforate the tape when they are released from their magnets by a no-current interval. Immediately the current is reapplied to the magnets so that they return the armatures to their home position, ready to punch the next character.

Since the DRPE's mechanism is not in motion while the unit is on-line waiting for a signal, longer life is assured.

AVAILABLE AS SELF-CONTAINED OR PACKAGE UNIT

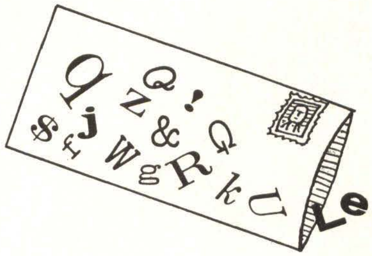
The DRPE punch mechanism, driving electronics, and tape handling facilities are available individually or packaged together in a relay rack or floor model cabinet. Either 50 or 60 cycles per second units are available.

More information on the DRPE punch is contained in our 8-page brochure, "TELETYPE DRPE HIGH-SPEED PAPER TAPE PUNCH." To obtain a copy, contact: Teletype Corporation, Dept. 71E, 5555 Touhy Avenue, Skokie, Illinois 60076.

machines that make data move

TELETYPE ®

CIRCLE NO. 19 ON INQUIRY CARD



Letters to the editor

IC LOGIC CARDS

To the Editor:

I read with great interest Mr. Koning's letter describing his company's products in the February, 1967 issue of Computer Design. I would like to take this opportunity to correct Mr. Koning's statements that his company alone offers IC cards to the government through a GSA contract, and covers the full MIL temperature range. Control Logic's Series C microcircuit product family is also offered to the government user via a GSA contract. This product line includes well over 200 items, provides both DTL and TTL, and operates in excess of 30 MHz. Control Logic, Inc. offers 0°C to 70°C as a standard temperature range and also offers these products in a −55°C to +125°C full temperature range.

Paul M. Nathan, Sales Manager
Control Logic, Inc.
Natick, Massachusetts

UNICON RECORDING SYSTEM

To the Editor:

I must admit that the UNICON Recording System described in CD "March, Page 38" is impressive, however, I do not think conventional magnetic tape recording is as limited as the report implies. Data density on magnetic tape passed the 10,000 bit-per-square-inch point in 1958 when Potter developed the first high-density commercial tape memory system. Using 1" tape and 21 tracks with an information density of 1,100 bits per inch in each track, one square inch of tape held 46,200 bits. If my memory is correct, over one hundred of these systems were delivered and put in service (Bendix G20 Computer System).

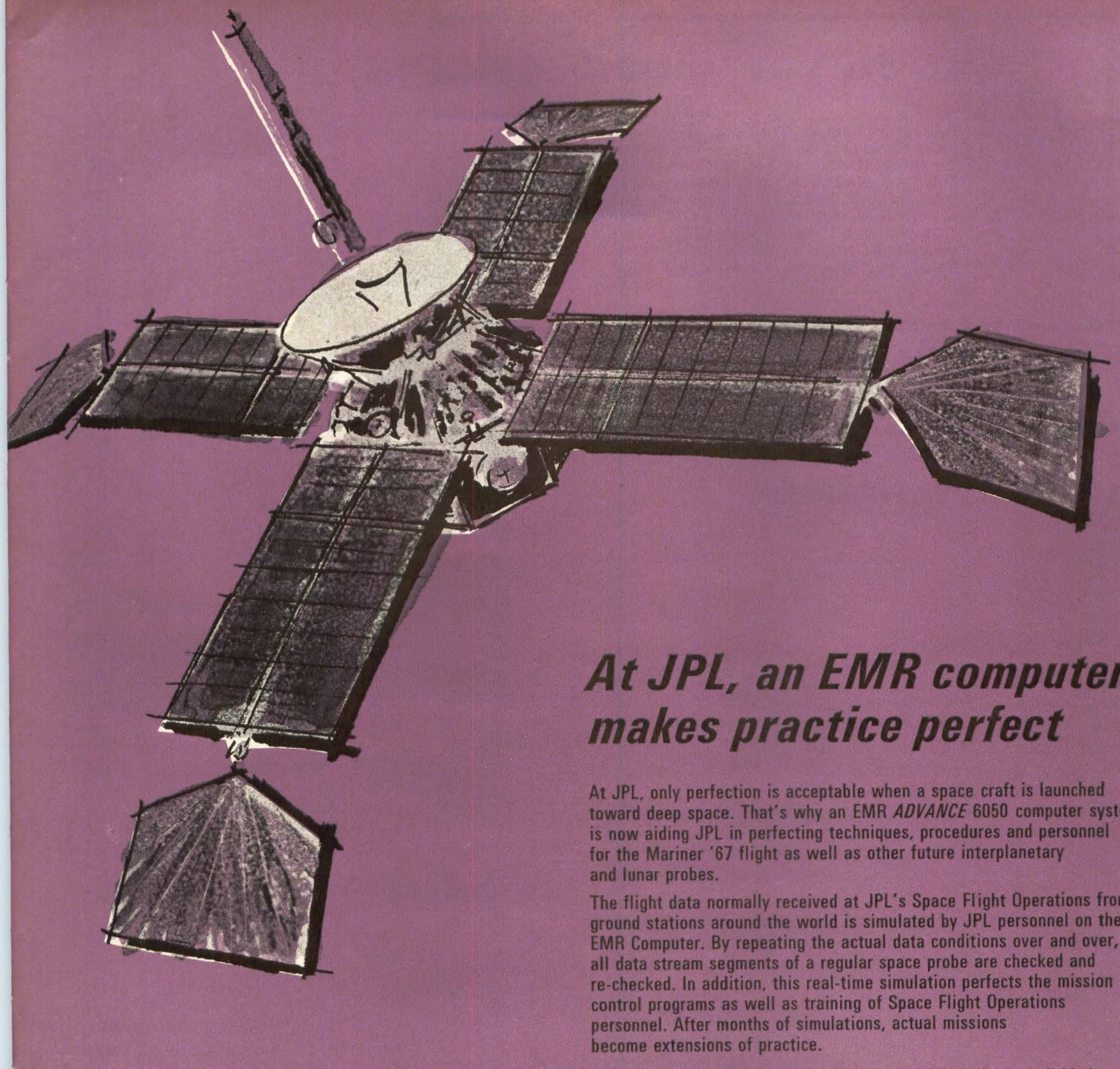
Today Potter's RAM Tape Loop Memory System uses a similar recording technique and packs 56,000 information bits into each square inch of tape. Experimentally, densities of 112,000 bits per square inch have been successfully tested. There does not appear to be an insurmountable limit to this technique.

Accidental erasure is a problem with any recording system. People load reels on machines and people make mistakes. As for accuracy, reading after writing is not unique to magnetic recording systems, having been in use for about seven years, but consideration of this important facet of a recording system by Dr. Baker does place his system in a unique position.

Very truly yours,

John A. W. Richardson,
Area Manager/Boston,
Northeast District
Potter Instrument Co., Inc.,
Natick, Mass.

Circle No. 21 on Inquiry Card



What do you think?

This department is devoted to a continuous interchange of ideas, comments, and opinions on significant problems facing the industry. What do you think about the impact of a computer-automated world and the engineer/scientist's role in it? What do you think about engineering unions — professional societies — industry conferences? Or any significant facet of your professional life. COMPUTER DESIGN will print your views here. Write to: CD Readers' Forum, Computer Design, Baker Ave., West Concord, Mass. 01781.

CD READERS' FORUM

LOGIC SYMBOL STANDARDS

TO CD READERS' FORUM:

Responding to your challenge for the computer manufacturers to state their views on logic symbol standards, we are pleased to present for your readers, the current position of Control Data Corporation on this subject. We do not propose, however, to enter into a public controversy of MIL-STD 806B vs. ASA Y32.14 for the fundamental reason that Control Data Corporation has an excellent Customer Engineering organization providing maintenance contracts to virtually all of its customers of commercial products, and thus CDC logic diagrams and the symbology on them are used almost exclusively by Control Data personnel. Therefore, for us, **logic symbol standardization is largely an internal concern** which has been resolved.

Recently, a study of logic symbols standards for integrated circuits was performed by a committee with representatives from six of our major hardware producing divisions and our Customer Engineering Department. Being open-minded in its investigation, the committee considered the existing MIL-STD 806B, ASA Y32.14, and the previous Control Data standard (which was an adaptation of the uniform symbols in Y32.14). The committee's recommendation is a further extension of the uniform symbology of Y32.14. Their decisions were based on the following factors, most of which also affect costs:

- Ease of preparation (no template required).
- Adaptation to automated drafting techniques (line printers, CRT displays, etc.).
- Compactness of information (speeds servicing).
- Ease of extending symbology for new circuits (a must for a multi-division company).
- Ability of a drawing set to "stand alone" (no reference documents needed).

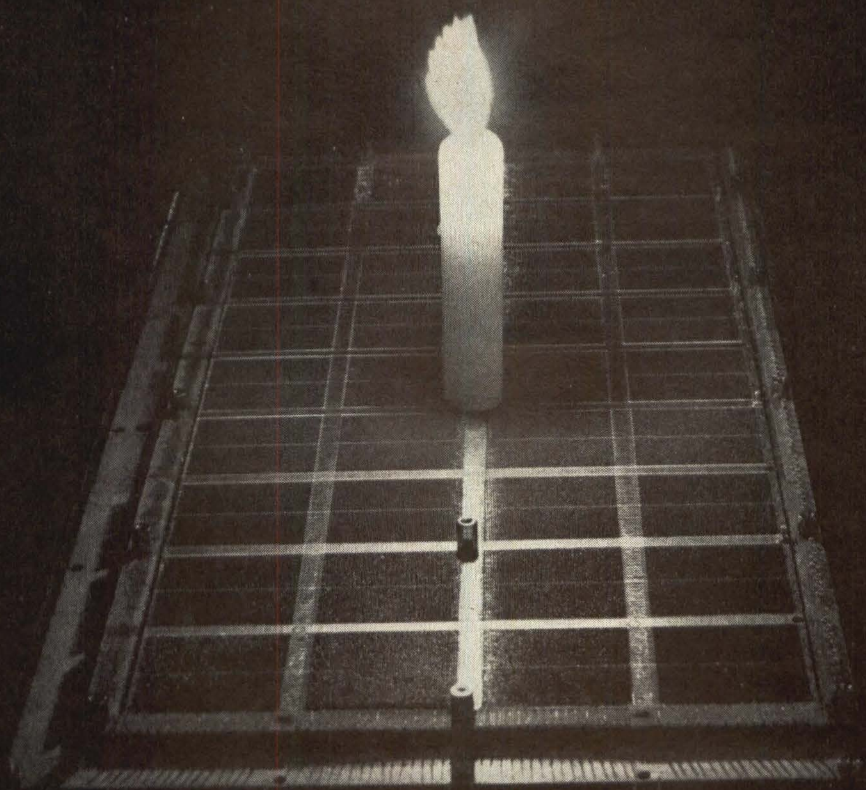
Undoubtedly, this proposed new Control Data standard on logic symbols will be adopted because it has evolved through the cooperative efforts of many people with extensive experience in the computer industry. It contains refinements and additions to Y32.14, yet does not violate what has been a good industry standard, in spite of its quality.

Control Data Corporation has had representation on the ASA Y32.14 committee through Mr. A. C. Gannett. We shall be pleased to offer our suggestions for refining and appending Y32.14 through that organization, thereby making our experience available for those who wish to participate in the USASI program of standardization.

Gerald I. Williams
Director, Engineering Standards
Control Data Corporation
Minneapolis, Minnesota

TO CD READERS' FORUM:

I have read with interest your January comments on logic symbol standards. As one of the members of the ASA Y32.14 committee, I would like to make the following comments. A premature standard can be detrimental since it can impede progress. The committee kept this point in mind while attempting to come up with a standard that would serve not only the designer and field maintenance personnel concerned with logically oriented machines, but also the mathematically oriented logicians as well. Furthermore, it was recognized that the distinct shape symbol desired by the military was important because of immediate possibility of use. On the other hand automatic techniques for making logic diagrams, integrated circuits, and new types of logic such as threshold logic, were on the research horizon. A standard that is outdated before



it is used is as worthless as no standard at all.

For these reasons, a dual standard was adopted. The object was to allow immediate use of standardized logic symbols in a system, yet allow new techniques, devices, and technology to grow without repression. Basically MIL-STD 806B is contained with the distinctive shape symbol of ASA Y32.14. The ASA standard contains as part of the standard a translation between the uniform shape and distinctive shape. It provides a great deal of flexibility. It may be used in a wide variety of different ways by different users, but as long as all of those who come in contact with the various adaptations are able to understand the meaning intended in an unambiguous manner, the purpose of the standard is served.

I commend the foresight of the other members of the Y32.14 committee for their long range view and hard work.

W. D. Rowe
Sudbury, Massachusetts

TO CD READERS' FORUM:

It has been of great interest to review and analyze the various comments and opinions dealing with graphic symbols for logic diagrams and particularly with respect to MIL-STD-806B and ASI Y32.14. Based on the available literature, which has been reinforced by engineers' analyses presented in CD, adequate justification seems to support MIL-STD-806B symbology as the most desirable standard once it is fully understood and properly interpreted.

Of course the term "most desirable" will be challenged by those who view the question from different points of interest and this is, apparently, where a good deal of argument is generated. In fact, use of the very term "standard" is open to the same challenge — whose standard? Standard in what sense? Standard for industrial producers' convenience — or standard for most efficient use by operating people in an operating system environment?

This reader's interest is in a standard for most efficient, time-saving use by technical people in an operating system, and so far no data have been adduced that would refute the basic premises of MIL-STD-806B, which were in turn based on an extensive study entitled, "A Comparison Of Two Logic Symbol Coding Techniques in A Simulated Digital Device Maintenance Environment," now available as U. S. Department of Commerce Clearinghouse Document No. AD-283-487. MIL-STD-806B has in practice proven to be a standard in the sense of an enduring norm and it is encouraging to note the great increase in its use as evidenced by the many technical publications and manufacturers now employing it, as contrasted to even a year ago.

In justice to document Y32.14, it should be pointed out that an introductory note states that such a standard implies a concensus of those substantially concerned with its scope and provisions, that the standard is intended as a guide to aid the manufacturer, the consumer, and the general public. Nowhere is it specified that the standard is considered the most efficient for use by an operating organization. It is this latter point with which this reader, and presumably DOD, is concerned. Just exactly why one department of the DOD should contravene its own standard is unknown to this reader, but twenty years of engineering experience with government departments inclines one to suspect contract officer and purchasing reasons.

In conclusion, it seems to this reader that those comments by Dr. Mott in the February issue of CD miss the point by carrying the argument ad hominem. This can never help the user, no matter how it may help a particular producer with a vested interest. Finally, insofar as user timesaving is concerned, the question of uniform versus distinctive shape symbology is conclusively settled in Document No. AD-283-487. And as an engineering matter, standards should not be formulated by producers' representatives sitting at a conference table.

Carl B. Cahill, P.E.
Electronics Engineer
Federal Aviation Agency
Washington, D.C.

commentary

Comments and opinions on topics of current interest to digital design engineering personnel. A monthly column organized and prepared under the direction of **T. PAUL BOTHWELL, Contributing Editor.**

COMPUTER-AIDED DESIGN OF DIGITAL EQUIPMENT

W. F. Jordan

The recent rash of technical articles, engineering papers, and editorial comments on computer-aided design might indicate that design automation is a revolutionary new concept that suddenly has burst forth upon the scientific community. According to some liberal interpretations in the technical literature, this concept will soon lead to the millenium when computers hum continually away, automatically designing and refining other computers.

This is, at best, exaggeration. Computer-aided design is not new. Designers of digital equipment have routinely used computers as design aids for many years. Hookup wire listing was the first widespread application. Since automated wire-wrapping machinery requires input data of a computer format, it was inevitable that a computer create the wire-wrap object program and while doing it sort, route, sequence, add up electrical loading, and tabulate all this data.

Another use has been computer-controlled drafting machines to create printed circuit artwork. A programmed system has even been used to lay out welded cord wood interconnections.[1] In all of these cases, the computer has created a product and a product documentation which are ideally suited to automatic manufacturing, automatic testing, and a "total-history" field documentation file.

For scientific work, electronic engineers have increasingly applied digital computers to handle difficult (or tedious) mathematical calculations. A vast and brilliant effort has recently resulted in the development of practical universal computer programs for circuit analysis. Programs such as NET I, ECAP, PREDICT, and SCEPTRE are capable of mapping networks, preparing equations, computing performance, and performing other complex tasks that otherwise would require the time of many creative engineers.

The author of this month's CD Commentary, W. F. Jordan, is a development engineer in the Memory Products Department of Honeywell's Computer Control Division in Framingham, Mass.

More IC's — More Computers

In part, this effort has been stimulated by the rapid application of integrated circuit technology. As these circuits increase in types and complexity, more programs will be written to assist the circuit designer. It is difficult, by manual techniques, to breadboard new-device geometry, worst-case circuitry, stray capacity, voltage-dependent capacity, distributed capacity, and distributed semiconductor effects. It also is difficult to monitor transient currents, low-level signals, parasitic oscillations, and non-instrumentation noise. It is often awkward to supply ideal input waveforms or bias voltages. And it is tedious to perform the repeated calculations necessary to determine yield-performance trade-offs by other than computer analysis.

Soon the human link will be eliminated from the design feedback loop. Statistical analysis considering performance-yield trade-offs will be completely automated. Computers will reiterate their analyses seeking optimum designs. After circuit values are determined, a program (e.g., CADIC) will determine the diffusion patterns needed for all integrated-circuit elements.[2,3] The geometry of resistors and capacitors will be calculated using design-rule algorithms. Semiconductor designs will be retrieved from a computer mass memory file. The output will be a complete set of machine drawn masks. A thorough statistical characterization of the designed circuit will be available long before production has commenced. This will, in fact, be design automation with automatic design synthesis and not merely an automatic engineering slide rule.

Interconnection technology will similarly evolve. An experimental program called ACCEL has shown how automated layout can work.[4] Circuit components are arbitrarily placed on a mathematical plane and their wiring interconnections (represented by vector tension forces) automatically pull them around until a stable (optimum) placement is determined. These forces even rotate the components for optimum angular placement. Card edges are modeled as a boundary of repulsive forces to limit the problem properly. Part two of this program routes the wiring lands by a topographical trial-

and-error technique. Obstructions are represented as peaks, and potential paths as valleys, to allow the creation of minimum altitude paths. Part three prepares a parts list, printed-circuit etch negative, assembly drawing, hole-drilling list, and wire jumper list.

As large-scale integration becomes more prevalent — and the requirement of higher computer speed and lower cost seem to make this inevitable — universal programs will be developed for monolithic chip layout and mask making. One approach that already has been developed is the discretionary, or test-and-wire technique, where complete slices filled with replicated circuits are tested and operable functions are automatically interconnected.[5] Only modern, high-speed computer programs can evaluate the tests, store results, and route the wiring with the efficiency necessary to make this approach practical.

More Computers — More Interaction

It is apparent that the time savings, cost savings, labor savings, and other benefits of computer-aided design will proliferate the development of more advanced programs for circuit analysis, design, and manufacture. Even now, special projects such as NASA's COSMIC are necessary to keep abreast of programs that are in existence.[6]

New machines, several orders of magnitude faster than existing equipment and with lower cost memories, will permit more real-time operation and the solution of even more complex problems than currently are considered possible. Peripheral equipment that enables the user to engage in remote, two-way communication with the computer in both alphanumeric and graphical languages will become more commonplace. Already programs (e.g., CIRCAL) have been demonstrated for on-line circuit analysis with live oscilloscope displays of schematics, curves, and tabular data.[7] By speeding up and making vivid the continuous interaction between engineer and computer, quicker designs, and probably better ones, will result. Obscure concepts, effects, and trends are made understandable by visual dramatization.

But the key to progress is software — software that condenses historical facts, empirical knowledge, and scientific data into truly universal programs. Appropriate software will enable the engineer to employ heuristics and engage the computer in a conversational mode, thus making maximum use of his own imaginative intelligence and the computer's problem-solving ability. As this software becomes available, the progeny of this generation of computers will help produce new generations, and automatic design will pervade the digital industry. Designers of digital equipment should keep abreast of the continuing developments in the field of computer-aided design in order to apply this powerful tool as the need arises.

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GOVERNMENT REPORTS ★★

COMPUTER SOFTWARE

Report defines such elements as computer hardware, programming and operating system functions, programming languages and processors, machine independence, procedurality, generality, interpreters, translators, assemblers, compilers, and generators. Discusses in non-technical terms the major developments in operating systems and recent trends in programming languages.

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Reliability requirements for microelectronic devices should be standardized and coordinated with an improved quality assurance program, according to a study. The study points out that long-range objectives expressed by both military and commercial users of microelectronic devices are a maintenance-free lifetime, a discard at failure maintenance at the level of complex modules or entire equipments, and logistic self-support or on-board spares. These objectives cannot be attained without a standard and rigid pattern of testing and quality assurance, lacking at the present time. The study reviews and evaluates some of the problems and possible interim solutions, and suggests an investigation for measuring the quality and reliability of a product.

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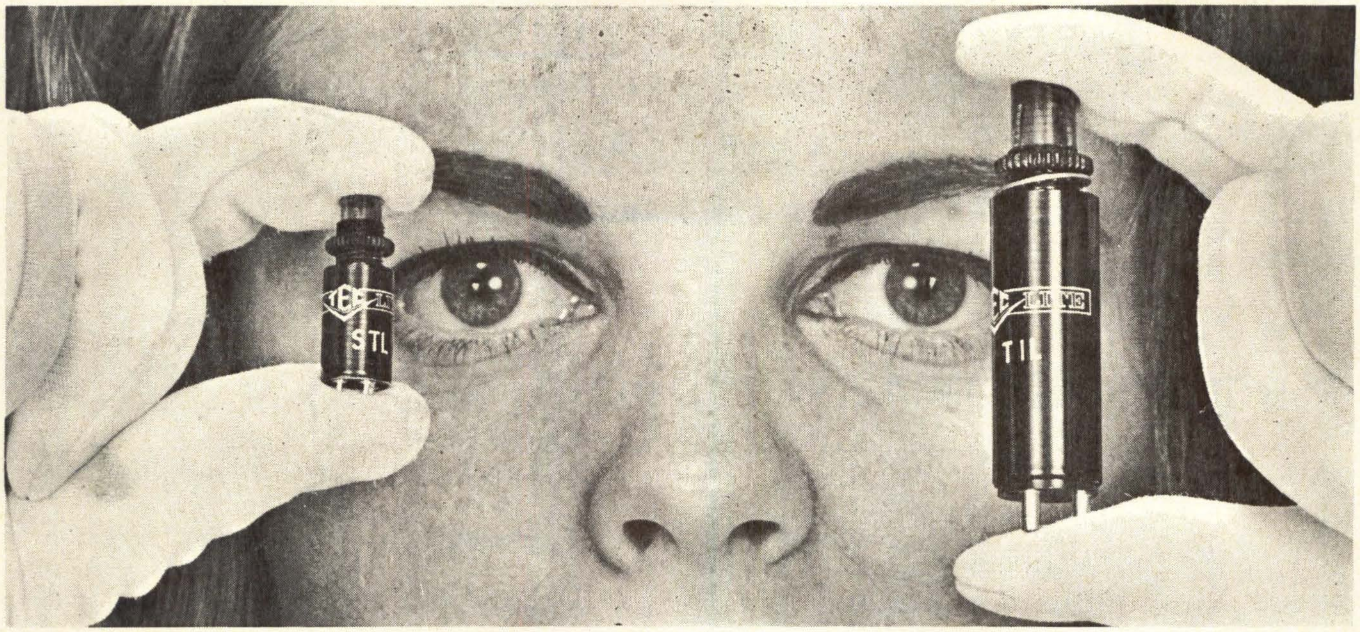

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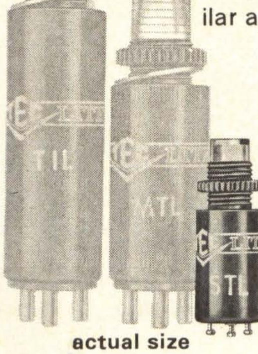

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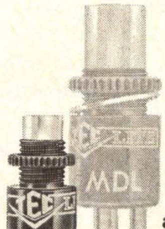

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MATHEMATICS REVISITED:

Selected Topics In Probability And Statistics

Dan M. Bowers, Contributing Editor

Part 10 – STATISTICAL SAMPLING

Statistical sampling is a part of our everyday life as consumers, voters, motorists, taxpayers, and television viewers. Marketing men sample us to determine how we will accept a new brand of soap. Politicians sample us to find out for whom we will vote. Traffic planners sample us to find out where we go, by what route, and how often. The Internal Revenue Service samples us to find out whether we cheat on our income tax. And network executives base their precarious jobs on what the Neilsen and Trendex ratings (samples) say we watch most frequently on the CRT display installed in our living room.

In terms of the topics we have discussed in previous articles, sampling is basically a means for determining the characteristics of a statistical distribution, without expending the labor necessary to compile all the constituent bits of data which comprise the distribution. This may sound like a mathematic confidence game, but in accordance with the "no something-for-nothing" rule, we shall find that we give away precision in order to reduce the work involved in gathering data. For example, using all 188 bits of data in the mutual fund example (Part 8, February issue), we calculated their mean to be \$11.48, exactly. With sampling techniques, we can say — using only 36 bits of data — that we are 95% sure that the mean is between \$9.18 and \$16.98. When the population of constituent bits of data is very large (e.g., every voter in the United States), samping is the only practical procedure, and is at any rate sufficiently accurate for a great many purposes.

Two important rules must be followed in statistical sampling, and they are embodied in the statement that a **random sample** must be taken **from the population of interest.** If we are taking a national voter preference sample, this means that every person who will vote in the election of interest must have an equal chance of being included in the sample. Entire books have been devoted to the problem of selecting a sample, and we will not belabor it here; suffice it to say that the proper selection of the sample is the crux of statistical sampling, and a poorly-designed sample cannot be salvaged by any fancy mathematics.

To illustrate both the effectiveness and the procedure of sampling, we shall return to the mutual fund price list. Since our population is defined as the items on that list, we are certain to have the population of interest. To insure a random selection, we shall use a book of random numbers; omitting the details of the process, we come up with the following listing of thirty-six random numbers between 1 and 188:

027	043	006	036	008	010
161	053	051	060	183	023
158	008	090	139	138	069
010	026	099	161	176	147
143	027	044	025	050	174
067	104	037	081	133	145

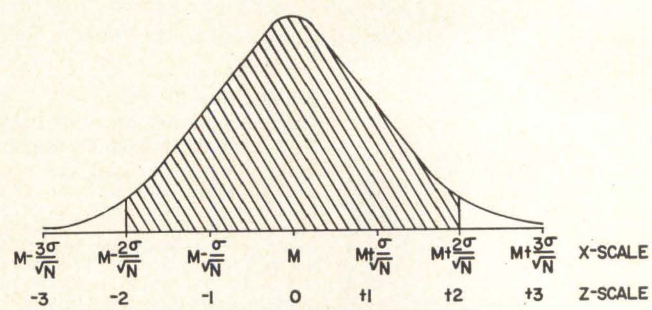

Fig. 1 Theoretical Distribution of the Sample Means.

Using the first three numbers from this list, we shall extract a three-data-bit sample from the mutual fund prices, using the 27th, 161st, and 158th prices in the list. They are:

\$32.69
\$14.67
\$ 7.52

The mean of these three prices is \$18.29. Following this procedure with the remaining random numbers,

we select eleven more samples of three bits each:

7.25	23.79	6.27	10.24	4.78	8.77
6.58	8.79	32.69	9.80	13.84	16.74
21.62	6.91	18.85	8.88	11.54	30.49
14.67	1.72	6.85	7.25	4.46	11.61
18.14	8.14	14.09	11.30	10.29	18.98
18.33	7.54	13.67			

The means of the twelve samples are:

18.29
11.81
13.16
19.27
9.64
10.05
18.67
12.19
12.95
11.11
9.96
9.81

The listing of twelve means constitutes a new kind of distribution, an **experimental sampling distribution**, and going back to the formulae in Part 5 of this series (August, 1966), we can calculate the mean and standard deviation of this distribution to be:

$$m_s = 13.08$$
$$\sigma_s = 3.45$$

We now have a description of the mutual fund price list, embodied in our experimental sampling distribution, and our problem is that we do not know how closely the mean and standard deviation approximate the actual parameters of the price list. To solve this problem we must determine, from the statistics of the price list, what the probabilities are of obtaining various values of m and σ from twelve sets of three bits each. This could be computed if we took all possible combinations of twelve sets of three bits each from the price list, but there are two problems involved: first it is approximately a day's work to do just that; and second, it doesn't seem "kosher" because in a real-life problem the price list is the unknown. Fortunately the theoreticians have solved the general case of this problem, and we need only accept two theorems and a definition.

• **Theoretical sampling distribution** of m_s — a distribution which describes the probabilities of obtaining various values of m_s while taking random samples of size n from a given population.

• **Standard Error Of The Mean** — if random samples of size n are taken from a population with mean m and standard deviation σ, the theoretical sampling distribution of m_s has mean m and standard deviation $\sigma/(n)^{1/2}$, which deviation is known as the standard error of the mean.

• **Central Limit Theorem** — if n is large, the theoretical sampling distribution of m_s can be approximated very closely with a Gaussian curve.

It is worth noting, parenthetically, at this point that since our $n = 3$, it hardly qualifies as "large". And furthermore our population of 188 items is sufficiently small to appall a self-respecting mathematician. Since, however, our purpose is to illustrate rather than calculate, we shall proceed with this manageable but unrigorous data base.

Let us take a special note of the Central Limit Theorem, and reiterate a point made in Part 6 (November, 1966): the distribution of the means of samples taken from any distribution is Gaussian. This is a cornerstone of statistical sampling. Our twelve samples are not sufficient for us to plot effectively the experimental sampling distribution, but if we took fifty-or-so samples, we would expect them to plot a roughly Gaussian curve.

From the above theorems, then, we can proceed to evaluate the meaningfulness of the information which our sampling of the mutual fund prices has provided. Assuming the theoretical sampling distribution of the sample means to be Gaussian, we know from the first theorem that it has mean m and standard deviation $\sigma/(n)^{1/2}$, where m and σ are the actual quantities we are trying to estimate through sampling, as shown in Fig. 1. From Table 1 of Part 6, we know that 95% of the area of this curve lies between the values $\sigma = -1.96$ and $\sigma = +1.96$, illustrated by the shaded area in Fig. 1. Put another way, we can say with a probability of 0.95 that any sample mean m_s will lie in the shaded area, i.e.:

$$-1.96 \leq \frac{m_s - m}{\frac{\sigma}{\sqrt{n}}} \leq 1.96, \ P = 0.95$$

Manipulating this equation, we find that:

$$m_s - 1.96 \frac{\sigma}{\sqrt{n}} \leq m \leq m_s + 1.96 \frac{\sigma}{\sqrt{n}}, \ P = 0.95.$$

Now we have an expression which tells us the interval in which the true mean of the population is to be expected. It tells us this in terms of our sampled data and provides us with a confidence factor in terms of the probability that this interval contains the true mean. Furthermore, in case $P = 0.95$ is unsatisfactory for the purpose of our sample, we can alter the confidence level by merely replacing the z-values of 1.96 with other appropriate values.

Let us now apply this technique to our sample from the mutual fund prices, and then check our results back against Part 8 to judge the value of the sampling process. We shall substitute our sampled m_s of 13.08, and for lack of any better information will use $\sigma_s = 3.45$ as the standard deviation of the population.

Doing this we have:

$$13.08 - (1.96)\frac{(3.45)}{\sqrt{3}} \leq m \leq 13.08$$
$$+ (1.96)\frac{(3.45)}{\sqrt{3}}, \ P = 0.95.$$

We can therefore say with 95% confidence that the true mean is between 9.18 and 16.98, i.e., "in the long run", 95% of similar samples will have come from a population whose mean is in this interval. If we vary the confidence level, we can create the following table:

P	Z	interval of m
0.95	1.96	$9.18 \leq m \leq 16.98$
0.90	1.64	$9.82 \leq m \leq 16.34$
0.80	1.28	$10.53 \leq m \leq 15.63$
0.70	1.04	$11.05 \leq m \leq 15.11$
0.60	0.84	$11.41 \leq m \leq 14.75$
0.50	0.68	$11.73 \leq m \leq 14.43$

The tradeoff, then, is between confidence level and the size of the interval: the more confidence we need to have, the less we have to be confident of, so to speak. Note also that **as larger samples are taken, the confidence interval narrows,** and we gain more information.

It is interesting to note that despite the facts that the size of our samples was ridiculously small, and our population was not, statistically speaking, large, the results of this sampling are quite good. Our sample mean of \$13.08 is only 0.27σ from the true mean of \$11.48, and our table of confidence intervals contains the true mean for all the cases where the probability favors that situation. Considering the other vagaries of the stock market and other sampled populations, we see that sampling provides useful information which could not be obtained at reasonable cost, or perhaps could not be obtained at all. One of the most familiar appearances of such terms as "60% confidence" is in the weather forecast. The population of data needed to create a 100%-confident forecast is such (aside from the data collection problem) that it has been estimated that 25 days of computation time on a CDC 6600 would be required to produce a 25-day forecast (which might by that time be termed a "hindcast").

The procedure which has just been illustrated is a problem in **estimation:** we have, through sampling, estimated the mean of a population. Next month we shall **REALLY** conclude this series of Selected Topics in Probability and Statistics (would you believe two more sections?) by applying these techniques to some other applications of estimation, a discussion of tests of hypotheses, and an introduction to some methods of testing for randomness.

Next Month . . .
Conclusion of
Selected Topics in
Probability and Statistics

School's out in June
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DC OUTPUT

from our man in Washington

Codes of ethics for those in the computer industry and for those who carry out computer processes have been called for by U.S. Senator Sam J. Ervin, Jr. (D.-N.J.). In a recent speech to the American Management Association's Annual Conference on Electronic Data Processing he urged self-regulation and self-restraints be exercised by all concerned with automatic data processing. He warned that if self-regulation is not achieved, strict legislative controls will be enacted, government R&D appropriations will be denied, and the "computer will become the villain of our society." Sen. Ervin urged management to give serious thought to the psychological impact of their information-gathering tactics on society and on particular communities. The Federal Government, he said, "must take the lead in this effort since its guidelines can be models for state and local government and private industry."

Legislation to strengthen the U.S. patent system has been proposed by the President. President Johnson told Congress that the system must be strengthened so that it can serve the technological advances it was designed to foster. The purposes of the legislation are: (1) To raise the quality and reliability of U.S. patents; (2) To reduce the time and expense of obtaining and protecting a patent; and (3) To speed disclosure of scientific and technological information. These recommendations are designed to bring the U.S. system more closely into harmony with those of other nations. Under the proposed legislation, standards would be clarified and in every case the inventor would be required to show that his invention is really new. Action is taken to reduce the likelihood of issuing patents which are later declared invalid by the courts. Third parties would be permitted to argue before a patent is issued that an invention does not meet the required standards. Under the proposed bill, most pending patents must be published no later than 24 months after they are filed, regardless of how long it takes to issue the patent. Computer programs would not be patented under the new proposal.

The initial phases of a government-wide information system have been designed and will become operational early in 1967, the Bureau of Budget reported in the first semi-annual report on the use and management of electronic computers in the Federal Government. The President's program of having Federal agencies seek new and better ways of using computers has resulted in redistribution within the government of equipment valued at $70 million, thereby avoiding expenditures for new equipment; a saving of $26 million by using time available on government computers at locations other than where the requirement existed, rather than acquiring additional equipment; and avoidance of approximately $200 million in annual rental costs by selective purchase of computers, many of which were bought within the past three years and have already been amortized. According to Budget Bureau Director Charles L. Schultze, "this record of accomplishments is impressive and encouraging. But there is much more that can and must be done to make computer systems more effective, improve further the utilization and methods of procurement, achieve greater compatibility among equipment and systems, and develop appropriate standards of performance."

The Federal Government should underwrite an extensive program to give each college and university student in the United States access to a computer by 1971. This was the sum total of the suggestions of the recent report of the President's Science Advisory Committee on Computers in Higher Education. The report notes that computers have become powerful tools of learning, but in 1965 less than 5 percent of the total college enrollment, all located in a relatively-few schools, had access to computing service adequate for educational needs. The panel recommended an expansion of Federal Government support for education and research in computer sciences; government agency support for allowing schools to be free to apply funds either to the purchase or rental of equipment; universities and government cooperation in the immediate establish-

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ment of large central educational computing facilities capable of serving institutions; and for the Federal Government to collect meaningful data concerning computers and the jobs, personnel, and educational facilities associated with them, and endeavor to make useful annual forecasts.

....

Modern technology — particularly computers — can do much to aid fighting crime, concludes recent report of the President's Commission on Law Enforcement and Administration of Justice. One recommendation of the commission calls for an experimental program to develop a computer-assisted command-and-control system for police use to be established with Federal support. Before such a program is developed and implemented there should be a great deal of analysis and experimentation. Many possible equipment combinations will have to be weighed, the commission believes. The development process will need continual modification and testing and should be guided by an organization experienced in the development of large computer-based systems.

Recent Government Contracts ....

SOUTH DAKOTA STATE UNIVERSITY, Brookings, South Dakota, a NASA contract for the study of the adaptability of FET models to computer-aided circuit design.

UNIVERSITY OF NOTRE DAME, Notre Dame, Ind., a $10,000 NASA contract for the study of computer-aided design and analysis of circuits and systems.

UNIVERSITY OF SANTA CLARA, Santa Clara, Cal., a NASA contract for the study of the analysis and design of solid-state circuits utilizing the NASA analysis computer program.

BURROUGHS CORP., Detroit, Mich., a $22,403,010 Federal Aviation Agency contract for the development of 177 radar digitizers which convert radar signals into computer messages.

GOVERNMENT REPORTS ★★

TRANSIENT RADIATION VULNERABILITY

Report investigates the pulsed ionizing radiation vulnerability of selected computer binary circuits and basic radiation-induced failure mechanisms. Information offered concerns loading effects, failure modes, and the preferred state of flip-flops when exposed to a transient radiation environment. Has direct application to studies which pertain to hardening techniques for flip-flops.

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INDUSTRY NEWS

MANY READERS OF COMPUTER DESIGN ARE AWARE OF THE EXCELLENT SEMINARS IN THE FIELD OF AUTOMATION AND COMPUTER TECHNOLOGY CONDUCTED BY RCA INSTITUTES. Here is their schedule for April, May, and June. April 3-7, Logic Design, Cherry Hill, N. J.; April 3-7, Digital Communications, Boston, Mass.; April 10-14, Digital Communications, Washington, D. C.; April 17-21, Logic Design, Denver, Colo.; April 17-21, Digital Systems Engineering, Palm Beach, Fla.; April 24-28, Digital Communications, New York City; May 8-12, Digital Systems Engineering, New York City; May 8-12, Logic Design, Detroit, Mich.; May 8-12, Digital Communications, Los Angeles, Cal.; May 15-19, Logic Design, Seattle, Wash.; May 15-19, Digital Systems Engineering, Albuquerque, N. M.; May 15-19, Digital Communications, San Francisco, Cal.; May 22-26, Logic Design, Long Island, N. Y.; June 5-9, Digital Systems Engineering, Rochester, N. Y.; June 5-9, Digital Communications, Palm Beach, Fla.; June 19-23, Logic Design, Atlanta, Ga.; June 19-23, Digital Systems Engineering, Detroit, Mich.; June 12-16, Digital Systems Engineering, Washington, D. C.; June 19-23, Digital Communications, Chicago, Ill. Further information on these seminars can be obtained by writing directly to: Mr. Bradford Daggett, RCA Institutes Seminar Program, 49 West 45th St., N. Y., N. Y. 10036 or by telephoning 247-5700.

BARCLAYS BANK LTD., OF GREAT BRITAIN, THE LARGEST BANK IN THE WORLD OUTSIDE OF THE UNITED STATES, HAS SELECTED A GIANT BURROUGHS B8500 ELECTRONIC INFORMATION PROCESSING SYSTEM for what is termed as the largest on-line, real-time banking system in the world. Valued at $32 million, it is believed to be the largest computer order ever placed by a private enterprise. Through the use of special terminal computers — custom designed to meet the requirements of banking — most of Barclays' 2,500 branches throughout the United Kingdom will be connected by telephone lines to the B8500 central system located in the bank's London headquarters. "To our knowledge, this is the largest order for an on-line, real-time data processing system ever placed by a commercial computer," Ray W. Macdonald, president of Burroughs Corporation, said. "There will be nearly 2,500 terminal computers in the system, operating on-line with a dual processor central system." Installation of the central B8500 for Barclays will be made early in 1969 and the complete on-line, real-time system will be operational in 1970 prior to decimalization in Britain.

A SMALL ELECTRONIC DEVICE THAT SCRAMBLES TELEPRINTER MESSAGES TO PROTECT THEM FROM UNAUTHORIZED INTERCEPTION DURING TRANSMISSION was shown recently at the International Security Conference by International Telephone and Telegraph Corp. The CRYPTEL 240 cryptographic machine scrambles messages for storage on punched tape prior to transmission. A similar machine is used to decipher the messages at the receiving end. The ciphered messages are completely compatible with standard teleprinter transmission schemes. Deciphering of received messages, which are punched on tape, is done automatically, when convenient, according to the order of priority given in the clear-text heading of each message. The basic cipher key in the device is a set of pins on a pinboard giving different codes that can be changed within minutes by non-technical personnel. The number of different settings is approximately 250 trillion, trillion (2.5×10^{26}). The scrambler is said to be easy to use and may be operated by technically unqualified staff. The machine is designed to work in conjunction with a standard teleprinter comprising a tape punch and a tape reader.

CONTROL DATA CORPORATION IS NOW MARKETING A NEW SUPER-SCALE COMPUTER SYSTEM KNOWN AS THE CONTROL DATA 6500, it was announced recently by R. D. Schmidt, vice president of sales. The machine was unveiled at a private demonstration of both 6500 hardware and software before a large group of data processing users. The Control Data 6500 utilizes two Control Data 6400-type processors. This is accomplished, according to the company, by completely eliminating the central processor overhead inherent in other dual processor systems, where the processors must handle both processing and input/output chores. Since the 6500 dual processors are free for processing only, they may be used simultaneously for processing two of the several jobs which can reside in the central memory at any given time. Thus, the 6500 achieves multi-programming and multi-processing by one central computer. The dual processor can also be used interchangeably during the calculation of a single problem, providing up to twice the computing power of the single-processor 6400 with only a nominal increase in system price. The 6500 uses either a 65K or 131K word (60-bit) core memory. Storage is in 4K word banks. Each central processor has its own 24 operating registers for a total of 48.

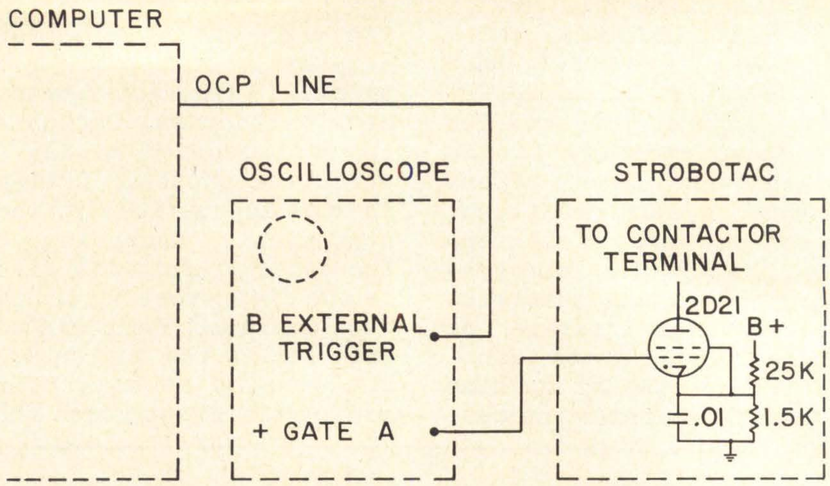


Fig. 1. Block diagram of diagnostic setup.

A DIAGNOSTIC TECHNIQUE FOR INPUT/OUTPUT EQUIPMENT

The diagnosis of hardware malfunctions is facilitated by a technique for synchronous oscilloscopic observation of waveforms and stroboscopic observation of mechanical parts.

CHARLES ERWIN COHN,
Reactor Physics Division,
Argonne National Laboratory,
Argonne, Ill.

In the diagnosis of malfunctions of electromechanical input-output equipment for computers, it is not always easy to determine whether the trouble is in the device itself or in the interface. Furthermore, the mechanical parts of these devices move so rapidly that direct visual observation of their action is impossible. Also, it is often difficult to display the electrical signals involved in a meaningful way.

An improved diagnostic technique has been developed which is intended to assist in eliminating these difficulties and in yielding more accurate diagnoses. Our computer (a DDP-24), like others in its class, has a number of output control pulse (OCP) lines. A pulse may be made to appear on any of these by executing an OCP instruction with the appropriate address. The diagnostic technique uses specially-written diagnostic programs that execute an OCP instruction addressed to an external line before each operation of the device under test. This OCP line is connected to the delaying sweep external-trigger input of an oscilloscope, and the waveforms of various signals in the interface may be thus displayed in synchronism with the operation of the device so that one may check the operation of the interface and examine the signals generated by the device. Such tests can very rapidly confirm or rule out the possibility of trouble in the interface.

In addition, the delayed trigger

from the oscilloscope can be made to trigger a stroboscope illuminating the moving mechanical parts of the device which will reveal the status of the moving parts at that point in the operating cycle. This allows the operation of the mechanical parts to be observed in detail.

The particular setup used here is shown in block diagram form in Fig. 1. Here, the OCP line is connected to the external trigger input of time base B on a Tektronix 545A oscilloscope. With the oscilloscope probes connected to the circuits under test, the waveforms at those points will be displayed on that time base in synchronism with the operation of the device. The stroboscopic function is performed by a General Radio Strobotac, type 631-BL. As shown in Fig. 1, a thyratron is connected across the contactor terminals of the Strobotac, which is operated in the "contactor low" mode. This thyratron is fired by the initiation of the "+Gate A" signal from the oscilloscope. With the oscilloscope operated in the "B intensified by A" mode, the left-hand edge of the intensified region indicates the instant of Strobotac firing, and the mechanical and electrical indications may be correlated. (The Strobotac was used here because it was available; a "power timing light" of the type used for timing automobile ignition systems would be less expensive and more convenient to manipulate.)

A number of special diagnostic codes have been written using this technique to diagnose the Selectric typewriter, the paper tape punch, and the line printer. The typewriter diagnostic continually types lines consisting of twenty repetitions of a selected character followed by a carriage return. A pulse is transmitted to one OCP line before each character typeout and to another OCP line before each carriage return. This allows all of the mechanical and electrical functions of the typewriter to be checked. Although the computer is not sensitive at this time to input signals from the typewriter, these signals may still be observed as they are generated by the typewriter transmitting contacts and as they pass through the interface circuits up to the point where they are gated with the typewriter input enable signal.

The punch diagnostic will either continually punch a selected character or alternately punch a line feed character (channels 1 through 7) and a stop code (channel 8). The line-printer diagnostic continually prints lines consisting of the entire character, set in rotation, followed by a few spaces. Pulses are emitted on separate OCP lines, when the printer is selected, before each character is transmitted to the printer buffer, before the print operation is commanded, and before paper-feed is commanded. A diagnostic for the buffer proper repetitively executes the load operation, loading a selected character and bypassing the print operation.

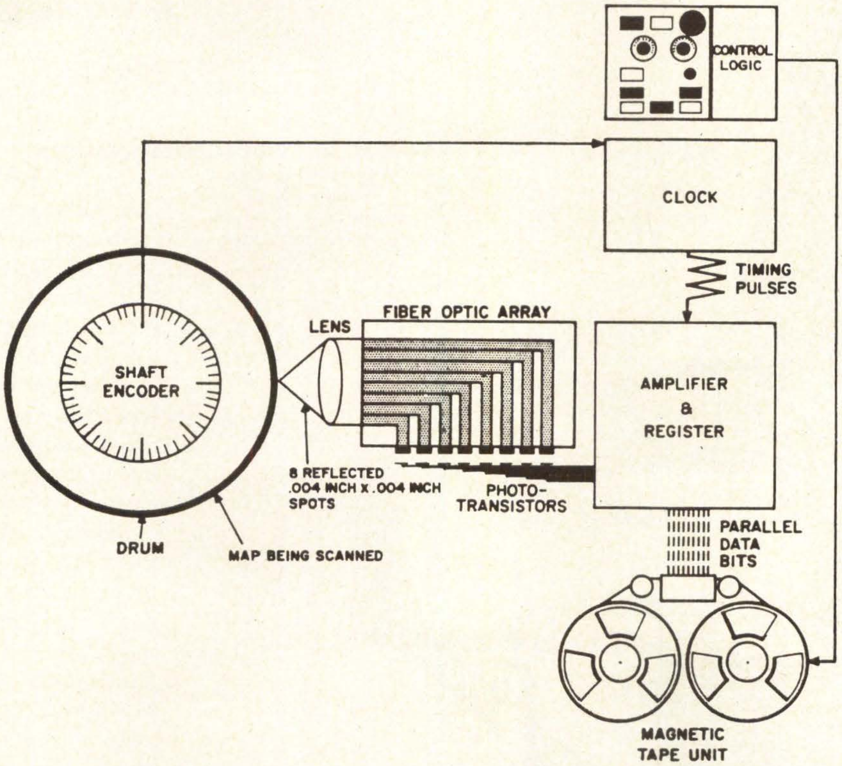
The printer, like other equipment of this type, produces signals which are sensed by central-processor instructions to determine whether a given operation is complete and another can begin. It is best if the diagnostic program does not use these signals, but rather incorporates dummy loops to provide the time delay appropriate for each operation. Under these conditions, the diagnostic can be used even if the circuits that generate the signals are not working.

This synchronization is also applied to the diagnosis of central-processor malfunctions. Sometimes a machine instruction will malfunction, often only when a particular data configuration exists in the machine registers. A diagnostic program is then written to establish the configuration in question, pulse an OCP line, execute the instruction, and repeat. The various circuits involved can then be readily checked. Since there are so many possible situations, these programs are written as needed.

If an on-line system has its OCP lines permanently connected to various external devices, it would be convenient to reserve one line for maintenance. Various diagnostic programs could then use this line for synchronizing with different functions.

Acknowledgements are due to Mr. W. R. Riihimaki for writing some of the diagnostic programs and otherwise assisting with the implementation of the technique. This work was performed under the auspices of the U. S. Atomic Energy Commission. **END**

CARTOGRAPHIC SCANNER TURNS MAPS INTO DATA FOR COMPUTER PROCESSING



This diagram illustrates the scanner/tape interface of IBM's experimental cartographic scanner.

The first automatic scanning device which converts maps into binary data for computer processing was reported in Washington, D. C. by IBM Corp. Called a cartographic scanner, the experimental device was developed and built in conjunction with the Canadian government by IBM's Kingston development laboratory. It now is being used in Ottawa to help handle data in a computer-based information system being developed for land resource development.

The cartographic scanner has a motor which turns a large drum (16 inches in diameter, 50 inches long). Vacuum pressure holds a specially-prepared map around this drum. The scanner is used "off-line" (independent of a computer's central processing unit), with a mag tape unit.

In preparing sources (or original) maps for scanning, a stylus traces eight-mil (eight thousandths-of-an inch) lines on white opaque plastic sheets. Only boundary lines are traced. The result is a map with a white background and transparent boundary lines. Because the surface of the drum is black, the map becomes white and black when it is mounted. When the drum is rotated, an eight-channel optical scan head travels a spiral path over the face of the drum. Each fiber optic channel covers a four-mil square area, and is pulsed at four-mil increments. Solid-state photo sensors are used in each channel.

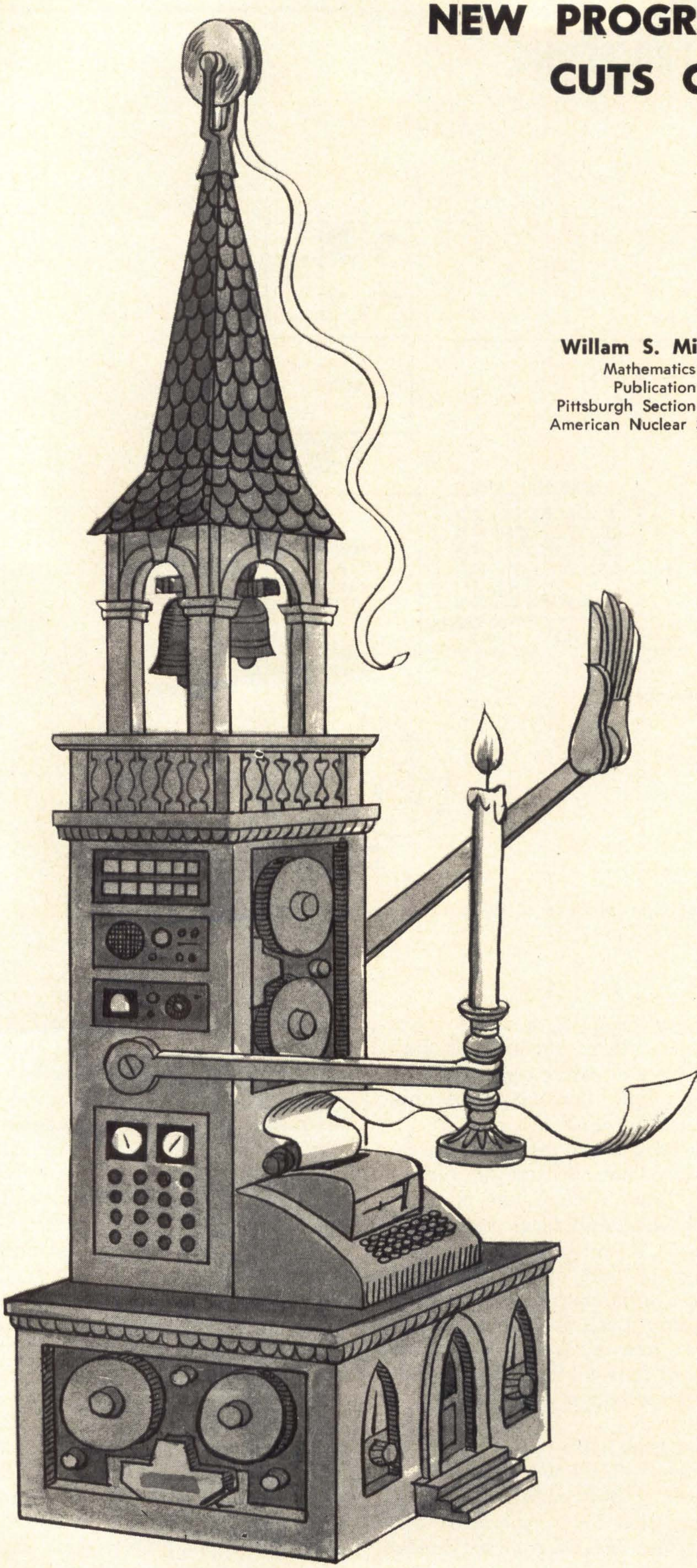
If at least half of the area under a channel is black when the pulse is received, a ONE bit is generated. If not, a ZERO bit is generated. The ONES and ZEROS from each pulse are recorded as a byte (eight bits) on magnetic tape. This eight-channel, parallel-to-serial method of scanning simplifies the data transfer to magnetic tape and decreases scanning time. Bytes are produced at tape speed, so a 16-square-foot map (18 million bytes) can be scanned in less than 11 minutes.

When a map has been scanned completely, the tape unit shuts off, the scan head automatically returns to the starting position, and the map can be removed. It takes less than a minute to mount a new map.

The device was described in a paper presented by Donald R. Thompson, of IBM's Kingston laboratory, at the 1967 ASP-ACSM (American Society of Photogrammetry-American Congress of Surveying and Mapping) Convention. END

NEW PROGRAMMING TECHNIQUE CUTS COMPONENT FAILURE BY 98.2%

A Simple Clerical Procedure



Willam S. Minkler,
Mathematics Editor,
Publication of the
Pittsburgh Section of the
American Nuclear Society.

Spokesmen for a local electronics firm this week announced a digital computer program that — through fresh application of an old technique — virtually eliminates lost time due to malfunction of computer components. Called OREMA (oh-RAY-ma, from the Latin "oremus," meaning "let us pray"), the program offers at selected time intervals prayers for the continued integrity of memory units, tape transports, and other elements subject to depravity.

Basically liturgical in structure, OREMA uses standard petitions and intercessions stored on magnetic filetapes in Latin, Hebrew, and FORTRAN. It holds regular Maintenance Services thrice daily on an automatic cycle, and operater intervention is required only for mounting filetapes and making responses, such as "And with thy spirit," on the console typewriter.

Prayers in Hebrew and FORTRAN are offered directly to the Central Processing Unit, but Latin prayers may go to the peripheral equipment for transfer to the Central Processor by internal subroutines.

Although manufacturer-supplied Prayer Reels cover all machine troubles known today, the program will add punched-card prayers to any filetape, as needed, after the final existing Amen block. Classified Prayer Reels are available for Government installations.

In trials on selected machines, OREMA reduced by 98.2 percent the average down time due to component failure. The manufacturer's spokesmen emphasized, however, that OREMA presently defends only against malfunctions of hardware. Requestor errors and other human blunders will continue unchecked until completion of the later version, to be called SINOREMA. END

A COMPUTER-LESS TELEVISION DISPLAY SYSTEM

R & D Report

J. L. NICHOLS,
Applications Engineer,
Fairchild Semiconductor,
Mt. View, Cal.

For major airports — a combination of video storage on a disk memory plus home-style TV sets.

An airline employee at a large terminal has just received information that a flight, due in the next few minutes, will be late. Plugging a special pen into a television monitor that is displaying flight arrival times, he erases from the TV screen the original arrival time, and writes the new time in its place. As he does this, all monitors in the terminal change in the same way as the one he is changing.

In another portion of the terminal another employee sits in front of a TV set and pushes buttons on a typewriter-like keyboard. A still picture of a departing jet appears on the screen. Another button is pressed and a list of arrivals and departures appears superimposed over the picture of the jet. Next, a small rectangle appears on the screen and dances around in response to activity at the keyboard, leaving characters on the screen in some places, filling in arrival and departure times that had previously been blank. A moment is spent proofreading the screen and then another button is pressed. The display appears on television monitors all over the terminal.

At a ticket counter an anxious traveler is searching for a friend. The attendant writes on the television monitor: Mr. Smith — call Ext. 2537.

A system such as this is possible with today's electronic technology. This display system requires no computer, and all the television monitors are standard 525-line home style television sets. Very little additional circuitry is required at those monitors that are to be used with a light pen, and this need not be connected in any way to the set. The central part of this display system contains a disk memory, that has recorded on each of several of its tracks the analog signal for a single television frame. The video outputs from all tracks are distributed by a standard cable television transmission system over a coax line so that the selection of the track to be displayed on a monitor is simply done by using the channel selector on the set. Each video track on the disk may be modified in several ways:

- The track may be cleared (leaving a blank raster);
- Video analog signal may be added to the contents of the track from a TV camera, TV tape, or another track;
- Characters may be added to a video track from a character generator;
- Bright or dark spots may be added to a track in response to a pulse received from a light pen.

A video tape recorder and playback unit are included to provide a large amount of video storage for single frames: a one-hour video tape reel stores over one-hundred thousand (100,000) single frames. The character generation is performed by adding to the video track light and dark spots to form the characters. Each character is generated in the format of a matrix of dots and the matrix of dots for every character that may be required is stored on the same disk memory with the video signals. Also on the disk is a track that contains, for all dots in the character matrix, strobe pulses which are positioned so that when the output of this track is added to the output of a video track, the monitor will show a bright checkerboard rectangle the size of a character matrix, and positioned where the next character supplied to the unit will be.

The incoming character selection code is the address of the location on the disk where this dot matrix for that character is stored. The selected dot matrix is read from the disk and stored in a temporary register whose shifted output is used to replace the contents of the selected video track at the times indicated by the strobe track. After the new character has been added to the video track, the strobe track is delayed so that the strobes are now positioned for the next character. This method of character generation requires very little hardware in comparison to other methods, yet allows an update rate of 30 characters per second (360 WPM).

When the light pen operation is initiated from a monitor, the control system supplies only every other frame from the video track to the monitors on that channel. The remaining frames are supplied at a constant brightness level that is sufficient to trigger the light-sensitive element in the light pen. The rising edge of output of the light pen is used to trigger a single shot whose pulse output is sent back to the disk. At the disk, this pulse is initially used to cause a bright spot to be ORed with the output of the video track thus causing a brightening of the otherwise constant-brightness sweep at that point. This spot now provides the user with an indication of the point of effect of the pen without actually writing on the video track. When the user sees the point of effect, he can then press a button on the pen which will cause the pulses received at the disk to be written onto the video track. Pushing the button the other way causes the video track to be erased when a pulse is received.

The combination of the video storage on a disk memory, plus standard TV sets as monitor, and using disk storage for character generation, provides a cheap and flexible display system. The ability to modify a display with a light pen from any monitor costs very little in additional hardware, and adds a great deal of flexibility. END

NASA TECH BRIEF

A SUMMARY OF A SPECIFIC TECHNICAL INNOVATION DERIVED FROM THE SPACE PROGRAM. ISSUED BY THE TECHNOLOGY UTILIZATION DIVISION OF NASA.

Computer Program Searches Characteristic Data of Diodes and Transistors

THE PROBLEM:

To devise a computer-based filing system which will provide a comprehensive, accurate, and ready reference to characteristic data of diodes and transistors.

THE SOLUTION:

A semiconductor information storage and retrieval system, which permits selective retrieval of information on diodes and transistors manufactured in the U.S. Any of the following types of information can be searched:

1. Device number
2. Maximum electrical characteristics
3. Typical electrical characteristics
4. Minimum electrical characteristics
5. Manufacturer(s)
6. Specifications to which each device can be procured
7. Numbers of reports describing pertinent reliability, test data, and failure information
8. Applicable comments.

HOW IT'S DONE:

The total system is composed of 12 separate digital magnetic tape files. Each file contains the applicable data for a major functional segment of the semiconductor field. Multipurpose devices are listed redundantly. The 12 individual files are:

1. General transistor file
2. Switching transistor file
3. Silicon controlled rectifier file
4. Unijunction transistor file
5. Field effect transistor file
6. General diode file
7. Reference diode file
8. Video detector file
9. RF mixer diode file
10. Switching diode file
11. Tunnel diode file
12. Variable capacitor file.

This system makes no attempt to judge the stored data; system design has been focused on providing the facts and suitable reference aids for human selection. When suitable retrieval requests are made of the file, the system will select and present to the user a listing of part numbered devices that fulfills his requirements. The system can thus be used to supply a complete listing of technical component information necessary for circuit designers, reliability engineers, and quality assurance personnel.

NOTES:

1. This program is now in operation at the Goddard Space Flight Center.
2. Inquiries concerning this invention may be directed to: Technology Utilization Officer, Goddard Space Flight Center, Greenbelt, Maryland 20771. Reference: B66-10529

PATENT STATUS:

Title to this invention has been waived under the provisions of the National Aeronautics and Space Act [42 U.S.C. 2457 (f)], to Booz-Allen Applied Research, Inc., 4733 Bethesda Avenue, Bethesda, Maryland. **END**

NEW IC-COMPATIBLE PULSE TRANSFORMERS

A new generation of pulse transformers has been developed that are fully compatible with present dual-in-line integrated circuits.

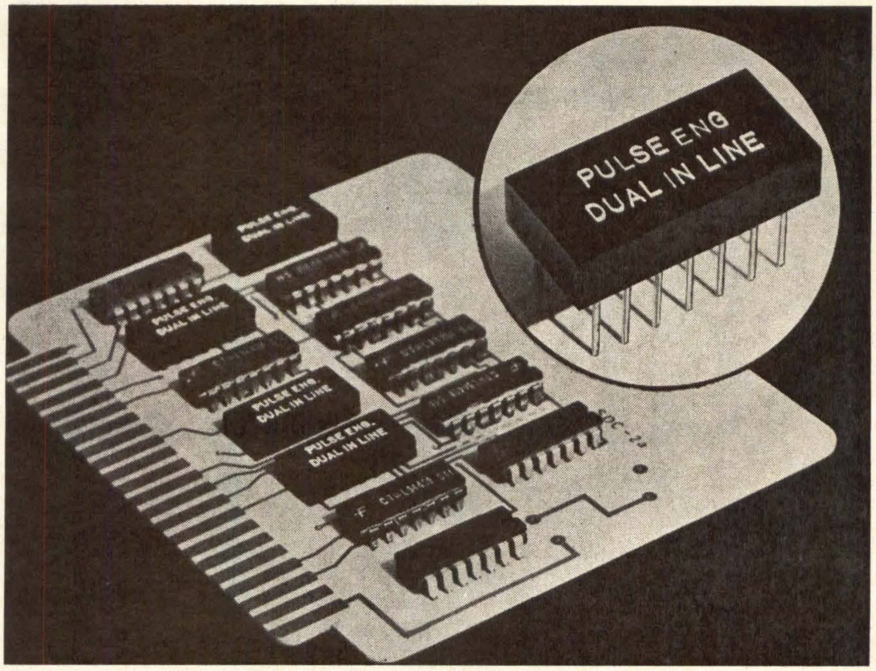
JAMES E. ROGERS,
Applications Engineering Mgr.,
Pulse Engineering, Inc.,
Santa Clara, Cal.

Unlike anything available in the past, a new line of pulse transformers conform to IC configurations, utilizing the same pin patterns and occupying the same board space. They lend themselves to rapid assembly and to automatic insertion techniques being developed in the computer industry. The new modules are essentially the same size as the dual-in-line IC's, yet, each contains up to 3 or 4 pulse transformers. They are designed to meet the performance requirements of IC's with their faster speeds, lower amplitudes, and shorter pulse durations.

Pulse transformers are finding increasing usage in core memory systems principally because these passive devices offer a wide range of functional qualities not found in any other single component or circuit. Now they match present IC's both physically and electrically, and circuit designers can readily take advantage of these unique properties — common mode isolation, inversion, voltage gain, current gain, DC isolation, wide band-pass capabilities, and no standby power dissipation.

The dramatic size reductions in transformers were made possible by two recent developments. First, the semiconductor, IC circuitry, and new 20 mil memory cores that require much lower ET constants than prior equipment. This permits a much smaller transformer core cross section. Secondly, multiple element packaging and new packaging techniques have greatly reduced the physical size of pulse transformers, and also substantially reduced their cost.

Just how well matched are these new pulse transformers to the electrical characteristics of present-day IC's? Let's take a look. Digital integrated circuits have pulse amplitudes of approximately 5 volts, pulse widths in the order of 50 to 500 nanoseconds, and rise times in the order of 5 to 15 nanoseconds. To apply a pulse transformer to a circuit with these characteristics, and provide acceptable droop, we need primary inductance values ranging from 25 to 250 microhenries with ET constants to 2.5V μsec. And from this basic platform other characteristics can be considered such as turn ratios, leakage inductance, coupling capacity, balanced windings, and common-mode rejection.



New IC compatible pulse transformers. Each module contains up to 3 pulse transformers.

From the above, let's select the "worst-case" values and see whether or not the new pulse transformers will, in fact, perform with today's integrated circuits.

Primary inductance	250 μH
ET constant	2.5V μsec (5V, 0.5 μsec)
Rise time	5 nanoseconds
Coupling capacity and leakage inductance	Consistent with rise-time requirement
Packaging	Dual-in-line or flat-pak

Now against the above let's compare the performance of a typical new pulse transformer in a coupling application.

Turns ratio:	1:1:1
Primary inductance:	240 μH min.
ET constant:	5.0V μsec
Rise time:	4.5 nanoseconds max.
Leakage inductance:	0.25 μH max.
Winding resistance:	0.65 ohms max. each winding
Pulse droop:	Less than 10%

As will be seen from the above, the new pulse transformers will more than match the required performance standards demanded by present integrated circuits. In addition to physical and electrical compatibility, we should not overlook the benefit that once installed, pulse transformers are an almost changeless component — unaffected by age, and virtually indestructible.

For more information on these new IC compatible pulse transformers:

Circle No. 101 on Inquiry Card

negative radix arithmetic

M. P. deRegt

Editor's Note: Computer Design *is pleased to present the first article in a series on "Negative Radix Arithmetic". A number system employing a negative base exhibits properties which are interesting in their own right, but also offers promise of revolutionizing the organization and design philosophy of the digital computer and kindred machines, particularly in view of the advent of the integrated circuit. In this series, Mr. deRegt will present an introductory course in Negative Radix Arithmetic, and will state the case for the design of systems based on the negative radix.* Computer Design *believes that the astute reader may well find that this technique is the key to a new generation of computing machines.*

PART 1

Introduction To Negative Radix Number Systems

The representation of numbers is one of the most abstract of concepts and its historical development has been in concert with cultural and economic development. Until some fifteen years ago, the binary number system was best known to number theorists and devotees of an ancient Chinese game known as Nim. The advent of relays, electronic switching circuits, and bi-stable-state storage devices created the use for existing binary theory and technology, as well as the demand for further development of binary system techniques. Automatic systems of number storage and operation using these two-state devices were clearly superior to any using multi-state devices, and a number system comprising only two symbols was clearly superior to one requiring ten. Concurrent with the representation of numbers went the development of representation of polarity, positive and negative. The polarity representations developed for human use were also not well adapted to computers, and the conventional "sign-and-magnitude" notation used by people was soon replaced for computers by one or the other of two forms of radix complement notation, since this greatly simplified the circuitry required for addition and subtraction.

Although many of the present-day requirements for speed, size, and reliability are being met by technological progress, modern digital computer designs are still fundamentally constrained by current concepts of representing numbers and their polarities. To overcome these limitations, research effort is being increasingly expended on the discovery of new means of number representation. In this series of articles we shall describe some results of one such effort: a system in which the radix or base is a negative rather than a positive number.

The Promise of Negative Radix Notation

Superficially, the advantages of negative radix notation appear to lie mainly in representation, because no separate polarity symbols are needed. However, the truly significant advantages stem from operational rather than representational considerations. The properties of negative radix number systems are such that arithmetic may be performed on a digit ("stage" in a machine) basis rather than on a number ("register" in a machine) basis. That is, an arithmetic operation on corresponding digits of a pair (or more) of numbers is invariant with respect to the polarities of the two (or more) numbers in which they are separately imbedded. Two independent implications follow: one, that a true variable-word-length operation is completely practicable, permitting modular construction in terms of quantity of digit positions; and two, that simultaneous operations on multiple (two or more) operands are completely practicable, permitting modular construction in terms of number of operands. These two implications are independent of device technology; however, they are particularly meaningful in relation to the rapidly increasing use of integrated circuits in computer design, and are most especially meaningful in the full exploitation of large-scale integration.

We shall discuss further the detailed consequences of this possibility of reducing operations to an assemblage

Maurits P. de Regt was born in Dordrecht, Holland on June 17, 1919. He received a B.S. degree from Webb Institute of Naval Architecture, New York, in 1942, and later studied Electrical and Industrial Engineering at the University of California at Berkeley. He then worked in the fields of shipbuilding and mechanical power transmission equipment. He entered the digital computer field when he joined the Boeing Airplane Company in 1953. Between 1956 and 1959 he headed the Digital Computer Laboratory of the Pilotless Aircraft Division. He subsequently served as District Sales Manager in Los Angeles for Philco's Computer Division, Project Director for command/control system software design for Technical Operations, Inc., and Principal Scientist in numerous assignments for Booz-Allen Applied Research, Inc. He joined Melpar's Systems Analysis Laboratory in February of this year. His interest in negative radix notation preceded his entry into the computer field, and followed a long-standing interest in number systems. He has patents pending on numerous negative radix computer circuits and modules.

negative radix arithmetic

continued

of modular, digit-oriented units, after we have demonstrated enough of the negative radix concept so that the reader has a feel for the mechanics of the techniques. It suffices for now to say that such an organization can be expected to confer the following advantages:

- **The drastic reduction of system-level logic and interconnections will reduce power consumption, increase reliability, allow greatly increased simultaneity of operations, and promote a true variable-configuration computer.**

- **The incorporation of complete operational logic in the digit-oriented unit will allow true variable-word-length operations, modular construction, program control of register length or program control of computer configuration. It will also promote easy hardware redundancy and graceful system degradation.**

- **The modularity of the operational unit will allow production efficiency in integrated circuit manufacture, since few different modules will be needed. Modularity of complex units will in turn be made economically possible by the negligible cost difference between simple and complex integrated circuits.**

WHAT IS NEGATIVE RADIX NOTATION?

In a digital computer, one of the most important of the design considerations is the number system in which numbers will be represented. The choice of number system is independent of the physical devices being used. Most computer designers choose either the binary or the binary-coded-decimal system, and next face the question of how to represent negative numbers-sign and magnitude, radix-complement, or diminished radix-complement.

Both of these questions, i.e., number system and negative number representation, can be answered simultaneously by the use of a negative radix. In such a system, the base is not positive — plus ten or plus two for decimal and binary, respectively — but negative. As stated earlier, such representation is conceptual, and is completely independent of the physical means of representing numerals. If there are advantages in such a system, they will apply regardless of the physical devices — cryotrons, cores, parametrons, transistors, relays, gears, or fluidic elements — used to construct the system. If there are advantages, they will apply whether we speak of serial or parallel, synchronous or asynchronous, small-scale or large-scale, low-speed or high-speed, general-purpose or special-purpose.

The most striking aspect of negative-radix arithmetic is its simplicity. Although it may seem confusing at first, it is in the same sense that manipulating small parts viewed by means of a dentist's mirror is confusing. An almost mathematics-free approach will be used in this series, so that the beauty and simplicity of the arithmetic is not obscured by ponderous mathematics nor obfuscated by elaborate symbology. These positive qualities will be clearly illustrated by examples, which will use manual algorithms to illustrate the small difference in difficulty and the large reduction in "rule" knowledge required for manipulation.

Positional Notation

Most of the mathematics that will be used will refer to the familiar polynomial defined below to show the general applicability of specific relationships or procedures. This polynomial defines positional notation, in which the weight of a digit in an integer is indicated by the value assigned to its position in a string of digits comprising the integer. A lack of any value for a given position is designated by the symbol zero.

The n-digit number represented by the sequence of n digits:

$$a_{n-1}\, a_{n-2} \ldots a_2 a_1 a_0$$

represents the quantity:

$$a_{n-1}r^{n-1} + a_{n-2}r^{n-2} + \ldots + a_2r^2 + a_1r + a_0$$

in which r is the base or radix and is normally an integer greater than unity, and a_i is taken from the set of r numbers $(0,1,2,\ldots,r-1)$. All positive integers may be uniquely expressed in this way. This polynomial notation may be extended to represent some fractions exactly (those having only prime factors of r in the denominator), and other fractions to any desired degree of accuracy, separating the integral and fractional parts by means of the radix point; thus, the $n+m$ digit number:

$$a_{n-1} \ldots a_0 \ldots a_{-1}\, a_{-2} \ldots a_{-m+1}\, a_{-m}$$

represents the quantity:

$$a_{n-1}r^{n-1} + \ldots + a_0 + a_{-1}r^{-1} + a_{-2}r^{-2} + \ldots + a_{-m+1}r^{-m+1} + a_{-m}r^{-m}$$

The familiar base ten system is formally called the denary system, and this system extended by means of the radix point is familiarly called the decimal system. Similarly, the familiar name for octanary (base 8) is octal. We shall be concerned in this series of articles with scales of notation in which r can be a negative integer, specifically, the negative decimal scale (-10) and the negative binary scale (-2). We shall also consider the quaternary $(+4)$, the negative octal (-8), and the hexadecimal $(+16)$, in which the symbols for the numerals are expressed in terms of negative binary numbers. These scales may include numerals that represent negative values: these will be denoted by bold-face type for the corresponding symbol of positive value (e.g., **8** is equivalent to *negative* 8).

Negative Radix Notation And Its Conventions

As an example of a number in base -10, the decimal quantity $+1783$ would be represented by 19823, which stands for:

$$1(-10)^4 + 9(-10)^3 + 8(-10)^2 + 2(-10)^1 + 3(-10)^0$$
$$= 10{,}000 - 9{,}000 + 800 - 20 + 3 = 1783.$$

Similarly, -1783 would be represented by 2397. In negative binary (base = -2), decimal -67, which is $-1{,}000{,}011$ in conventional binary, is represented by 11,001,101:

$$1(-2)^7 + 1(-2)^6 + 0(-2)^5 + 0(-2)^4 + 1(-2)^3 + 1(-2)^2 + 0(-2) + 1 = -128 + 64 - 8 + 4 + 1 = -67.$$

An ambiguity exists in the phrase "a negative binary number", since the reference may be to a negative number in base $+2$, or to a number of either polarity in base -2. The number system whose base is -2 will therefore be referred to as the "negabinary" system whereas the conventional base $+2$ system will be called simply the binary system. Common names for other positive base systems will similarly be prefixed when referring to their negative base counterparts.

In all these articles, the following conventions will be observed; all are based on the general polynomial presented above. Positions in the polynomial will be indicated by means of the radix superscript; for example, position 2 (or stage 2 or digit 2) will refer to the quantity a_2r^2, which is the *third* term to the *left* of the radix point; a_{-4} will refer to the *fourth* digit, position, or stage to the *right* of the radix point. In general, a_i will refer to the $(i+1)^{th}$ position to the left if i is positive or zero, and to the i^{th} position to the right if i is negative.

Polarity symbols + and − (read "positive" and "negative" as adjectives) will be used *only* in front of positive-radix numbers; unsigned numbers will generally be negative-radix numbers. Addition and subtraction operations will be indicated in text rather than by symbols, in order to avoid confusion with polarity designations. Numbers *spelled out* will always be positive decimal. Numbers in other bases will be indicated by numerals (e.g., 193_{-10} is read "one-nine-three, base -10" and not "one hundred ninety-three").

Examples:

(1) $+13 = 13_{10} = 193_{-10}$

Read: "thirteen equals one-nine-three, base -10"

(2) Addition base $+10$:

Add:

$$\begin{array}{r} +3 \\ -14 \\ \hline -11 \end{array} \quad \text{or } (+3) + (-14) = (-11)$$

Read: "positive three plus negative fourteen equals negative eleven".

3. Subtraction base -10:

Subtract:

$$\begin{array}{r} 3 \\ 26 \\ \hline 197 \end{array} \quad \text{or } 3 - 26 = 197$$

Read: "three minus two-six equals one-nine-seven".

Other conventions will be defined and explained as they are introduced.

Before proceeding to a detailed description of negative-radix arithmetic, a special decimal system that follows similar rules will first be explained. This special system is an extension of the familiar decimal in which the set of numerals is increased to include $-1, -2, \ldots -9$. The application of normal arithmetic rules to this system will have an effect which is exactly analogous to the application of negative-radix-arithmetic rules to negative-radix numbers.

A SPECIAL DECIMAL SYSTEM

Consider a system of number representation in which the radix is $+10$ and the numerals comprise 0 and both positive and negative values of the integers 1 through 9, or nineteen numerals in all. Then the value of the n-term polynomial:

$$a_{n-1}r^{n-1} + a_{n-2}r^{n-2} + \ldots + a_ir^i + \ldots + a_2r^2 + a_1r + a_0$$

for $r = +10$ and for $-9 < a_i < +9$ may be represented, just as for a conventional decimal number, by the sequence of n digits:

$$a_{n-1}\, a_{n-2} \ldots a_2a_1a_0.$$

In this special system we shall restrict the set of negative digits, $a_i = (\bar{1}, \bar{2}, \bar{3}, \ldots \bar{9})$, to those positions for which i is odd; and we shall restrict the set of positive digits, $a_i = (1,2,3, \ldots 9)$, to those positions for which i is even; a zero will be permitted in any position. No polarity symbol will be used. Thus, we might have 1 $\bar{2}$ 3 $\bar{5}$ 4 or $\bar{6}$ 0 0 1. Conversion from such a system to conventional decimal is straightforward, and a few examples will suffice to explain.

Example 1: Convert 1 $\bar{2}$ 8 $\bar{5}$ 9 and $\bar{6}$ 7 $\bar{2}$ 4 to decimal. Each number may be resolved into its positive and negative parts. For example, the positive part of the first one is $+10809$, and the negative part is -2050. These two parts may then be added algebraically to obtain the normal decimal number, thus:

$$\text{Add} \quad \begin{array}{r} +10809 \\ -\ 2050 \\ \hline +\ 8759 \end{array}$$

Similarly, the second number may be converted by resolving it into $+704$ and -6020:

$$\text{Add} \quad \begin{array}{r} -6020 \\ +\ 704 \\ \hline -5316 \end{array}$$

The arithmetic for making these conversions is conventional decimal, which is the system that the separate number parts are expressed in. For conversion back to special decimal, however, the arithmetic of the special decimal is used.

Special Decimal Arithmetic

The arithmetic tables for the special decimal system are exactly the same as the arithmetic tables for conventional decimal, except that the presence of negative digits requires use of the laws of signs. The arithmetic of special decimal is also best explained by a few simple examples.

Example 2: Add $\bar{2}$6 and 7 in special decimal, and convert to conventional decimal.

$$\text{Add:} \quad \begin{array}{r} \bar{2}6 \\ 7 \\ \hline \bar{1}3 \end{array}$$

In this example, the sum of 6 and 7 is 3, carry 1. The 1 added to the $\bar{2}$ in the tens column gives $\bar{1}$. A more

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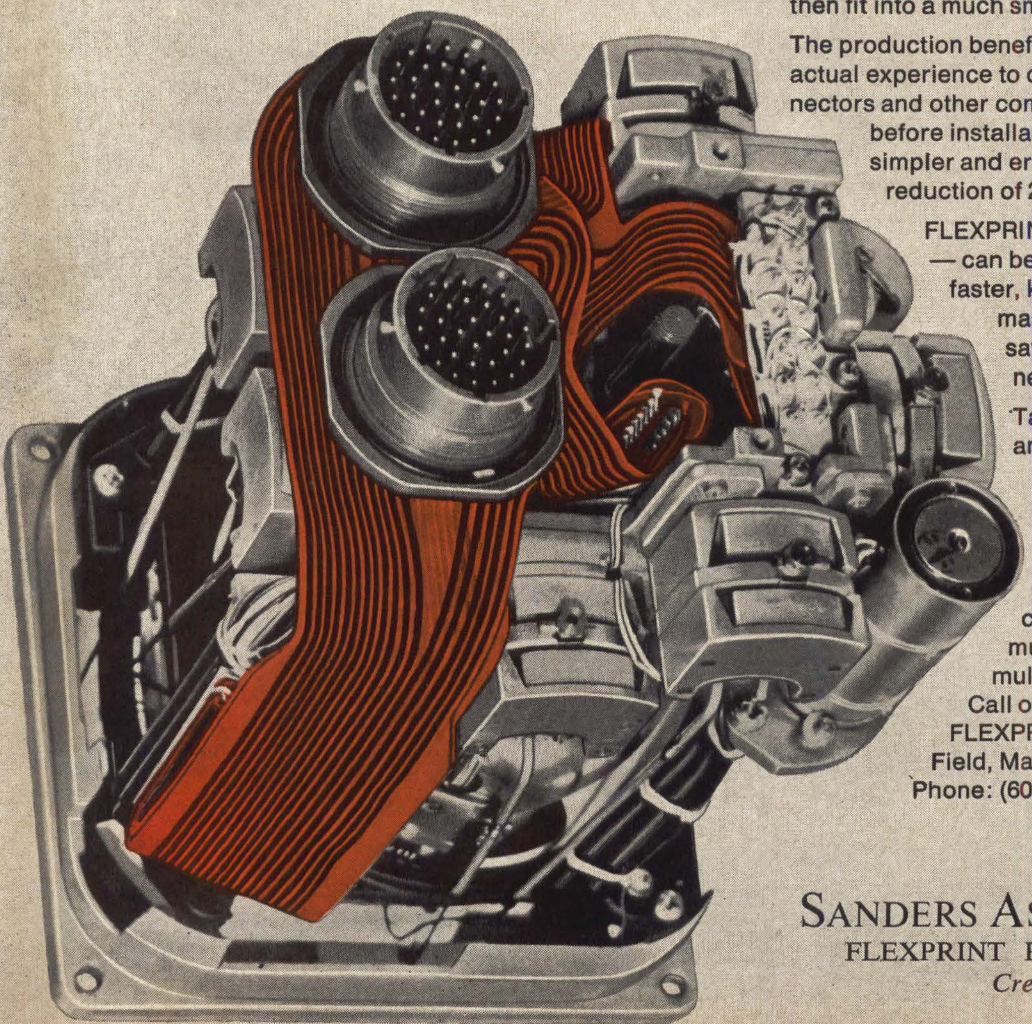

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negative radix arithmetic

continued

complete explanation is provided by expanding the numbers, as follows:

$$\begin{array}{ll} \text{Add:} & 2(10)^1 + 6(10)^0 \\ & \quad\quad\quad + 7(10)^0 \\ \hline & 2(10)^1 + 13\,(10)^0 \\ & 2(10)^1 + 10\,(10)^0 + 3(10)^0 \\ & 2(10)^1 + 1(10)^1 + 3(10)^0 \\ & 1(10)^1 + 3(10)^0 \end{array}$$

If the numbers are converted to conventional decimal, we have the following:

$$\begin{array}{lr} \text{Add:} & -14 \\ & +\ 7 \\ \hline & -\ 7 \end{array}$$

Example 3: Add 326 and 92.

$$\begin{array}{lr} \text{Add:} & 326 \\ & 92 \\ \hline & 218 \end{array}$$

In this example, the sum of 6 and 2 is 8, with no carry. The sum of 2 and 9 is 1, carry 1. (Note that *all* digits, including the carry, are negative.) For the hundreds position, the sum of 3 and the carry-in of 1 is 2.

Converting the operands to conventional decimal and adding, we have:

$$\begin{array}{rcl} 326 = +306 + -20 = & +286 \\ 92 = +2 \quad + -90 = & -88 \\ \hline & +198 \end{array}$$

Note that this operation, although nominally addition, was really subtraction. In special decimal, however, adding the same quantities requires true addition. This is true, even though the carry-in was negative, because carry-in is a digit-level algorithmic process, and not a word-level arithmetic operation.

Since the signs of adjacent columns in special decimal are different, a carry-out from any column will, in general, be subtracted from the sum of the next higher column. If the sum of the next higher column happens to be zero, then the subtractive carry-in will generate an *additive* carry-out. This is illustrated in the next example.

Example 4: Add 308 and 9 in special decimal.

This problem is more clearly explained by using the expanded form of the numbers:

$$\begin{array}{r} 3(10)^2 + 0(10)^1 + \ \ 8(10)^0 \\ 9(10)^0 \\ \hline 3(10)^2 + 0(10)^1 + 17(10)^0 \\ 3(10)^2 + 1(10)^1 + \ \ 7(10)^0 \end{array}$$

Note that the second term is not negative, although it must be by the rules of special decimal. In order to force a negative digit, we note that $1 = 10 - 9$, and thus we can write:

$$\begin{array}{l} 3(10)^2 + \quad (10-9)(10)^1 + 7(10)^0 \\ 3(10)^2 + 1(10)^2 - 9(10)^1 + 7(10)^0 \\ 4(10)^2 + 9(10)^1 + 7(10)^0 \end{array}$$

In the short form of the example, the procedure may be explained as follows:

$$\begin{array}{lr} \text{Add:} & 308 \\ & 9 \\ \hline & 497 \end{array}$$

The sum of 8 and 9 is 7, carry 1. The sum of 0 and 1 is 9, carry 1 (or 10 + 9; in other words **1** = 19). The sum of 3 and the carry-in of 1 is 4.

In subtraction, a borrow of 1 can be considered to be a carry of **1**, and conversely, a borrow of **1** is equivalent to a carry of 1. Since the polarities of alternating columns alternate, borrows are therefore additive for the next higher column. The examples will illustrate.

Example 5: Subtract

$$\begin{array}{r} 26 \\ 7 \\ \hline 39 \end{array}$$

The difference of 6 and 7 is 9, borrow 1 (carry **1**). The difference of **2** and 0, with a carry-in of **1**, is **3**. The expanded form of the example will serve as a more detailed explanation.

$$\begin{array}{l} 2(10)^1 + 6(10)^0 \\ \quad\quad\quad\quad 7(10)^0 \\ \hline 2(10)^1 - 1(10)^0 \\ 2(10)^1 - 1(10-9)(10)^0 \\ 2(10)^1 - (10)(10)^0 + 9(10)^0 \\ 2(10)^1 - (10)^1 + 9(10)^0 \\ 3(10)^1 + 9(10)^0 \end{array}$$

Converted to conventional decimal, this example becomes:

$$\begin{array}{lr} \text{Subtract:} & -14 \\ & +\ 7 \\ \hline & -21 \end{array}$$

Two more subtraction examples will be given; the examples on the left are in special decimal, and on the right, in conventional decimal.

Example 6: Subtract

$$\begin{array}{rcr} 326 & \quad\quad & +286 \\ 92 & & -\ 88 \\ \hline 434 & & +374 \end{array}$$

Example 7: Subtract

$$\begin{array}{rcr} 308 & \quad\quad & +308 \\ 9 & & +\ \ 9 \\ \hline 319 & & +299 \end{array}$$

Now conversion from conventional decimal to special decimal can be explained by means of a few examples.

Example 8: Convert +8759 and −5316 to special decimal.

The basic procedure is to resolve the number into two signed parts, one containing the digits in even positions, alternating with zeroes, and the other the digits in odd positions, alternating with zeroes:

$$+8759 = (+0709) + (+8050)$$

By changing the sign of both the operation and the polarity of the odd position part, the two parts may be converted directly to special decimal.

$$+8759 = (+0709) - (-8050) = 0709 - 8050$$

These two parts may then be subtracted using special decimal arithmetic.

```
 0709
 8050
12859 = +8759₁₀
```

In the second example, the signs of the even position part are changed because the number is negative:

$$-5316 = (-5010) + (-0306) = (-5010) - (+0306) = 5010 - 0306$$

```
5010
0306
----
6724
```

The rules for multiplication follow from the rules for addition; in short, the carry-out is normally subtractive. If one of the product digits is a zero, then the carry-out from that position is additive.

The following example will illustrate.

Example 9: Find the product of 19 and 19.

```
Multiply:  19
           19
          ---
           11
          19
          ---
          001
```

The product of 9 and 9 is 1, carry 8. The product of 1 and 9 is 9, and this product added to the carry-in of 8 gives 1, or 9 + 8 = 1. The product of 19 and 9 is thus 11. For the second line, the product of 9 and 1 is 9, and the product of 1 and 1 is 1. The product of 19 and 1 is thus 19. Now the sum of 1 and 0 is 1; the sum of 1 and 9 is 0, carry 1; the sum of 1 and the carry-in of 1 is 0. This completes the example.

Representation and arithmetic in the special decimal are therefore relatively easy, although a little "left-handed" (for right-handers). Now, because even positions have positive weight and the odd positions have negative weight in both special decimal and negadecimal (base -10), the rules for special decimal, which are not so confusing to understand or to apply, may be used for negadecimal. Note that in negadecimal the weights derive not from the numerals, which all have positive values, but from the powers of the radix, which, since the radix is negative (-10), will be positive for even powers and negative for odd powers.

Since conversion between negadecimal and special decimal is accomplished simply by changing to, or from, bold-face type on all non-zero digits in odd positions, checking examples in negadecimal by converting to special decimal is easy, and may clear up otherwise difficult points. This procedure is recommended in examples in the articles which follow.

BASIC NEGATIVE DECIMAL ARITHMETIC

The rules for negative radix arithmetic (as for the special decimal) are the same as for conventional arithmetic, except that the sign of the carry is changed. In other words, a carry becomes a borrow, and a borrow becomes a carry, just as in the special decimal. However, the borrow terminology will not be used; instead, both carries and borrows will be called carries, and signed numerals will be used, as in the special decimal. Thus, 9 x 7 in negadecimal is three, carry negative six. Expressed as a product, 9 x 7 = 63, which, in expanded form, is equivalent to $-6(-10)^1 + 3(-10)^0$.

Because counting is the simplest arithmetic operation, it will be useful to introduce both the arithmetic and the representation of negadecimal by counting. For a reason which will be apparent later, we shall start by counting down from zero. The first negative integer is obtained by subtracting one from zero.

```
Subtract:  0
           1
          --
          19
```

In this operation, 0 less 1 is 9, carry 1. In expanded form, this is equivalent to $1(-10)^1 + 9(-10)^0$. The succeeding counts are straightforward. We thus have the following sequence, with decimal equivalents:

Negadecimal	Decimal
0	0
19	−1
18	−2
17	−3
16	−4
15	−5
14	−6
13	−7
12	−8
11	−9
10	−10

At this point, subtracting unity results in the following operation:

```
Subtract:  10
            1
           --
           29
```

As before, 0 less 1 is 9, carry 1. This time the 1 is added to the difference of 1 and 0, which gives a total of 2, as shown in the example. We thus continue with the table:

Negadecimal	Decimal
10	−10
29	−11
28	−12
27	−13
26	−14
25	−15
24	−16
23	−17
22	−18
21	−19
20	−20
39	−21
38	−22

and so on.

Counting up from zero, the first nine integers have the same form as in decimal:

Negadecimal	Decimal
0	0
1	+1
2	+2
3	+3
4	+4
5	+5
6	+6
7	+7
8	+8
9	+9

At this point, the operation is as follows:

Add: $\begin{array}{r} 9 \\ \underline{1} \\ 190 \end{array}$

The sum of 9 and 1 is 0, carry **1**. The sum of 0 and **1** is the same as the difference between 0 and 1, which we found to be 19 in the first count-down. The next nine are straightforward:

Negadecimal	Decimal
9	+9
190	+10
191	+11
192	+12
193	+13
194	+14
195	+15
196	+16
197	+17
198	+18
199	+19

For the next integer, form the sum of 199 and 1.

$$\begin{array}{r} 199 \\ \underline{1} \\ 180 \end{array}$$

The table then continues:

Negadecimal	Decimal
199	+19
180	+20
181	+21
182	+22
183	+23
184	+24
185	+25
186	+26
187	+27
188	+28
189	+29
170	+30
171	+31
172	+32

The numbers in the special decimal examples in the preceding section can be converted to negadecimal simply by changing from bold-face type. Repeating these examples below, negadecimal conversion and arithmetic are illustrated. The explanations for negadecimal may be paraphrased from those given in the preceding section, remembering only to change the sign of the carry (but note that the *effect* is *not* changed).

Examples

1. Convert 12859 and 6724 to decimal.

$$\begin{array}{r} +10809 \\ \underline{-\ 2050} \\ +\ 8759 \end{array} \qquad \begin{array}{r} -6020 \\ \underline{+\ 704} \\ -5316 \end{array}$$

In each of the following examples 2 through 7, negadecimal will be given on the left and the decimal equivalent on the right.

2. Add 26 and 7, and repeat for decimal.

$$\begin{array}{r} 26 \\ \underline{7} \\ 13 \end{array} \qquad \begin{array}{r} -14 \\ \underline{+\ 7} \\ -\ 7 \end{array}$$

3. Add:

$$\begin{array}{r} 326 \\ \underline{92} \\ 218 \end{array} \qquad \begin{array}{r} +286 \\ \underline{-\ 88} \\ +198 \end{array}$$

4: Add:

$$\begin{array}{r} 308 \\ \underline{9} \\ 497 \end{array} \qquad \begin{array}{r} +308 \\ \underline{+\ 9} \\ +317 \end{array}$$

5. Subtract:

$$\begin{array}{r} 26 \\ \underline{7} \\ 39 \end{array} \qquad \begin{array}{r} -14 \\ \underline{+\ 7} \\ -21 \end{array}$$

6. Subtract:

$$\begin{array}{r} 326 \\ \underline{92} \\ 434 \end{array} \qquad \begin{array}{r} +286 \\ \underline{-\ 88} \\ +374 \end{array}$$

7. Subtract:

$$\begin{array}{r} 308 \\ \underline{9} \\ 319 \end{array} \qquad \begin{array}{r} +308 \\ \underline{+\ 9} \\ +299 \end{array}$$

8. Convert +8759 and −5316 to negadecimal.

$$\begin{aligned} +8759 &= (+0709) + (+8050) \\ &= (+0709) - (-8050) \text{ (in decimal)} \\ &= 0709 - 8050 \text{ (in negadecimal)} \end{aligned}$$

Subtract

$$\begin{array}{r} 0709 \\ \underline{8050} \\ 12859 \end{array}$$

$$\begin{aligned} (-5316) &= (-5010) + (-0306) \\ &= (-5010) - (+0306) \\ &= 5010 - 0306 \end{aligned}$$

Subtract

$$\begin{array}{r} 5010 \\ \underline{0306} \\ 6724 \end{array}$$

9. Find the product of 19 and 19.

Multiply:

$$\begin{array}{r} 19 \\ \underline{19} \\ 11 \\ \underline{19} \\ 001 \end{array}$$

The details of the steps in these simple examples are left as an exercise for the reader. In the next article,

negative radix arithmetic

continued

negative radix representation will be presented much more fully, in a discussion covering negative decimal, negative binary, negative radix codes, and use of negative digits, fractions, and number ranges.

ARITHMETIC, COMPUTERS, AND INTEGRATED CIRCUITS

Before going on to the more detailed discussions of the succeeding articles, it is of interest to review some of the properties of negative radix notation which are already apparent, and to describe some of the design concepts to which these properties lead. The purpose of this series is in fact to teach negative radix arithmetic, not only because it is extremely interesting in its own right, but to stimulate rapid development of its properties and their exploitation in computer design. Such encouragement would be warranted even if only minor improvements could be foreseen; the fact is that the rapidly expanding semiconductor technology appears to make "a computer on a slice" eventually feasible. A serious and completely fundamental obstacle to this objective derives from the fact that each register in a computer arithmetic unit requires its own control circuitry. This design fact of life can be traced directly back to the limitations imposed by the requirement for knowledge of operand and result magnitudes and polarities. This knowledge, by definition, is on a word level rather than a digit level. The basic property of negative radix notation as illustrated in the preceeding examples, is that digit positions carry both magnitude and polarity information. This removes the above limitations since a *priori* or a *posteriori* knowledge of operand or result magnitudes and polarities is not necessary. The potential therefore exists for chaining (for example) accumulator modules together to any desired length without concern with such things as carry-ins to the least significant digit, end-around carries, overflows, numerical shifts, etc. This is not easy to do in normal binary because the most significant digit is different from all others: it carries polarity information rather than magnitude information.

There are other interesting properties but these are more in the nature of constraints, to be compared with analogous constraints in other number systems. The property noted above is the key to possible realization of advanced computer organization and corresponding software concepts. These advanced concepts may perhaps be of as great importance to the semiconductor industry as to the computer industry, since their full exploitation is dependent upon large-scale-array technology.

Integrated circuits and the manner in which they are produced tend to reduce the importance of both the number of components in a circuit and its complexity. In two production items of different complexities, the biggest cost difference is more likely to result from a somewhat higher reject rate of the more complex item than from an intrinsic difference in production cost. One effect of this fact will be to tend to force system complexities from high system levels down to lower system levels. Current improvements in IC production techniques are of such a nature as to diminish even more the difference in end cost between simple and complex circuits. Thus, if arithmetic can be accomplished by decreasing the logic at the register (word) level, and increasing it when necessary at stage (digit) level, there are clearly advantages in doing so.

The basic requisites for making large-scale arrays practicable appear to be a high measure of general applicability combined with easy partitioning. There must be relatively few basic array designs and each of these designs should be sufficiently general-purpose to be useful over a wide range of design functions, and should require relatively few interconnections with other modules. The digit-oriented nature of negative radix arithmetic appears to lend itself to modules designed to have these requisites.

First of all, because the arithmetic is digit rather than word-oriented, complete operation logic can be built into the stage. As illustrated in the examples, addition in negative radix *always* means the addition of the individual operand digits, and not sometimes subtraction of operand digits. In a computer, the ADD command may then be applied to each stage, regardless of word polarity. Since carry-in is intrinsically a digit-level operation, the possibility of negative, as well as positive carries-in, only result in a slight increase in stage complexity, a small matter in an IC technology. Chaining such stages together will result in complete arithmetic registers or accumulators, which will not require logic circuitry other than operation code decoding. Secondly, arithmetic of higher magnitude radix, such as $+4$, -8, $+10$, $+16$, and so on, may be performed by stages in which the arithmetic is actually fully parallel negative binary (that is, all negabinary carries within each stage are generated simultaneously). Each such stage may also contain complete operation logic, so that a chain comprising an accumulator will need no exterior control logic except operation code decoding. At an extreme, such a stage may be byte size — that is, be of radix $(-2)^8$, or base $+256$, and contain the logic necessary for performing all normal functions: shifts left and right, complementation, addition, subtraction, and comparison. Registers comprising many such stages will require only the data input and command input lines, and data output lines. Overflow is simply the carry-out of the MSD stage.

If it is possible to extend the length of a register by merely connecting additional stages at the high order end without higher level changes in logic, then the possibility is introduced of doing so under program control. Such a possibility may be realized by dividing a very long register into a number of smaller ones, and thus performing the identical arithmetic operation on a number of small-sized operands. This procedure is possible simply because no separate provisions are necessary for polarity manipulation, and overflow detection is easily programmed.

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CIRCLE NO. 36 ON INQUIRY CARD

The essential simplicity of both the arithmetic and the logic will permit placing a large number, say several hundred, of such stages on a single wafer. Such wafers may be chained to make a register of several thousand stages. With appropriate additions to the logic and storage capability of each stage, the potential exists for a variable configuration computer, in which the actual configuration of registers may be set up by software.

A further elaboration may be described in which the control information for an operation in a register defined as above may be stored in the lower order three or four positions of a word, permitting either data or control information to be handled in a given register position. Such a design would further reduce the interconnections and partitioning problems of large-scale arrays; there would only be input/output lines. Additional logic in each stage would provide for transmission at terminal stages of carries (for adjoining digital differential analyzer integrators); of shifts (for the less significant portions of partial products and remainders); of commands (for block processors); or of any combination for special configurations. *The possibility that these configurations might be established by software in nanoseconds is of great importance in exploitation of large-scale arrays.*

The reliability of such a long chain would be very low. A redundant circuit would be provided for each stage, so that faulty stages can be detected and bypassed; again, stage-oriented arithmetic makes this possible. The net effect of faulty stages dropping out is a gradual reduction in the overall length of the chain. Thus, a computation for which the chain is divided into many registers will tend to become more serial and less parallel. Information on the current net length may be made available to a monitor or supervisory routine to permit computation of optimum register configurations. This ideally describes graceful degradation and self-repair.

A configuration such as the above allows for faulty stages in production, and automatically bypasses them from the beginning. Initial tests will be required to assure that each majority is not in fact a majority of errors. The size of an array would thus be limited only by physical considerations. A large array is completely general purpose, and may, under program control, be configured at any time to a digital differential analyzer, an incremental computer, a general-purpose computer, block processors, or any combination (hybrid) thereof, by the user.

There are also reliability implications which accompany the exchange of complexities from high to low level. If the high-level interconnections are reduced in number, the system reliability is inherently increased. The increase of complexity at the lower level will offset this reliability increase to a greater or lesser degree, but the problem is now concentrated in the general area of interconnection within the chip or wafer where failure rate is low and operating time over many applications is high. The effect, as integrated circuit production techniques improve, is an increase in reliability coincident with a decrease in unit circuit cost. Also, properly interconnected large-scale arrays could be designed with a high degree of built-in redundancy. The effects on computer production of transferring system complexities, connections, etc., from higher to lower system levels by means of large-scale arrays can be summarized as follows:

- lower production costs
- smaller size
- lower power consumption
- higher reliability
- redundancy easily built in
- standardization of functional arithmetic modules.

These advantages can be realized with modules based on negative radix representation.

The foregoing touches on some ways in which computer design may exploit the advantages of negative radix notation, utilizing both hardware design and software innovations. The information which will be presented in coming articles will enable the reader to decide for himself the extent to which these are solid potentialities.

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A. Lazarkiewicz and W. Balaskinski, *"A Simple Experimental Computer with Negative Basis,"* Mathematics of Computation, Vol. 15, No. 75, pp. 275-285, July 1961.

Note:

Part 2

of this series will appear in the June issue . . . .

NEW PRODUCTS

PUSHBUTTON ROTARY SWITCH

Miniature pushbutton rotary switch permits complete panel sealing to prevent contamination of switch and panel interior. Individual modules can be sealed from dust and moisture. Recommended specifically for military communications equipment and those subjected to hostile environments where panel sealing is required. Designed to meet the requirements of MIL-S-22710. It is available in all 8- and 10-position standard octal and BCD codes. Button extends only 3/16″ beyond the panel. Digitran Co., Pasadena, Cal.

Circle No. 266 on Inquiry Card

IC TESTER

New tester designed to test integrated circuit logic cards can be supplied with simple adapters that allow rapid, go-no-go, programmable testing of any DTL or TTL logic card. The tester can be utilized in single-operation tests involving as many as 16 individual, self-sequencing steps requiring less than 3 seconds total test time. The sequence is programmed by insertion of patch cords into a patch panel on the unit. For high-volume, repetitive testing, prepatched panels can be supplied. Stepping operation is performed by a rotary stepping switch with gold-plated contacts. The unit automatically stops at any step where the test board fails. The test unit provides a check of logic function operation as well as correct voltage levels. A counter indicator on the card tester allows the operator to determine the exact malfunction in the IC board being tested. Also, a single-step test switch is provided for detailed trouble-shooting on the test board. Wyle Laboratories, Products Div., El Segundo, Cal.

Circle No. 259 on Inquiry Card

DIGITAL RECORDER

A new asynchronous digital recorder, the Model ADR-100, writes data at the rate of 2000 characters per second which is said to be approximately 4 times faster than other asynchronous recorders currently available. Another feature of the system is its ability to record during the start interval in the asynchronous mode, assuring the acquisition of all random input signals. Three models of the NRZ-I system are designed to complement and be compatible with the seven-channel IBM systems 727 and 729 and the 800-bpi nine-channel IBM 360. Packing densities of the Model ADR-100 are 200, 556, and 800 bpi, with a recording error rate of better than 1 in 10^6 bits. Skew is held to less than 250 microinches. Revere-Mincom Div. 3M Co., Camarillo, Cal.

Circle No. 212 on Inquiry Card

BINARY DISPLAYS

Microminiature rear projection read-outs include a driver decoder module that provides binary to decimal conversion. The package utilizes silicon transistors and features forbidden code rejections with a standard input code of 8, 4, 2, 1. Once the input is accepted it will translate to decimal, and light one of eleven lamps to display the desired character. Industrial Electronic Engineers, Inc., Van Nuys, Cal.

Circle No. 275 on Inquiry Card

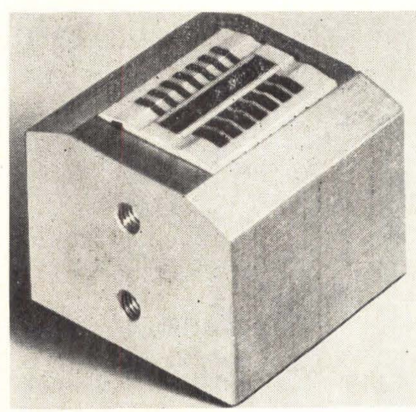
TINY CHIP RESISTOR

Subminiature chip resistors with a resistance range of 100 ohms to 250K measure as small as 0.010″ by 0.110″ by 0.010″. Temperature coefficient is ±150 ppm. These resistors are said to be particularly suitable for use in integrated circuits or in printed circuitry. The resistor, which has solderable terminations, can also be mounted directly on a ceramic printed circuit board by heat sink attachment. Mepco, Inc., Morristown, N. J.

Circle No. 270 on Inquiry Card

RECORDING HEAD

A new 7-track, IBM-compatible magnetic recording head is said to offer an unconditionally-guaranteed life of 2000 hours. The outstanding feature of the new head is reported to be its almost complete immunity to wear due to a patented manufacturing process. Called all-glass bonding, the process combines pole pieces of a ceramic, non-magnetic ferrite, and glass into a single, mechanically homogeneous structure with an all-ferrite recording surface. This surface is said to permit extremely hard surface finishes of unprecedented smoothness and flatness ensuring good head-tape contact and minimal head and tape wear. In addition, the absence of organic materials practically eliminates the problem of foreign particle build-up on the



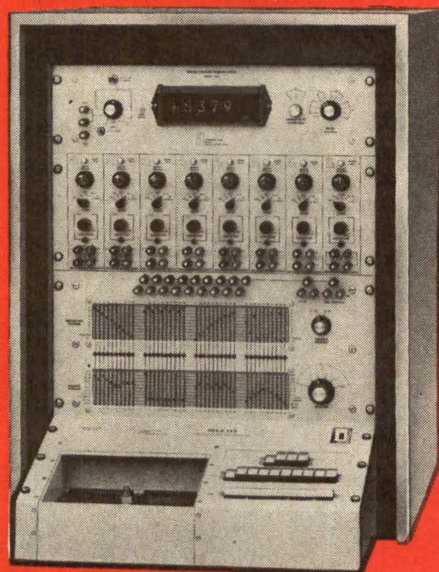
head surface thereby reducing the possibility of head induced dropouts and the amount of maintenance required to ensure reliable head and tape operation to a minimum. No relapping or recrowning is required for the life of the head. Ferroxcube Corp. of America, Saugerties, N. Y.

Circle No. 251 on Inquiry Card

NEW

semi-automatic integrated circuit analyzer

MICA 150



COMPUTER TEST CORPORATION

Now the integrated circuit user can get all the flexibility and performance of an expensive, large scale IC test system in an accurate and reliable DC bench top analyzer.

The new MICA-150 Modular Integrated Circuit Analyzer tests all IC configurations of up to 40 pins with unique programming, fast pushbutton sequencing and built-in DVM readout.

Fast, Versatile Programming Two independent 10x40 crossbar switches and rapid pushbutton sequencing provide up to 40 tests on a single device without re-programming. For example, it's now quick and easy to check a 10 pin device using four completely different test programs without resetting any switches to advance the test from pin-to-pin or program-to-program. Additional flexibility allows the built-in DVM to measure current on one pin of the device and voltage on another—all pre-programmed.

Universal Test Adapters Through use of universal test adapters, the MICA-150 is designed to check ICs according to the number of pins of a particular package, not device or circuit type. Adapters are available for diode, transistor, TO-5, flat-pack, dual in-line and other package configurations, and can also be provided for Kelvin connections.

Accurate Digital Readout Specifically designed for the MICA-150 analyzer, the built-in Digital Volt/Ammeter has a conservatively rated readout accuracy of 0.1% with a four digit display. Other features include automatic ranging and polarity selection, self-calibration, automatic voltage or current readout selection. Measures currents as low as 1 nanoamp, voltages to 1 mv.

Modular Design Modular construction allows users to select an economical, customized tester without obsolescence problems. Maximum capacity of eight function generators permits later expansion, including modules for AC and pulse testing, without additional modifications.

Variable Soak Time Marginal device operation can be easily detected through use of an adjustable test time control which provides a period for thermal stabilization prior to measurement. A continuous position on the control allows parameters to be varied while observing results.

Precision, Wide Range Power Supplies Highly precise supplies utilize multi-turn calibrated potentiometer controls with high resolution and repeatability. Constant current supplies are continuously variable from 0-100 ma with voltage compliance adjustable to 100v. Constant voltage supplies are variable from 0-100v with automatic current limiting to 100 ma to provide device protection.

QUICK ACTION REPLY

Detailed technical literature on the MICA-150 will be mailed immediately upon receipt of this request.

Attn.: A. Norman Into, Marketing Manager
Computer Test Corporation, Three Computer Drive
Cherry Hill, N.J. 08034 • Phone: (609) 424-2400

Name____________________

Company____________________

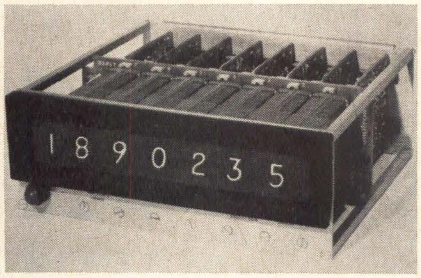
Address____________________

City__________ State_____ Zip_____

NEW PRODUCTS

IC COUNTER/DISPLAYS

Complete line of integrated circuit counters and displays is available in either building block form or as custom counter and display systems. The forward counter features a 25 MHz decade divider utilizing TTL integrated circuitry for increased re-



liability and noise immunity. The bi-directional counter has reversing capability up to 5 MHz. The counters can be used individually or in conjunction with continuous or latching displays. Transitron Electronic Corp., Wakefield, Mass.

Circle No. 224 on Inquiry Card

DIGITAL RECORDER

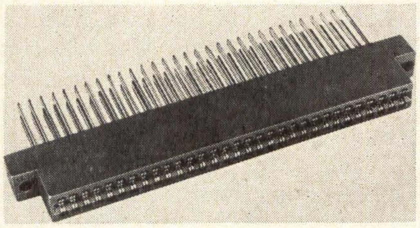
New digital recorder with 18-column capacity, prints at rates up to 20 lines per second. According to the manufacturer, high reliability has been designed into the recorder by a reduction in the number of moving parts and by careful design of those that are used. For example, the recorder has a photoelectric coding system in place of rotating electrical contacts, and there is no "start-stop" inked-ribbon mechanism. Acoustical noise level, a problem with digital recorders in this speed class, is said to be below that of an electric typewriter. The digital recorder converts binary-coded decimal data into printed decimal form on paper similar to that used in adding machines. Sixteen different characters can be printed in each column. Changes in format and coding are made simply and economically without requiring circuit changes. Hewlett-Packard, Palo Alto, Cal.

Circle No. 242 on Inquiry Card

PRESSURE MEASUREMENTS

A new instrument system allows conversion of pressure measurements to digital code, with resolution as high as one part in 300 thousand. Repeatability is as high as two parts in 300 thousand. Pressure measurement limits for the system are from one micron to 50,000 pounds per square inch. Applications of the system include digital printout of transducer calibrations; digital readout of pressures versus time for microbarometry; measurements at remote locations, with wired or telemetered data transmission to a central location; remote readings of pressures measured in hostile environments (e.g. high radiation levels); measurement of pressures where the measurements will be used in data processing; measurements where pressure versus time plots must be made; or any application where accurate readings must be made. Data may be printed out, punched on card or tape, or entered directly into a computer system. Texas Instruments, Houston, Texas.

Circle No. 244 on Inquiry Card



CARD EDGE CONNECTORS

Card edge connectors accept single or double-sided printed circuit cards 1/16″ thick with pads on 0.156″, 0.150″, 0.125″, or 0.100″ centers. These connectors, available in a variety of configurations, house from 15 to 86 phosphor bronze contacts with selective gold-over-nickel plating. The long bifurcated cantilever contacts have smooth insertion and withdrawal characteristics and provide two points of contact with each printed circuit pad for reliability. The one piece insulators are molded from diallyl phthalate, phenolic, or other thermosetting plastics, and have a protective closed-entry design. Amp Inc., Harrisburg, Pa.

Circle No. 232 on Inquiry Card

PHOTOELECTRIC SHAFT ENCODERS

Through use of integrated circuits, a new line of direct reading, natural binary, photoelectric shaft encoders features completely self-contained electronics. Units are available in 3 standard diameters of 2.5 in., 5.5 in., and 10 in. with resolution and accuracy to 15 digits, 19 digits, and 20 digits per revolution, respectively. In addition to size and weight reduction, incorporation of integrated circuits significantly improves reliability and permits operation of these encoders over a temperature range from −55°C to +125°C. For industrial applications, the new line is also available in low cost models with an operating temperature range of 0°C to +70°C. Wayne-George Corp., Newton, Mass.

Circle No. 237 on Inquiry Card

KEYBOARD-PERFORATOR

High-speed keyboard-perforator unit was designed for the graphic arts industry. The keyboard contains 54 keys arrayed exactly as found on a high quality electric typewriter rather than the 64-70 keys normally encountered on the graphic arts version of tape perforator keyboards. The unit produces all the codes required for computer justification of the tape by single stroke operation of the keys except for quad (line location) functions which require a double stroke; and character, word, or sentence deletion which require one, two, or three strokes of the delete key, respectively. The keyboard can accept input at 15 characters/second average and combinations of any two characters at a significantly higher rate. All character keys are mechanically interlocked and there is a single character mechanical memory to permit storage of a character if it is entered before the cycle on the previous character is completed. Teletypesetter code is standard for the graphic arts applications, however, the unit is optionally available in any five, six or seven level code to satisfy the need of graphic arts or other applications requiring information and control tapes. Connecticut Technical Corp., Hartford, Conn.

Circle No. 267 on Inquiry Card

HYBRID COMPUTING SYSTEM

A new completely-integrated medium-scale hybrid computing system, designated the EAI 690, is expected to find principal application in the aerospace, bio-medical, process, and education fields. Specific system and software packages have been planned for each industry, though the basic system is general-purpose. Digitally, the system offers a 16-bit instruction and data word plus protect bit, a protected core memory with 32,768 word storage capacity, a 1.65 microsecond memory cycle time, a repertoire of 62 instructions, multi-level interrupt capabilities, and a capacity to communicate with up to 64 peripheral devices. Maximum I/O rate is 1.2-million 8-bit bytes per second. In the analog portion of the system, the user is provided high dynamic and static accuracy, 500 kc bandwidth operational amplifiers, a system pre-wired for expansion to 156 analog amplifiers, extensive parallel logic capability, servo-set pots, and low (10-volt) power requirements. High-speed data transfer, monitoring and control interface. and logic control linkage are provided by the linkage system. It enables the digital system to perform all the functions required for automatic set-up, check-out, and operation of the analog system. It also minimizes the number of digital instructions required to produce information transfer while maintaining the program flexibility necessary for a hybrid system. Prices of 690 systems will range between approximately $110,000-$300,000, with the average operational system priced at about $200,000-$250,000. Electronic Associates, Incorporated, West Long Branch, N. J.

Circle No. 211 on Inquiry Card

CRT FIBER OPTICS

A new cathode ray tube faceplate consists of a fiber optic band across the center of the plate, with clear glass on either side to complete the disc. This arrangement is said to provide a cost advantage by limiting the fiber optics only to the area used. The fiber optic faceplate brings the CRT image to the front surface, eliminating parallax. Thus, photo contact prints may be made or the image may be viewed through a translucent overlay, such as a map or grid. The faceplate is available up to 10 inches in diameter, with the fiber optic insert up to 5 inches wide. The insert is glass solder sealed to the clear glass filler segments for vacuum tight integrity. The fiber optic portion may be ground and polished flush with the fillers or, where greater thickness is needed, may be stepped on the outside. The fiber optic segment may have a numerical aperture from 0.3 to greater than 1.0; fiber size is available from 5 to 30 microns. Chicago Aerial Industries, Inc., Barrington, Ill.

Circle No. 238 on Inquiry Card

REED RELAYS

Ultra-miniature reed relay occupies about 0.055 cubic inches per pole. It is believed to be the world's smallest reed relay. Twenty-five 4 pole units can be mounted on a 3½" x 6½" printed circuit board. Units incorporate glass reed switches mounted in a glass-filled nylon protective frame. They are encapsulated in a stress-free compound which has virtually the same thermal coefficient of expansion as glass. Contacts are rated and specified at a full 4 watts although in-plant testing is said to have resulted in over 14 million operations MCFF at a full 7 watts. Wheelock Signals, Inc., Long Branch, N. J.

Circle No. 281 on Inquiry Card

SOLID-STATE PROGRAMMER

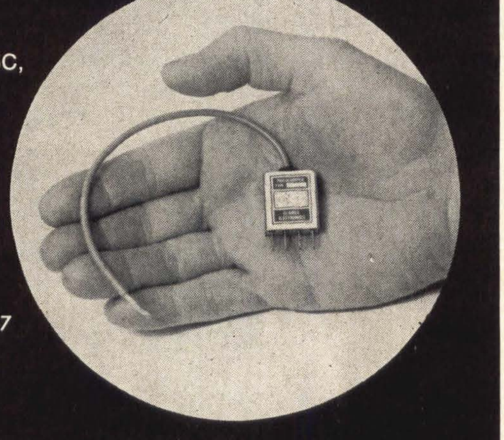
A new multiple output solid-state programmer utilizes integrated circuits to perform logic and counting functions to control, in a selectable time sequence, the operation of semi-automatic machines, process control equipment, recording, and tracking systems. The programmer initiates and terminates timing cycles, with duration as low as hundredths of a second and up to 29.9 seconds, to an accuracy of one millisecond. It not only provides these short program periods to the required accuracy, but also accommodates any special requirements such as program holds or interrupts. Modular plug-in construction supplies maximum flexibility for adaption to the particular requirements of user installations. Input power required is one amp of 115 vac, 60 Hz. Leach Corp., Los Angeles, Calif.

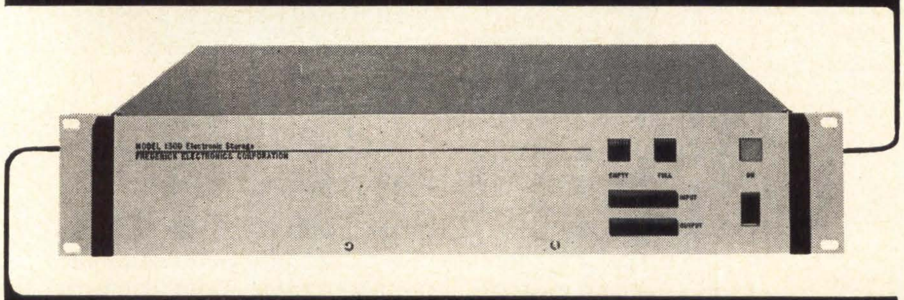
Circle No. 283 on Inquiry Card

ANALOG-TO-DIGITAL CONVERTERS

A new series of analog-to-digital converters features 6, 8, 10 and 12 bit accuracies and conversion speeds up to 83,000 per second. These converters operate on the principle of successive trial-and-error voltage comparisons; i.e., a precision reference voltage is automatically varied in a binary fashion until its amplitude equals that of the input analog signal. The conversion cycle is then halted and the resulting binary value of the reference voltage attenuation represents the value of the input signal directly. Special features of the converters include integrated circuit units mounted on miniature plug-in boards, pushbutton self-calibration capability, modular construction, and ease of installation. The unit is enclosed in a compact, KB size MIL-T-27 can. Sequential Electronic Systems, Inc., Elmsford, N. Y.

Circle No. 289 on Inquiry Card



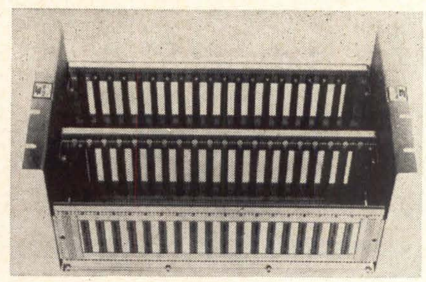


NEW PRODUCTS

TIME DISPLAY UNITS

A new series of time display units use integrated circuits and Nixie displays. These units make it possible to have time information, as produced by a time code generator, visible at all locations in a test facility. The display units may be at any distance up to several miles from the time code generator, visible at all locations in a test facility. The display units may be at any distance up to several miles from the time code generator. Models are available to operate from time codes in either serial modulated carrier form or in parallel form. Either IRIG or NASA codes may be used. All models are provided with an auxiliary BCD parallel code output. Outputs may be arranged in a "daisy chain" manner with a parallel input display model; up to 200 feet distant or up to four display units can be connected to each auxiliary output directly. Electronic Engineering Co., Santa Ana, Cal.

Circle No. 261 on Inquiry Card



PC CARD ENCLOSURE

Printed circuit card enclosure, designed for stacking, is said to offer advantages of requiring fewer parts, less assembly time, and greater savings. Available in 16 standard sizes, it is made completely of aluminum. Guides have sufficient "float" to allow for tolerance accumulation between card guides and connectors. Connector panel is assembled with machine screws and nuts rather than self-tapping metal screws. Elco Corp., Willow Grove, Pa.

Circle No. 208 on Inquiry Card

FUNCTIONAL TEST MODULES

A line of 20 MHz test modules for memory testing, telemetry timing, and circuit evaluation is packaged in building-block form to provide high-performance signal parameters for both bench testing and systems applications. Functions of the various modules can be combined for a wide variety of timing (trigger, sync, delay, width) and pulse (rise time, fall time, amplitude) controls. The new line is expected to lower costs by permitting the engineer to specify only the hardware required for his custom system. As requirements change, the system can be expanded and modified with additional plug-in modules. The new "Series 2000" includes a trigger module, a timing module, positive and negative current driver modules, and two enclosures, one with and one without power. Additional modules to be released shortly include a current/voltage calibrator, wide-band amplifier, discriminator, high-performance voltage drivers, sense switch, driver switch, and programmable units. All modules measure 5 x 2¾ x 10 inches. Both front and rear logic connections provide added wiring versatility. The modules also feature open and short-circuit protection with an operating temperature range from 0 to 50C. Honeywell, Computer Control Div., Framingham, Mass.

Circle No. 227 on Inquiry Card

MAGNETIC DISC MEMORY

Magnetic disc memory is a random-access storage device of the head-per-track type, available with capacities up to 16,896,000 bits. The unit uses a maximum of four 12″ diameter magnetic discs rotating on a common shaft as the storage medium. Average access time is 17 milliseconds and transfer rate is 1 mc. Eight-track flying heads are held in contact with the discs when the unit is not operating. When the discs are up to speed, the heads fly at a uniform spacing of 50 microinches. A maximum of 64 data tracks are used per disc surface. Computer Accessories Corporation, Goleta, Cal.

Circle No. 269 on Inquiry Card

NEW PRODUCTS

TOGGLE SWITCH

With a minimum electric life of 40,000 cycles, a new subminiature toggle switch will serve virtually any manual switching requirement. Working terminals and contacts are solid coin silver for low resistance, low heating, and high capacity of 5 amperes at 115 VAC rating. Case material is general-purpose phenolic. C&K Components, Incorporated, Watertown, Mass.

Circle No. 234 on Inquiry Card

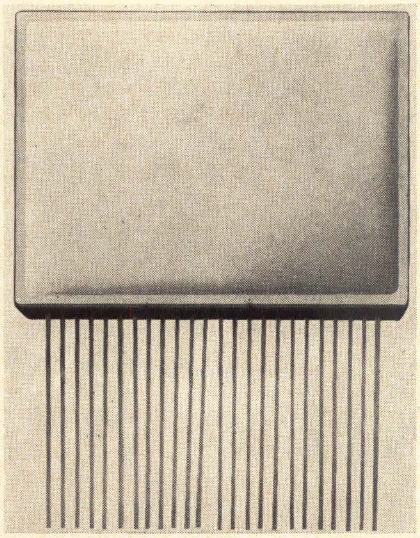
INCREMENTAL INTERFACE

A highly versatile incremental recorder interface offers such features as selection of word length up to 8 digits, selection of record length up to 4,095 words, variable recording rate up to 400 characters per second, fixed data of 12 digits, internal or external sync, and choice of binary or BCD mode. Designed with portability in mind, the unit permits the coupling of a variety of digital source devices into an incremental recorder. The unit is supplied complete with mating cables. Digi-Data Corp., Bladensburg, Md.

Circle No. 205 on Inquiry Card

SHIFT REGISTERS

Two new types of shift registers are available in the recently developed "Micro-Electronic Modular Assembly (MEMA) package. They are the first of what will be a full line of standard circuits in the MEMA package. Advantages of the MEMA pack are described as permitting 275 monolithic circuits per cubic inch, reduced testing and assembly cost at both the component and system levels, and improved reliability as a result of reduced interconnection wiring. The two new shift registers are assembled with TTL logic elements and provide serial or parallel input and output, 1.0 MHz clock rate, and low power dissipation (190mW for the 20-bit register). Dimensions of the MEMA package



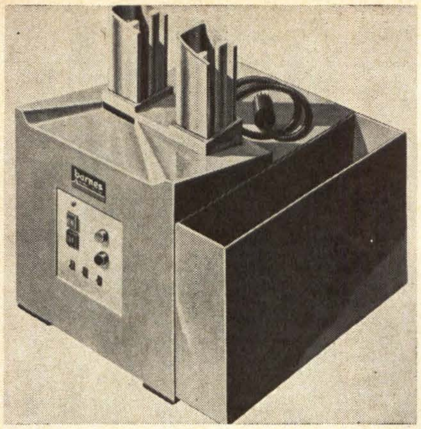
are 1.0" x 0.75" x 0.08". Amelco Semiconductor, Mountain View, Cal.

Circle No. 258 on Inquiry Card

MEMORY EXERCISER

A general-purpose memory exerciser for production and development testing of sub-microsecond core memory systems provides a range of full cycle speeds from 400 nanoseconds to 500 milliseconds. The machine will test and stop on error memories with 100 nanosecond access time. It performs error check and generates a new address in 200 nanoseconds. Built with integrated circuits the exerciser generates up to 65,536 addresses of 40-bit words. At $19,500, the Model 3602 is said to be the lowest priced general-purpose exerciser currently available. The exerciser features timing stability of ±1 per cent and "jitter" of ±0.1 per cent. The highly accurate timing permits the user to substitute variable timing from the exerciser for fixed timing in the memory. In this way, the exerciser can be used to explore the design subtleties of memory hardware by investigating circuits and subassemblies with variable timing. Honeywell, Computer Control Div., Framingham, Mass.

Circle No. 222 on Inquiry Card



IC TEST HANDLER

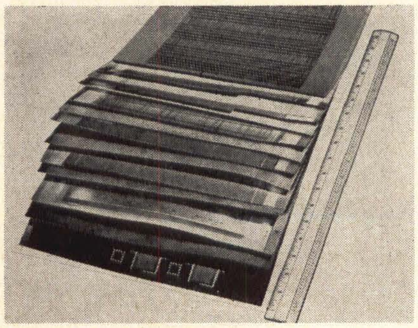
Semi-automatic test handler for flat package integrated circuits accepts carriers, either manually loaded, or in magazines, presents them to test probes, and ejects them into a magazine (good units) or into a bulk bin for reject or second class units. Feeding of the carrier is manual by means of a tray and chute arrangement or automatic by means of carrier magazine. The magazine capacity is 100 carriers. Typical test rate is 2400 to 3200 devices per hour. Visual polarization of carrier is required when being manually loaded, however fail safe provisions are made for identification of improperly loaded carriers. Barnes Development Co., Lansdowne, Pa.

Circle No. 246 on Inquiry Card

PC REED ASSEMBLIES

Printed circuit board assemblies consist of the appropriate type and quantity of reed relays and associated components mounted and soldered on a printed circuit card. They are complete circuit packages ready for direct insertion into an edge-type connector. The card is 5½" x 6" (special sizes are available), made of copper-laminated epoxy-glass. A nickel gold plating is applied over the copper circuit paths after the boards have been etched. On double-sided boards, plate-through holes are used to interface connections. Gold-plated, bifurcated connectors are used. The terminals are spaced on 0.2 inch centers and are designed for solderless wrapped connections. Automatic Electric, Northlake, Ill.

Circle No. 265 on Inquiry Card



MULTILAYER PRINTED CIRCUITS

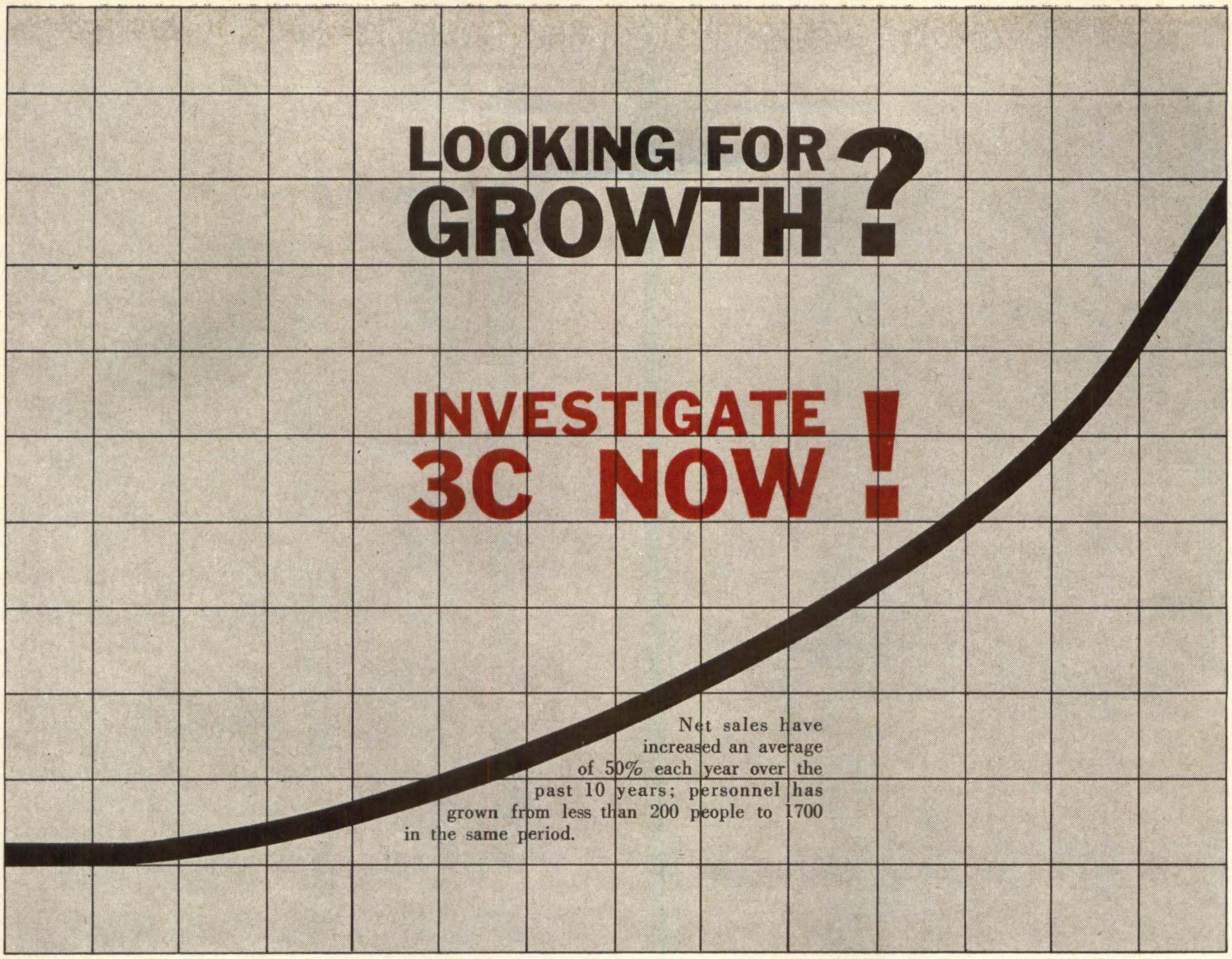
A multilayer printed circuit board of 15 layers is intended for use in EDP systems applications. With multiple ground planes and signal circuits, it retains compact dimensions due to precision techniques which allows 7000 holes to be placed in an area only 10" by 18". The board, which is 0.065" in thickness, is fabricated to the Institute of Printed Circuit specifications. Methode Electronics, Incorporated, Printed Circuit Div., Chicago, Ill.

Circle No. 201 on Inquiry Card

CLOCK OSCILLATOR

Integrated circuit clock oscillator is a complete crystal oscillator enclosed in a proportional temperature control oven for superior frequency stability characteristics. The complete unit occupies 0.84 cubic inches and is said to outperform other oscillators many times its size. The Model 726 features a low aging, high reliability "Koldweld" crystal, integrated circuit oscillator, and proportional temperature control oven encapsulated in a metal case. Frequency range is 701-1000 KC with stability at ±8ppm over a temperature range of −55°C to +60°C. Output voltage at load is logic zero +0.2 ±0.2 VDC, logic one +2.8 VDC minimum. Wave form is square with 50/50 ±15% symmetry and 20 nanosecond typical rise time. Input to oscillator is 5 VDC ±10%, 15 MA. Oven input is 28 VDC, 20 MA at +55°C. Monitor Products Co., Inc., South Pasadena, Cal.

Circle No. 274 on Inquiry Card



3C offers, to its customers, a total digital capability; to our professional engineers we offer a dramatic, dynamic growth potential. Continued market acceptance of our new DDP-516, DDP-416, and DDP-124 computers, I/C logic modules and core memory systems has created key opportunities for professional design engineers with experience in integrated circuits, high speed switching circuits and A/D-D/A circuitry to work on our next generation of digital equipment.

If you want growth, in a challenging atmosphere, call or wire collect, Mr. Martin Dorfman (617) 235-6220, or send your current resume to Honeywell, COMPUTER CONTROL DIVISION, Old Connecticut Path. Framingham, Massachusetts 01701.

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BAR CODE READER/SORTER

A bar code reader/sorter enables the high-speed sorting of ordinary paper documents with the accuracy and economy previously available only with punched card sorting equipment. The use of ordinary paper results in substantial savings in paper, printing and mailing costs. The unit sorts intermixed paper documents ranging in size from 2¾″ by 3¼″ to 4½″ by 8⅓″ and in weight from 12-pound paper to card stock at a speed of 1800 per minute. With an optional, second paper transport operating simultaneously, the effective throughput is increased to 3600 documents per minute. Because the reader/sorter uses vacuums and air pressure to separate and control paper, it can process paper that is folded, crumpled, dog-eared, stapled, or torn. It will mis-sort no more than 0.001 per cent of the documents, or only one in one hundred thousand. As the paper documents move through the reader/sorter at 400 inches per second, they pass by a reading station with an ultraviolet light source. The unit reads and interprets fluorescent bar codes at rates up to 144,000 characters per minute and routes each document to one of 12 output pockets. The bar codes, which can represent numeric or alphanumeric data, can be printed on either side of the documents by conventional printing means. Recognition Equipment, Inc., Dallas, Texas.

Circle No. 286 on Inquiry Card

SPEECH DELAY SYSTEM

A new speech delay system uses magnetostrictive delay lines as the delay medium. The system is said to combine high performance delay lines with new modulation techniques to provide the required delays in a solid state system of extreme reliability and long life. A brief summary of performance specifications includes delay time to 100 ms or more; frequency response within ±1 db, 20Hz to 20kHz; dynamic range 0 to −40 dbm; and distortion of 5% maximum. Unit mounts in a 19″ relay rack and is powered by common dc voltages. Digital Devices, Inc., Syosset, L. I., N. Y.

Circle No. 280 on Inquiry Card

BINARY CODE SWITCH

Compact switching matrix for memory, programming, data, voice, and broadband switching applications offers 2,040 switching contacts in 670 cubic inches. Switch includes ten modules, each with 17 multiple positions having 12 make contacts per position. Maximum power voltage is 56V, minimum 44V. The Ericsson Corp., New York, N. Y.

Circle No. 284 on Inquiry Card

LITERATURE

Pushbutton Switches

A 22-page catalog contains detailed information and illustrations on the modular design of new pushbutton switches and fully describes the basic module elements, module functions, and assemblies as well as accessories. The catalog shows how the modules can be used in an almost infinite number of combinations to solve a wide variety of switching problems. Complete mechanical, electrical, and environmental specifications are included. Centralab, Milwaukee, Wisc.

Circle No. 312 on Inquiry Card

Digital Readouts

New booklet describing a line of optimum contrast illuminated digital readouts discusses the features of the units from two viewpoints — display features: extreme brilliance (average 1000 foot lamberts), wide angle viewing, and clarity; and equipment features: space weight efficiency, low voltage operation, the use of light pipe segments, and ease of maintenance. Also contained in the booklet is a presentation of the operating principles of the seven segmented bar readout and a chart of the characters produced. Tung-Sol Div., Wagner Electric Corp., Newark, N. J.

Circle No. 320 on Inquiry Card

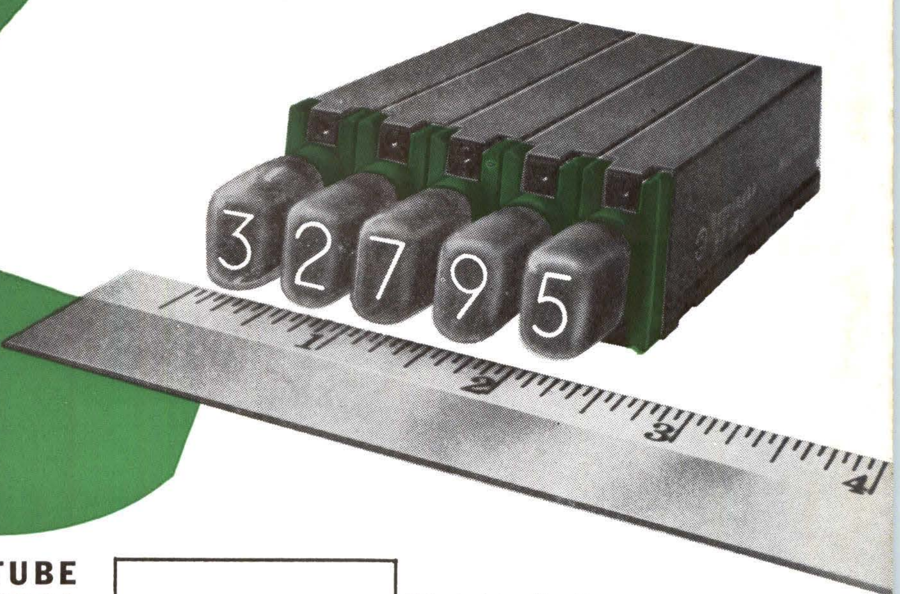
Tubeaxial Fans

Literature describes a new line of 6″ tubeaxial fans. The fans deliver up to 429 CFM and are capable of working against static pressures up to 0.88 in. Designed for application in computer, data processing, communications, and test gear, these fans feature quiet long life operation and comply with all applicable military specifications. Eastern Air Devices, Dover, N. H.

Circle No. 329 on Inquiry Card

ADVERTISERS' INDEX

now...you can package a 5-DIGIT display with DECODING in 2 1/2 inches



BURROUGHS MINIATURE NIXIE® TUBE DECODER DRIVERS, BIP-9203/BIP-9201

- **Compatible with integrated circuits**
- **Accept 4-line 8-4-2-1 BCD inputs (positive or negative logic)**
- **0.3″ character display**

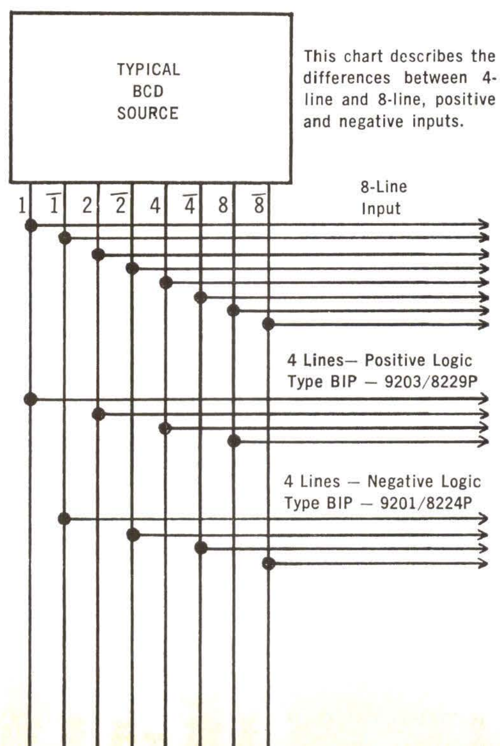
Standard Size NIXIE tube decoder/drivers

- **Accept 4-line or 8-line 8-4-2-1 BCD inputs (positive or negative logic)**
- **Complete assemblies available**
- **0.6″ character display**
- **Have dimming and blanking capabilities**
- **Compatible with integrated circuits.**

For additional information contact Burroughs Corporation, Electronic Components Division, P.O. Box 1226, Department D, Plainfield, New Jersey 07061.

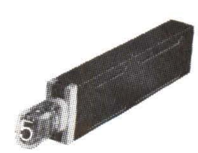
Burroughs Corporation

CIRCLE NO. 51 ON INQUIRY CARD



This chart describes the differences between 4-line and 8-line, positive and negative inputs.

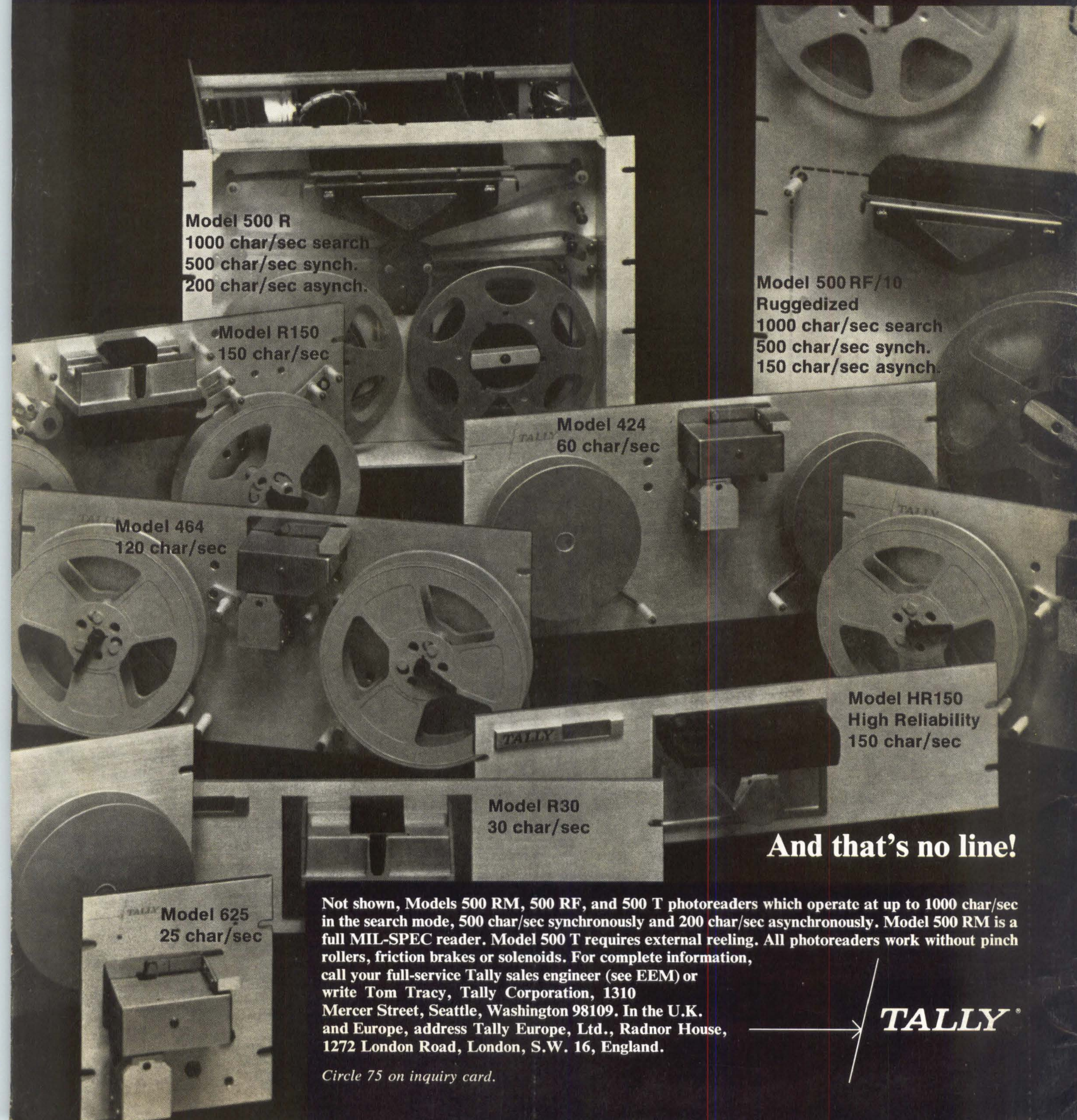
BIP-8200 SERIES



BIP-9200 SERIES

What a line!

The broadest, most complete array of perforated tape readers available.
25 to 1000 char/sec.... mechanical and photoelectric.



And that's no line!

Not shown, Models 500 RM, 500 RF, and 500 T photoreaders which operate at up to 1000 char/sec in the search mode, 500 char/sec synchronously and 200 char/sec asynchronously. Model 500 RM is a full MIL-SPEC reader. Model 500 T requires external reeling. All photoreaders work without pinch rollers, friction brakes or solenoids. For complete information, call your full-service Tally sales engineer (see EEM) or write Tom Tracy, Tally Corporation, 1310 Mercer Street, Seattle, Washington 98109. In the U.K. and Europe, address Tally Europe, Ltd., Radnor House, 1272 London Road, London, S.W. 16, England.

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