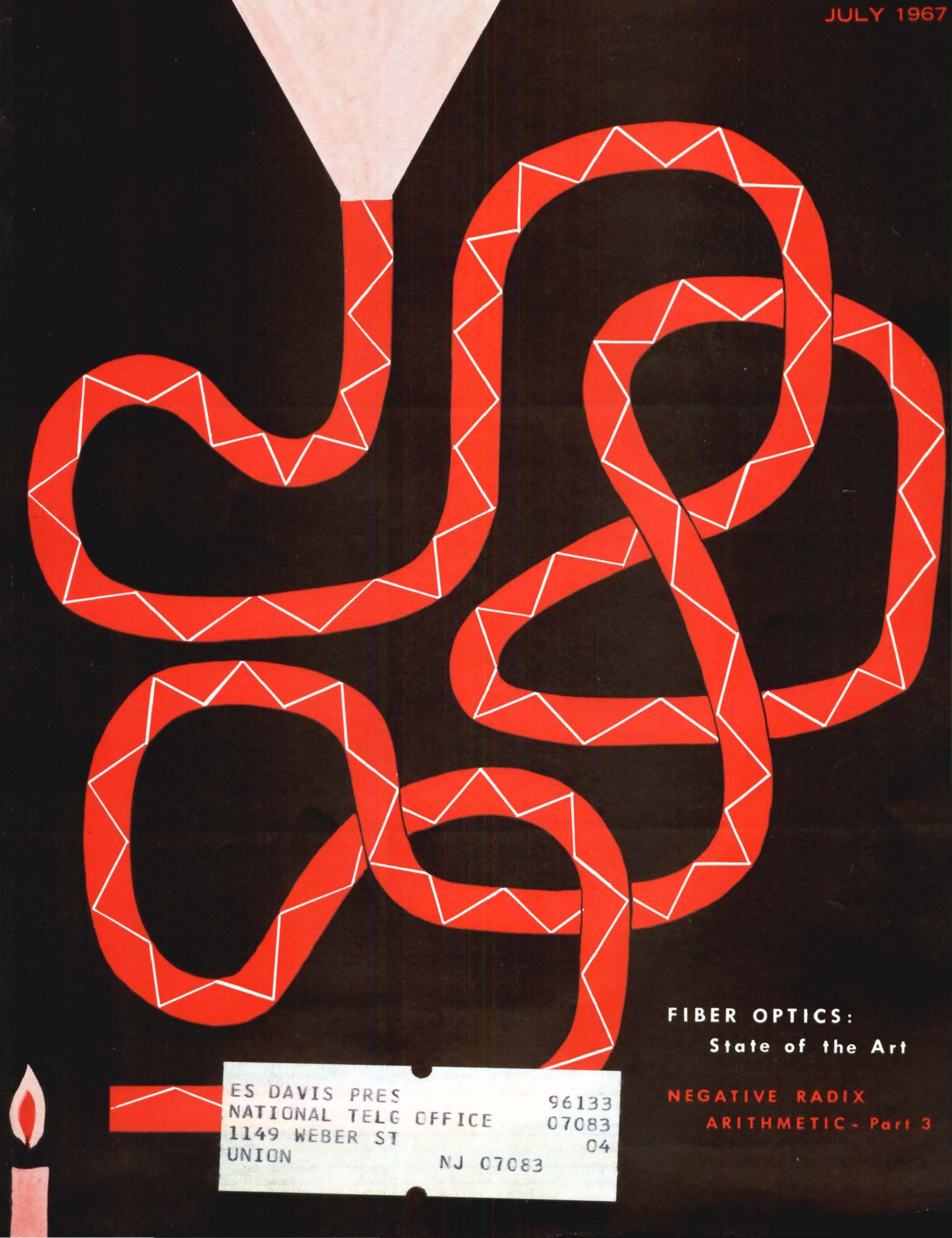
COMPUTER DESIGN

THE MAGAZINE OF MODERN DIGITAL ELECTRONICS

JULY 1967



FIBER OPTICS:
State of the Art

NEGATIVE RADIX
ARITHMETIC - Part 3

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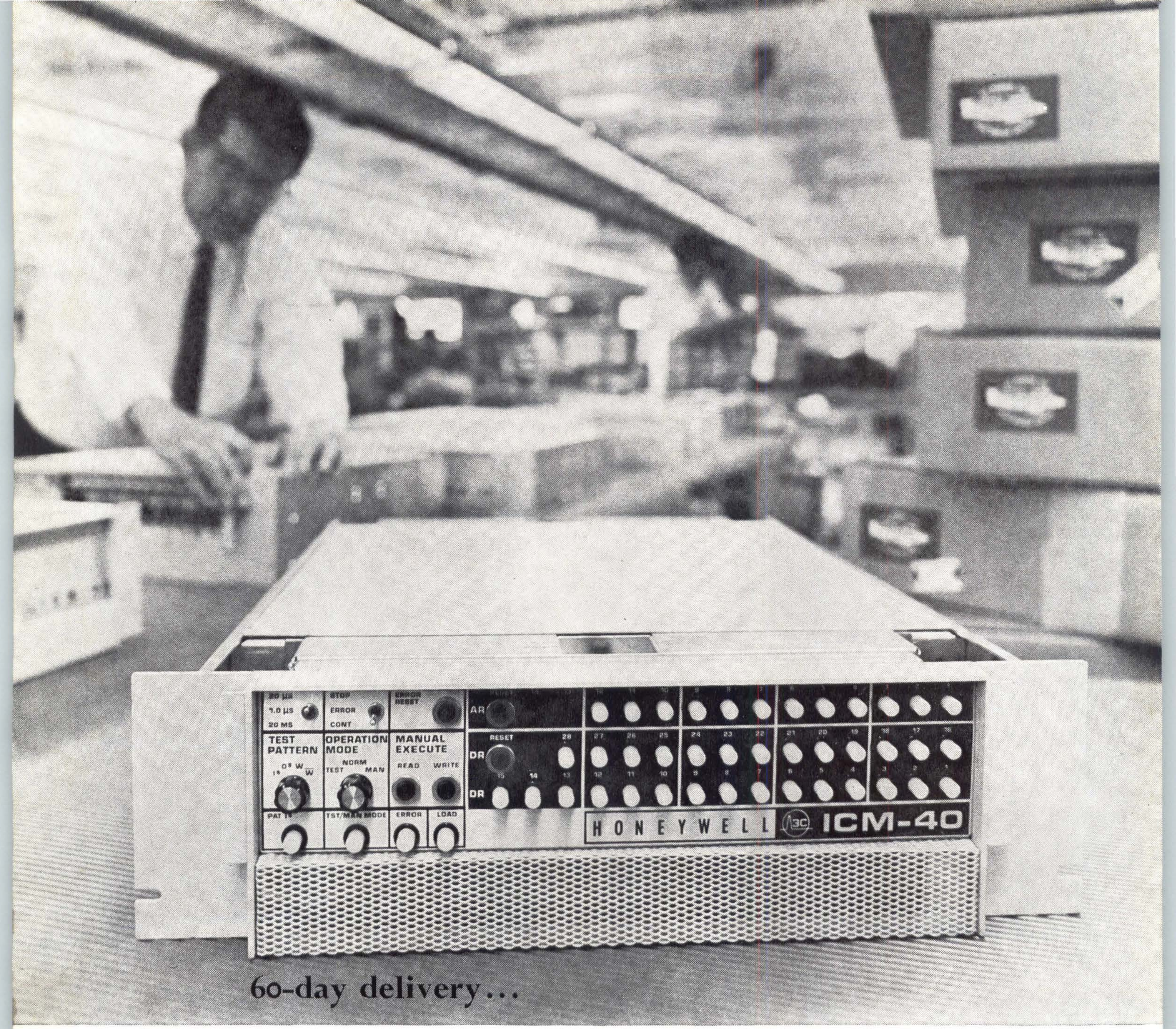


60-day delivery...

...helps you meet tight schedules when you use I/C μ-STORE core memories

Our one microsecond ICM-40 memories are ready now to meet your tightest delivery schedule — 60 days or less on standard models with capacities of 4,096, 8,192, 16,384 and 32,768 words.

If you've drawn a block marked "core memory" recently, let us show you ***μ-STORE*** speeds, capacities, and fast delivery capability. You'll find that both our ICM-40 and ICM-47 (670 nanosecond full cycle time) have been designed to offer a custom solution to your memory problems. Write for our new brochure. It sums up all the facts. Honeywell, Computer Control Division, Old Connecticut Path, Framingham, Massachusetts 01701.

Honeywell

COMPUTER CONTROL DIVISION

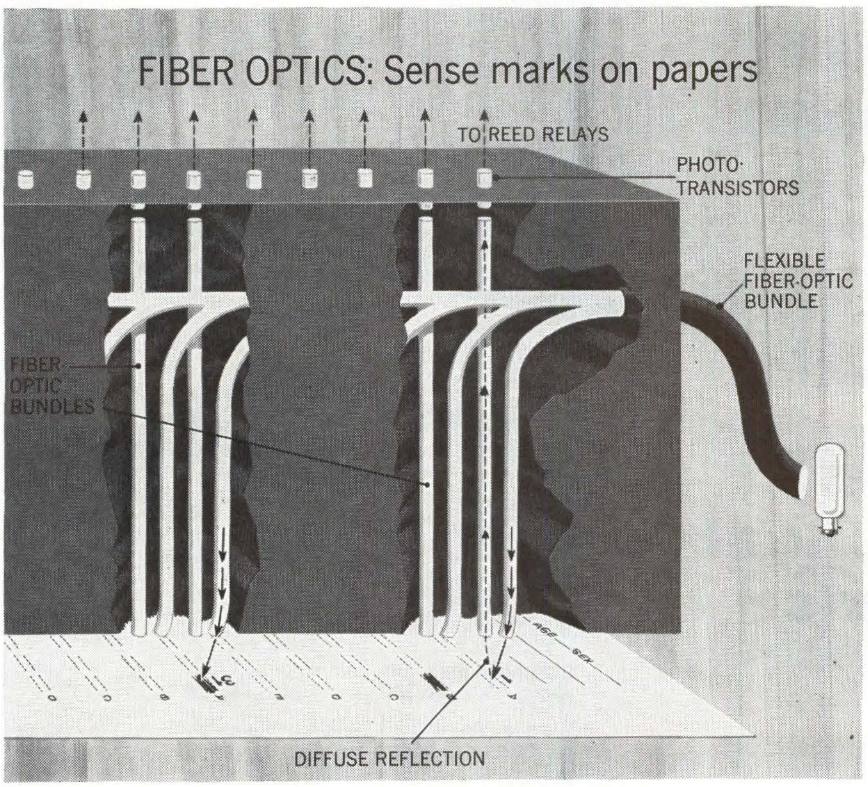
CIRCLE NO. 1 ON INQUIRY CARD

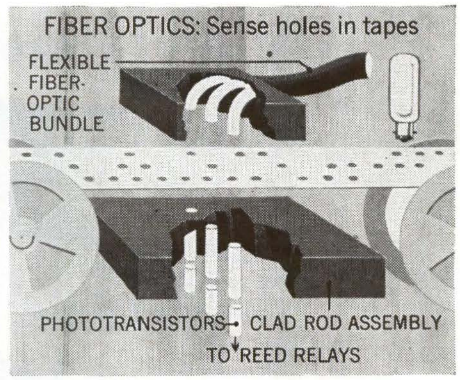
Problem:

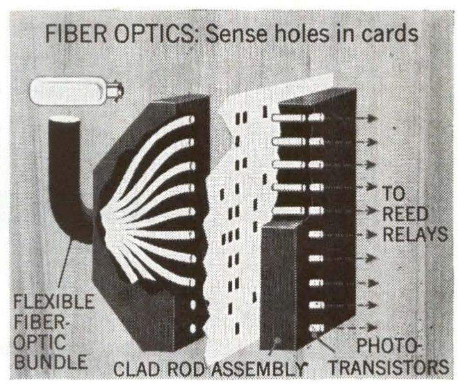
Get faster, more efficient "read in" of data.

Solution from American Optical:

Fast, quiet, reliable fiber-optic "readers" for data processing.







Electro-optical systems incorporating fiber optics are operating at up to four times the speed of electro-mechanical systems. When a combination of fiber optics, phototransistors, and reed relays is used, reading of basic data is not controlled by mechanical limitations. The use of fiber optics allows wide design freedom to increase system operating speed.

In addition, electro-optical devices provide inherently quieter operation. And the need for continual replacement of expensive electromechanical components is eliminated. The use of fiber-optic devices isolates heat and eliminates friction, the major causes of wear and failure. In most applications, both initial cost and use cost can be reduced by design simplicity.

American Optical know-how makes such design simplicity possible. AO pioneered fiber optics and today produces the most widely used sensing devices. This accumulated practical design and application experience, along with research and production capability, is readily available to you.

Contact AO now and lessen the time and expense of getting from exploration to application. Sorters and collators, verifiers and key-punch equipment, printers and readers, teletypes—most any data processing equipment—can benefit from these American Optical fiber-optic devices. Write American Optical Company, Fiber Optics Department, Southbridge, Massachusetts 01550. Or call 617-764-3211.

NEW FROM **AMERICAN OPTICAL COMPANY**®

SPACE-DEFENSE DIVISION—SOUTHBRIDGE, MASSACHUSETTS

CIRCLE NO. 2 ON INQUIRY CARD

INVAC SERIES-200
Photoelectric Keyboard

This Keyboard is more than just a Manual Input Device

It solves
interface logic problems (strobe, shift and interlock included)

It eliminates
customer code conversions (built-in universal encoding)

It provides
dual code outputs (any code or code combination up to fourteen bits . . . simultaneous outputs for codes that total 14 bits or less)

It prevents
invalid code generation (blocks unused code keys, automatically)

It minimizes
external storage registers or buffers (simple speed maximizer prevents operator from exceeding system speed)

In addition to these unique advantages, the INVAC SERIES-200 Photoelectric Keyboard provides all of the standard features found on all keyboards manufactured by Invac Corporation. These include universal code selection and engraving of keys, choice of number of keys, keyboard lockout and a true typewriter "feel".

Invac Corporation also makes Photoelectric Keyboards as manual input devices. But chances are you need more than just a manual input device. Consider, for example, the functions to be performed by the keyboard and the peripheral equipment. The INVAC SERIES-200 Photoelectric Keyboard with its universal encoding capability will perform them all and at less cost. This is also true in systems where code changes are planned, or in effect. Since these savings are realized at each station, the total savings for large systems are significant indeed.

Write for information on the new INVAC SERIES-200 Photoelectric Keyboard. It's new, it's reliable, it's a great cost saving performer.

IT'S INVAC FOR ADVANCED PERIPHERAL EQUIPMENT

INVAC CORPORATION

26 Fox Road, Waltham, Mass. 02154
Tel. (617) 899-2380

CIRCLE NO. 3 ON INQUIRY CARD

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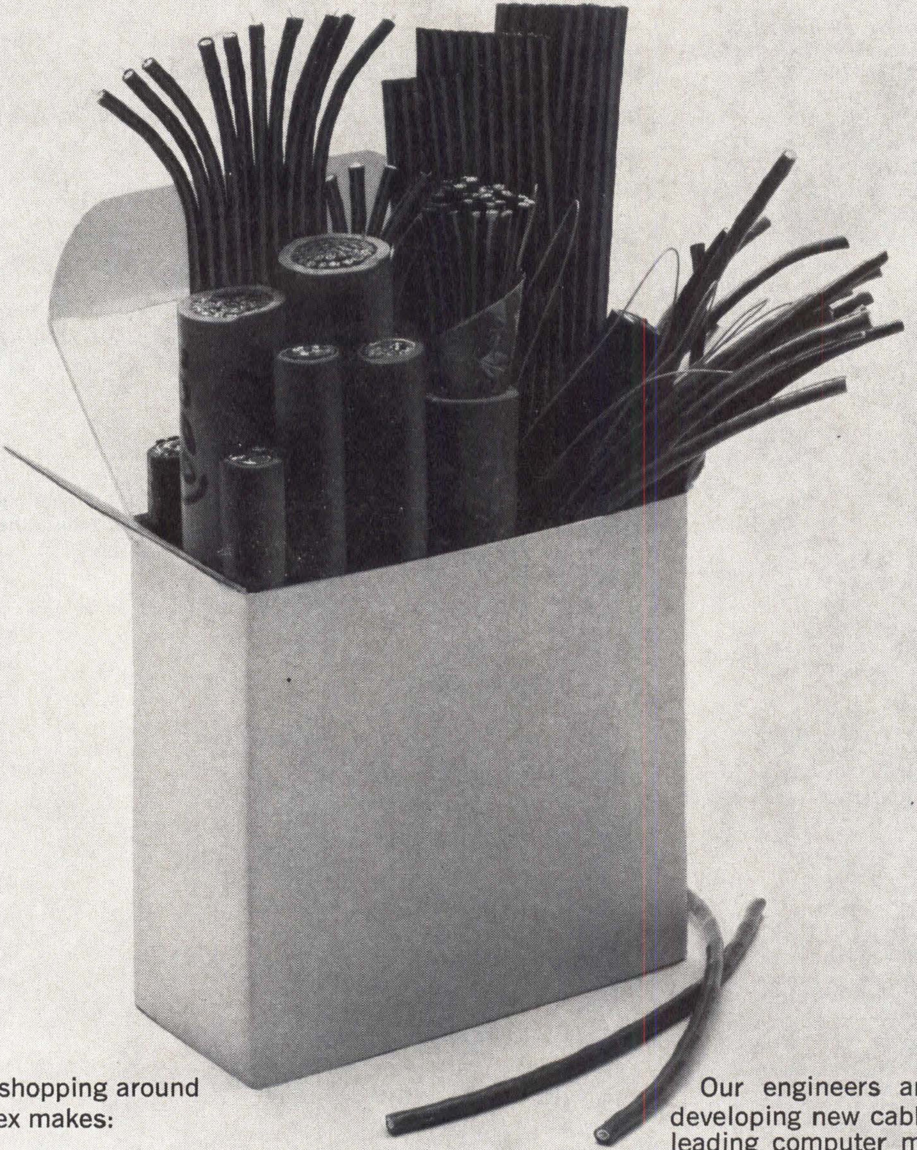
COMPUTER DESIGN

THE MAGAZINE OF MODERN DIGITAL ELECTRONICS

FEATURES

DEPARTMENT

Yes. You can get every wire and cable you need for a computer system in one neat package...from Brand-Rex



You save a lot of shopping around because Brand-Rex makes:

- *Back-Panel Wires*
- *Hook-Up Wires*
- *Miniature, Air-Spaced Coaxial Cable*
- *Power Supply Wires*
- *Patch Cord Wires*
- *Interconnecting cables and Communication Cables.*

You can have just about any configuration . . . single wire, round cable, ribbon cable, custom profiles . . . and your choice of insulations including Kynar, Polysulfone, Teflon (FEP and TFE), PVC, semi-rigid PVC, PVC/nylon, polyethylene, foamed polyethylene, FEP/nylon, Rulan and Neoprene. Matched colors if you want.

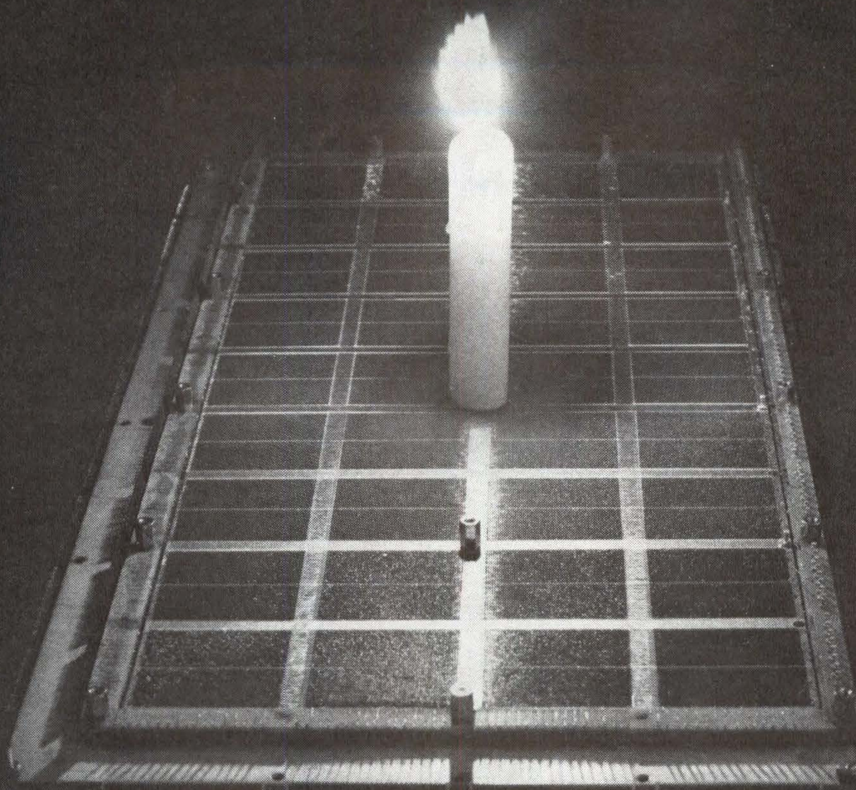
Our engineers are constantly developing new cable designs for leading computer manufacturers. So if existing Brand-Rex products don't meet your needs, we'll come up with new designs that will.

Hooking-up a computer system? Get all the wire and cable from one good source. Ask Brand-Rex.

AMERICAN ENKA CORPORATION
BRAND-REX DIVISION
WILLIMANTIC, CONNECTICUT 06226
PHONE 203 423-7771

CIRCLE NO. 4 ON INQUIRY CARD

CIRCLE NO. 5 ON INQUIRY CARD →



in a memory system somewhere, one of our 2½ D stacks is celebrating its first birthday

After we shipped that one, we started delivering stacks at the rate of nearly one a day. Several hundred to date. Capacities ranged from 4,096 to 16,384 words of 8 to 25 bits. Cycle times went from 900 to 650 nanoseconds. Some were off-the-shelf designs, some slightly modified.

All had wide operating margins and low system noise.

But one of the most important specs was reliability. For example, internal stack connections were reduced by 80%. Drive lines were shortened, and the inhibit winding was eliminated. The result was unsurpassed stack dependability and increased operational speed.

With a brand new design, that first birthday is very very significant. Infant mortality has plagued many an engineer. Now we're confident any one of our stacks could be around for a golden anniversary.

There's a new four-page brochure waiting to be requested. It has all the specs. Write for Litpak 2C.

EM electronic memories

12621 Chadron Ave., Hawthorne, Calif. 90250, (213) 772-5201

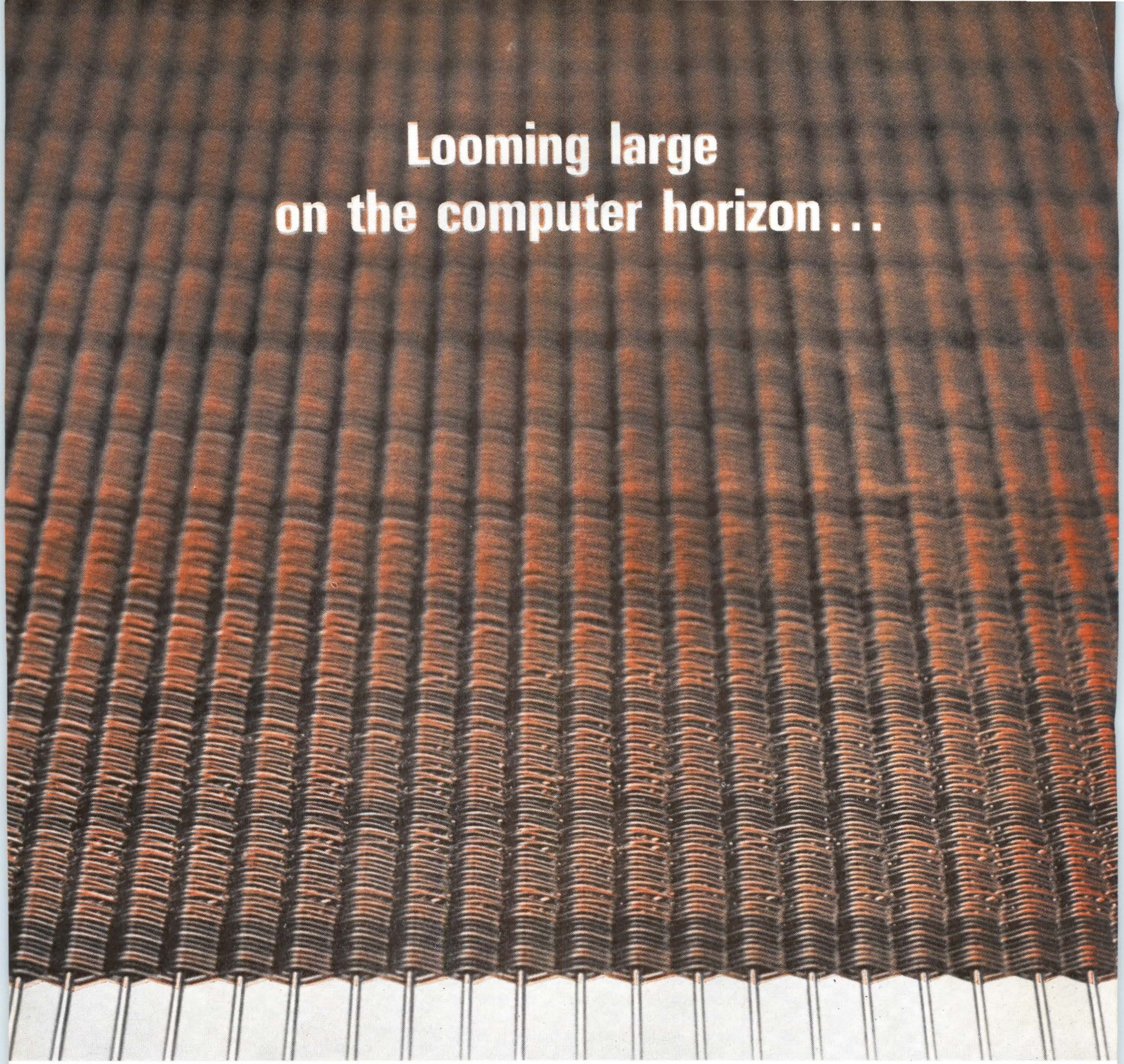
This 16-bit, real-time computer is so fast you can have one in 60 days.

It's our SEL 810A, for high-speed data acquisition and control. All integrated circuits, 3 levels of priority interrupt, 4K memory, teletype, high-speed hardware multiply and divide, real-time I/O structure, and an outstanding software package. Over 50 in the field. Price: $23,950. Systems Engineering Laboratories, 6901 West Sunrise Blvd., Fort Lauderdale, Florida 33310, Area Code 305 587-2900. Offices also in Washington, D.C.; Los Angeles, California; Boston, Massachusetts; San Francisco, California; Cleveland, Ohio; Houston, Texas; Huntsville, Alabama; and Orlando, Florida.

Systems Engineering Laboratories

CIRCLE NO. 6 ON INQUIRY CARD

CIRCLE NO. 7 ON INQUIRY CARD →



the WOVEN PLATED WIRE MEMORY

Keep in mind: its thirteen advantages apply equally to military/commercial computer, telemetry, and data-handling systems. About the memory plane shown at left: 2,592 non-destructive readout (NDRO) bits. Completely potted to withstand aerospace environments of shock, vibration, and temperature. Ultra-high-speed, low-power operation. ■ Keep General Precision, Inc., Librascope Group in mind to stack some planes or supply a complete system for your next memory application. Plated, woven, and fabricated in the U. S. A. Write for brochure.

GP GENERAL PRECISION INC.

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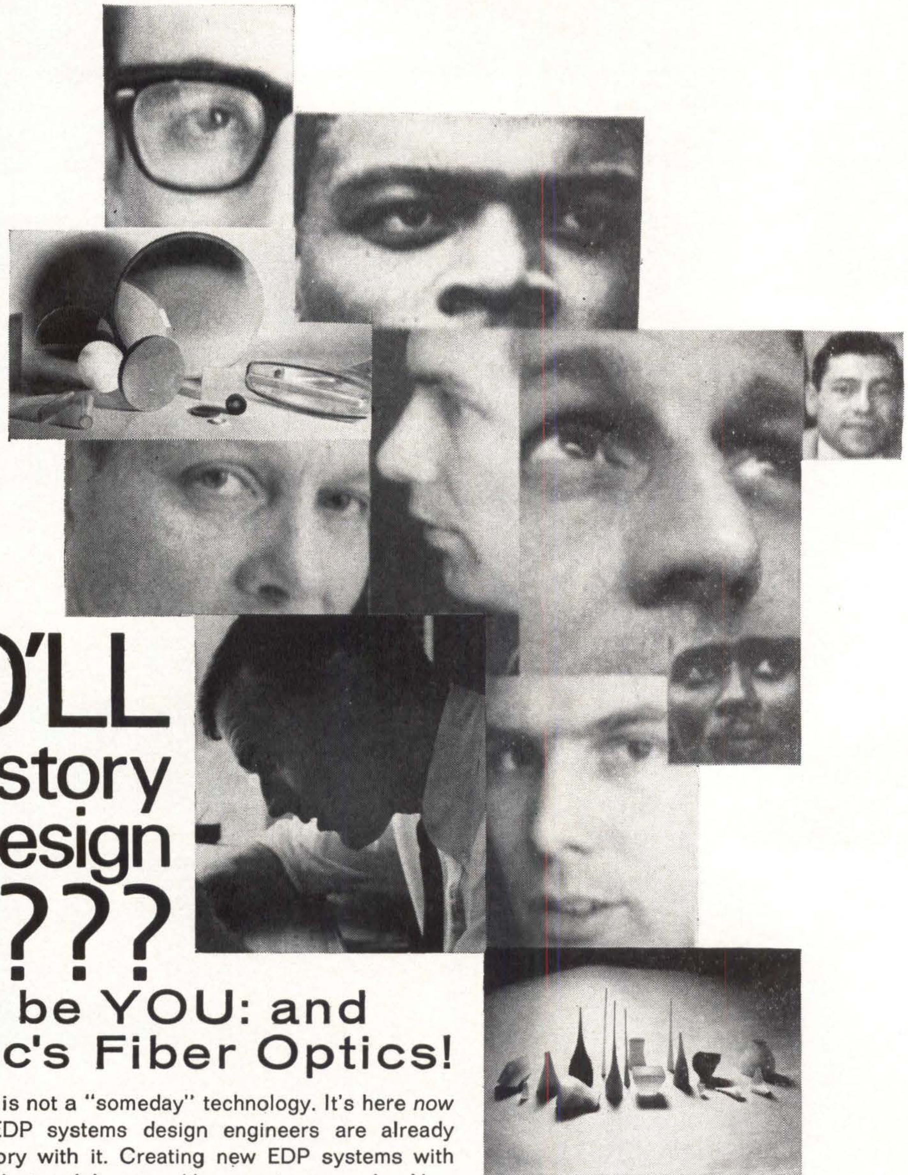
808 WESTERN AVENUE • GLENDALE, CALIFORNIA 91201



WHO'LL make history in EDP design ?????

Could be YOU: and Mosaic's Fiber Optics!

Fiber optics is not a "someday" technology. It's here *now* . . . and EDP systems design engineers are already making history with it. Creating new EDP systems with superior talents. Advances like greater speeds. New capabilities. Design freedom. Greater reliability and lower costs.

Do you know what happens when you use Mosaic's fiber optic faceplate on a CRT, vidicon, or orthicon tube? Your recording sensitivity is greatly increased (in some cases, as much as 40X) enabling you to compromise on the tube design. With the effect of a zero thickness window, you get improved contrast and resolution, and can take *direct* accurate measurements on the image.

Have you heard about Mosaic's Fiber Optic systems? On new EDP printers, readers, punched tape and card verifiers, keypunch and teletype equipment, they beat heat, wear and friction-prone mechanical systems hands-down: with increased reliability, greater efficiency, speeds over 4 times faster and lower cost!

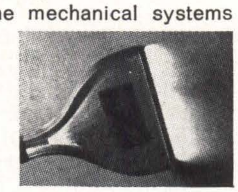
Mosaic's fiber optics can help *you* make history in EDP design, *now* . . . a field that leaves you no time for old design notions. Give those specific design problems of yours a hard look, today. Then contact Mosaic Fabrications. We know fiber optics inside-out. We're the largest single source of fiber optics technology, capability, and productivity in the world!

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 far ahead!

Call or write . . .
Mosaic Fabrications, Inc.,
Galileo Park, Sturbridge,
Mass. 01518, (617)
347-9191 for descriptive literature today!

Bendix Electronics

CIRCLE NO. 8 ON INQUIRY CARD



CIRCLE NO. 9 ON INQUIRY CARD

DATA/620-i **NEW**

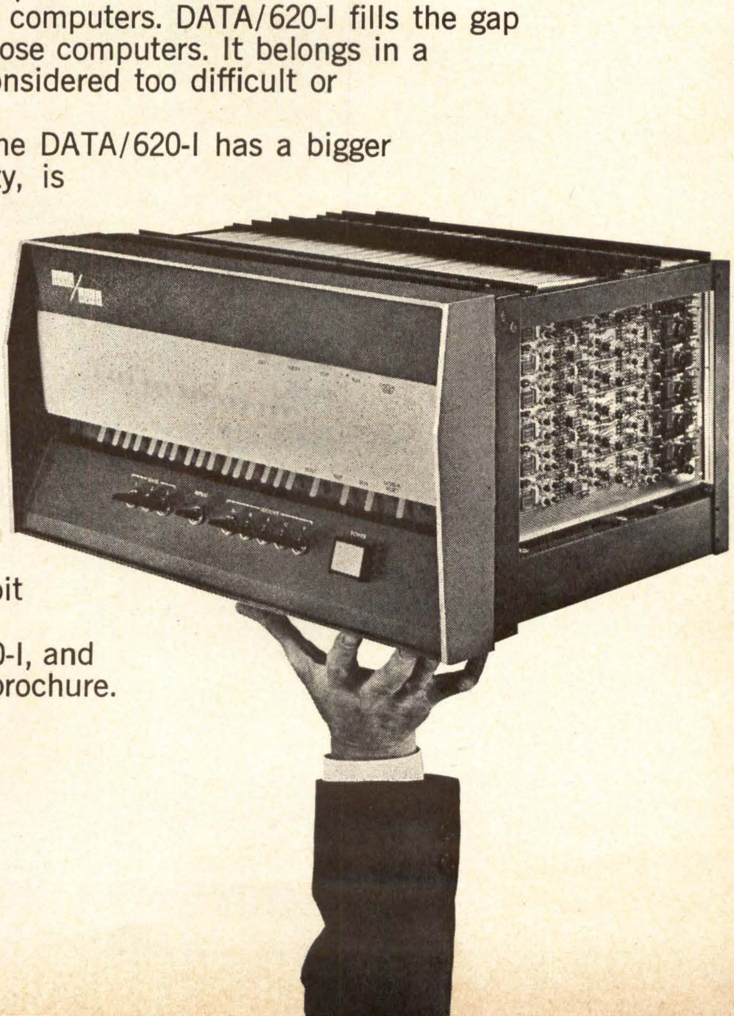
DATA/620-i **SMALL**

DATA/620-i **FAST**

DATA/620-i **SYSTEMS COMPUTER**

The DATA/620-I integrated circuit computer is the newest member of the DATA/620 family of system computers. DATA/620-I fills the gap between general purpose and special purpose computers. It belongs in a system, and solves problems previously considered too difficult or expensive for computer solution.

Designed for faster problem solution the DATA/620-I has a bigger instruction set, integrated circuit reliability, is smaller, has one-half the components, and costs less than any computer in its class.



DATA/620-I comes complete with software, field-proven and refined on the DATA/620.

Extremely compact, the DATA/620-I requires only 10″ of 19″ rack space. It's available with memory modules from 1024 to 32,768 words of 16 or 18 bits, and with a selection of control, arithmetic and I/O facilities, including D.M.I.'s unique Micro-Exec.

Price: $13,900 with 4096 words of 16 bit memory, including ASR 33 teletype.

We are very proud of our new DATA/620-I, and would like to tell you more in a fact filled brochure. Please write for one.

DATA MACHINES

1590 Monrovia Avenue, Newport Beach, California
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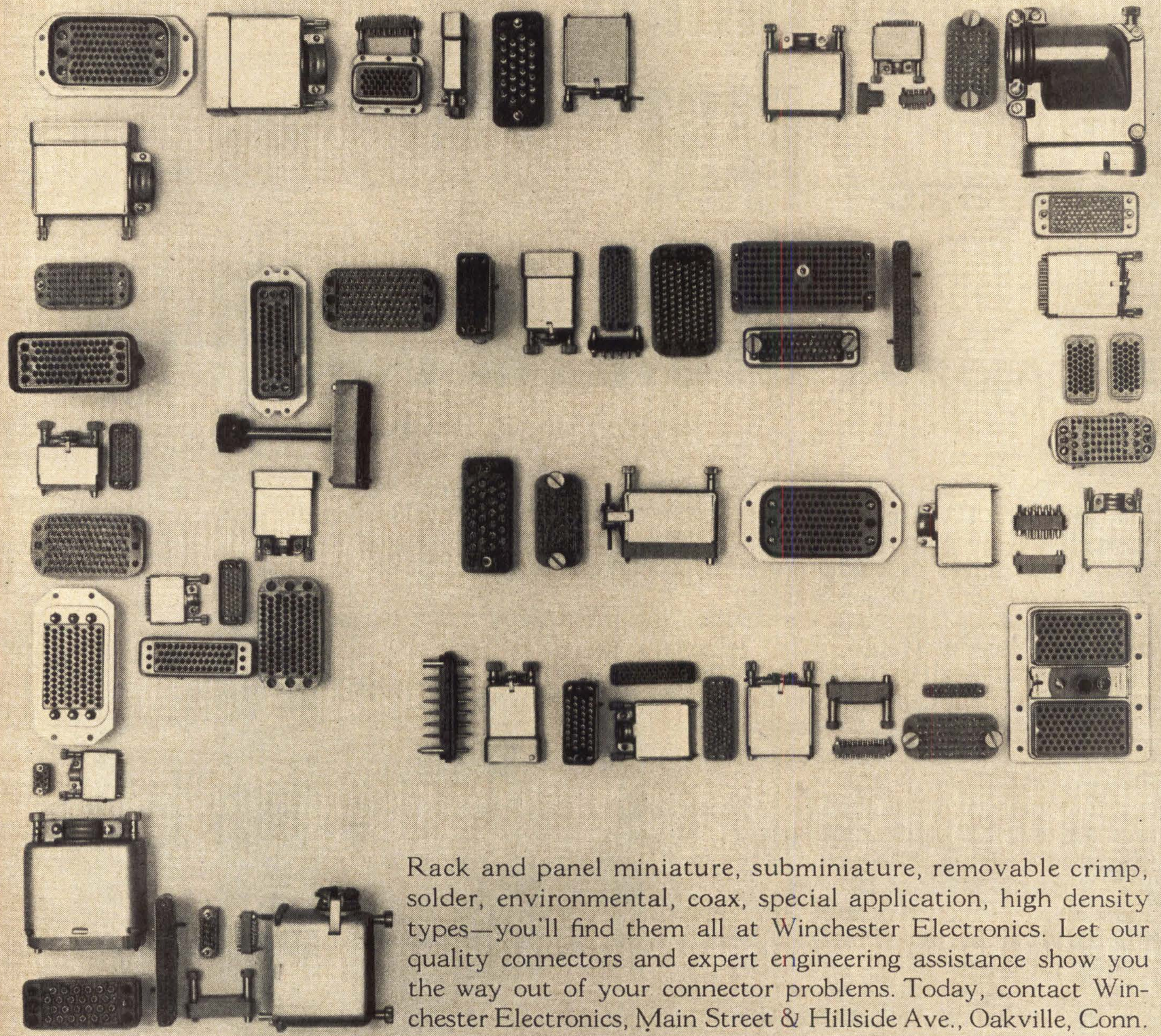
Division of DECISION Control, Inc.

Find your way to Winchester Electronics for the best selection of quality rack and panel connectors.



Rack and panel miniature, subminiature, removable crimp, solder, environmental, coax, special application, high density types—you'll find them all at Winchester Electronics. Let our quality connectors and expert engineering assistance show you the way out of your connector problems. Today, contact Winchester Electronics, Main Street & Hillside Ave., Oakville, Conn.

WINCHESTER ELECTRONICS
DIVISION OF LITTON INDUSTRIES

THE COMPONENT GAP

and how to close it

There's a gap in computer components today.

It's the gap between maximum reliability and maximum economy. Between components you can depend on — absolutely — and prices that'll give your budget some breathing room.

How can you close The Component Gap? Easy. Talk to *Matsushita of Japan.* (We speak English, French, German and — if you prefer — Japanese.)

Matsushita is one of the biggest producers of electronic components on earth. We make over *one billion* a year.

We produce system-designed components, digital and analog, from input to output. We're already doing it for leaders in American computers. With substantial savings, too. And we can *custom-design* components to suit your exact needs. In any quantity. With fast delivery anywhere you want.

For more facts about us, mail the coupon. No obligation. Do it now. Get yourself (and your budget) out of that Gap.

MATSUSHITA ELECTRIC CORP. OF AMERICA

Shown: Precision record/playback heads for ultra high speed data processing: narrow head gap, 7 Mhz band width. Snap-action switches. Multiple circuit toggle switches. Subminiature tantalum capacitors. Subminiature capacitor-resistor network. Subminiature pulse transformer filters, 2 hz- 300 Mhz band pass. Relays, high current to dry circuit.

Mail to: Mr. Bob Yoshida, MATSUSHITA ELECTRIC CORP. OF AMERICA, System Components, Dept. CD-7, P.O. Box 3980, Pan Am Bldg., 200 Park Ave., NYC, NY 10017.

OK. Show me how Matsushita can help me close The Component Gap between reliability —and economy. No obligation.

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CIRCLE NO. 11 ON INQUIRY CARD

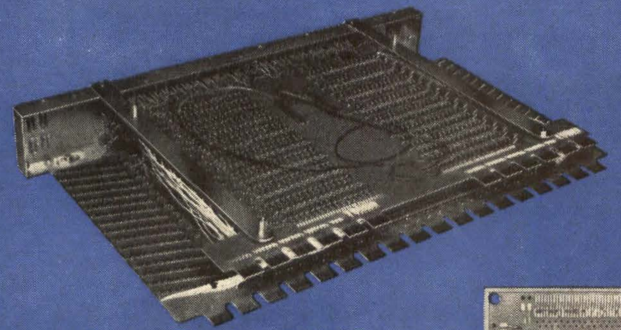
Quality memory stacks in quantity when you want them from FABRI-TEK

In any quantity, you get consistent, unit-to-unit, **precise-match** quality when you order memory stacks from **Fabri-Tek.** That's what our customers tell us. They say the same thing about our complete memory systems, too. And we **know** how close they compare-test.

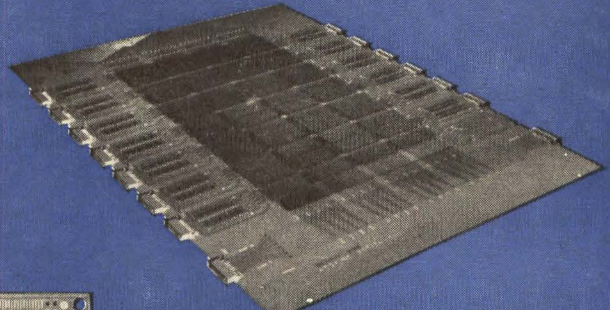
Seems we have the knack of maintaining matchless matching quality in any size production run. We also have the ability to deliver on schedule. Could be why we now have more large-production contracts than any other memory product manufacturer. Could be a good reason for **you** to check **Fabri-Tek** . . . for quality in any quantity of memory stacks or complete memory systems.

Are you a memory specialist? Fabri-Tek's expanding sales volume dictates a need for qualified people. Interested? Call collect or write today.

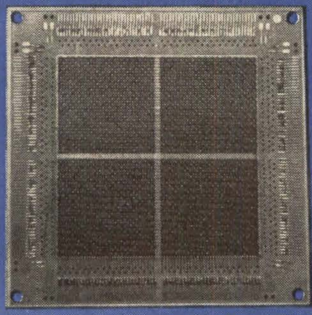
That's what G. E., SDS, Interstate Electronics, Litton Industries, Northrop and others get.



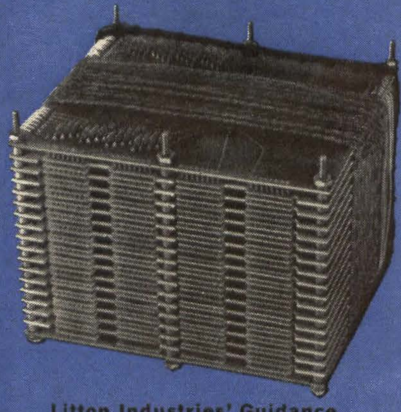
General Electric — GE/PAC* 4020 16K x 25 (modular increments of 4K); 1.6 microseconds; 30 mil cores; 2½ D; heated stacks.



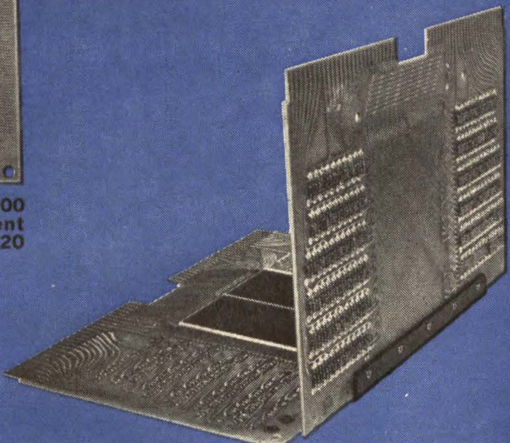
Interstate Electronics — IEC 1010 8K x 18; 1 microsecond; 30 mil and 80 mil cores; 2½D.



Northrop Nortronics—NDC 1000 Series Computer Development 16K x 14; 2 microseconds; 20 mil cores; 3 wire; 3 D.



Litton Industries' Guidance and Control Systems Division —CORCT LCM-710 memory series; LCM-728 computer series 4K x 32; 2 microseconds; 30 mil and 80 mil cores; 3 D.



Scientific Data Systems — Sigma 2, 5 and 7 Computers 4K x 9 (opened); Sigma 2 900 nanoseconds; Sigma 5 and 7 850 nanoseconds; 23 mil cores; 2½D.

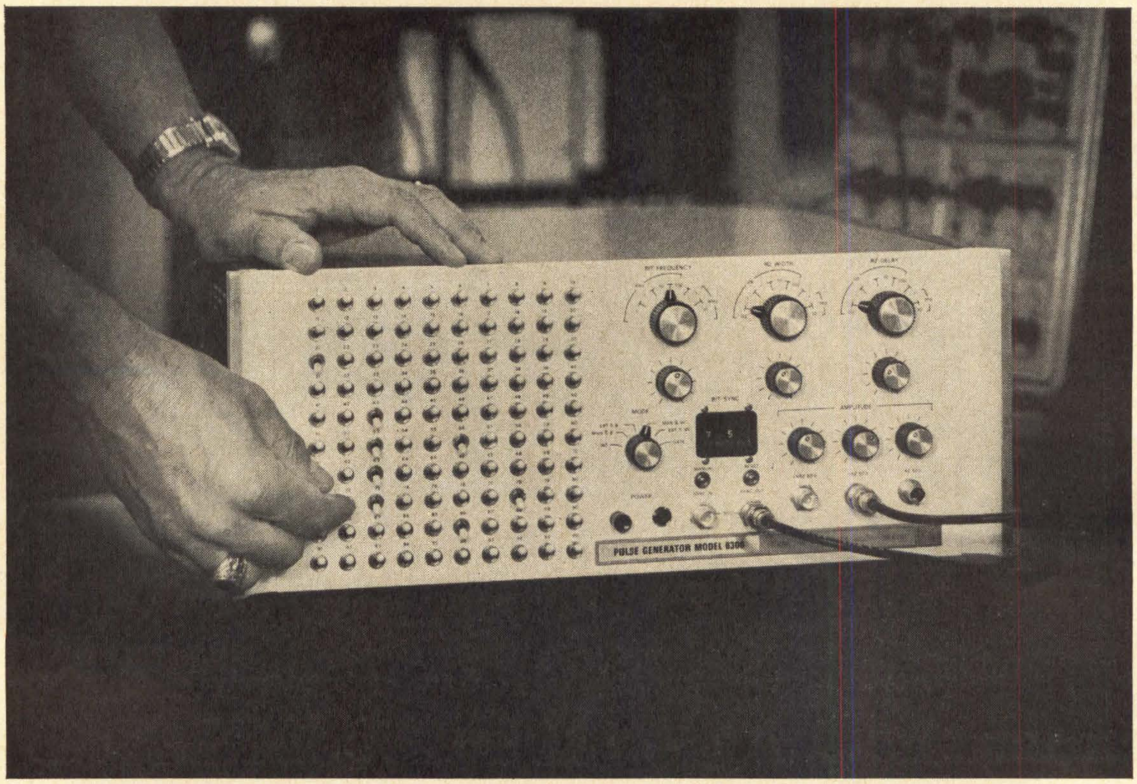
*Reg. T.M. of General Electric Company

Want proof?
Fabri-Tek is now shipping up to 250 stacks per week.
Call, teletype or write Fabri-Tek Incorporated, 5901 South County Road 18, Minneapolis, Minnesota 55436.
Area Code 612-935-8811. TWX 910-576-2913.

FABRI-TEK LEADS IN MEMORY TECHNOLOGY

CIRCLE NO. 12 ON INQUIRY CARD

Verbose.



New TI Model 6300 Word Generator.

This seems to be an appropriate description of our new word generator, since it knows more than a nonillion words (one of these may be the word your computer circuit can't understand). At least we think it knows this many. Although it talks quite rapidly (100,000 words per second, 100-bit words*), some smart mathematician said it will take 4×10^{18} years to hear the whole story. This disturbed a couple of our engineers because they don't like to leave a project unfinished (one of them was heard to mutter a 6-bit word). If you don't have a lot of time to spare in design or production testing, send for our new Series 6350 Word Generator data sheet. It has only about 300 words, and it won't take you long at all to get the whole story on our new word generator.

Write Industrial Products Group, Texas Instruments Incorporated, 3609 Buffalo Speedway, Houston, Texas 77006.

*We can make it talk faster and use shorter words, if you wish.

TEXAS INSTRUMENTS
INCORPORATED

CIRCLE NO. 13 ON INQUIRY CARD

911

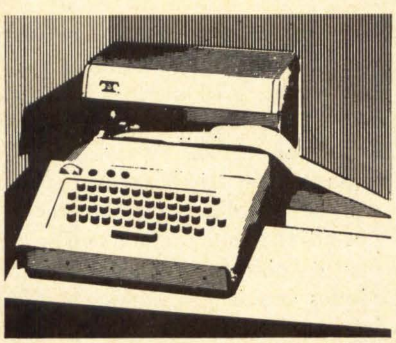
it's in the cards...

Besides offering a wide variety of paper tape punches and readers, Teletype has equipment that can also punch cards. Print on them as well. We call it Teletype CARData equipment.

CARData sets transmit and receive data both typed and punched on the upper portion of single or fanfold cards. They operate at 10 characters per second (100 words per minute) or less when necessary. CARData equipment uses the 8-level code compatible with the official United States of America Standard Code for Information Interchange (USASCII).

MOVES FIXED DATA QUICKLY

Wherever the repetitive entry of fixed data is necessary, Teletype CARData sets are effective in improving operating efficiency while reducing errors. Here are a few examples of the applications of CARData equipment: customers' names and addresses as well as product numbers can be put on cards for repeated use in preparing sales orders and invoices; computer program instructions can be entered into cards providing remote computer programing; identifying parts numbers can be kept on cards to simplify inventory reporting; and many more.



CARData KEYBOARD PUNCH

TYPES AND PUNCHES

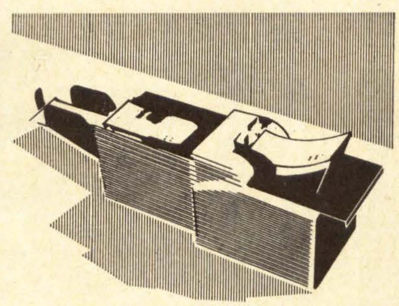
Both typing and punching on the upper portion of cards are provided by the table-mounted CARData send-receive keyboard punch. It can also print and punch paper tape in either on-line or local applications.

Equipped with a four-row keyboard similar to that on an ordinary typewriter, the CARData set is easy to operate. It punches 10 characters per inch with printing along the upper edge above and six spaces behind the corresponding perforations.

The CARData keyboard punch is capable of printing 64 different graphics, and suppresses the printing of control code combinations not associated with printing graphics. It automatically responds to the reference hole located in prepunched feedhole cards to perform such specific functions as card separation, rapid card ejection, and print suppression.

DOUBLE DUTY

The CARData reader, including a card collector, can be used as a table-mounted unit or mounted directly on a Teletype Model 35 ASR (automatic send-receive) set. When used with the Model 35 ASR, the reader START feature can be actuated from the ASR's keyboard. This aids the operator in combining fixed data from the cards and variable data from the keyboard.



CARData READER WITH AUTOMATIC HOPPER FEED

A "card-tape out" control actuator senses the end of a card or tape and stops reader operation after the last code position has been read. An EJECT button causes cards to be ejected many times faster than the reading speed.

CARData equipment also includes an automatic hopper feed, which automatically feeds individual cards into the reader.

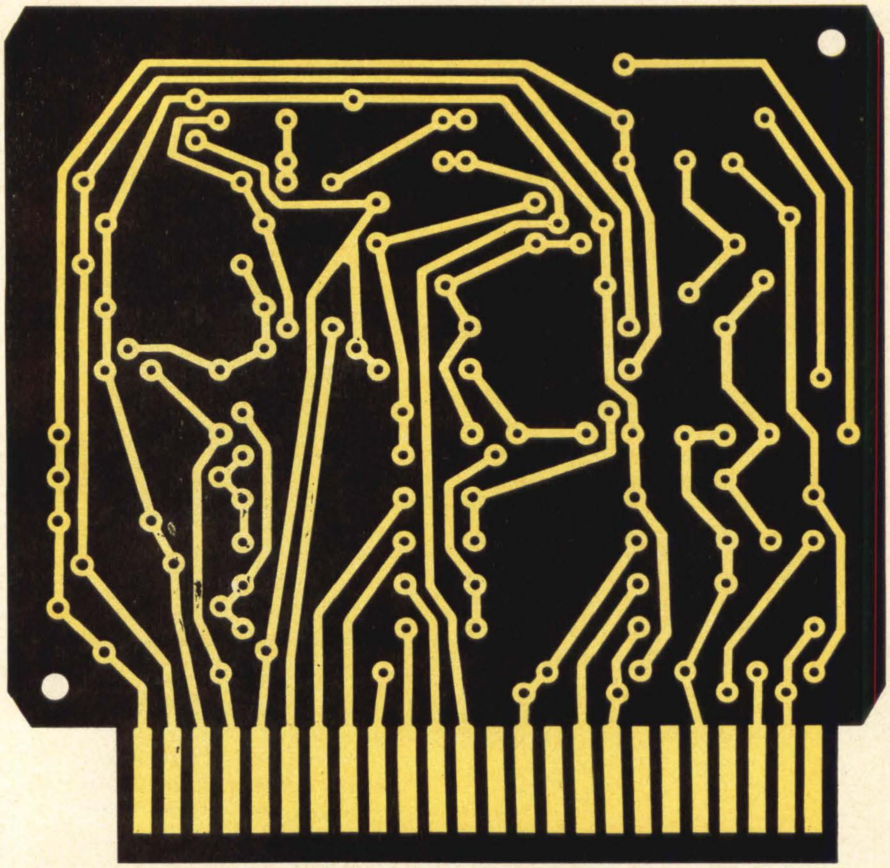
Further details on Teletype CARData equipment are explained in a new brochure. To obtain your copy, contact: Teletype Corporation, Dept. 71G, 5555 Touhy Avenue, Skokie, Illinois 60076.

machines that make data move

TELETYPE ®

CIRCLE NO. 14 ON INQUIRY CARD

The Clearest Logic:



Logic modules are built on printed circuit cards. Hole location and front-to-back registration must be very accurate for machine assembly. **Hand assembly is costly.** Plated thru-holes must provide positive continuity. **Rejects are costly.** Circuit boards for logic modules must be easily solderable. **Poor solderability is costly.** Printed circuit cards must be delivered in volume quantity for large-scale logic module production. **Time delays are costly.**

These are the reasons that Cinch-Graphik boards are built with such exacting precision. **Anything less is too costly.**

CINCH-GRAPHIK

DIVISION OF UNITED-CARR

MEMBER THE CINCH ELECTRONICS GROUP

200 South Turnbull Canyon Road, City of Industry (Los Angeles), Calif. 91744 • Phone (213) ED 3-1201. Cinch-Graphik is a member of the Cinch Electronic Group with offices in 33 principal cities throughout the United States, Great Britain, Canada, Australia and West Germany. Offices are listed under "Cinch," "Cinch-Monadnock," "Cinch-NuLine," "Cinch-Plaxial" or "United-Carr Incorporated."

CONSISTING OF CINCH MANUFACTURING COMPANY, CINCH-GRAPHIK, CINCH-MONADNOCK, CINCH-NULINE, UCINITE (ELECTRONICS) AND PLAXIAL CABLE DEPT.

CIRCLE NO. 15 ON INQUIRY CARD

Letters to Editor

LOGIC MINIMIZATION

To the Editor:

Robert Levine's article "Logic Minimization Beyond the Karnaugh Map" in the March '67 issue, gave an interesting approach to a minimization problem. However, either the sample function given:

$$F = \overline{A}\,\overline{C}\,\overline{D} + \overline{B}\,\overline{C}\,\overline{D} + \overline{A}BCD$$

is a poor example or else the minimization itself is unnecessary. The reason being that this sample function can be factored by inspection to the form:

$$F = \overline{C}\,\overline{D}\ (\overline{A} + \overline{B}) + \overline{A}BCD$$

which would only require 11 inputs, the same number arrived at by the author's more complicated method.

Sincerely yours,

Sheldon Kornbluth,
Project Engineer,
Otis Elevator Company
Brooklyn, N. Y.

Author's reply:

The example given in my article was made simply to illustrate the technique. The method for obtaining ""inhibiting functions" can be expanded to "n" variables. Given enough time any Boolean expression can be simplified by the good old pot-adjustment method. The various graphical and algebraic techniques enable more efficient designs by presenting the designer with an insight into simplification in general. In addition, computer programs for Boolean simplifications are available. The pot-adjustment method requires all possible combinations to become part of the software. The graphical/algebraic techniques present a converging sequence.

Very truly yours,

Robert Levine

DATA COMMUNICATIONS

equipment for on-line, real-time processing

you'll get your share!

Time-sharing of a remote computer has made electronic data processing a practical tool for companies of every size. It places a computer at the finger-tips of every engineer or businessman who needs to take advantage of its capabilities.

KEY TO TIME-SHARING

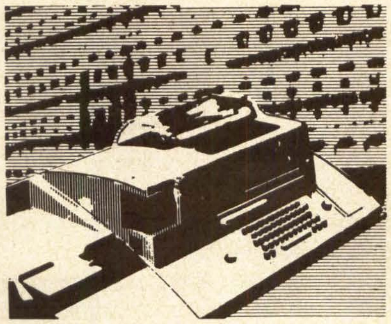
Terminal equipment is the key to fast, accurate collection, integration, and distribution of data. Without reliable terminal equipment, time-sharing of computers from remote locations would be impossible. And Teletype data communications equipment is one of the most extensively used as terminals because of its extreme versatility, reliability and economy.

Teletype machines can provide both hard copy and punched tape. They operate on a variety of code levels including an 8-level code compatible with the United States of America Standard Code for Information Interchange. USASCII is the official language of many computers and other business machines.

The many capabilities of Teletype equipment in time-sharing systems are best described through the following actual applications.

UTILITIES SHARE BILLING SYSTEM

A number of rural electric and telephone cooperatives have joined together to form their own computer



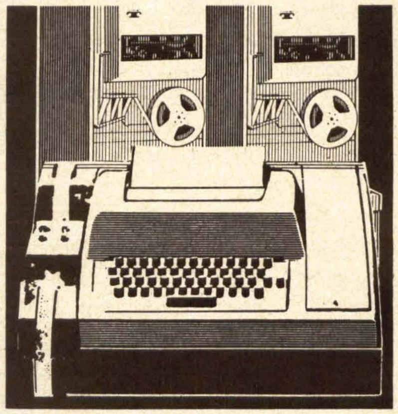
time-sharing system. Presently, the cooperatives are using Teletype Model 35 ASR (automatic send-receive) sets to send billing information to a data processing center. Bills are immediately prepared at the center and mailed directly to customers or transmitted back to the participating cooperative for mailing from that point.

Eventually, the system will be expanded to include other accounting services as well as inventory control, property records, and engineering applications.

A PERSONAL COMPUTER FOR EXECUTIVES

Executives of various companies throughout the midwest area can now make use of a real-time computer even though they are miles apart. This is made possible by using terminal equipment such as the Teletype Model 33 ASR sets to communicate over existing communications lines with a time-sharing computer center located in Chicago.

The system is designed to handle a variety of data problems automatically and almost simultaneously from 40 communications lines.



There are many examples of other time-sharing systems such as the one used by an offshore gas producer to monitor and control 40 gas wells in the Gulf of Mexico. Again, Teletype sets serve as the terminal equipment at the computer center.

Additional time-sharing applications are described in our new brochure, "HOW TELETYPE EQUIPMENT MOVES DATA FOR YOUR BUSINESS OR INDUSTRY." To obtain your copy, contact: Teletype Corporation, Dept. 71G, 5555 Touhy Avenue, Skokie, Illinois 60076.

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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 SYMBOLS STANDARD

TO CD READERS' FORUM:

Although I have been a proponent for years of a standard which symbolized abstract logic concepts to the greatest degree, it has become apparent that there is little chance for a general acceptance of such a viewpoint. It has become equally apparent that the 806-B standard is becoming — as was stated in your Readers' Forum in January — a **de facto** standard and is resisted mostly by those who claim it to be circuit oriented or "non-mathematical."

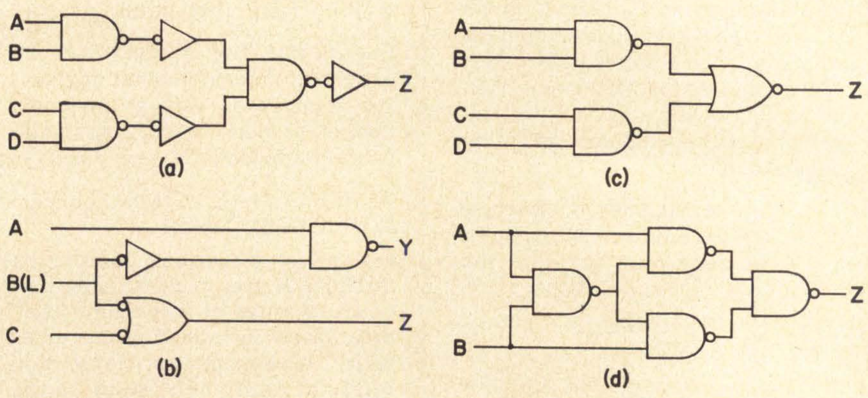
For this reason, I have taken a careful look at 806-B to see whether a logician could actually live with it: whether logic concepts can be translated into diagrams based on 806-B without tortuous transformations, or whether an 806-B diagram can be "read" by a logician, again without retransformations. Somewhat to my surprise I have found that once certain concepts are accepted, 806-B is an excellent standard from a logician's viewpoint and, in my opinion, is even superior to other standards presumably oriented towards logic rather than physical concepts. Thus, although I doubt that it was planned this way, and although the material in the Standard discussing logic concepts is a wallow of confusion, I have become convinced that 806-B can be accepted and used with equal facility by both technician and the logician, each interpreting and using a diagram from his particular viewpoint.

As an outgrowth of this work, on logic symbol standardization, done here at Airborne Instruments Laboratory in cooperation with our Standards Department, I have prepared an article entitled: "How to Succeed in MIL-STD-806-B Without Half-Trying." I hope that you agree that this can be an important contribution towards achieving a single general standard, for any such standard has to be accepted by the two classes of users. The alternative — one standard for the logician and another for the technician — would be unfortunate and it is the thesis of my article that it is unnecessary.

Paul M. Kintner,
Technical Assistant to the Exec. Vice-Pres.,
Airborne Instruments Laboratory,
a Division of Cutler-Hammer, Inc.,
Deer Park, N. Y. 11729

HOW TO SUCCEED IN MIL-STD-806-B WITHOUT HALF-TRYING

Fig. 1 shows a group of quite simple logic functions implemented with NAND/NOR circuits and shown in terms of the logic symbol standard MIL-STD-806-B. There are few designers who can "read" such diagrams without being reduced to confusion. This is not really the fault of 806-B; rather, the trouble comes from a lack of understanding on the part of most designers on the nature of logic concepts and their implementation with physical devices. Actually, the logic interpretation of an 806-B diagram, as well as the implementation of logic through 806-B symbols, can be quite straightforward. MIL-STD-806-B thus can be as "mathematical" as any other standard and an 806-B diagram can be interpreted equally-well in terms of logic or physical behavior.



(a) $Z = A \cdot B \cdot C \cdot D$
(b) $Y = \overline{A \cdot B}$; $Z = B + \overline{C}$
(c) $Z = A \cdot B \cdot C \cdot D$
(d) $Z = A \cdot \overline{B} + \overline{A} \cdot B$

Fig. 1 Example of logic functions shown in terms of MIL-STD-806-B logic symbols. (All input/output active states are high (H) unless otherwise indicated.)

Logic Polarity

"Reading" diagrams such as those in Fig. 1 is a matter of interpreting

DATA COMMUNICATIONS

equipment for on-line, real-time processing

two for the show...

At first glance, the Teletype Model 35 ACS (Automated Communications Set) looks like a standard Model 35 ASR (automatic send-receive) set . . . except that the ACS has two paper tape readers.

WHY TWO READERS?

The most important advantage of having a second paper tape reader is that it enables the set to combine fixed data in the tapes with variable data from the keyboard into a complete programed tape. This eliminates repetitive manual typing, form positioning and programing.

As a result, the Teletype Model 35 ACS improves management control; increases billing and ordering accuracy; improves revenue control and customer services; and speeds up the processing of order forms.

Since the Model 35 ACS uses an 8-level code compatible with the United States of America Standard Code for Information Interchange (USASCII), it can be used in data systems to communicate directly with computers and other business machines. Operating speed is 10 characters per second (100 words per minute).

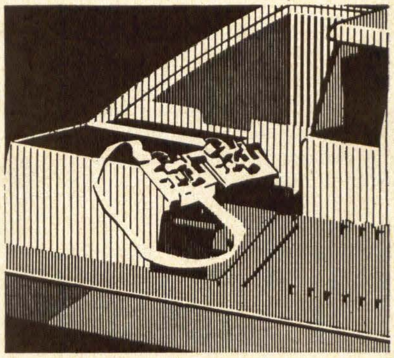
VERSATILE DATA COMMUNICATIONS

The two paper tape readers of the Teletype Model 35 ACS work together to provide versatile data communications. The first tape reader accepts a program and format tape that automates three important operations: the continual movement of the typebox to its appropriate position on the paper; the punching of on-line control codes to automatically transmit the finished message; and the typing of certain fixed data.

The second reader senses and interprets punched paper tape that contains semi-fixed data. This could be customer's name, address, and terms. Employing a "command" signal, the two readers alternately interoperate at programed intervals. There is no limit to the number of different programs the set can follow.

HERE'S EVEN MORE VERSATILITY

Besides incorporating all the standard features of a Teletype Model 35 ASR set, the Model 35 ACS can be



equipped with several important optional features. These include a push button data generator that can automatically print out up to 24 alphanumerics or other characters at the push of a button; and a fixed field length applique, which adds mandatory and permissive field control to be programed into the machine through the program tape.

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the symbols from a logic viewpoint; the key to this interpretation lies in the concept of logic polarity. Logic polarity is simply the relation between abstract logic values and physical signal values; specifically, that physical value — typically "high" or "low" for electronic switching circuits — which is agreed to correspond to logic "1" or "truth."

806-B makes provision for the indication of logic polarity on lines entering and leaving diagrams with the designation (H) or (L). The first of these means that the logic polarity is "high" — a high voltage signal value is to be taken as corresponding to logic "1" (the active state); the second symbol means that a low voltage value corresponds to logic "1." The small circles (or absence of circles) on the symbols of Fig. 2 can also be interpreted as indicating logic polarity: the small circle corresponds to a "low" polarity (L), the absence of a circle can be taken as a "high" polarity (H). Thus the 806-B AND, OR symbols of Fig. 1 can be interpreted in two ways: a technician might say that a symbol of Fig. 2(a) means that the output is low if both inputs are high; the logician would say that the circuit generates an AND-function when a "high" polarity is indicated on the inputs and a "low" polarity on the output.

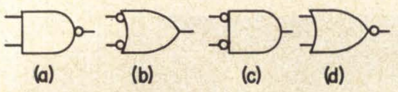

Fig. 2 AND, OR symbols taken from the 806-B tables. Small circles (or absence of circles) can be interpreted as polarity indicators.

The Amplifier Symbol

The technician and logician will make what appears to be quite a divergent interpretation of the symbol shown in Fig. 3, which is used in 806-B to represent a single-input circuit, in this case an inverting circuit. The technician would call the circuit an inverter whose output is high if the input is low (or vice versa). The logician, if he assumed logic polarity as with the symbols of Fig. 2, would come to the rather surprising conclusion that the logic operation performed is an identity, and the circuit has no effect on the logic value!

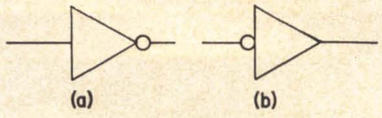

Fig. 3 806-B symbol for single-input logic circuit. Shown are two representations for an inverting circuit.

A moment's reasoning demonstrates the validity of the logician's conclusion. Assume a circuit represented by the symbol of Fig. 3(a). If the signal value into this circuit is high, the output must be low. However, according to the polarity indicators on the symbol, high means "1" on the input, but low means "1" on the output — therefore we have logic "1" on both input and output. It is evident that this will also be true for a non-inverting circuit and we have our first rule of "reading" 806-B logic diagrams:

- Rule-1: The amplifier symbols of 806-B representing single-input circuits are interpreted as logic identities and can be ignored when reading an 806-B diagram from a logic viewpoint.

Armed with this rule, the logic performed by Fig. 1(a) is evident at a glance: ignoring the amplifier symbols, we obtain $Z = (A \cdot B)(C \cdot D)$.

The NOT Operation

The amplifier symbol is something the logician can ignore but the technician must take into account; it is reasonable that there be something the technician does not have to consider but the logician must recognize. This exists and is the NOT-operation which, on the 806-B diagram, must be deduced. The key to the deduction is simple: a NOT-operation (logical inversion) is generated (implicity) whenever there is a polarity mismatch on the diagram. A polarity mismatch is defined here as a connection, between two symbols or from an input or output line to a symbol, where the logic polarities are different on the ends of the connection. Fig. 4 gives examples of polarity mismatches.

Again, a little reasoning will show that a polarity mismatch can only be interpreted logically as a NOT-operation. Assume a mismatch as shown in Fig. 4(a); further, assume a low signal value on the connection. Now, according to the logic polarities shown, this low signal value means "1" at the left end of the connection; however, at the right end the low signal value indicates a value of "0" (since a high signal means "1" here). Actually, the concept is but a companion of the interpretation of the amplifier symbol: there we had a change of signal value without a change of logic value; we now have a change in logic value without a change in signal value. Our second rule is then:

- Rule-2. NOT-operations are deduced from the 806-B through polarity mismatches: a NOT-operation is assumed to be generated, in effect, between two symbols or from an input/output line to a symbol, whenever the logic polarities are different at the ends of the connection.

The two rules applied to Fig. 1(b) easily show the logic generated. There is a mismatch between the output of the AND-symbol which

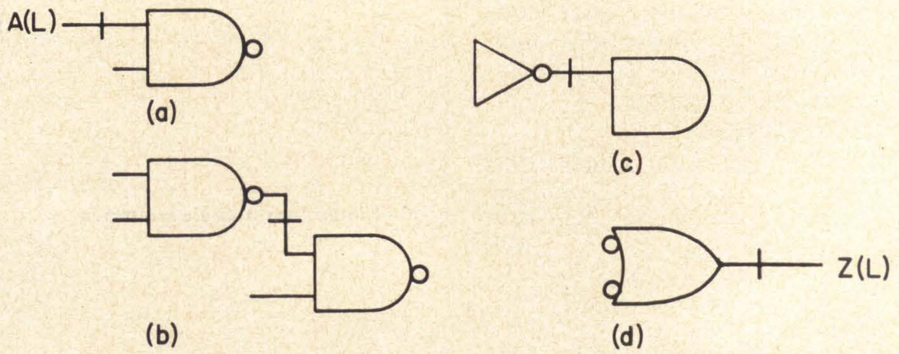

Fig. 4 Examples of polarity mismatches. Small vertical slashmark identifies mismatch connection.

has a "low" polarity and the desired polarity of Y which is assumed (H). Therefore, the correct logic expression for Y is $\bar{A} \cdot \bar{B}$. Note that there are no mismatches on the inputs to the AND-symbol and the amplifier symbol can be ignored. There is a single mismatch at the OR-symbol, between C (assumed (H)) and the symbol; the logic generated for Z is then $B + \bar{C}$.

(It should be pointed out that the interpretation of Fig. 1(a) previously made is valid only because there are no mismatches in the diagram.) Applying the two rules to Fig. 1(c) results in:

$$Z = \overline{\bar{A} \cdot \bar{B} + \bar{C} \cdot \bar{D}}$$

based on mismatches at both the inputs and output of the OR-symbol. Now, this is an example of a problem sometimes encountered in reading the diagrams of others: a clumsy logic expression difficult to interpret due to an originally clum-

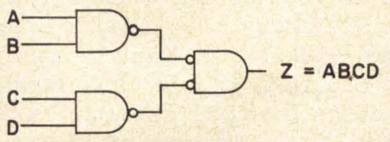

Fig. 5 Simplification of the diagram of Fig. 1(c).

sy logic implementation. The reader can sometimes make things clearer by interchanging AND, OR symbols (the equivalents are given in the tables of the 806-B standard) if by so doing the number of polarity mismatches is reduced. For Fig. 1(c), the mismatches can be eliminated entirely by replacing the OR-symbol by its AND-equivalent as shown in Fig. 5. The resulting logic expression is then far simpler: $Z = A \cdot B \cdot C \cdot D$.

Fig. 1(d) is an example of the "block" diagram approach often taken with 806-B; the diagram amounts in reality to little more than a circuit interconnection diagram and can be called "logic" only with a very liberal interpretation of the term. But, the logic (in the usual sense) can be deduced if two of the AND-symbols are replaced by equivalent OR-symbols as shown in Fig. 6. The output of the left OR-unit is seen to be $(\bar{A} + \bar{B})$. The outputs of the AND-units are then $A(\bar{A} + \bar{B})$ and $B(\bar{A} + \bar{B})$ which reduce to $A \cdot \bar{B}$ and

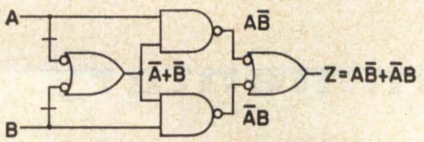

Fig. 6 Simplification of the diagram of Fig. 1(d).

$B \cdot \bar{A}$. The output is then evidently the exclusive OR-function $A \cdot \bar{B} + \bar{A} \cdot B$.

Logic Implementation Through 806-B

The same concepts developed for interpreting an 806-B diagram can be used to construct a diagram from a logic expression. This can be done in a straightforward way without algebraic transformations. The implementation can proceed in a series of steps. For illustration, the logic expression $Z = \bar{A}(B + \bar{C})$ will be implemented using what is sometimes termed a "positive NAND-circuit" (a common integrated logic circuit).

- **Step 1** — The AND, OR symbols are placed on the diagram corresponding to the AND, OR operations of the logic expression, ignoring (for the moment) NOT-operations. The symbols are chosen from the 806-B tables in accordance with the circuits being used. Fig. 7(a) shows this first step in terms of the illustrative problem.

The succeeding steps might be described as "polarity management": the designer interconnects the diagram according to the principle previously developed: polarity mismatches correspond to NOT-operations.

- **Step 2** — All direct connects are made which do not violate the polarity principle. Two such connections can be made for the illustrative problem, as shown in Fig. 7(b): one because no NOT-operation is involved and another because a NOT-operation is required and a polarity mismatch can be utilized.
- **Step 3** — Inverting circuits, shown by the 806-B amplifier symbol, are introduced to either eliminate polarity mismatches (if no NOT-operation is called for) or to force a mismatch if a NOT-operation is indicated. Three such cir-

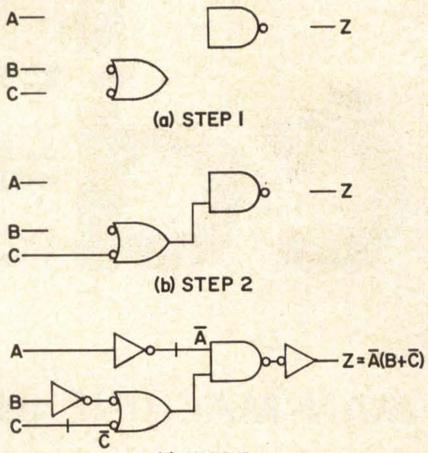

Fig. 7 Implementation of $Z = \bar{A}(B + \bar{C})$. A, B, C, and Z all have (H) polarities.

cuits are introduced for the illustrative problem, shown in Fig. 7(c). Two circuits eliminate mismatches; the circuit connected between the A-input and the AND circuit can be regarded as forcing a mismatch to obtain $\bar{A}$.

Shown on the diagram is a simple device for helping in the identification of polarity mismatches: a small vertical slashmark. This can assist the logic reading of the diagram without bothering those interpreting the diagram from a physical viewpoint. The reader may like to test his skill at implementation using these steps by starting with the expression given in the caption of Fig. 1, and obtaining the diagrams. (The last expression should be expanded to $Z = A(\bar{B} + \bar{A}) + B(\bar{A} + \bar{B})$ before implementing.)

The reader may sense that the 806-B symbols are being used here as a design tool: the Boolean algebra transformations theoretically required for implementing logic through inverting circuits are avoided through what amounts to graphical means: the elimination or creation of polarity mismatches as described accomplishes exactly the same objective. Further, the resultant diagram is readily interpreted logically without any retransformation to determine (in a recognizable form) what the original logic ideas of the designer were. In short, MIL-STD-806-B can be a valuable aid to the designer if certain fundamental concepts are understood.

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.**

MAN-MACHINE INTERFACE IN PROCESS CONTROL APPLICATIONS

W. W. Bolander

The man-machine interface is of critical importance in most computer installations, but nowhere more so than in process control computer systems. There are various reasons for this. In process control systems the operator is more concerned with the process, not with the computer. He is not particularly interested in whether system control and process information is obtained from a computer network or from a conventional instrumentation and control system. He has other duties than to interface consciously with the computer. Therefore, the ideal installation would not force him to learn new skills or to perform unnatural or additional tasks. He should be permitted to switch from manual and computer mode without significant changes in his work pattern.

The ability of an operator to exercise judgment is vital in process control systems. While the theoretical goal is to remove the man from the control loop completely, this is seldom practical or economical. He senses some process information which may be impractical to consider in the computer. Unfortunately, one of the hard lessons that computer system suppliers have had to learn is that the instrument interface that is available for manufacturing or process control applications is often inadequate for the job. One example that comes to mind is the detection of ignition in a reaction furnace. A radiation-sensing device used to sense ignition was hampered by dust within the combustion chamber, and thus could not be relied upon. Further, the refractories were hot from previous reactions and the furnace was a tilt type that caused the relative position of the instrument and the walls of the combustion chamber to change. As a result, the instrument occasionally reported no ignition when, in fact, ignition had occurred, and at other times "saw" the hot walls of the chamber and reported a false ignition condition. When imperfect process instrumentation exists, the process operator must, at times, provide input to resolve conflicts or ambiguities in the process information.

The source of each input required by the computer should be evaluated. Does it come from an operator, from instrumentation, or a combination of the two? This evaluation should consider the following factors: accuracy, frequency, reliability, and economics of the input. Generally, if the quantity is measurable, the frequency of input is sufficiently great, and a well-defined computer response exists, the input would be provided by instrumentation.

The author of this month's CD Commentary, W. W. Bolander, is the manager of the Industrial Control Development Department at Honeywell's Computer Control Division.

Principles In Developing Interface

There are a number of principles that should be followed in determining how best to develop the interface.

- It should be determined by the problem as well as by the tools that are available.
- The process logic and the way the man interfaces with the system should remain basically the same for computer control as for other types of control. An operator can be successfully retrained to some extent to work with computer systems — if he continues to perform a natural work pattern and if the computer mode of control is consistent with his other mode of control, i.e., manual control.
- The total system must be well-defined at the time

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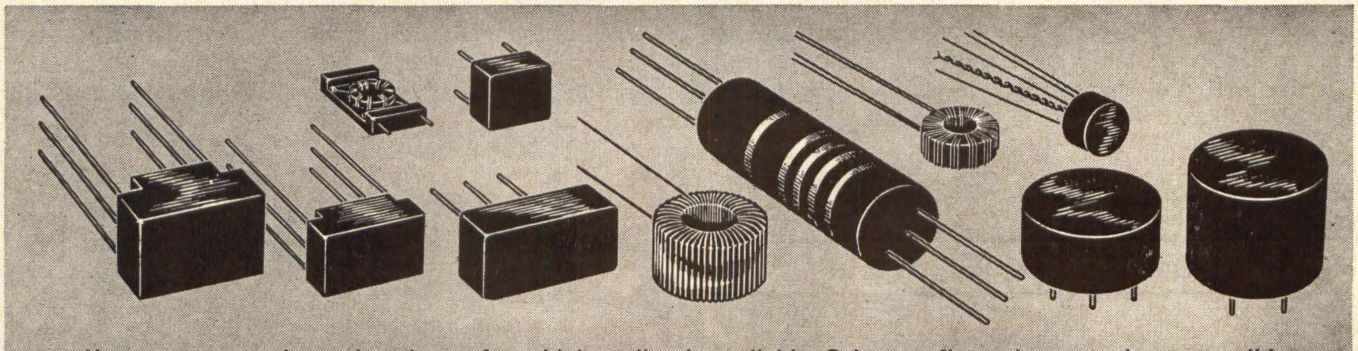

Here are commonly used packages for which tooling is available. Other configurations are always possible.

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of system design. Factors include the identification, frequency, method, and format of information to be communicated to different operator locations and other communication links; and the methods by which the inputs are to be obtained. Generally, the better the process and the control network can be defined, the simpler and less expensive and more effective will be the ultimate computer system.

• The computer should be capable of following the operator rather than the operator following the computer. The output stations — and any manual input stations — should be near where the operator is required to be as various events occur during the process. This will require remote and varied operator stations instead of a centralized location in some applications.

• The computer system should be designed to provide acknowledgements for the operator of his entries. When an operator depresses a pushbutton, for example, an acknowledgement light initiated by the computer should provide the operator with the intelligence that the computer has recognized his action.

There should be a strong incentive for the operator to do **what** he is instructed to do **when** he is instructed to do it. One way of insuring this is to design the system so that the process logic cannot proceed unless he follows the proper procedure. Another way is to design the system to make the operator's job easier, or his efforts more effective.

• If the operator normally pushes a button to initiate an event, say, open a control valve, a second contact on the same switch should be used to signal the computer. The button must meet the environmental needs; if in a steel plant, the button should be large and rugged, and sealed to prevent the entry of dust, dirt and deleterious liquids. Pushbutton and switches, rather than typewriter and keyboards, should be employed; lights and in-line digital displays should be considered. If scopes and typewriters are designed into the system, they should be primarily considered for computer output — not input.

• The peripheral hardware should be designed with the man and the environment in mind. Exotic-type I/O devices should be avoided in most applications. In a laboratory or central computer room, where the atmosphere is clean and air conditioned and where the computer is used by highly-trained personnel, it might be logical to specify scope input and display devices, data plotters, teletypewriter terminals, and special keyboards. In applications where control is exercised in the process area, the process and the operators would be better accommodated with special-function pushbuttons, etc.

• In many applications, rather extensive information about the system is required for operator display, e.g., demand logs, alarm summary. The traditional method for displaying this information is by the slow, limited-reliability typewriter. A scope display could have significant value for this application as well as those requiring other than alphanumeric display. An excellent application of a pictorial display is one that has been proposed for a large oil producer. The condition of tanks, piping, and valves in a large tank farm will be shown graphically on a scope display system. The operator will be readily able to determine the status of the materials in the system and then establish the flow patterns desired.

Undoubtedly, as more experience is gained and as more sophisticated equipment is developed for interfacing the computer with the process, a more effective interface with the operator to his process will result. There is no question but that this hardware will be forthcoming and that the trend towards centralized controls will tend to stimulate their application. In more extensive industrial control-type applications, the present state-of-the-art is such that man is still the most effective, flexible, economical, and reliable over-all observer, and thus should be the key around which the system is built.

GOVERNMENT REPORTS ★★

BASIC PROPERTIES OF ERROR-CORRECTING CODES

Properties normally considered peculiar either to block codes for noisy channels or else to variable-length codes for noiseless channels, are defined in a uniform manner in a report prepared by the Parke Mathematical Laboratories. Correcting ability, decodability, and synchronizability are among the basic notions. All are formulated for variable-length codes over arbitrary alphabets for noise channels. The report gives theorems which establish all the logical implications which exist between the properties considered, and furnishes examples which illustrate their differences.

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BOOK REVIEWS

THE CHALLENGE OF THE COMPUTER UTILITY

Douglas F. Parkhill

Mr. Parkhill's book is essentially what it claims to be, a brief discussion of the status and potential in "Computer Utilities." The book covers three principal subject areas; a general review of computer technology, descriptions of current "Computer Utilities," and a discussion of their potential capabilities and technological requirements.

The first six chapters of the book are devoted to the first two main subject areas: computer technology and the current status of Computer Utilities. So far as the author has chosen to go into depth, he provides an excellent survey of computer technology applicable to the main theme of the book. The general reader or the computer professional seeking a brief but broad discussion of the subject will find this much of the book both informative and well-organized.

The last three chapters depart from the straight technological reporting of the early part of the book and deal generally with the future. The author attempts to cover a broad set of problem areas generally of interest to people who want to understand and perhaps predict the future impact of this technological development. The subjects covered range from social implications through advanced computer technology.

It is naturally quite difficult to write about the future in a concise and factual manner but, even granting this, the last part of the book represents something of a disappointment. The author provides no discussion of the economics of Computer Utilities and how they might be affected by technological advancements in the *near future*, a subject of considerable importance. Instead, after showing (at the end of Chapter 6) that there are some real economic problems now facing Computer Utilities, he dismisses them by stating that they will be solved by modular-type computers, and ends all further discussion of economics.

This lack of quantitative examination of the near future is particularly noticeable in the last chapter in the section on "needed technical developments." Under this heading, the author discusses such technological problem areas as data transmission, inquiry consoles, natural language programming, exotic logic such as perceptrons and threshold devices, and "adaptivity." Unfortunately, all that he offers on these interesting subjects is the general information that technological advancements which if they were to occur, and have major economic consequences, would probably affect Computer Utilities.

To say, for example, that radical reductions in the cost of data transmission bandwidth and development of a versatile console costing less than $1000 will greatly increase accessibility to these systems, hence bring about the "Fireside Computer," is to say very little unless the statement is backed up with a quantitative discussion of the *need* for cheap bandwidth and an evaluation of the likelihood of these economic goals being achieved on a time scale. Such evaluations are made quite regularly by planning activities within the industry and are of critical importance in guiding investment decisions. In the area of data transmission, there is plenty of information available on such supporting technological areas as satellite communications, integrated circuitry, and CRT displays to permit an incisive and quantitative evaluation to have been made.

In conclusion, the book offers excellent technological reporting on the current status of Computer Utilities but contributes little in the way of critical examination of the future. Price: $7.95. Publisher: Addison-Wesley, Reading, Mass. 01867.

Reviewer: Walter A. Levy

ELECTRONIC DIGITAL SYSTEMS

R. K. Richards

The author of the two most widely-used reference books in the field of digital electronics (Arithmetic Operations in Digital Computers, 1955, and Digital Computer Components and Circuits, 1957) has written the first book on digital systems which uses the conceptual rather than the case-study approach. Rather than learning the details of a particular system and then having to extend this knowledge to the general case, the reader of this book will acquire general knowledge which can be applied to particular cases.

The presentation of this book is similar to that of Dr. Richard's two previous books, that is, the engineering reader can study the entire book to acquire a body of knowledge or he can use it as a reference for specific topics of interest. The bulk of the book is devoted to the stored-program and stored-program-computers, with relatively brief discussions of the related subjects of digital data transmission and message switching, combined analog-digital techniques, cybernetics, and system reliability. It is a worthy addition to the preceding two volumes, revised versions of which are promised and needed. Price: $15.00. Publisher: John Wiley and Sons, Inc., 605 Third Ave., N. Y., N. Y. 10016.

Reviewer: Dan M. Bowers

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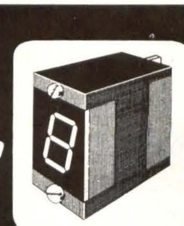

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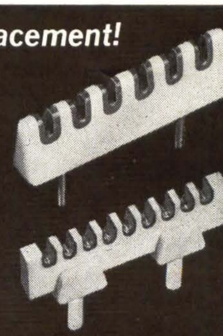

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DC OUTPUT

from our man in Washington

Advanced instrumentation and data requirements of NASA were outlined recently by Gene G. Mannella of NASA's Research Center, Cambridge, Mass. Computer technology will be challenged on future space missions by the greater variety of more complex equipment-associated experimentation. To cope with the volume and complexity of coming measurements, improved capabilities must be achieved in data handling systems, he believes. One important factor which needs to be recognized in the development of more sophisticated computer systems is the longer operational periods involved in future missions — earth orbital missions of several weeks or months to missions to Jupiter requiring four or more years. All of this indicates a need for vastly improved operating life on-board systems, he said. In addition, advanced missions generate a need for much better off-line storage to help handle functions such as systems monitoring, diagnostic test routines, and task scheduling. Techniques must be developed, the NASA representative said, which will permit elementary decision functions aboard unmanned vehicles for alteration of mission profiles without continuous recourse to human intervention, and ultimately, to a more sophisticated type of integrated experiment package in which the instrumentation comprises a laboratory which is controlled continuously by the on-board computer.

....

Congress is considering a Post Office Department request to reclassify all computer-produced billings as first-class mail, netting, according to POD, some $20 million in additional revenue. Presently, statements and accounts prepared by EDP equipment may be sent third-class mail and in some cases, even computer-produced letters can be granted this lower rate. Congress will try to clarify this foggy but fast-growing area.

....

Increased efforts on the part of various Federal agencies to use new systems, techniques, and equipment to improve the storage, retrieval, and dissemination of information was attested to by a recent national symposium. The symposium, sponsored by the National Archives and Records Service, brought together about 1,000 key government leaders to discuss putting information retrieval to work in the office. As part of its efforts, 3½-day office information retrieval workshops are planned to be held in Washington starting in late 1967 and in GSA regional offices later. The workshops are primarily for management analysts, systems personnel, and others who must conduct information retrieval feasibility studies or design or install information retrieval systems.

....

An improved model of FOSDIC — Film Optical Sensing Device for Input to Computers — has been completed by the National Bureau of Standards for use with the computers of the National Weather Records Center at Asheville, N. C. FOSDIC IV reads data on past weather conditions from microfilms of punched cards from the Center's archives. The machine performs logical operations on the data it reads and also selects certain data to be recorded on magnetic tape for later input to the computers. This will enable past weather conditions to be compared with more recently gathered data, so that the Center can study long-range weather patterns and improve its present prediction services.

....

Once again the General Accounting Office has found errors in the government's acquisition and use of computers. In the most recent case, the U. S. Army was the subject of the GAO investigation. During 1965 and 1966, the Army replaced data processing equipment used in supply at important command depots in the Pacific area with large-scale computer systems. "Benefits expected to be derived from these computers could not be fully realized," GAO concluded, "because improvements and corrections of supply problems had not been completed prior to installation." Because of continuing problems, a large percentage of supply transactions cannot be processed routinely by computers. GAO did not ask the withdrawal of the computers at this time but called attention to all military agencies "to illustrate the need for correct-

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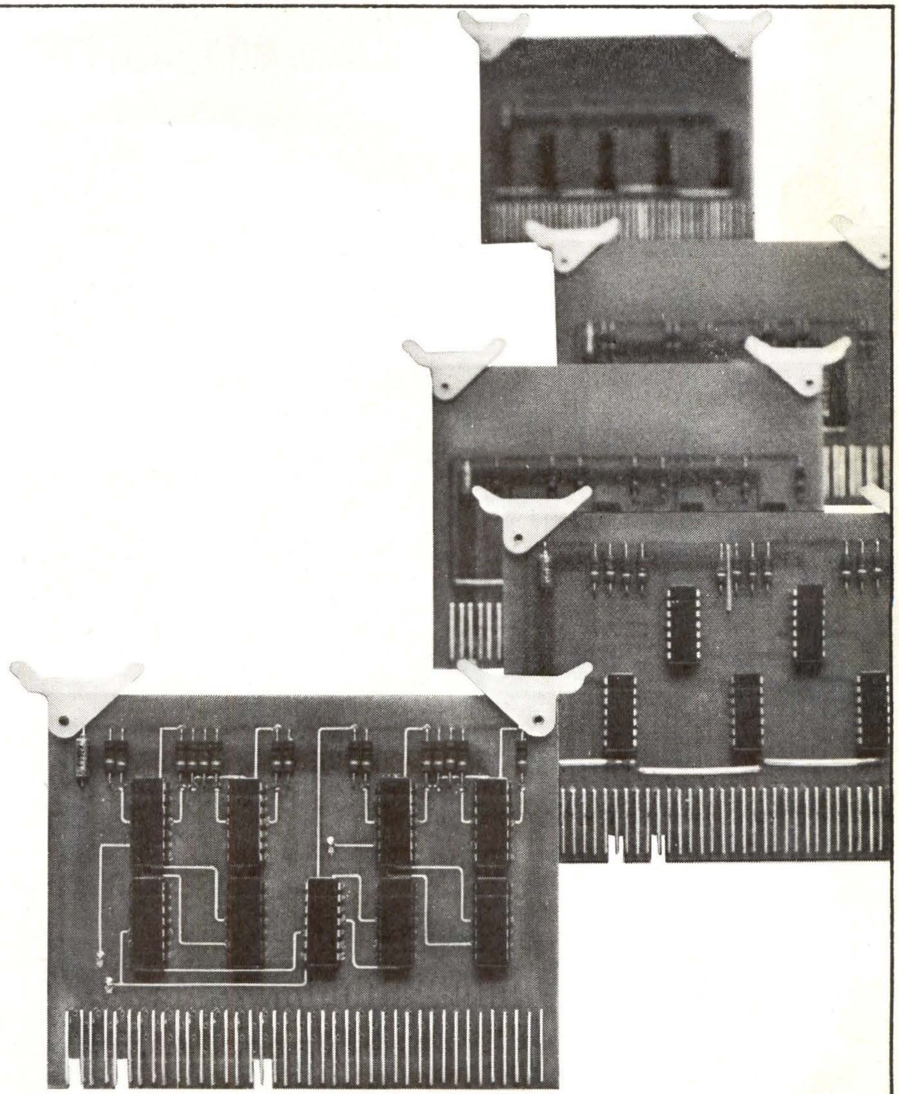

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ing basic weaknesses in operating systems if the most effective utilization of automatic data processing equipment is to be realized."

Recent Government Contracts

WASHINGTON UNIVERSITY, St. Louis, Mo., has received a $1,000,000 modification to a previously-awarded contract to expand the effort under the scope of contract and provide for continued research in macromodular computer systems. The Defense Supply Service, Washington, D. C. is the issuing agency.

BENDIX CORP., Teterboro, N. J., has received a $2,782,-863 increment to a contract for production of electronic data processing equipment from the Air Force. The Aeronautical Systems Division is the contracting agency.

COMCOR, INC., Anaheim, Cal., received a $1,156,000 firm, fixed-price contract for the procurement of an integrated computer system from the Air Force. The Systems Engineering Group, Wright-Patterson AFB, Ohio, awarded the contract.

IBM CORP., Washington, D. C., has received a $1,140,618 delivery order, against a GSA schedule, for lease of pilot equipment (one IBM 360 System) for the national Automatic Data Processing Program for Army Materiel Command's logistics management. The U. S. Army Electronic Command, Fort Monmouth, N. J., issued the delivery order.

GOVERNMENT REPORTS ★★

HARDWARE AIDS FOR AUTOMATA DESIGN

Describes progress in the design and construction of hybrid computing hardware leading to the construction of neural nets and discusses the significance of such hardware to automata theory. A simple network is constructed containing a least one representative of each of five basic types of circuits; the logical properties of the building blocks are described.

Order from Clearinghouse, U. S. Dept. of Commerce, Springfield, Va. 22151. Order No. AD 645439. Price: $3.00 (microfiche 65 cents).

EXPLORATORY EXPERIMENTAL STUDIES COMPARING ONLINE AND OFFLINE PROGRAMMING PERFORMANCE.

Studies measuring the performance of programmers under controlled conditions for standard tasks are described in this report. It notes methodological problems encountered in designing and conducting the experiments, limitations of the findings, and hypotheses to account for results.

Order from Clearinghouse, U. S. Dept. of Commerce, Springfield, Va. 22151. Order No. AD-645438. Price: $3.00 (microfiche 65 cents).

DIALOG: A CONVERSATIONAL PROGRAMMING SYSTEM WITH GRAPHICAL ORIENTATION.

Report described an algebraic language for on-line use with a graphical input-output console device. It is a computational aid for the casual user, requiring a minimum of experience or instruction, and it provides basic facilities for graphical and numeric input and display, on- and off-line program preparation and storage, and hard copy presentation of results.

Order from Clearinghouse, U. S. Dept. of Commerce, Springfield, Va. 22151. Order No. AD-646857. Price: $3.00 (microfiche 65 cents).

MATHEMATICAL COMPUTER PROGRAMS

Report outlines several mathematical programs and programming techniques for digital computers. These computer programs, for the most part run on IBM computers, are available separately or as a collection through the NASA Technology Utilization program, and may be of use to centers with limited systems libraries and for instructional purposes for new computer operators.

Order from Clearinghouse, U.S. Dept. of Commerce, Springfield, Va. 22151. Order No.: NASA SP-5069. Price $3.00 (microfiche 65 cents).

STUDIES IN AUTOMATIC LANGUAGE PROCESSING

IBM has developed a computerized linguistic basis for application to practical and theoretical problems in automatic language processing. The three main parts of this work are: development of a formalism for expressing grammatical information; establishment of a sentence analysis procedure based on the formalism; and creation of a grammar of English expressed in terms of the formalism but motivated by transformational theory.

Order from Clearinghouse, U. S. Dept. of Commerce, Springfield, Va. 22151. Order No. AD-624-305. Price: $4.00.

A COMPUTER FOR VOCODER PITCH EXTRACTION

MIT's Lincoln Laboratory has designed a small integrated-circuit computer to perform vocoder pitch extraction as a part of the Lincoln Experimental Terminal. The computer operates on the peaks of an incoming speech signal using hybrid analog-digital techniques and computes at three millisecond intervals an 8-bitbinary word measuring pitch period to the nearest 80 microsec increment, and a binary decision indicating whether the incoming signal is voiced or unvoiced. MIT notes that the low cost and small size of integrated circuits made feasible the design of a special-purpose computer to extract pitch information from the speech input to a pitch-excited channel vocoder. Containing some 1150 integrated circuit elements, 26 discrete-component operational amplifiers, and 16 analog gate circuits, the computer occupies a volume 5¼" x 19" x 22".

Order from Clearinghouse, U. S. Dept. of Commerce, Springfield, Va. 22151. Order No. AD-629361A. Price: $2.00.

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Lockheed's EMR Computer System is always looking for something to complain about
In a fleet atomic submarine, 12,000 miles from home, hundreds of feet down in a hostile environment, the Poseidon missile must pass its final test with perfect marksmanship. To get the ultra-high performance demanded, Lockheed Missiles & Space Company developed Auto-SACE, an Automatic Shorebased Acceptance Checkout Equipment system. Using EMR computers, Auto-SACE will communicate directly with test station operators to perform both automatic checkout and central processing functions associated with the Poseidon Missile. Using high-speed digital techniques and CRT displays, checkout is performed at the unit level as well as the missile system level.
ADVANCE 6020 and 6040 computers are used for the central computer systems as well as the sub-station computers.
Why ADVANCE Series Computers?
Lockheed's experienced technical staff members surveyed the computer field and determined EMR's Computer Division system hardware and software presented the best solution to their problems. High speed input/output features of the ADVANCE Series processors made them particularly well-suited to the Auto-SACE system.
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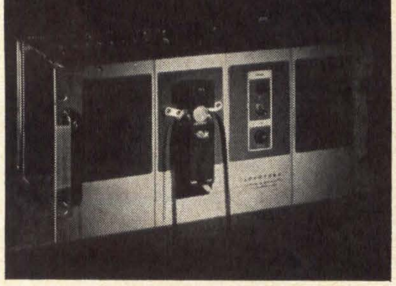

DIGI-STORE® DS-2 is a **bidirectional, incremental** magnetic tape unit offering these advantages . . .

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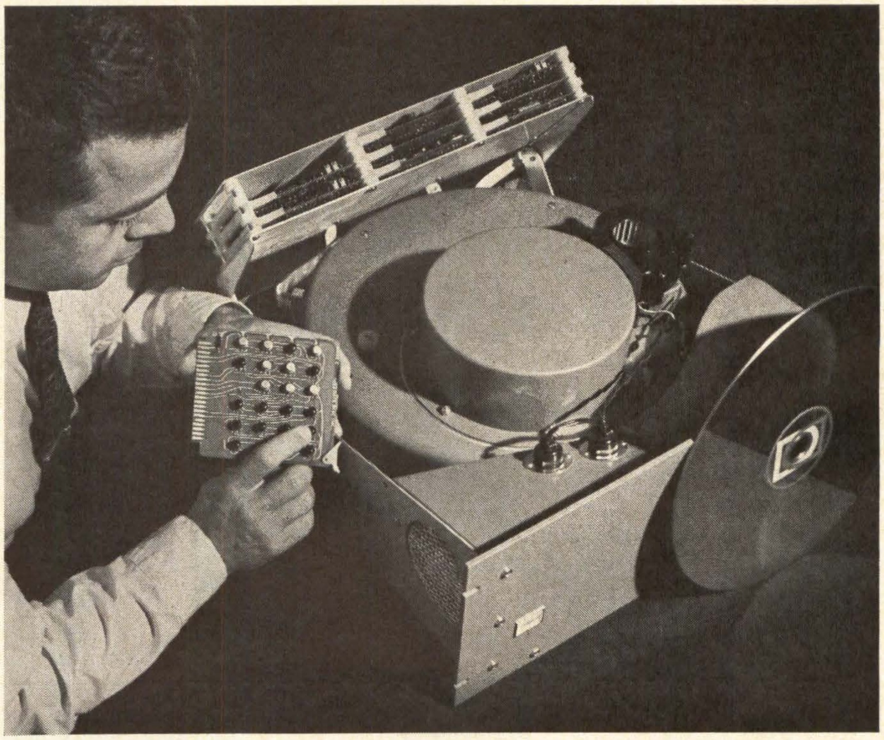
INDUSTRY NEWS

THE NATION'S COMMERCIAL BANKS ARE PROCEEDING IN A "PIECEMEAL AND HIGHLY WASTEFUL MANNER" IN THEIR EFFORTS TO DEVELOP COMPUTER-BASED INFORMATION SYSTEMS, the American Bankers Association was told at a recent conference. This charge was made by Robert V. Head, manager of Management Information Technology for Computer Sciences Corp. at the ABA's annual National Automation Conference here. At a panel session on the "Fabulous Software Snarl" in the banking industry, Head asserted the banks' current efforts to develop information systems based on computers are duplicative and contribute to the confusion in software for the industry. What is needed, Head asserted, is a cooperative effort by the commercial banks to develop a new computer programming language for use throughout the banking industry. Only by pooling their resources can the banks hope to fully realize the tremendous potential of their new third generation computers within a reasonable period of time, according to Head. The banks' software problems stem from three factors, Head noted. These are the shortage of skilled programmers and system designers, the demand for an increasing number of computer-based banking services, and the advent of the third generation of computers. A computer programming language designed specifically for banks would provide the industry with the basic requirement for this type of system. Head recommended that ABA sponsor the required research and development, drawing on the specialized professional skills found among the independent software companies.

DEVELOPMENT OF COMPUTER SYSTEMS TO AUTOMATE OPERATION OF MISSILE PROCEDURE TRAINERS FOR THE AIR FORCE GROUND CREWS OF MINUTEMAN ICBM's was disclosed by Sperry Rand Corporation's UNIVAC Federal Systems division. One of the computer systems, including a UNIVAC 1218 computer and 1532 Input/Output console, is being installed in the Missile Procedure Trainer at Chanute Air Force Base, Ill. Others were delivered in March and April, 1967, to Vandenberg AFB, Calif., Malmstrom AFB, Mont., and Grand Forks AFB, N.D. Strategic Air Command and Air Training Command personnel will use the systems as part of the Air Force's MOPT (Minuteman Operational Procedures Trainer) program built for the advance Minuteman system, WS-133 B. Each of the 1218 computers contain 32,768 words of information-storage and eight input/output channels. The solid-state circuitry, memory elements, and other electronic components are housed in a ruggedized cabinet measuring only 22¾ by 24½ by 72 inches high. Power consumption is only 1,200 watts, about equal to the amount required by many household appliances. The 1218 specializes in the real-time processing of large amounts of complex data. An average multiply instruction requires only 38 microseconds and an add instruction only 8 microseconds.

A WESTINGHOUSE ELECTRIC CORP'S PRODAC 50 COMPUTER WILL BEGIN PLAYING AN INTRIGUING GAME FOR ALL THE WORLD TO SEE. That's when the world's first computer-controlled outdoor electric sign will be lighted on the North Side, facing Pittsburgh's Golden Triangle across the Allegheny River. The sign will consist of a symbol only, the Westinghouse Circle W trademark. In all, there will be nine blue Circle W's. Each emblem will consist of nine geometric elements — the circle, three dots, four lines in the W, and the letter's underscore — for a total of 81 light circuits. This makes possible 81 factorial ways in which the lights can come on (81 times 79 times 78 and so forth) or 10121. The patterns of lights will have a number of sequences and these sequences will be changed from time to time to introduce new and intriguing ways of assembling the nine trademarks. Because of the tremendous number of sequences available, it will be possible to change patterns at intervals without repeating patterns that have been used before. The great flexibility of the computer will permit changes to be made as new and interesting sequences are devised.

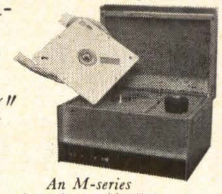
Bargain price memories for people suspicious of bargains



Data Disc can deliver this 6,400,000-bit disc memory for $6,400 when you buy ten, $7,400 when you buy two, and $9,400 for one alone.

We can offer this low price per bit without sacrificing quality because our "in-contact" recorders store twice as many bits per inch as older "floating head" recorders. We don't try to cut the cost of discs, drives, heads or electronics. All components are built for maximum reliability—and cost accordingly. But simply because it takes fewer components to store any given number of bits, you get the storage capacity you need at a lower cost.

The F-series head-per-track system pictured above comes with storage capacities of 6.4, 3.2 and 1.6 million bits. It has an average access time of 16.7 ms, and stores 100,000 bits on each track — enough to fill the core memory of a small computer. Data can be entered and retrieved very rapidly —at three megabits per second. And the whole system fits in 8¾″ of rack space.



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COMING EVENTS

RCA SEMINARS SCHEDULE

RCA INSTITUTES HAS ANNOUNCED THEIR LATEST SCHEDULE OF 5-DAY SEMINARS IN COMPUTER TECHNOLOGY. The July through December 1967 schedule is as follows. July 10-14, Logic Design, Minneapolis, Minn.; July 10-14, Digital Systems Engineering, Seattle, Wash.; July 10-14, Digital Communications, New York, N. Y.; July 17-21, Logic Design, Pittsburgh, Pa.; July 17-21, Digital Communications, Denver, Colo.; July 24-28, Digital Systems Engineering, Cherry Hill, N. J.; July 31-Aug 4, Logic Design, Dallas, Texas; July 31-Aug 4, Digital Communications, Washington, D. C.; Aug 7-11, Logic Design, Washington, D. C.; Aug 7-11, Digital Electronics, New York, N. Y.; Aug 14-18, Digital Systems Engineering, San Francisco, Cal.; Aug 21-25, Logic Design, Rochester, N. Y.; Aug 21-25, Digital Communications, Los Angeles, Cal.; Aug 21-25, Digital Electronics, Chicago, Ill.; Sept 11-15, Logic Design, San Francisco, Cal.; Sept 11-15, Digital Electronics, Washington, D. C.; Sept 11-15, Integrater Circuits, New York, N. Y.; Sept 18-22, Digital Systems Engineering, Atlanta, Ga.; Sept 18-22, Digital Communications, Los Angeles, Cal.; Sept 18-22, Digital Communications, Dallas, Texas; Sept 25-29, Digital Systems Engineering, Denver, Colo.; Sept 25-29, Digital Communications, Long Island, N. Y.; Sept 25-29, Integrated Circuits, Boston, Mass.; Oct 9-13, Logic Design, Chicago, Ill.; Oct 9-13, Digital Communications, San Francisco, Cal.; Oct 9-13, Integrated Circuits, Cocoa Beach, Fla.; Oct 16-20, Logic Design, New York, N. Y.; Oct 16-20, Digital Electronics, Dallas, Texas; Oct 16-20, Digital Systems Engineering, Washington, D. C.; Oct 16-20, Integrated Circuits, Los Angeles, Cal.; Oct 23-27, Digital Systems Engineering, Rochester, N. Y.; Oct 23-27, Digital Electronics, Detroit, Mich.; Oct 30-Nov 3, Digital Communications, Cherry Hill, N. J.; Oct 30-Nov 3, Integrated Circuits, Denver, Colo.; Nov 6-10, Logic Design, Albuquerque, N. M.; Nov 6-10, Digital Systems Engineering, Long Island, N. Y.; Nov 6-10, Digital Electronics, Atlanta, Ga.; Nov 13-17, Digital Communications, Chicago, Ill.; Nov 13-17, Logic Design, Detroit, Mich.; Nov 13-17, Digital Electronics, New York, N. Y.; Nov 13-17, Integrated Circuits, Pittsburgh, Pa.; Dec 4-8, Logic Design, Denver, Colo.; Dec 4-8, Digital Systems Engineering, Los Angeles, Cal.; Dec 4-8, Digital Electronics, Boston, Mass.; Dec 4-8, Integrated Circuits, Washington, D. C.; Dec 11-15, Logic Design, Washington, D. C.; Dec 11-15, Digital Communications, New York, N. Y.; Dec 11-15, Digital Electronics, San Francisco, Cal.; Dec 11-15, Integrated Circuits, Dallas, Texas;

For more information write directly to: Mr. Bradford Daggett, RCA Institutes Seminar Program, 49 W. 45th St., N. Y., N. Y. 10036 or telephone (212) 247-5700.


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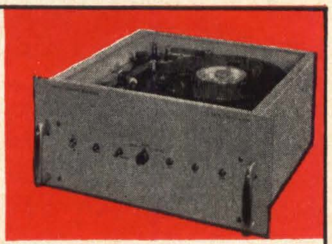
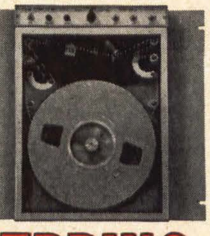
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2 Modify the μA709C to meet your exact requirements. It's simple. Just add a capacitor or a resistor or two. With every order of 25 units or more* we'll include a free Linear Applications Handbook that shows you exactly how. And the μA709C is versatile enough to perform virtually any function. (For a partial list of what you can use it for, see below.)

3 Count your savings. Even if you spend another $5.00 on auxiliary parts and assembly (and in most cases you'll spend far less) your total cost will be about half of what you'd pay for a ready-made circuit. Multiplied by 10,000 units that adds up to a ton of money.

4 Get started. Get the μA709C. It's readily available from shelf stock. Just call your Fairchild Distributor or the nearest Fairchild Sales Office.

*In fact, this offer is good for orders of 25 or more of any Fairchild linear integrated circuit.

Typical Characteristics μA709C

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Open Loop Voltage Gain	45,000
Output Voltage Swing	±14V @ R_L = 10kΩ
Input Voltage Range	±10V
Input Resistance	250kΩ
Input Offset Voltage	2mV
Input Offset Current	200nA

Typical Applications:

PRECISION VOLTAGE SUPPLIES
TEMPERATURE CONTROLLER
DIFFERENTIAL THRESHOLD COMPARATOR
PREAMPLIFIERS
HIGH GAIN, LOW DRIFT DC AMPLIFIER
LOGARITHMIC AMPLIFIER
MULTIPLIER
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MODULAR CRT DISPLAY CONSOLES

Functional Modules Permit User to Tailor System To Specific Cost/Performance Requirements

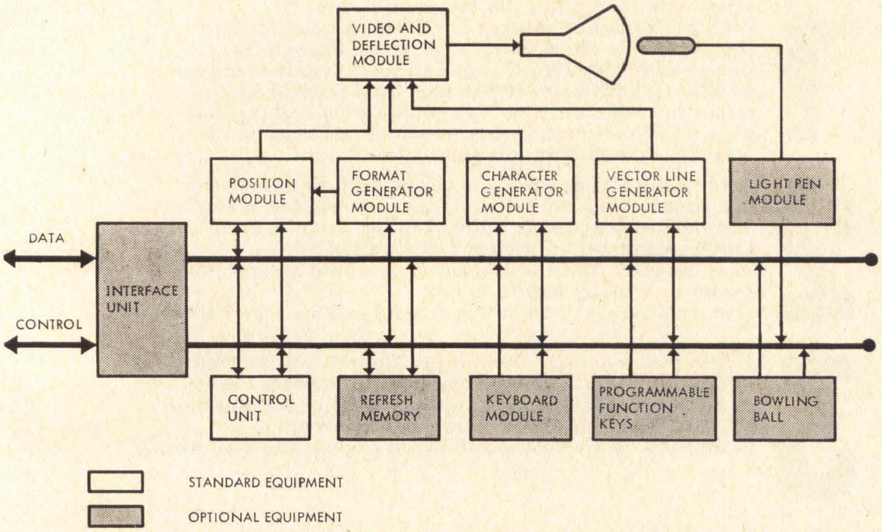

Fig. 1 Block diagram of Tasker's modular CRT display system.

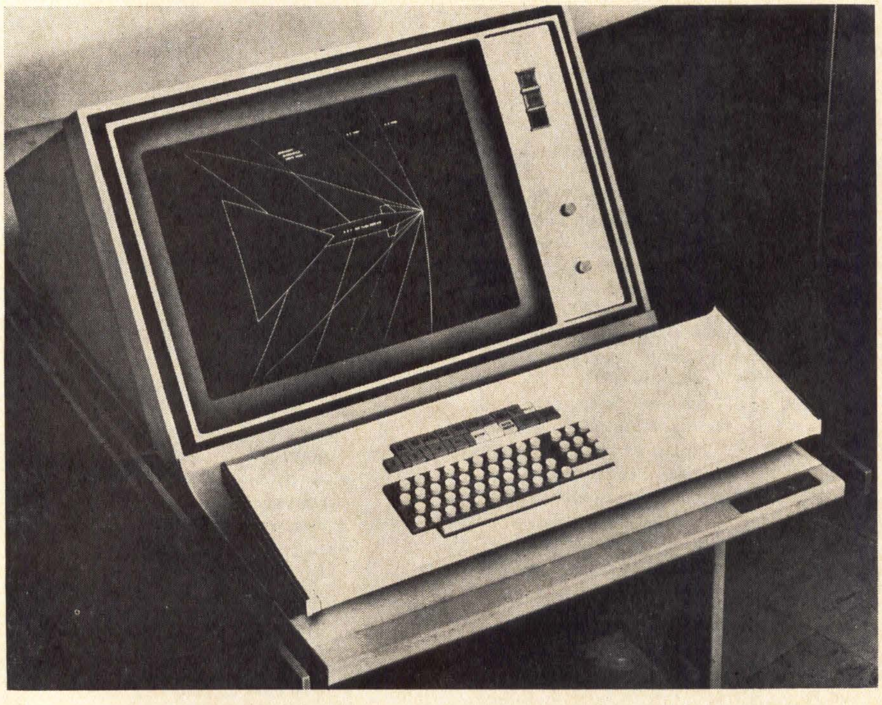

Fig. 2 Profile of a supersonic transport is shown on Tasker's Series 9000 CRT Display System. Line drawing shows effect of secondary shock waves on SST.

A three-year company-sponsored development program at Tasker Industries has produced a high-speed, real-time cathode-ray-tube display system that can be furnished in a variety of configurations to suit any number of applications, complex or simple. A description of the system's typical modules, given below, not only serves to describe Tasker's new system but it is a good explanation of the basic operations of CRT display systems for those readers who have yet to encounter them.

A functional diagram of the system's modules is shown in Fig. 1. The logic and circuit networks are divided into functional modules, each of which performs a distinct operation. As a prelude to describing the particular functions accomplished by each one of the modules, it is important to note that the interface unit is the key element which permits the display system to accommodate any type of computer with unique interface characteristics and command structures. In effect, the interface unit not only accomplishes the physical connection of signals between a computer and a display, but further, the interface unit acts as a command format translator. This characteristic of the interface unit causes computer commands to be translated into a command language suitable for control of the individual functional modules and, conversely, it translates data, which is generated at the display, into a command language compatible with the associated computer.

Commencing with the basic modules of the display system, which provide the positional and intensifying signals for driving the electron beam of the CRT, we see the video and deflection module. The composition of the video and deflection module is in many ways dependent upon the particular cathode ray tube and the desired performance characteristics. Several of the parameters are inter-related, although, generally speaking, CRT tubes with less than 92° deflection angles can achieve significantly higher writing speeds and beam movement velocities than the 92° deflection angle CRT for any given amplifier size. The function of the video and deflection module is to receive horizontal (X) and vertical (Y) deflection voltages plus video gating (Z) signals from other functional modules and transform these into signals which will deflect the electron beam to a position on the CRT face as prescribed by the X, Y input voltage analogs.

The function of the position module is to accept digital position commands from the interface unit or a refresh memory and convert this digital position into an equivalent pair (X and Y) of analog position voltages. Depending upon the selected CRT size, and desired positional resolution, the position module can accommodate up to 4096 grid divisions in each of the two axes.

The control unit in itself does not perform any single function for a given display operation, but rather, it functions as a sequencer for the control of all other functional modules and the routing of data between the interface unit and the functional modules.

Up to this point in the description, the modules which have been described form the basic elements which are necessary for the positioning and intensification of the CRT electron beam.

The addition of a vector line generator module provides the capability to interpret digital commands into equivalent voltage excursions which will cause the "painting" of intensified lines on the face of the CRT. These vector lines afford the display a graphics capability for the presentation of line segments in any direction with lengths of essentially 0 (one grid division) to a full screen diameter. The video gating networks associated with the vector generator permit any desired line to blink at a predetermined rate or to appear as dashed or dotted segments.

For the display of alphanumeric characters and/or special symbols, a character generator module is added, the function of which is to accept digital commands and translate these into equivalent small signal excursions in the X and Y axes which describe the selected symbol. The character generator module has a wide flexibility in both symbol style and repertoire. In most cases, when characters are to be displayed, they will occur in formatted positions, as in the case of text. In order to accomplish this positional arrangement of characters to form text, a format generator module is included which serves to modulate the main position coordinates for the spacing of characters and the spacing of lines of characters.

The remaining functional modules, shown as shaded boxes in the block diagram, perform ancillary functions to enhance optional features of the display system. The refresh memory is an optional unit, which is included in display systems whenever there is a desire to decrease the storage and input-output transfer rate requirement on the computer. Where a refresh memory is not included as a part of the display system, refreshing of the display must be accomplished by repetitive transfer of display frames from the computer at some rate between 30-60 times per second. The selection of a refresh rate for either computer refresh or local refresh is dependent upon the quantity of data to be displayed and the light output requirements for flicker-free presentations. Although delay line memories and drum memories are offered and can accommodate many of the refresh requirements, it has been Tasker's experience that the system's high-performance characteristics are best satisfied by means of a magnetic core memory. A typical memory size which satisfies a majority of applications is 4096 words with 16 bits per word, having a full-cycle time of 2 microseconds.

The keyboard module, offered as an option, is utilized for the entry of alphanumeric and/or special symbolic data into the refresh memory or the computer for purposes of the display composition, editing, or instructions pertinent to a data base. In most applications, the number and type of symbols provided on a keyboard are a duplicate of the symbol repertoire available from the character generator module. In those cases where the associated computer is accomplishing the refresh operations and software control of display generation, editing, and the like, it is often more advantageous to accomplish an interface directly from the keyboard to the computer I/O bus as opposed to transferring keyboard data via the interface unit and direct memory access channel of the associated computer.

Programmable function keys, usually a group of 16 - 32, are individual push-type switches which are used to initiate discrete operations, either within the display system or via software routines in the associated computer. In effect, it is an aid which allows the operator to control a set of display commands manually. Some typical function key labels include: line erase, page roll-up, store message, light pen plot, etc.

The bowling-ball module, also known as a track-ball, is also an operator aid which provides a facile means of positioning a cursor to any given point on the CRT face in a very accurate manner, without precise manual manipulations. Some of its uses are in establishing the end points of vectors to be displayed on the CRT, or for "hooking" any desired display element on the CRT screen.

The light pen module, offered as an option, provides the capability for the operator to communicate with elements of the display (vectors, characters and points) in a manner comparable to the use of a wand or pointer. This capability enables the operator to hook any displayed element and through servoing via the computer software program, he may, in effect, draw graphic presentations on the display. (A typical display is shown in Fig. 2.) The light pen itself merely detects the presence of light within a matter of a few microseconds after the electron beam has caused phospher illumination within the aperture of the light pen. Modification of the displayed data for generation of new display data by this technique is accomplished primarily by the software routines which utilize these time-dependent signals.

Tasker Industries, located in Van Nuys, Cal., has reported that these display systems, called the Series 9000, have been ordered by the U.S. Navy, Stanford Research Institute, and leading manufacturers. For more information:

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negative radix arithmetic

M. P. deRegt

Part 3
Addition and Subtraction

Editor's Note: Part 1 of this series, in the May 1967 issue, introduced the concept of negative radix number systems. In last month's issue, Part 2 described and illustrated negative radix terminology, conventions, and properties.

In the first article of this series, it was pointed out that the significant advantages of negative radix notation for computer technology lie in the operational aspects of the arithmetic rather than in the representational aspects of numbers and polarities. The representational properties were described in some detail in the second article, to provide a proper foundation for concentrating on the more important operational aspects of the arithmetic in the remaining articles of the series. Following the plan of the first and second articles, the discussion on arithmetic will be confined largely to base -10, that is, negative decimal. It may seem incongruous to talk about decimal arithmetic in a series of articles addressed to computer professionals, but the purpose of these articles is to help the reader to acquire an understanding of negative radix representation and arithmetic. This objective is more easily met through examples, using genuine numbers, than through abstract mathematics, using an impressive array of symbols. The more familiar the symbols and numbers, and the more familiar the rules, the easier it will be for the reader to understand the important information. In this third article, the discussion of each arithmetic operation will be made in both normal decimal and negadecimal terms, to make the approach clearer to the reader, by allowing him to make an automatic comparison between the two.

Nothing is more familiar — even to computer engineers — than the decimal system, the digits 0 through 9, the operation symbols $+$, $-$, $\times$, and $\div$, the decimal addition and subtraction "facts" and the multiplication tables. A discussion based on the radix -2, using numerals 0 and 1 would result in irritating strings of 0's and 1's representing binary numbers which are impossible to remember long enough even to transcribe onto a sheet of paper, and which reveal virtually nothing as to their magnitude. In short, they have no "character." More importantly, a number system using only two numerals is riddled with special cases, and generalizations are virtually impossible to recognize. It will be much easier for the computer engineer to extend his knowledge of negadecimal to negabinary, than the reverse. Besides, many people will find doing negadecimal arithmetic to be fun.

When one achieves a true similarity with negative radix arithmetic, then many properties of base -2 systems will become similar even before we give detailed consideration of such systems. It will then be easy to focus on those properties peculiar to negative binary systems and to comprehend fully the important differences between it and conventional binary.

The general rule for negative radix arithmetic, stated in the first article, is simply that it is like positive radix arithmetic, except that the sign of the carry is changed. The basis of this rule was illustrated by means of a special decimal system which uses negative numerals as well as positive, and in which only positive numerals and zero may occupy even-numbered digit positions, and only negative numerals and zero may occupy odd-numbered digit positions. Therefore, the effect of a carry-in is subtractive, and the effect of a borrow is additive.

In a system having a radix of -10, and using the normal numerals 0, 1, 2, . . . , 9, this same general property holds, that is, carries are subtractive, and borrows are additive. In order to avoid confusion, carries and borrows are both called carries, with the carry digit having appropriate polarity, positive or negative.

DECIMAL ALGEBRAIC ADDITION AND SUBTRACTION

In manual decimal addition involving numbers of both signs, it is necessary first of all to examine the signs of both operands. If they agree, it is only necessary to find their sum, and prefix their common sign. If they disagree, however, it is necessary to determine which of the two operands is the larger, find their difference, and assign to the result the sign of the larger operand. This rather involved process, known as algebraic addition using the rules of signs for addition, is more graphically described in the flow chart of Fig. 1, which also shows subtraction to be governed by the same process after the sign of the subtrahend has been changed. The chart is not a rigorous flow chart, but is intended to show the decisions and steps of manual addition and subtraction, and to illustrate the essential complexity of these operations.

Referring to the flow chart, the "find" operation is just that: it is the process of finding in a (memorized) table the sum or difference of each pair of operand digits. This is not so much a computation process as it is a table-look-up process. Decimal addition performed using this flow chart, therefore, requires a table of digit sums and a second table of digit differences, which are represented by Table 1 and Table 2, respectively, and are, of course, quite ordinary in most respects. In these tables, the sums and differences of a pair of digits are given as two-digit numbers. The right-hand digit of the sum or difference represents the sum digit, or S_i in the flow chart. The left-hand digit represents the carry digit, symbolized by C_{i+1}. Note that the carry digit in the digit difference table is either 0 or N (which is used to represent -1). The N-carry convention takes the place of the borrow convention, as noted earlier.

There are several ways in which Tables 1 and 2 differ from normal decimal addition and subtraction tables. The first is recognition of the fact that the operations on the digits are not necessarily the same as the operations on the operands. As shown in the flow chart of Fig. 1, addition of signed operands may involve either addition or subtraction of individual digits; the same thing applies to subtraction of signed operands. The tables are therefore called "digit sum" and "digit difference" tables, and the words augend, addend, minuend, and subtrahend were intentionally not used to identify the variables, in order to prevent confusion between the original multi-digit operands, and the single-digit "operands" of the tables.

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negative radix continued arithmetic

A secondary way in which these tables differ is that the carry-in is included as a variable. Thus each table is in effect two tables: the result of combining a carry digit with an operand digit may be found in the table formed by the first three columns, and the digit sum of this result and the other operand digit may be found in the table comprising the third through twelfth columns.

A third way in which the tables differ lies in the use of N or negative unity, as the carry digit in the digit difference table. Use of this convention permits the difference as well as the sum of any pair of digits to be represented by an unsigned two-digit decimal number.

The addition and subtraction flow chart and tables of conventional decimals are presented to emphasize that this thoroughly familiar process is actually quite complex. This will provide a basis for comparison, when in the next section, the flow charts for manual negadecimal arithmetic are presented, together with the corresponding digit sum and digit difference tables.

NEGADECIMAL ADDITION AND SUBTRACTION

In negadecimal arithmetic, we could refer to the tables as addition and subtraction tables rather than as digit-sum and digit-difference tables, because in negadecimal

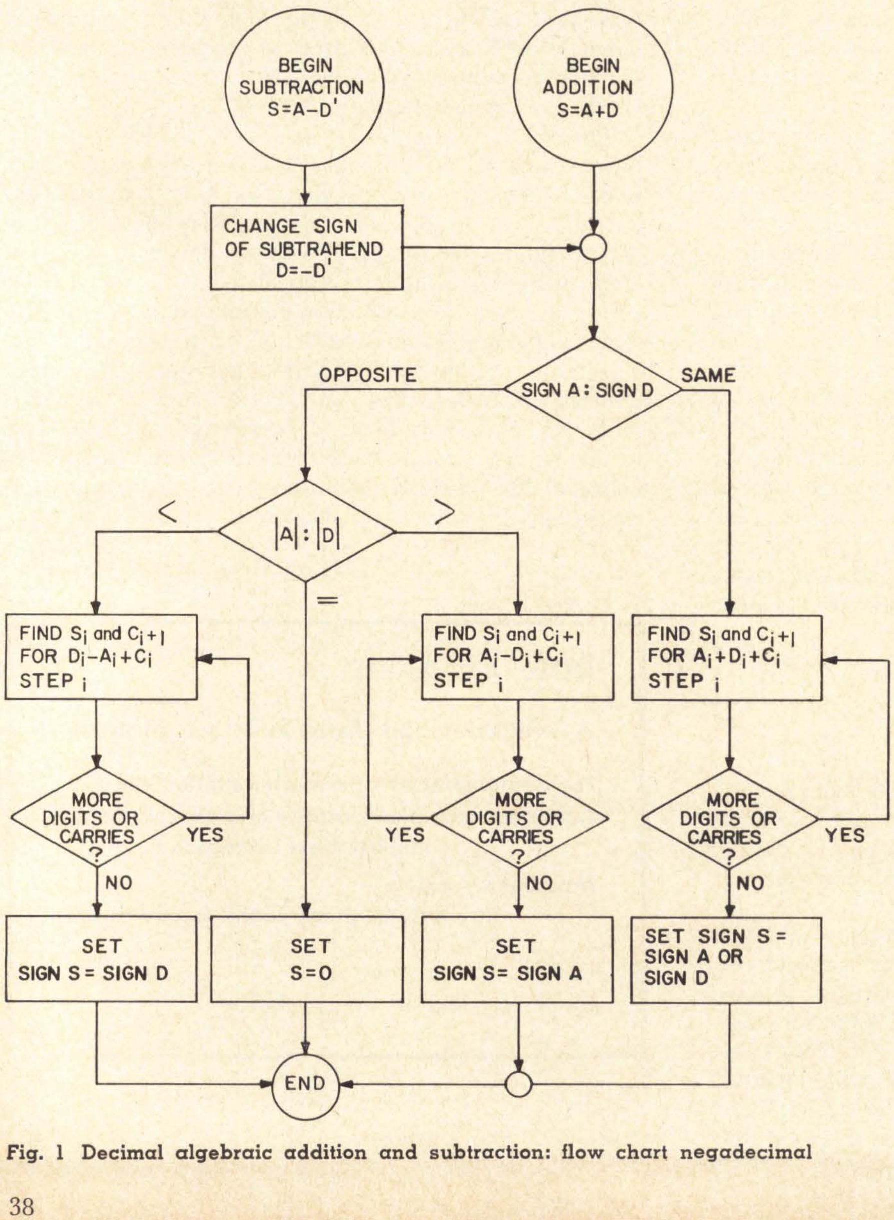


Fig. 1 Decimal algebraic addition and subtraction: flow chart negadecimal

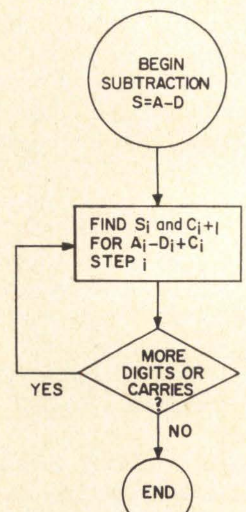


Fig. 2 Manual negadecimal addition: flow chart

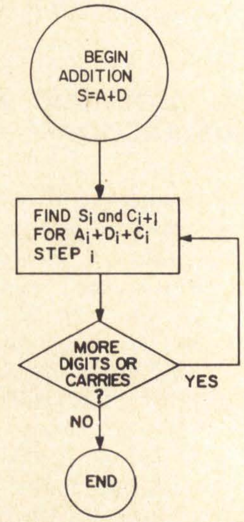


Fig. 3 Manual negadecimal subtraction: flow chart

TABLE 1

DECIMAL DIGIT SUM TABLE

2nd Operand Digit if Carry is		First Operand Digit									
1	0	0	1	2	3	4	5	6	7	8	9
–	0	00	01	02	03	04	05	06	07	08	09
0	1	01	02	03	04	05	06	07	08	09	10
1	2	02	03	04	05	06	07	08	09	10	11
2	3	03	04	05	06	07	08	09	10	11	12
3	4	04	05	06	07	08	09	10	11	12	13
4	5	05	06	07	08	09	10	11	12	13	14
5	6	06	07	08	09	10	11	12	13	14	15
6	7	07	08	09	10	11	12	13	14	15	16
7	8	08	09	10	11	12	13	14	15	16	17
8	9	09	10	11	12	13	14	15	16	17	18
9	–	10	11	12	13	14	15	16	17	18	19

TABLE 2

DECIMAL DIGIT DIFFERENCE TABLE

Subtractive Digit if Carry is		Additive Digit									
N	0	0	1	2	3	4	5	6	7	8	9
–	0	00	01	02	03	04	05	06	07	08	09
0	1	N9	00	01	02	03	04	05	06	07	08
1	2	N8	N9	00	01	02	03	04	05	06	07
2	3	N7	N8	N9	00	01	02	03	04	05	06
3	4	N6	N7	N8	N9	00	01	02	03	04	05
4	5	N5	N6	N7	N8	N9	00	01	02	03	04
5	6	N4	N5	N6	N7	N8	N9	00	01	02	03
6	7	N3	N4	N5	N6	N7	N8	N9	00	01	02
7	8	N2	N3	N4	N5	N6	N7	N8	N9	00	01
8	9	N1	N2	N3	N4	N5	N6	N7	N8	N9	00
9	–	N0	N1	N2	N3	N4	N5	N6	N7	N8	N9

the operations of addition and subtraction are "pure" — that is, **addition of two operands of any polarity involves only sums of pairs of digits** and **subtraction of two operands of any polarity involves only differences of pairs of digits.** This fact, vividly illustrated in Figs. 2 and 3, epitomizes the statement made in the first article that the main advantages of negative radix notation are operational rather than representational. Comparison of Fig. 2 and Fig. 1 (less the subtraction blocks), and of Fig. 3 with Fig. 1, will reveal the striking simplicity and purity of the processes of negative radix addition and subtraction.

In Fig. 1, note that two decision steps are required before operations on the digits can begin, and that **these decisions involve properties of both entire operands.** Also, the blocks at the bottom imply that certain of these properties must be remembered until the end of the computation. Neither the decision blocks nor the final blocks are present in Figs. 2 and 3. Operation on the digits begins immediately, independent of polarity and magnitude properties of the entire operands, and when the final pair of digits (or the final carry) have been processed, the operation is complete. **No reference need be made to properties of the operands.**

Although machine operations using radix complement notation are simpler than the manual operations described above, certain of the manual procedures are merely mapped over either into equivalent machine procedures or conventions, or result in complications in other aspects of machine computation. Thus, radix complement notation solves certain problems in addition and subtraction, but creates even stickier ones in multiplication and division (with which we live). Sign-and-magnitude notation is nice for multiplication and division, but addition and subtraction in it closely resemble the manual algorithm of Fig. 1. In both of these forms of notation, the problem of operand-level decisions remains.

Reference to the negadecimal addition and subtrac-

TABLE 3

NEGADECIMAL DIGIT SUM TABLE

Addend digit if carry is			Augend Digit									
N	1	0	0	1	2	3	4	5	6	7	8	9
0	–	–	19	00	01	02	03	04	05	06	07	08
1	–	0	00	01	02	03	04	05	06	07	08	09
2	0	1	01	02	03	04	05	06	07	08	09	N0
3	1	2	02	03	04	05	06	07	08	09	N0	N1
4	2	3	03	04	05	06	07	08	09	N0	N1	N2
5	3	4	04	05	06	07	08	09	N0	N1	N2	N3
6	4	5	05	06	07	08	09	N0	N1	N2	N3	N4
7	5	6	06	07	08	09	N0	N1	N2	N3	N4	N5
8	6	7	07	08	09	N0	N1	N2	N3	N4	N5	N6
9	7	8	08	09	N0	N1	N2	N3	N4	N5	N6	N7
–	8	9	09	N0	N1	N2	N3	N4	N5	N6	N7	N8
–	9	–	N0	N1	N2	N3	N4	N5	N6	N7	N8	N9

TABLE 4

NEGADECIMAL DIGIT DIFFERENCE TABLE

Subtrahend Digit if Carry is			Minuend Digit									
N	1	0	0	1	2	3	4	5	6	7	8	9
–	0	–	01	02	03	04	05	06	07	08	09	N0
–	1	0	00	01	02	03	04	05	06	07	08	09
0	2	1	19	00	01	02	03	04	05	06	07	08
1	3	2	18	19	00	01	02	03	04	05	06	07
2	4	3	17	18	19	00	01	02	03	04	05	06
3	5	4	16	17	18	19	00	01	02	03	04	05
4	6	5	15	16	17	18	19	00	01	02	03	04
5	7	6	14	15	16	17	18	19	00	01	02	03
6	8	7	13	14	15	16	17	18	19	00	01	02
7	9	8	12	13	14	15	16	17	18	19	00	01
8	–	9	11	12	13	14	15	16	17	18	19	00
9	–	–	10	11	12	13	14	15	16	17	18	19

tion tables, Tables 3 and 4, will reveal that not all changes are for the better, since in each table there is an extra column to correspond to an extra carry possibility. In Table 3 for digit sums, all rows save the first have carry digits of either 0 or N. The N reflects the fact that the sign of the carry is changed in negative radix arithmetic. The top row is slightly different; it has a carry digit of 1 in one particular digit sum. This single instance of a carry of positive unity arises when both operand digits are 0, and there is a carry-in of N. Since N is not itself included in the set of digits, it cannot be used as a sum digit to give a digit sum of 0N for the table. Instead, the negadecimal number whose value is -1 is used, which is 19. This gives a sum digit of 9, and a carry digit of 1. The carry digits must therefore include not only 0 and N which represent virtually all carry possibilities, but 1 as well. Hence, Table 3 has three carry columns, which comprise, with the 0 augend column, a sort of 4-column sub-table to combine the addend digit with the carry digit.

A similar analysis may be made for Table 4, except that here the anomalous carry is an N, which arises when a minuend digit of 9 is combined with a subtrahend digit of 0, with a carry-in of 1. The total is ten, which is represented as 190; however, the table is constrained to use two-digit differences, and N0 is used instead. Again, three carry columns are needed.

Use of the flow-chart, Fig. 2 or Fig. 3, together with the appropriate table, Table 4 or Table 5, respectively, should enable anyone to do negadecimal addition or subtraction. Use of the tables can easily be learned by using Fig. 1 and Tables 1 and 2 for decimal arithmetic; the negadecimal tables are used in exactly the same way. Naturally, negadecimal tables can be quickly learned, since they are exactly the same as the decimal table except for the change of sign of the carry. The single situation in each operation which gives rise to the anomalous carry is easily memorized and recognized.

Examples of both addition and subtraction, in both negadecimal and decimal are presented in following sections. A number of variations are possible in operand sign and magnitude, and an example for each of these variations is presented; these will illustrate the complexity of the positive radix operation as compared with the simplicity of the negative radix counterpart, using equivalent numbers.

Addition Examples

The variations possible in positive radix addition are summarized in Table 5. The first column refers to an example number, the second and third columns give the sign or polarity of the augend (A) and addend (D) respectively, and the fourth column gives the relative magnitudes; the "don't care" entries indicate that differences in magnitudes do not provide additional variations when the operand polarities are the same. (This is illustrated in Fig. 1 by the fact that the sign comparison decision block precedes the magnitude comparison decision block.) In the examples to follow, negadecimal and the corresponding decimal illustrations are given on the left and right, respectively.

- Example 1 (+, +, don't care):

267	+147
122	+ 82
389	+229

- Example 2 (−, −, don't care):

1953	−147
98	− 82
1831	−229

- Example 3 (+, −, >):

267	+147
98	− 82
145	+ 65

- Example 4 (+, −, =):

267	+147
1953	−147
0000	0

- Example 5 (+, −, <):

122	+ 82
1953	−147
0075	− 65

- Example 6 (−, +, >):

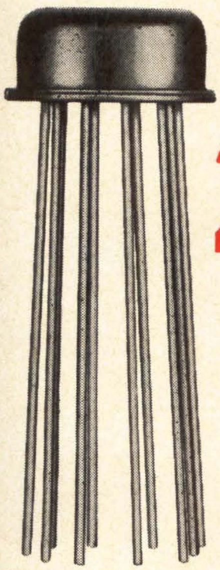
1953	−147
122	+ 82
0075	− 65

- Example 7 (−, +, =):

98	− 82
122	+ 82
000	0

- Example 8 (−, +, <):

98	− 82
267	+147
145	+ 65



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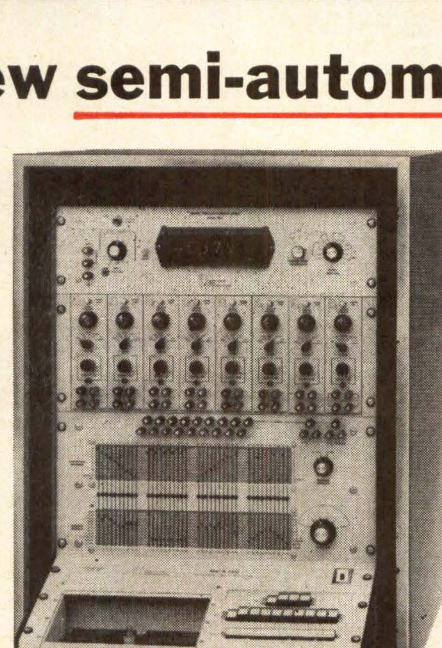

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negative radix arithmetic

continued

At some risk of overstating the obvious, several things should be noted about these examples, which confirm the implications of the flow chart.

• The performance of the decimal examples requires a considerable amount of "mental" preprocessing — comparison of signs, comparison of magnitudes, and mental rearrangement of operands.

• Of the eight decimal addition examples, representing all possible variations of signs and magnitudes of the operands, only the first two use the digit-sum table. Of the other six, four use the digit-difference table, and two need not go past the preprocessing (comparison) stage.

• The eight negadecimal examples were all worked in exactly the same way. None required knowledge of polarity or magnitude, position was not relevant, and preprocessing was not required.

It is true that even with the operation sign left out, the decimal examples do look a little overburdened with signs. But it must be remembered that the positive polarity symbol is only explicit evidence of an invisible but nevertheless information-bearing convention.

Subtraction Examples

The variations in subtraction follow the same general pattern as in addition, allowing for the fact that the sign of the subtrahend is changed as a first step. However, several additional variations are included when signs of original operands are unlike, as shown in the summary of Table 6. Again, the examples have negadecimal on the left and decimal on the right.

TABLE 5

VARIATIONS IN POSITIVE RADIX ADDITION

Example No.	Polarity of A	Polarity of D	A:D
1	+	+	DON'T CARE
2	−	−	DON'T CARE
3	+	−	>
4	+	−	=
5	+	−	<
6	−	+	>
7	−	+	=
8	−	+	<

TABLE 6

VARIATIONS IN POSITIVE RADIX SUBTRACTION

Example No.	Polarity of A	Polarity of D	A:D
9	+	+	>
10	+	+	=
11	+	+	<
12	−	−	>
13	−	−	=
14	−	−	<
15	+	−	>
16	+	−	<
17	−	+	>
18	−	+	<

• Example 9 (+, +, >):

26087	+13927
374	+ 234
27713	+13693

• Example 10 (+, +, =):

26087	+13927
26087	+13927
00000	0

• Example 11 (+, +, <):

374	+ 234
26087	+13927
194307	−13693

• Example 12 (−, −, >):

194133	−13927
1846	− 234
194307	−13693

• Example 13 (−, −, =):

1846	− 234
1846	− 234
0000	0

• Example 14 (−, −, <):

1846	− 234
194133	−13927
027713	+13693

• Example 15 (+, −, >):

26087	+13927
1846	− 234
26241	+14161

• Example 16 (+, −, <):

374	+ 234
194133	−13927
26241	+14161

• Example 17 (−, +, >):

194133	−13927
374	+ 234
195979	−14161

• Example 18 (−, +, <):

1846	− 234
26087	+13927
195979	−14161

The subtraction examples illustrate again the simplicity and beauty of negadecimal arithmetic in contrast to the complexity and confusion of decimal. Negadecimal subtraction is pure subtraction — there is no preprocessing: the first thing to do is to subtract the first pair of digits, according to the digit-difference table, which is the only table used. The operation is complete when there are no more digits or carries.

SUMMARY AND LOOK-AHEAD

Although negative radix arithmetic has a number of advantages over conventional arithmetic, it will probably never be popular with people. Human beings are too smart — they can do very complex things with relative ease, using capabilities other than pure computation. The advantages of negative radix notation for people are therefore not very important, whereas the disadvantages are emphasized. The major intrinsic disadvantage is that negadecimal numbers of identical magnitude but opposite polarites look completely different, and people test for two magnitudes being equal simply by comparing symbol shapes: if all symbols in corresponding positions agree, the magnitudes are equal; if they are not equal, then magnitudes may be easily compared by comparing the positions and magnitudes of the most significant digits. This cannot be done in negative radix, even between two numbers of the same polarity. Also, in terms of arithmetic operations, there are few, if any, economies in manual calculations: numbers have either the same or more digits and the digits somehow seem always to be larger. (There is probably a theorem or lemma or something lurking here, and perhaps someone ought to look for it.)

The practical potential of negative radix notation lies in its use by machines, which are not as clever as people. It is here that the simplicity of the algorithm, and the independence from the polarity and magnitude properties of entire numbers, can be fully exploited. The slightly greater complexity of the digit sum and digit difference tables (for negabinary) is compensated for by the fact that this increased complexity occurs at the digit or stage level, rather than at the number or register level. The implications of the importance of integrated circuits as propounded in the first article, are therefore quite clear.

Multiplication will be covered in the next article, and division will be introduced. Multiplication turns out to be quite simple, but division — let's face it — is a little complicated, although primarily from a manual point of view. Both operations are extremely interesting.

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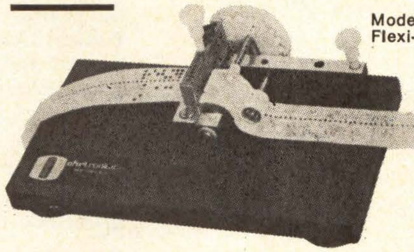

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FIBER OPTICS: State-Of-The-Art Report

During the past two years, Fiber Optics has begun to develop from a promising laboratory curiosity to a basis for useful devices. In keeping with our policy of informing our readers concerning techniques and technologies which are, or may become, important to them, the staff of COMPUTER DESIGN presents a survey of the historical progress of Fiber Optics, a review of fundamentals, the present state-of-the-art, and the future prognosis as it affects digital systems.

COMPUTER DESIGN gratefully acknowledges the cooperation and assistance of the following companies, who supplied information for use in preparing this article:

American Optical Company, Southbridge, Mass.

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Corning Glass Works, Corning, N. Y.

E. I. duPont de Nemours and Company, Wilmington, Del.

Iota-Cam Fiber Optics Corporation, Wakefield, Mass.

Mosaic Fabrications, Inc., Sturbridge, Mass.

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Acknowledgement is also made to the following direct sources of information:

"Shedding Light on Fiber Optics," **by Rene deLyon, AMP, Inc.**

"Fiber Optics: Principles, Properties, and Design Considerations," **by Walter P. Siegmund, American Optical Company (Presented at the annual meeting of The NATO Avionics Panel, July 1962).**

Mr. A. C. Menadier, Director of Marketing, Poly-Optic Systems, Inc.

Mr. Russel E. Horton, Sales Manager, Mosaic Fabrications, Inc.

Dr. Charles J. Koester, American Optical Company.

The "new" phenomenon behind Fiber Optics was discovered by the British physicist, John Tyndall, who observed light following a curved path within a stream of water in the year 1870. The use of a glass fiber to "conduct" light was explored by a number of experimenters in the period 1920-1930, but Fiber Optics technology as we now know it really emerged in the early 1950's with the old experimental results augmented by new theory and advanced manufacturing processes; within ten years it had advanced sufficiently that working devices could be made and sold. By 1965, the United States market had grown to about six million dollars, with an indicated expansion of about 50% per year.

The first market of any significance was the aerospace industry: remote fire detectors, radar-scope magnifiers, Lox tank monitors, image intensifiers for space-probe cameras. Within the past few years, however, increased Fiber Optics capability (and decreased costs) has led to applications in decorative lighting, instrumentation, medicine, and data processing. Medical technicians, long frustrated by their inability to view the subjects of their investigations directly, were quick to grasp the unique remote viewing capabilities of fiber optics; on an experimental basis, they applied FO techniques to remote visual inspection of human stomachs and even watched the operation of dogs' hearts — from the inside! In data processing, numerous applications have already been perfected — and punched card perforated tape readers, optical character recognition systems, light pens for cathode-ray-tube display systems — and more are under development.

The Editors of Computer Design believe that many more applications can be and will be made in equipments designed by and used by our digital engineering readers. This comprehensive coverage is intended to fulfill the twofold purpose of educating the reader in a technology which he will soon meet in the equipments with which he deals, and of stimulating the creative digital designer to think in terms of how he can use this newly-emergent technology to make more reliable, more effective, or less costly digital machines, devices, and systems.

BASIC FO PRINCIPLES

The speed of light in matter is less than its speed in free space, or in air. A review of optical refraction in any basic physics test will disclose that refraction is caused by this dissimilarity in speeds, whenever a light ray passes from one medium to another, at an angle different from 90°, as shown in Fig. 2. Whenever refraction occurs, a reflected ray is also present, that is, some of the optical energy is reflected back from the interface between the two media. The angle of incidence and the angle of refraction are related by Snell's Law:

$$\frac{\sin i}{\sin r} = N$$

where N is the index of refraction, i is the angle of incidence, and r is the angle of refraction. The index of refraction is constant for any two materials, and is the ratio between the speeds of light in the two media. When light passes from some denser medium into air, the angle of refraction is greater than the angle of incidence, $r > i$, and since $r \leq 90°$, there must be a limit to the value of i, beyond which no refracted ray will emerge into the air. This is called the **critical angle,** and rays striking the surface at angles greater than this will be totally reflected.

If light shines on the end of a glass rod, much of the light that enters will be caught inside the rod, unable to escape out the sides because of total internal reflection. This light will be reflected a number of times from the walls and finally escape from the far end, much like microwave energy is transmitted along a waveguide.

The same thing happens when the diameter of the rod is made very small. In fact, there is no substantial change in the behavior until the diameter of the rod becomes comparable to the wavelength of light — say 5 microns, and a fiber 50 microns (0.002 in.) in diameter behaves just like a rod. Light is still trapped in the fiber by total internal reflection and carried to the far end. The only difference is an increase in the number of reflections per unit length, and the surface quality of a fiber must therefore be very high if the light is not to be lost by surface scattering. A ray of light in a 50-micron fiber may be reflected 3000 to 4000 times per foot. Transmission efficiency is affected by a number of factors including transmittance properties of the material, the reflection properties of the surface, and (as might be expected from experience with transmission line theory) the terminations of the line and the resultant end losses.

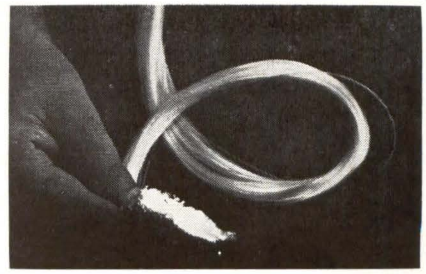


Fig. 1 Light transmission through a bundle of loose optical fibers (Corning).

Numerical Aperture

An important parameter of an optical fiber is the acceptance angle, or numerical aperture (N.A.) of the fiber, which is a measure of the fiber's light gathering power. As shown in Fig. 3, the N. A. can be found from the refractive indices of the fiber, its jacket, and air through Snell's Law and elementary trigonometry. Properly designed lenses can be used to increase significantly the apparent angle of acceptance.

In practice, one finds that the N. A. is not as sharply defined as the formula implies, particularly as the size of the fibers is reduced. Diffraction, striae, and surface irregularities on the fiber walls all tend to diffuse the N. A. The range of nominal N. A.'s available is limited only by the materials from which the fibers can be made, and the pairing of these materials with those available for use as the jacketing material. It is possible to obtain almost any value of N. A. up to about 1.2 using pairs of available glasses. The designer is often confronted with a compromise between N. A. and transmittance, since higher indices of refraction are generally accompanied by lower transmittance in the blue end of the spectrum.

Coating or Jacketing: Optical Crosstalk

Efficient conduction of light through fibers is made possible by the almost incredible perfection of the phenomenon of total reflection in the absence of disturbing influences. In principle, the conditions for total reflection exist at any smooth interface between two transparent media having different refractive indices. Thus, a smooth glass fiber in air should conduct light efficiently. In practice, however, one finds that the presence of minute defects and contamination at the interface interferes with the total reflection phenomenon by absorbing or scattering away a fraction of the incident light, and these losses become serious in fiber optics since each ray may undergo hundreds or thousands of reflections in its passage through the fiber. Thus, one usually finds that uncoated, freshly-drawn glass fibers rapidly lose their initial transmission efficiency, due to surface contamination.

Even if it were possible adequately to protect uncoated fibers from contamination they still would be unsuitable in many applications due to leakage of light from one fiber to the next. This leakage, sometimes called "optical crosstalk," is due to the penetration of the electromagnetic field into the rarer medium during total internal reflection. The extent of this penetration is only of the order of the wavelength of light but when another fiber is brought to within this distance some of the light energy from the original fiber leaks across the interface.

Attempts were made to prevent this leakage by coating the fibers with a highly reflecting metal, but the absorption of light by the metal at every internal reflection virtually destroyed the transmission efficiency of the fibers. Only through the use of a transparent dielectric coating was it possible to avoid crosstalk and also maintain high transmission, and both glass and plastic materials are in use as the coating material.

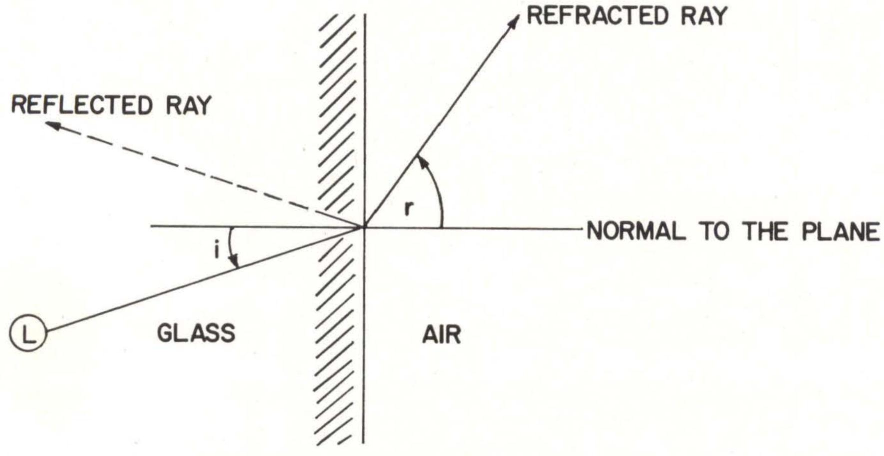


Fig. 2 Optical refraction

Transmittance of Optical Fibers

The transmission of light in optical fibers is governed by a number of factors including the transmittance properties of the core and coating materials, the quality of the reflecting interface, residual light leakage through the coating, and various end losses. To calculate the theoretical transmission of a fiber even with simplifying assumptions requires an elaborate integration process. A useful simplification is to consider the losses in transmission as consisting of line losses (attenuation) and end losses.

Line losses vary exponentially as a function of the length of the path of light, and are due to absorption by the core material, plus absorption by the cladding and scattering due to imperfections at the core-cladding interface. The transmission of fibers as a function of wavelength, in general, depends primarily on the trans-

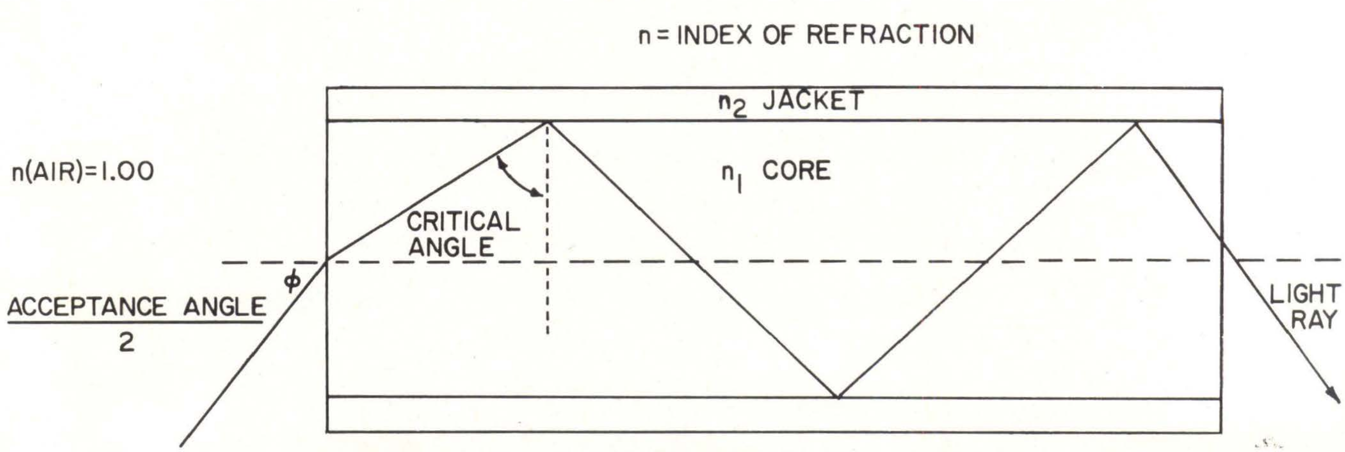


Fig. 3 Numerical aperture of a fiber.

$$\text{N. A.} = n \sin \phi = \sqrt{n_1^2 - n_2^2}$$

mission characteristics of the core and secondarily on those of the cladding, since the light transmitted by the fiber spends most of its time in the core and thus is most influenced by the absorption of the core material.

The factors which determine the end losses in fibers include: 1) Fresnel reflection from the entrance and exit faces of the fiber, 2) the packing fraction, and 3) the effective numerical aperture. The last of these together with the distribution characteristics of the incident light determine the amount of light which can be accepted. The Fresnel reflectance R is given by the equation:

$$R = \frac{(n-1)^2}{(n+1)}$$

where n is the index of refraction of the core material. The transmittance at each of the fibers is one minus the reflectance:

$$t = 1 - R$$

Since an infinite number of reflections do not occur between the ends of the fiber, the transmittance is the product of the end transmittances:

$$T_F = t^2 = (1 - R)^2$$

The Fresnel reflection losses may range from about 9% to 17% for both end faces.

The packing fraction is the ratio of the cross-sectional area occupied by the fiber cores to the total area. The loss due to this factor may range from a few percent in large fibers to as much as 40% for small fibers. Both the fiber coating and any space between fibers contribute to this loss. The cross-sectional geometry can be used to determine the packing losses, which are usually in excess of 10%.

PRESENT FO TECHNOLOGY

Forms of FO

The simplest form of fiber optics is the **single fiber** (Fig. 4), which can be used to conduct light to or from small areas with high efficiency. In small diameters they act as optical waveguides, and can be made to transmit only selected modes of electromagnetic radiation, a property which is useful in the field of optical masers. Single fibers can be made of almost any diameter from about 2 microns (80 micro inches) to ¼ inch, and in lengths up to 150 feet (at what point a fiber becomes a rod is clearly somewhat arbitrary); however, most flexible fibers fall in the range from 50 to 100 microns (2-4 mils) in diameter. Where a small core size is required without the need for a small overall diameter, it is customary to increase the cladding thickness to provide an overall diameter of about 50 microns for ease in handling.

Fig. 4 Group of single fibers

Fig. 5 Light from small flashlight travels a looped path through a light guide to dot model's cheek (DuPont)

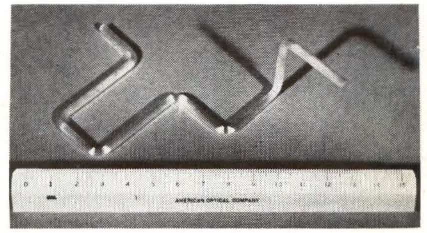


Fig. 6 Image conduit (American Optical)

Collecting a bundle of single fibers, each capable of carrying the illumination applied to it from one end to the other with almost perfect fidelity, becomes a means of transmitting graphic or pictorial information from one point to another. Resolution is limited only by the size and physical packing density of the individual fibers, and "picture" size is limited only by the ability of the user to obtain (and pay for) a sufficient quantity of suitable fibers. In order to transmit an actual image by fiber optics, the relative positions of each filament must be the same at the output end as the input end of the bundle. Their length and route between input and output are unimportant since the light they conduct is trapped within the fiber. Fibers thus organized are referred to as **coherent** bundles. Bundles arranged with no particular attention paid to their relative positions between input and output are referred to as **noncoherent;** their purpose is simply to carry light from input to output with no attempt being made to preserve the form or image of the source at the output end.

Fiber optic **light guides** (light conduits) are noncoherent bundles of single fibers which are either cemented or fused together at the ends and free to flex in between. The usual fiber size is about 80 microns, and the function is merely to transmit light from one end to the other (Fig. 5).

Multi-fibers consist of a number of individual fibers coherently fused into a single strand or rod. A multifiber has essentially the same mechanical properties as a single fiber of the same dimensions and will be either flexible or rigid depending on its diameter. Flexible multi-fibers consisting of a square array of 36 fiber elements each 10 microns in diameter are regularly used as the building blocks, 60 x 60 microns in cross-section, for flexible fiberscopes. Rigid multi-fibers containing a large number of fiber elements are used in the assembly of fused fiber optic plates; they can be used alone to transfer images (i.e., rigid fiberscopes or image conduit) and can be readily bent by heating to conform to any prescribed path (Fig. 6).

Flexible fiberscopes are coherent bundles of single fibers or multifibers fitted with suitable lenses at either end and used to transfer images along flexible paths. The numerical aperture and transmission properties of the fibers (or multi-fibers) used in these bundles are generally the same as in the case of flexible light guides. Early versions of fiberscopes were made with up to 30,000 single fibers of about 50 microns in diameter and thus provided only limited resolution, but more recently, resolution of 10^6 elements per cm^2 has been achieved. Principle defects are broken or defective fibers and misalignment amounting to as much as 30 microns in some instances; for many applications, i.e., viewing a remote dial or other indicator, image quality has proved to be acceptable.

Fiberscopes are presently being offered in lengths up to 4 meters but longer ones could be built, if needed. One alternative which has been used to provide a greater length is to couple two fiberscopes together but this involves additional losses in transmission and resolution as well as in flexibility. The largest cross-section regularly available is about 1 cm square and this requires a protective sheath of about 25 mm. in thickness. Larger cross-sections can be supplied but usually at the expense of flexibility.

Fused fiber bundles are multi-fibers fused together to form a solid block of almost any shape or size, capable of transmitting an image from one face to the other (Fig. 7). The most common configuration is the fiber optic faceplate used as a tube face for a cathode-ray-tube. Fused fiber bundles can also be tapered to give image magnifications or demagnifications (Fig. 8). The principal optical properties to consider in fiber optic faceplates are numerical aperture, resolution, and image contrast. Transmittance is generally not a problem except in the ultraviolet. In most faceplate applications where a phosphor is in contact with the fibers, a high N. A. is desirable and in some cases, such as in image intensifiers where very low light levels are involved, it is essential. The resolution of fused fiber optic faceplates is primarily a function of fiber size but it is also influenced by the fiber shape, the numerical aperture, and the degree to which stray light is suppressed. To obtain maximum resolution fiber plates have been made with fibers as small as 3 microns, although most "high resolution" plates have a fiber size of about 5-6 microns.

In addition to the optical properties, there are certain thermal and chemical properties of fiber optic faceplates which are important. In most instances, such plates must be vacuum tight and remain so when subjected to the usual bake-out and sealing temperature cycles. Expansion coefficients must be matched to envelop materials to prevent excessive strain or fracture. In some applications, such as in image intensifiers; the photocathode materials may interact with certain constituents in the fibers; these must either be avoided altogether or isolated by means of an inert coating between the photocathode and the fiber optic plate.

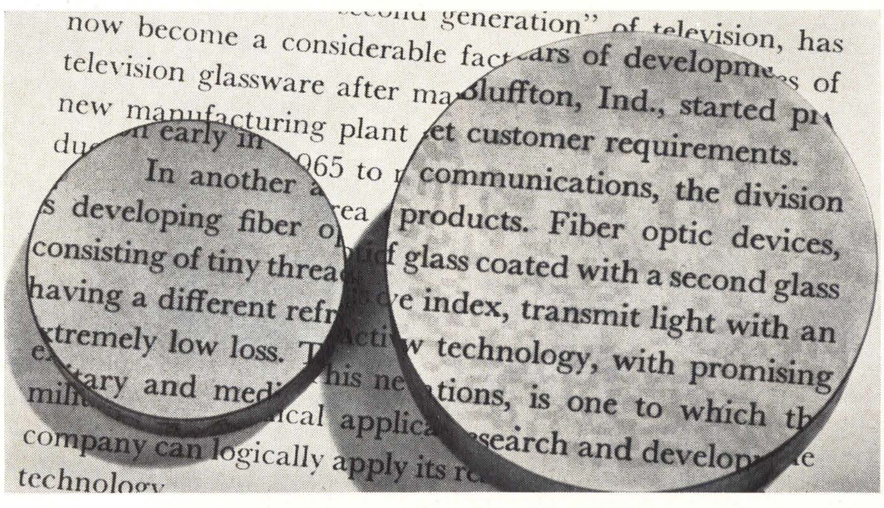


Fig. 7 Fused fiber optic faceplates (Corning)

Glass vs. Plastic

Until three years ago, the activity in FO was based entirely on the use of glass as the core material, although plastic cladding was used in some instances. Within the past three years, two companies have developed and begun marketing plastic or polymer FO in competition with glass: Poly-Optic Systems, Inc., of Santa

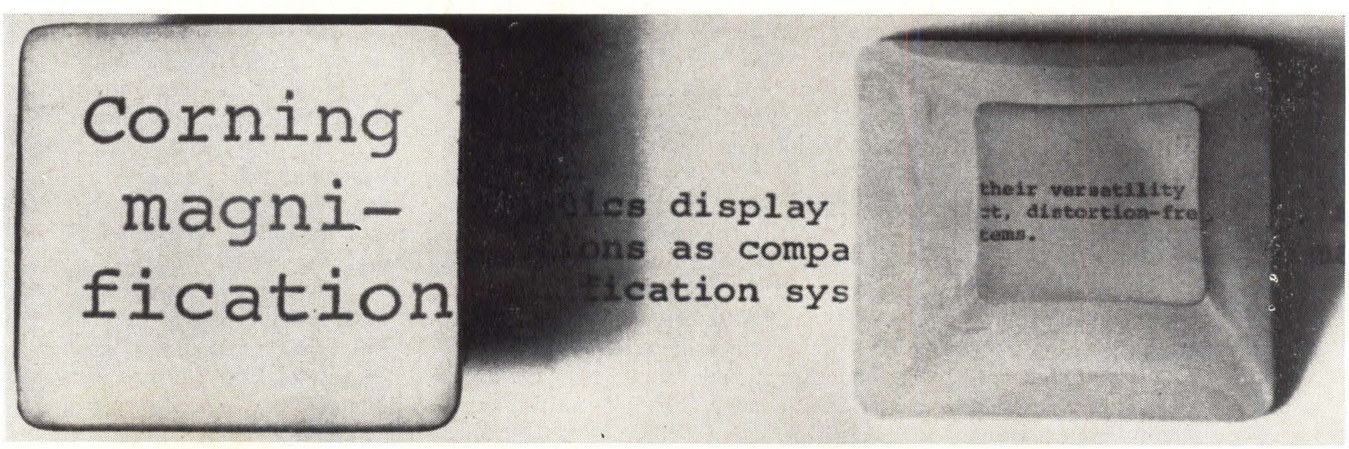
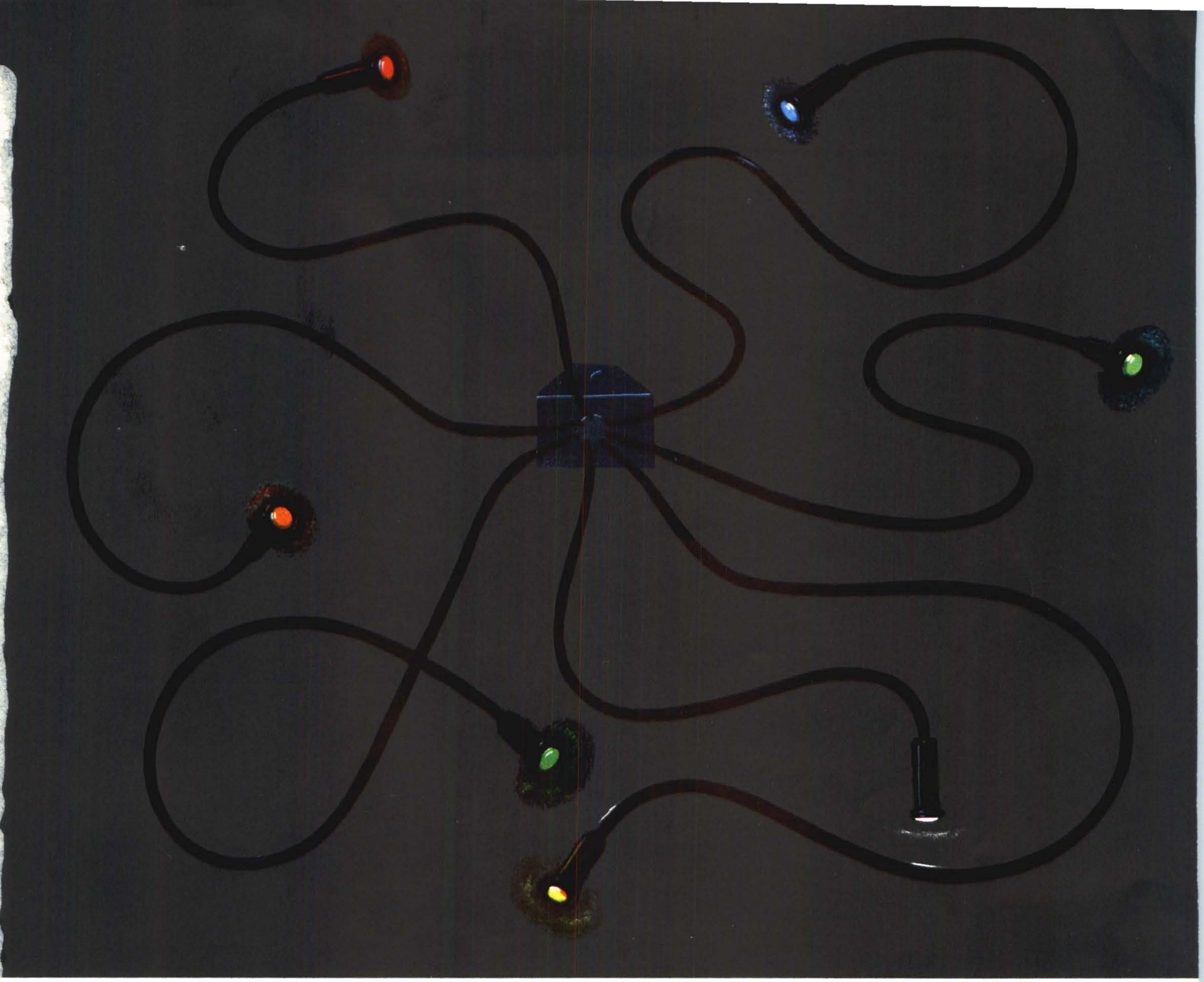


Fig. 8 Fiber optic magnifier (Corning)



Here it is—a complete fiber optics system from AMP that transmits light to multiple displays from a single source. Our unique AMPILLUME* system includes everything—an efficient light source, collector and display lenses, mounting devices, fiber bundles—all requirements for a complete illuminating system.

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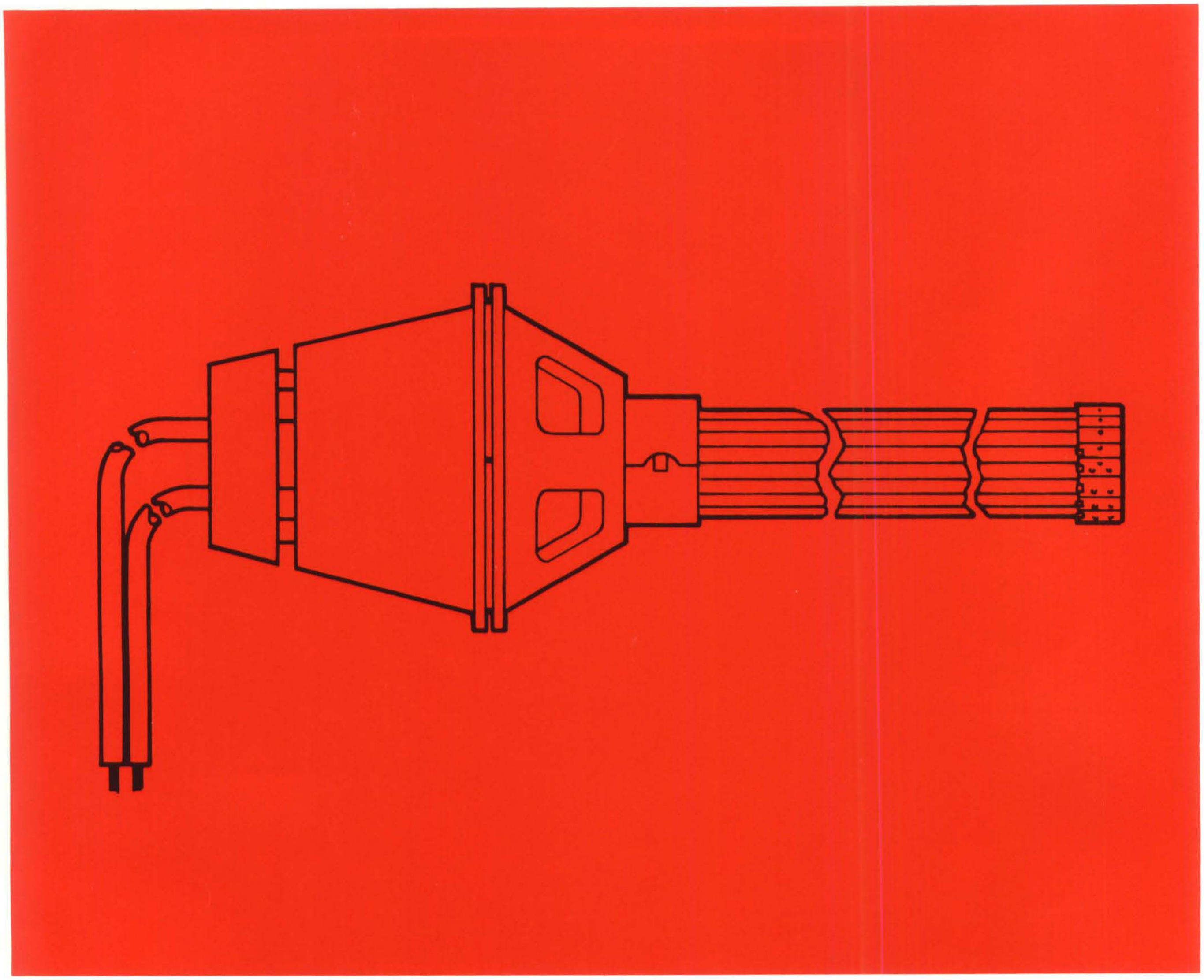

New light source

AMP has designed a high-efficiency light source assembly which aids light transmission with minimum loss. Collector and display lenses are available to concentrate or spotlight the visual display—colors can also be provided.

Crimped fittings are used to fasten and position the optical bundles in place. AMP, a leader in crimp technology, has developed a method to control this critical crimping pressure for maximum security with minimum light loss.

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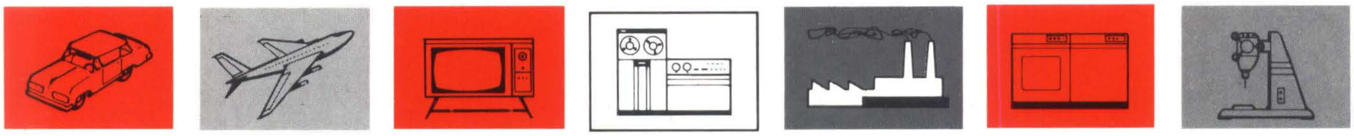


Ana, California, and E. I. duPont de Nemours and Company of Wilmington, Delaware under the trade name "Crofon." DuPont claims that its Crofon provides light transmission comparable to that of glass, is produced at a much lower cost than that of glass, and may be handled easily in equipment and processes similar to those used for insulated wire, including automated cutting, trimming, fitting, and bundling into wiring harnesses. DuPont, at present, manufactures only non-coherent light guides, using 10-mil diameter fibers, and claims an excellent combination of toughness, light transmission, flexibility, and reliability. The angle of acceptance for Crofon light guides is 70°; light loss at each end is a theoretical minimum of 4% (for a perfectly-polished interface) but will be 15%-20% when sliced with a sharp blade. The operating temperature is −40°F to 175°F; absorption of infrared wavelengths by the plastic causes a rise in temperature, and light sources with a minimum of IR radiation are recommended. Lengths up to 10 feet are reasonable. Minimum bending radius of bundles containing 16 to 64 fibers is ¼ to ¾″. Transmission is relatively uniform in the visible region, falls off rapidly in the near ultraviolet, and there are areas of strong absorption in the infrared (see Figs. 9 and 10). DuPont sees the advantages of plastic to be in its toughness and flexibility, the fact that it (unlike glass) can be manufactured in almost unlimited lengths and is therefore adaptable to automated manufacturing processes, and that its low price will open applications previously economically unattractive.

Poly-Optic markets "multiplex" bundles of "AST polymer" fibers, which are claimed to be virtually indestructible (and thus have no broken fibers in a bundle) and can be flexed thousands of times with no loss in performance. Scattered light and crosstalk are said to be less than for comparable glass bundles, and transmission is uniformly excellent from infrared to the near ultraviolet. End losses due to Fresnel reflection and the packing density of the bundle are approximately 30% for 3 mil fibers; however, the fact that AST polymer fibers can be made much larger and still retain their flexibility offers the opportunity to reduce the end losses by taking advantage of the higher packing density inherent in larger fibers. Poly-Optic provides fibers with diameters of 1-62.5 mils. Internal transmission loss is less than 10% per foot. The angle of acceptance is 71°. Minimum bending radius of a single fiber is 20X its diameter and minimum bending radius of a multiplex bundle is 0.140″. Lengths of up to 6 feet are available. Temperature range is

Note: Transmission values are for light guides with carefully-polished ends.

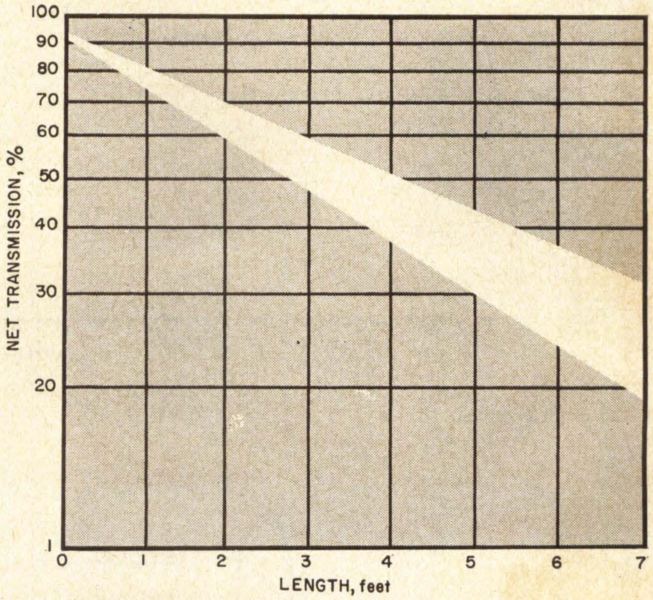
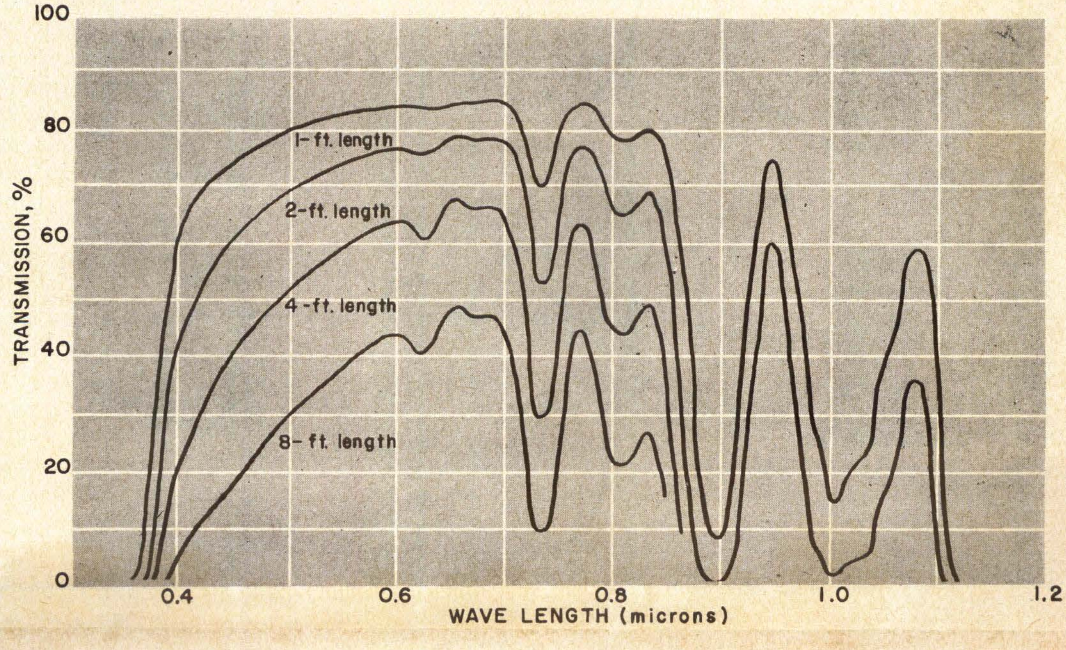


Fig. 9 Transmission of white light through Crofon light guides (DuPont)

Fig. 10 Spectral transmission of Crofon light guides (DuPont)



−40°F to 180°F; optical performance does not suffer even at cryogenic temperatures, but flexibility is then no longer present. AST polymer fibers withstand extended and intense irradiation without alteration to their transmission characteristics. Poly-Optic is able to manufacture a wide variety of fiber sizes, and is thus able to optimize the packing density of a bundle according to the application, which is the basis of their "multiplex" bundles. They have recently announced 1 mil fibers and are striving for even smaller diameters, so as to match the resolution available with glass image transmitting devices.

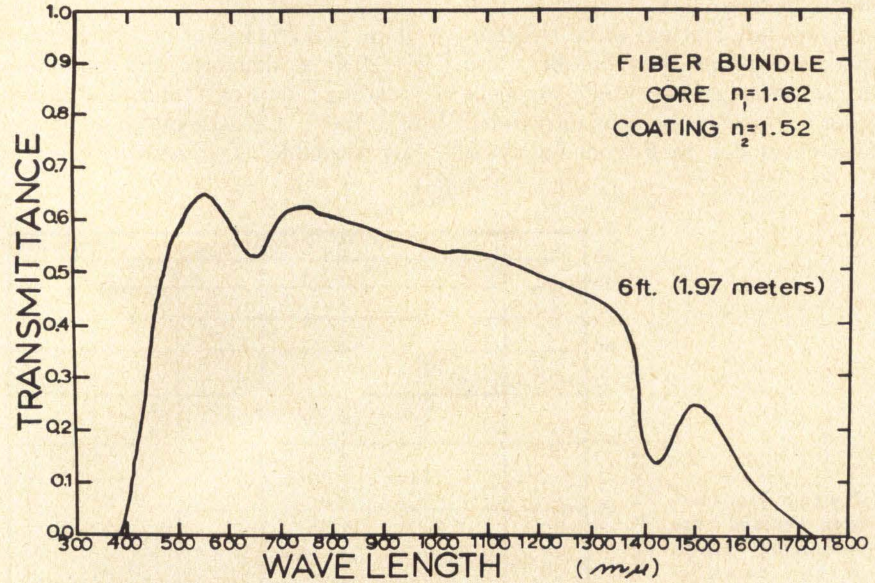
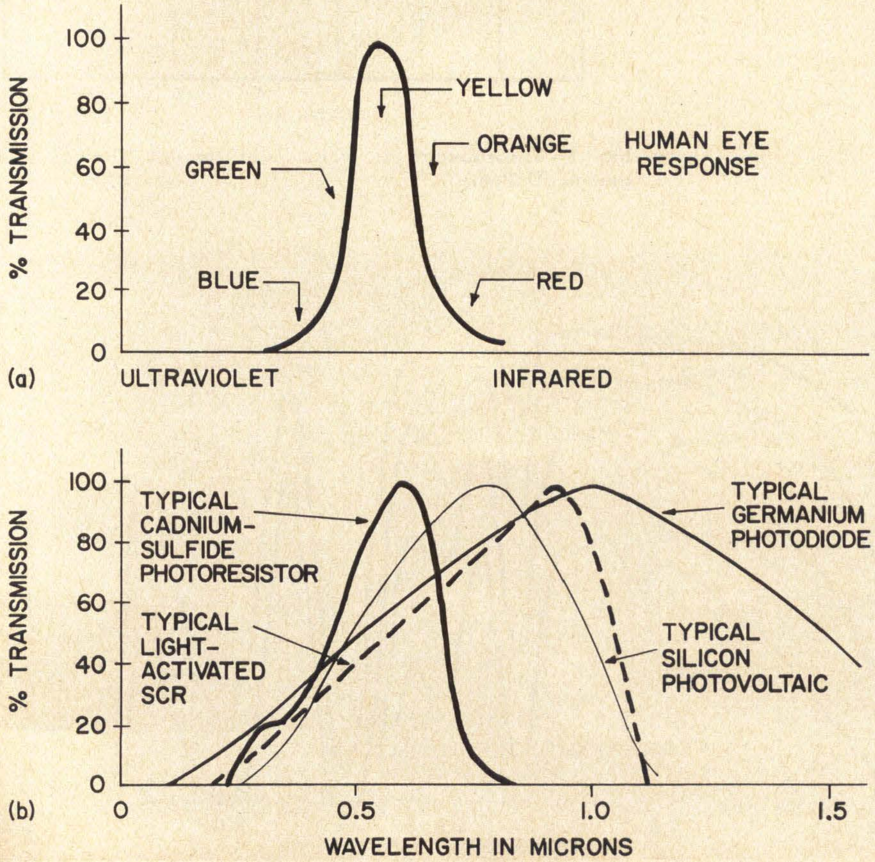


Fig. 11 Spectral transmittance curve for a glass fiber bundle (n_1 = 1.62, n_2 = 1.52) (American Optical)



Committed, at the present, to glass are at least eleven companies. Glass fibers by Corning Fiber Optics can be made to 0.15 mil in diameter, in lengths up to six feet, with an N. A. of 0.63; they can be bent around a radius of 50 mils. Corning fibers operate in the temperature range from −50°F to 700°F and are virtually immune to chemical atmospheres. In addition to the low-index-of-refraction cladding material, the fibers are coated with a lubricating material to protect the cladding surfaces from abrasion in handling and flexing applications. Bundles of 1/16" diameter containing several thousand fibers have been subjected to 150,000 flexing cycles about a 2-inch radius with no perceptible loss in light transmission.

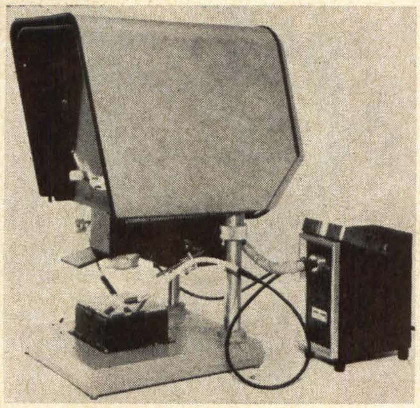
The superior transmittance of glass in the near infrared is cited by Dr. Walter P. Siegmund of American Optical Company, Southbridge, Massachusetts, as one of the advantages of glass fibers: Fig. 11 shows a spectral transmittance curve for a 6-foot length of a bundle of American Optical's fibers. Dr Siegmund also offers the following comments on the question of glass vs plastic.

"A certain kind of market is going to be especially effective for plastic fibers. Since they seem to be much less expensive in large quantities, volume markets such as the automotive will benefit from their availability. On the other hand, there are certain physical limitations with plastics which will limit their application, particularly where high temperatures are involved.

"In the visible spectrum, there is little difference between glass and plastic in the area of light loss. In glass, we have measured a loss of 7% per foot of length, somewhat greater in the blue end of the spectrum. Glass has a decided transmission advantage in the near IR, where it is very good out to at least 1.5 microns, although this limit is a function of fiber length. By comparison, the latest plastic innovations show quite strong absorption bands in the near IR, around 0.73 microns, 0.9 microns, and 1 micron.

"In the near ultra-violet spectrum,

Fig. 12 Spectral response of human eye and photodetectors (AMP)



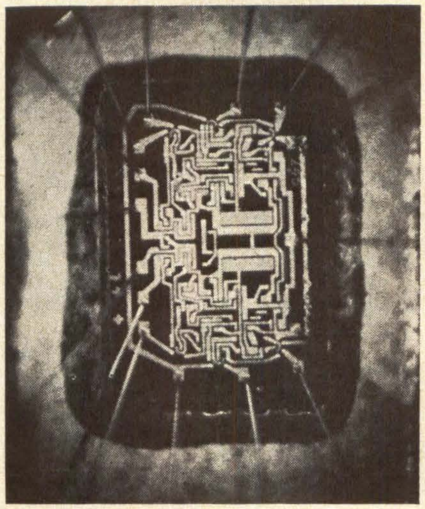


Fig. 13 Fiber Optics-Illuminated Comparator with magnified integrated circuit (right) (Iota Cam)

ordinary glass and plastic cut off about the same, around 0.38 microns for a 4 ft. length, although we offer one glass that goes out to about 0.34 microns.

"Another advantage of glass is the wide choice of refractive indices."

Mr. Russell E. Horton, Sales Manager of Mosaic Fabrications, Inc., Sturbridge, Massachusetts, comments on the cost question that "on similar applications, glass fiber optics can be competitive with any other known material which is used to make fiber optics. The majority of fiber optics components are custom made and the specifications vary tremendously from one application to another."

Fig. 12 illustrates (a) the spectral response of the human eye and (b) the response of some typical electronic components, for comparison with the transmittance curves of Fig. 10 (duPont Crofon) and Fig. 11 (American Optical glass).

AVAILABLE DEVICES AND SUPPLIERS

The available fiber optics devices may be roughly categorized as: noncoherent bundles (light guides), coherent bundles (image guides), and fused (coherent) bundles (faceplates). In describing available devices we shall also attempt to cover present applications areas; however, it should be noted that exhaustive coverage of applications is not possible due to the rapidly-expanding nature of the industry, the industrial secrecy involved in new proprietary developments, and the security classified nature of military applications (the present largest market). Fibers are being used in amusement parks, decorative lighting, tactical weaponry, data display and retrieval, process instrumentation, laser transmission (for ignition of explosives and propellants), high-voltage switching, photo-pens for computerized design and educational purposes, automotive and appliance illumination, data encoding and decoding, edge sensors, photometry, liquid-level sensors, plus a multitude of dental and medical applications. The three largest market categories are information systems, commercial instrument panels, and the medical/dental area.

To a considerable extent, present FO source companies operate as custom houses, or job shops, marketing just enough standard products to interest the large OEM accounts in volume purchases of custom-made components. As more investments are made in internally-developed products for broad consumption, this characteristic will change; however, it might be expected that there will always be a substantial custom nature to the business, much as there is in the wire-and-cable industry.

Noncoherent Bundles — Light Guides

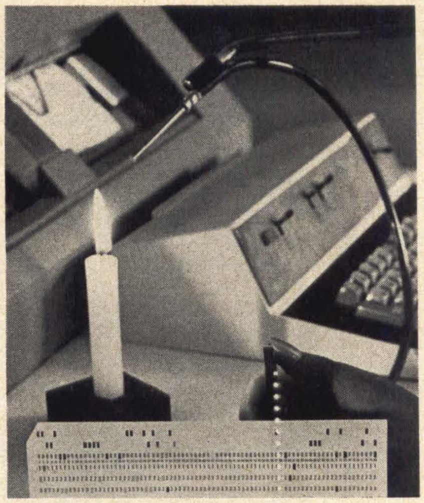
Noncoherent bundles are widely used to convey intense illumination either to or from space-limited and otherwise inaccessible physical locations. Several commercial units complete with light source and flexible fiber optics bundles are available for general applications where remote light is required. Typical is the Illuminator line offered by Poly-Optic (as was shown in Fig. 5). A built-in incandescent lamp excites the bundle and its output end may be placed at any convenient location and requires little more surface area than the light-producing bundle end. Typical bundles are ⅛″ diameter and produce a cone of illumination of 70° included angle.

Fig. 13 shows a fiber-optics-illuminated comparator, using an illuminator made by Iota Cam, used for integrated circuit inspection and manufacturing. The main advantage offered by fiber optics in this case is to allow up to 100 percent magnification without introducing measurable heat at the chip or inspection area, since the light source and its heat are located remotely from the inspection area. The insert shows a typical photograph taken from the ground-glass screen of the comparator.

The IBM 1442 card reader and IBM 59 verifier presently installed in hundreds of data processing systems employ fiber optics to route light to the 12 positions of the punched card detection system; phototransistors are employed to detect the presence or absence of punched holes as cards are moved past the reading station.

Fig. 14 shows the fiber optics bundles; the fibers are between 20 and 50 microns in diameter, arranged in bundles 0.9 mm in diameter. With a 60° included angle of divergence at the exit end, essentially all of the light from each bundle falls upon the surface of a 1.27-mm FO rod across a 0.3-mm gap through which the cards pass. At the far end of the larger rod a lens system and phototransistor converts the hole or no-hole into electrical information. IBM also employs fiber optics as a source of illumination in the IBM 1230, 1231 and 1232 optical readers to sense pencil marks on documents. In each case a single light source can be "shared" and used to illuminate a number of small areas thus offering much greater sensing resolution than could be achieved by depending on individual light sources.

The flexibility and efficiency of light-transmission of fiber optics bundles are put to good use by a num-



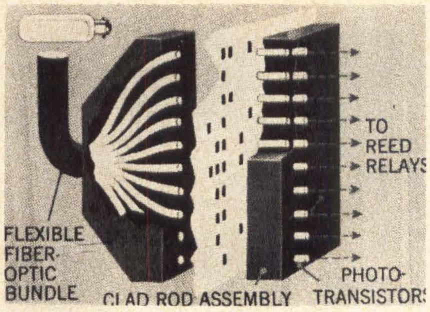


Fig. 14 Fiber Optics in a punched card reader (IBM and American Optical)

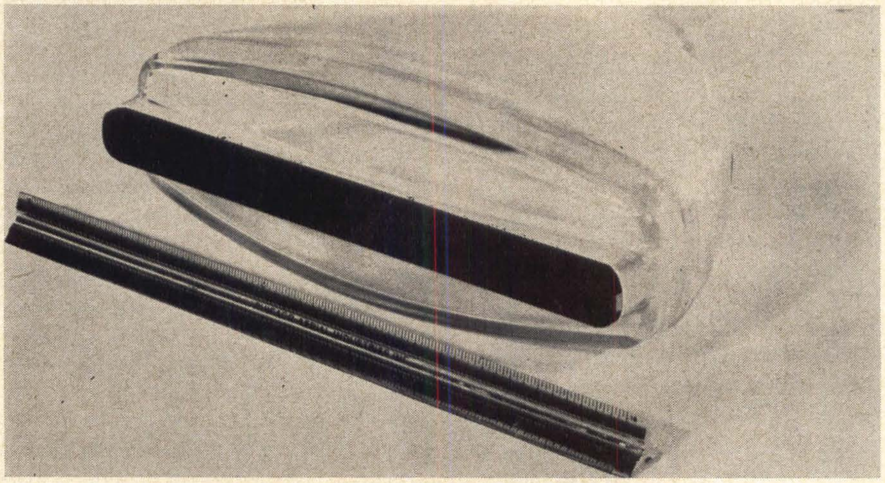


Fig. 15 Fiber Optics line scan CRT faceplate (Chicago Aerial)

ber of manufacturers of light pens that allow CRT display observers to "point to" selected areas of their displays for selective addressing. Exact coordinates are derived by the system since light reaches remote detectors at a particular time in the raster scan when the input end of the fiber optics bundles "sees" the scope beam. Noncoherent bundles are also used in monitor and control systems that require remote observations of light (and heat) conditions. Fire detection and visual remote "temperature" monitoring are excellent applications of noncoherent bundles where only the average color or intensity are important and there is no need to preserve the actual image of the source.

Coherent FO: Image Guides, Image Conduit, Fiberscopes

If flexible glass fibers are systematically arranged into a bundle, they will transmit an image which will be undisturbed when the bundle is bent. If the fibers are completely loose from each other (except at the ends), the bundle will be very flexible, and can be modified in any way between the two ends. If a lens is now mounted on one end so that it casts an image on the ends of the fibers, and an eyepiece is mounted at the other end so the fibers can be seen under some magnification, the result is a "flexible fiberscope." With such an arrangement, it is possible to see around a corner or into one's own ear. Useful endoscopes (medical fiberscopes) have been made in this fashion for looking into the human body.

A flexible fiber bundle having a useful cross-section of 0.3 inch x 0.4 inch made up of 2-mil (50 micron) fibers will contain about 30,000 fibers. If each fiber is considered to contain one image element, this is a fair quality picture, but not nearly as many image elements as are often found in other optical systems. A television picture, for instance, has about 250,000 image elements while the field of a microscope may have 500,000.

If the above fiber bundle is made up of fibers 15 microns in diameter, the number of image elements transmitted will exceed 300,000, i.e., comparable to television quality but short of microscope quality.

The American Optical Company has developed a technique, called "wavelength multiplexing," which uses dispersing elements, such as prisms, at each end of the fiberscope to improve the image quality.

This system encodes the information before it is transmitted through the fiber bundle and then it decodes the information at the exit end of the fiber bundle. Normally, each fiber in a coherent bundle transmits the light from one image point. In the wavelength multiplexing system, the light from a single object point is spread in a spectrum and is then picked up by a number of fibers. Therefore, information from any one object point is carried by many fibers and, if a single fiber is broken or misplaced, the image is not seriously impaired. A further advantage of the new system is that a full fiberscope is not required. That is, instead of a fiberscope consisting of 1,000 rows of 1,000 fibers each, American Optical claims that it is now possible to use only 7 rows of fibers and still obtain a full size image with full resolution. The method is called, "wavelength multiplexing" because each fiber acts as an information channel carrying information from several object points. The improvement in image quality comes about because information from any one object point is carried by many fibers and, therefore, the distracting effects of a broken fiber or the spaces between fibers are eliminated.

One type of problem to which flexible fiberscopes have been successfully applied is industrial inspection of hard-to-reach areas. Conventional borescopes have long been used to inspect the insides of tubes and vessels for defects in manufacture and wear. Their use has been limited, however, by the rigidity of the borescope. With the flexible optical system of the fiberscope many new inspection problems can be solved. In the manufacture and maintenance of aircraft or other complex structures it is often necessary or desirable visually to inspect critical areas which are not really accessible. In many such cases a fiberscope may offer the solution. The flexible sheath of an industrial type fiberscope suitable for such inspection problems actually contains two fiber bundles, one of which carries the image formed by the objective lens at the forward end of the device to the eyepiece and the other carries light from a small lamp located near the eyepiece to the field of view. A variable transformer supplies the lamp power. Medical fiberscopes are based on the same principles but generally are required to have much smaller diameters. The following are sample applications for fiberscopes, image guides, and other coherent FO bundles.

• The inspection of the gasoline level detector in an automobile fuel tank; in this case, the optical system, as well as the protective sheath, was designed to be used immersed in gasoline.

• Optical viewfinder for a photo-reconnaissance aircraft; because of the severe space problems in a particular high performance reconnaissance aircraft, it was felt that a fiber optic system might be designed which would occupy less space and could be more easily fitted to the existing structure than would a conventional optical relay system. One other mechanical consideration in this type of system is the requirement to withstand a variety of environmental stresses including high G-loading, shock, vibration, and the wide range of ambient temperatures and pressures characteristic of aircraft operating environments.

• On the Saturn V first-stage boosters, the image of what occurs inside the Lox oxidizer tank at critical flight points is relayed by fiber optics to a camera in an external pod; the camera is jettisoned and recovered at sea. Also in use on Saturn V, a quite unusual instrument is used to view two areas in the first stage engine with one "branched" fiberscope, and a single lens relays the output image to a TV camera, for relay to the ground; the objective lenses are behind special IR filters for protection from the ambient heat.

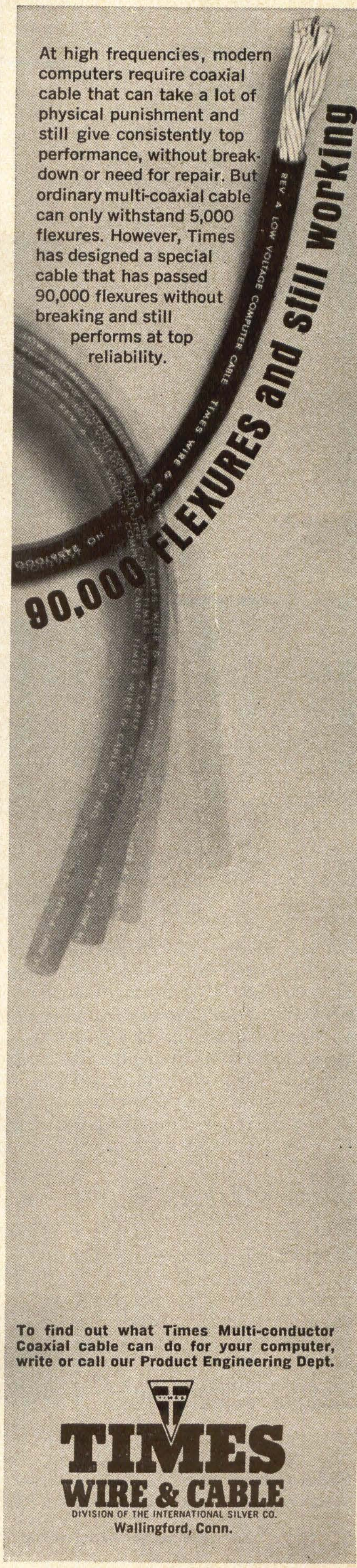
• Monitoring of electron beam welding.

Another interesting possibility with coherent FO is the creation of image rearrangement or scrambling devices. A coherent bundle may be arranged in one pattern at one end and in some quite different pattern at the other end. The arrangement at one end may be orderly and at the other end random, in which case the function might be called "scrambling." By this method it is possible to code a message so that it cannot be read without an identical bundle for decoding. It is not necessary, however, that the arrangement be random. The pattern at one end can be rearranged to conform to any other pattern at the other end. For instance, a round bundle might be used to catch the light of a star, and the bundle rearranged at the other end into a straight line to fill the slit of a spectrograph. For high-speed photography, a bundle with a picture projected on one end can be spread out to a straight line at the other end and a film moved rapidly past the linear end. In all of the above cases the picture can be recomposed by sending the light back through the identical bundle, or through a complementary bundle.

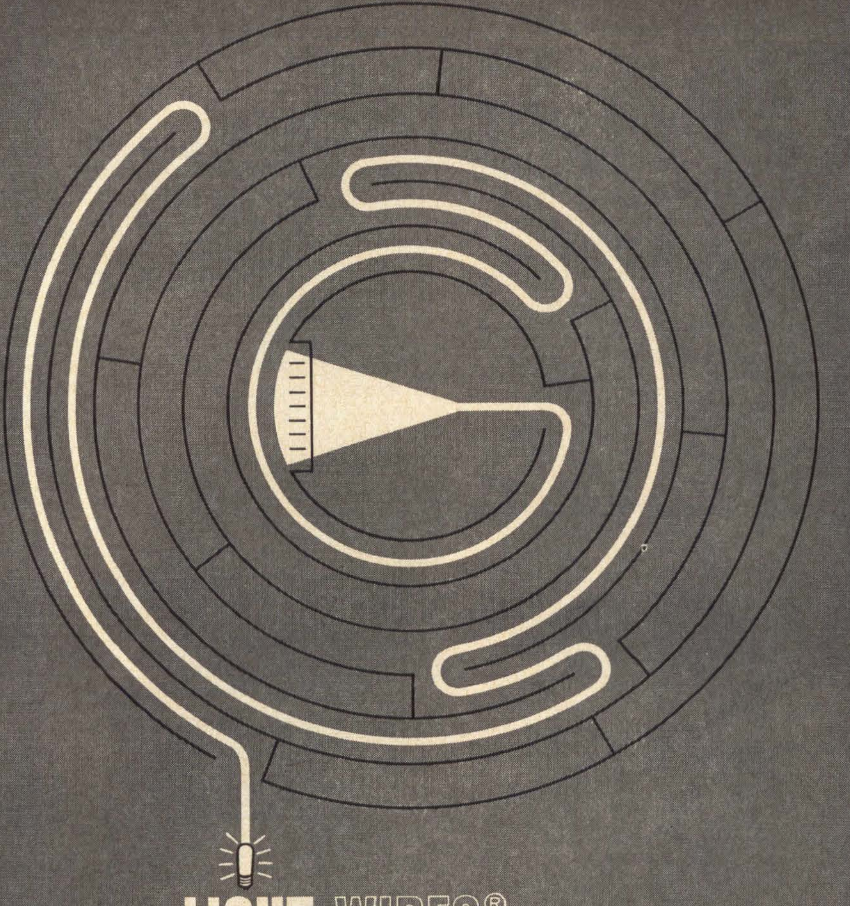
Fused Coherent Bundles — Faceplates, Field Flatteners, Image Intensifiers

The normal curvature of a cathode-ray-tube face can readily be "straightened" using fibers of appropriate length to align output ends of fibers whose input ends are in contact with the CRT face. This technique is especially useful in applications using a CRT light source for scanning and interpreting and as a modulated light source for printing on light-sensitive paper or film moving at right angles to the in-line fiber ends. For photographic fidelity, the output ends of the fibers can be maintained in direct contact with the flat film.

Another possible use for fiber optics in a CRT is in connection with visual display under conditions of high-ambient illumination. Ambient



CIRCLE NO. 30 ON INQUIRY CARD



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NOTE: *For applications requiring the transmittance of an image, Bausch & Lomb Coherent Light Wire bundles are available in any length up to 4 feet.*

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ADVANCING ELECTRONIC/OPTICAL INSTRUMENTATION

light falling on an ordinary CRT is diffusely reflected by the phosphor and reduces the contrast of the display. Under severe conditions the display is washed-out altogether. By means of a special type of fiber optic faceplate it is possible to reduce substantially the amount of ambient light which can reach the phosphor screen without significantly reducing the brightness of the display over a restricted viewing angle. Such a faceplate consists of fibers having a double coating and a relatively-low numerical aperture. Any light incident upon the faceplate at angles greater than the acceptance cone of the fibers (i.e., the viewing angle) is absorbed by this outer coating and never reaches the phosphor screen. An additional advantage of such a faceplate is the absence of parallax between the image on the phosphor and the face of the tube, thereby permitting more accurate measurements to be made on the image. Uses for this type of faceplate include radar or other CRT displays in an aircraft cockpit (where a hood is a hindrance to the pilot), in control tower operations or in any situation where high ambient illumination is a problem, and a restricted viewing angle can be tolerated.

Another advantage of fiber optic plates is the ability to flatten, or to curve deliberately, an image by modifying the surfaces of the plate; for example, in image intensifier tubes, CRTs, etc. This property of field flattening is particularly useful in electrostatically focussed tubes, in which field curvature results from the electron optics. The following are some sample applications of fused coherent bundles.

- The Navy's multi-mission AN/AWG-10 Weapons Control System includes a built-in self-test device which is located some distance away from the radar operator who must monitor its output; fiber optic magnifiers are used to provide the necessary wide cone of view that could not be achieved by conventional optical magnification.

- A fiber optic faceplate is used with the lunar TV camera as an image intensifier, helping to produce useful television pictures for relay to earth.

- Fiber optic magnifiers are ideal

CIRCLE NO. 31 ON INQUIRY CARD

Table 1

MANUFACTURERS' LITERATURE

A complete set of manufacturers' literature on fiber optics can be obtained by circling, on the reader inquiry card, numbers listed below.

COMPANY	READER INQUIRY NO.
American Cystoscope Makers, Inc., Pelham Manor, N. Y. (Glass fibers, light guides, image guides and fiberscopes)	120
American Optical Company, Southbridge, Mass. (Glass fibers, light guides, image guides and fiberscopes, coding bundles, field flatteners, magnifiers, and CRT faceplates)	121
AMP, Incorporated, Harrisburg, Pa. (Synthetic fiber optics assemblies using duPont Crofon, light splitters and collectors, remote illumination systems, coding-wheel programmers and shaft-position encoders)	122
Bausch & Lomb, Rochester, N. Y. (Glass fibers, light guides and illuminators, image guides and fiberscopes, tachometers)	123
Chicago Aerial Industries, Inc., Barrington, Illinois (Sub. of Bourns, Inc.) (Glass fibers, light guides, image guides, coding bundles, shape transducers, field flatteners, magnifiers, image intensifiers, and CRT faceplates)	124
Corning Glass Works, Corning, N. Y. (Glass fibers, light guides, image guides, field flatteners, magnifiers, image intensifiers, CRT faceplates)	125
Donner Electronics, Melrose, Mass. (Glass fibers, light guides, image guides)	126
E. I. duPont de Nemours Co., Wilmington, Del. (Synthetic fibers, light guides)	127
Flexi-Optic Laboratories, Somerville, Mass. (Glass fibers, light guides)	128
Iota-Cam Fiber Optics Corp., Wakefield, Mass. (Glass fibers, light guides, light pens, illuminators, comparator for IC inspection)	129
Mechanical Technology, Inc., Latham, N. Y. (FO assemblies, light guides and probes, read heads and scanning heads for displacement measurement)	130
Mosaic Fabrications, Inc., Southbridge, Mass. (Sub. of Bendix Corp.) (Glass fibers, light guides, remote monitors, image guides, image conduit, imagescopes, field flatteners and faceplates)	131
Northrop Corp., Nortronic Div., Beverly Hills, Cal. (Fiber Optic data link)	132
Optic Technology, Inc., Palo Alto, Cal. (Glass fibers, faceplates)	133
Poly-Optic Systems, Inc., Santa Ana, Cal. (Synthetic fibers, light guides and illuminators, branched arrays, tapered guides, image guides, converters, lenses)	134
RCG Corp., Billerica, Mass. (Light guides, light pens)	135
Sensor Precision Industries, Inc., Medfield, Mass. (Glass light guides)	136
Sylvania Electric Products, Inc., Seneca Falls, N. Y. (CRT with FO faceplate)	137
Welch Allyn, Inc., Skaneateles Falls, N.Y. (Read heads, mark-sense devices, light pens)	138

for film enlargers, photoelectric exposure systems, and other critical viewing applications that demand precise image enlargement and transfer. They also find use in situations where mechanical stress, dirt, dust, and other contaminants exclude the use of other optical systems; cases in which input and output are not planar are easily solved by appropriately-contoured fiber optic magnifiers.

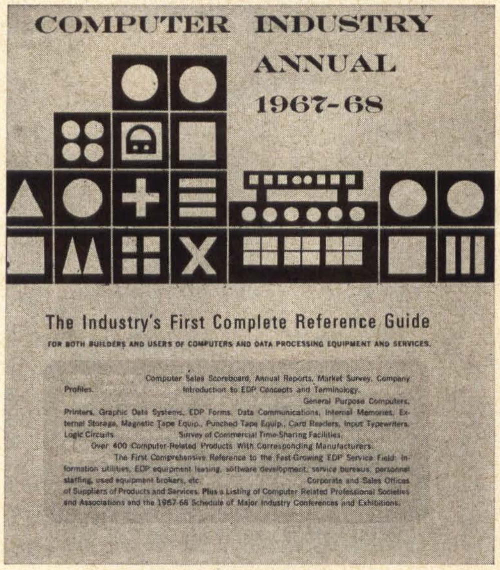
• A fiber optic faceplate which brings the intensity modulated line display of a line scan CRT to the front surface, eliminating parallax. By moving photo sensitive paper past the line scan, contact prints can be generated of photos, charts, or other information (see Fig. 15). This tube is expected to have application in copying equipment, automatic printing equipment, telemetering systems, and computer communications and read-out systems.

WHITHER FIBER OPTICS?

The information systems industry is recognized as a major potential user of fiber optics. As the ability of the FO industry to produce useful fiber configurations at attractive prices increases, the data processing equipment designer will find many ways in which light circuits can replace electrical circuits or electromechanical assemblies. The ability to combine "bits" of light from a number of sources into a compact image suggests a number of special-purpose applications. The ability to sense light from a number of sources by a single detector suggests an OR function. The ability to transmit light intensity and color information suggests still another series of applications. Fiber optics can be used to sense movement — or lack of movement — in continuous-processing monitors. It has applications wherever optical monitoring makes sense, to study changing shape, size, color, or position. In viewing devices, it may also have quite specialized uses, in looking around a corner, or into a crevice, and the recent concern with time-sharing and the man-machine interface may well lead to new uses for this emerging technology.

MANUFACTURERS' LITERATURE

Table 1 contains a listing of all companies known to be supplying fiber optic materials and devices, with a summary of their products. Full sets of descriptive literature can be obtained by circling the appropriate reader inquiry numbers in Table 1.



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COMPUTER SCIENCE RESEARCH REVIEW

Annual report in selected essay form of highlights in research in information processing for 1966 at Carnegie Institute of Technology.

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COMPUTER TECHNOLOGY

A review of Soviet developments in computer technology. Forty-five abstracts from Soviet open-source literature are arranged alphabetically by author within each of the following categories: components, design, applications, and associated systems. An author listing is included.

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A HANDBOOK FOR ESTIMATION OF COMPUTER PROGRAMMING COSTS

Based on experience and rules of thumb to date, this handbook provides the operating manager of computer programming projects with a methodology and data that can help him forecast resources required and incorporate these estimates into cost evaluation studies, project plans, and cost control systems. The handbook gives guidelines for estimating resources; i.e., man-months, computer hours, and months elapsed, to be used in conducting the six activities which constitute the programming process. The activities are preliminary planning and cost evaluation; information system analysis and design; computer program design, code, and test; information system integration test; information system installation and turnover; and computer maintenance. Each activity is treated as a separate section of the handbook and includes a list of cost factors with an indication of their influence on costs and planning factors. Although far from comprehensive, the handbook, the authors feel, can fill a void with useful guidelines which can be kept dynamic with personal experience of the user adapted to individual needs.

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NEW PRODUCTS

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The best features of both thin-film and monolithic technologies have been combined to produce an extremely high density microminiature sense amplifier package. The degree of miniaturization and performance could not have been achieved by either the thin-film or monolithic technique alone, according to the manufacturer. The sense amplifier consists of an integrated circuit, a thin-film input threshold circuit, and a thin-film transistor output stage. Three sense amplifier circuits are contained in a single 3/8 x 3/8 x 0.070 14-lead flat pack. Initial production is underway in support of the core memory requirement. Halex, Inc., El Segundo, Cal.

Circle No. 234 on Inquiry Card

PUNCHED TAPE STATION

New punched tape processor station offers, in one convenient location, a punched code registration gauge, a precision punched tape splicer, a manual tape punch, and two manual winders. This flexible processor handles 5, 6, 7, and 8 channel code punched tape. With the two manual winders, the operator can wind in either direction. The addition of a center feed unwinder to the processor station allows the selection of either end of the tape in one operation. Other optional equipment is available with the processor, such as attachments for Teletype and for NAB hub reels. Data-Link Corp., Los Altos, Cal.

Circle No. 238 on Inquiry Card

INCREMENTAL RECORDER

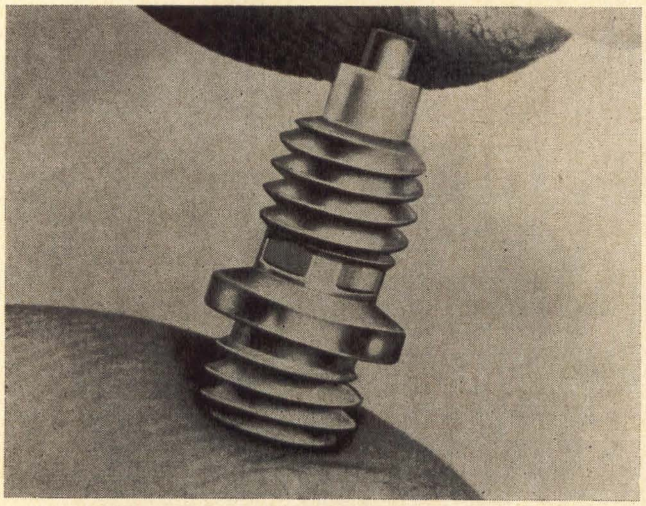
New incremental magnetic tape digital input/output recorder features the ability to accept data from slow input devices for fast output. The integral unit can asynchronously record and reproduce eight bit parallel characters at any rate up to 120 characters per second. The same unit will record or read characters at a synchronous (continuous) rate of 1600 characters per second, allowing it to be efficiently connected to the communications input/output channels of most computers. Buffering is provided on a removable 3″ diameter reel of 1/4″ wide magnetic tape. Data capacity of this reel is 140,000 characters (40 eight bit characters per inch using 800 bit per inch density). A special dual storage feature allows larger capacity. Tally Corporation, Seattle, Wash.

Circle No. 242 on Inquiry Card

4-LINE READOUT

A digital display and decoder/driver unit operates directly from integrated circuits due to the low-level input requirements. Only 4 lines from BCD logic signals are required reducing wiring costs. Both the display and decoder/driver operate from a single supply consisting of full-wave rectified line voltage obtained from a 4-diode bridge rectifier. Regulation and filtering are not required. M. B. Associates, Philadelphia, Pa.

Circle No. 262 on Inquiry Card



TEST POINT CONNECTOR

A new test point connector is said to offer an extremely high degree of stability and uniformity of insertion and retention values and is considered to be a major in its field. This miniature device for use with an 0.031″ dia. pin has extensive applications in the testing of computer electronic circuits. The body of the test point is silver plated brass, and the insulator is Teflon. A stamped, wrap-around type contact of gold-plated, heat-treated beryllium copper is utilized as opposed to screw machine type contacts normally used. Hugh H. Eby Company, Phila., Pa.

Circle No. 246 on Inquiry Card

A-D CONVERTERS

A new analog multiplexer-quantizer which can be computer-controlled is capable of accepting as many as 128 different analog signals, performing 12-bit analog-to-digital conversion on each, and providing a multiplex output suitable for data-logging applications or computer entry. The new instrument, named the 2701, is said to be ideal for handling multiple FM discriminator outputs, in an FM telemetry system, where eventual data processing will be done by a digital computer. Under either manual or computer control, the 2701 receives inputs directly from analog data sources such as FM discriminators; it converts the data into 12-bit parallel binary words as sampling speeds selectable up to 60,000 sps, and outputs binary words. Under control of a computer program, the 2701 can address data channels in any order or sequentially, synchronously, or asynchronously. EMR Telemetry Div., Sarasota, Fla.

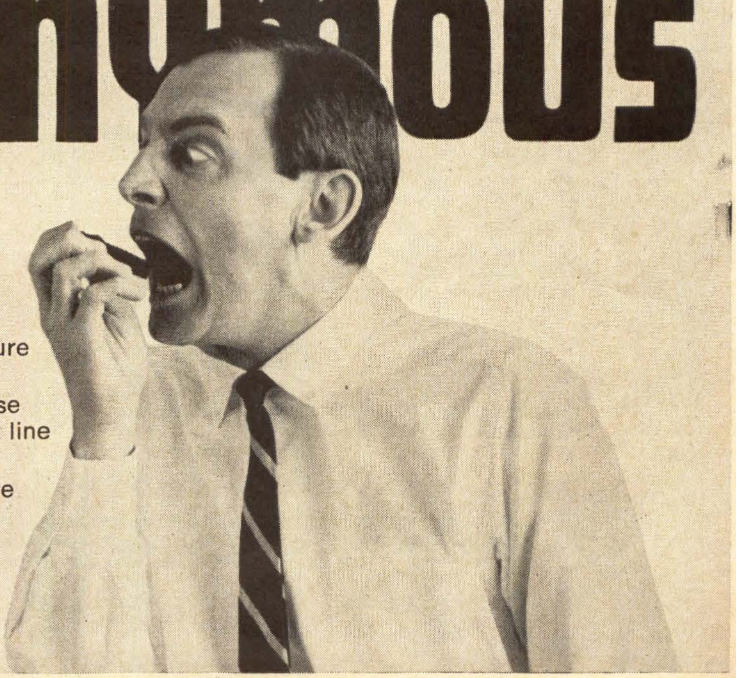
Circle No. 231 on Inquiry Card

DISPLAY DEMONSTRATOR

A portable, fully-operative demonstrator that includes several types of lighted pushbutton switches, word indicator lights, and unlighted pushbutton and toggle switches is now available for desk-side inspection by design engineers concerned with the man-machine interface aspects of information display and control. The demonstrator was designed to provide a means of quick comparison of various units under actual operating conditions, and to assist in determining proper light levels for optimum visibility under known ambient light conditions. Each switch series is displayed to show the key functional features, mounting methods, wiring requirements, and ease of maintenance. A master dimming switch controls the light intensity making it possible to determine the proper color filter value and intensity required. The small size of the demonstrator permits its placement on or near actual prototype equipment to achieve the effect various switch types or colored lens arrangements would create. Master Specialties Co., Costa Mesa, Cal.

Circle No. 258 on Inquiry Card

OP-AMPS ANONYMOUS



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Do as thousands of successful men have done. Use Fairchild's all-new linear integrated circuit product line to achieve Total Monolithic Integration.

For helpful data kit, including instructional brochure and free 24" x 31½" poster, contact:

OP-AMPS ANONYMOUS

Fairchild Semiconductor, P. O. Box 1058,
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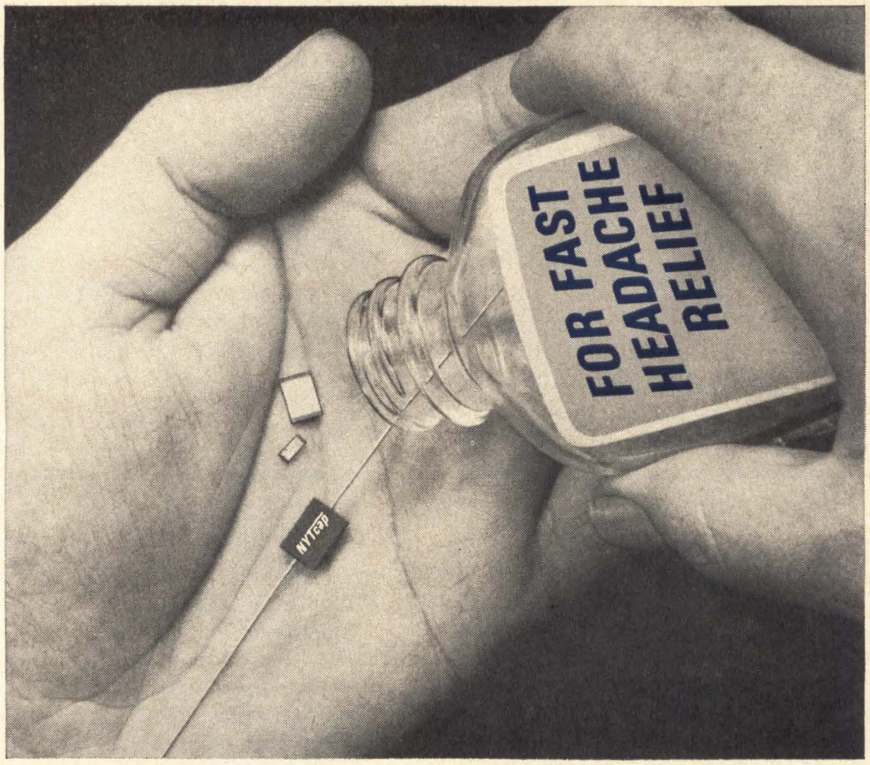

Cure for circuitry headaches

Solve your critical circuitry problems with two extraordinary new miniaturized ceramic capacitors — the product of Nytronics research and development in the continuing pursuit of excellence.

New NYT-CHIP, an ultra-stable chip capacitor, has such advantages as superior packaging flexibility and mounting versatility, particularly for outboard mounting on integrated, thick and thin film circuitry. Dimensions, with tinned terminals, 0.170" x 0.065" x 0.070", with capacitance range of 4.7 pf through 220 pf, and 0.280" x 0.195" x 0.070" for 270 pf to 4700 pf.

NYT-CAP, an ultra high stability ceramic capacitor series is packaged in a miniature molded epoxy tubular package 0.1" diameter by 0.250" in length, with capacitance range of 4.7 pf to 220 pf. The remainder of series in miniature, molded epoxy case 0.350" long by 0.250" wide by 0.1", with a range of 270 pf to 4700 pf.

Both NYT-CHIP and NYT-CAP have a temperature coefficient that does not exceed ±40 ppm/°C over temperature range of —55°C to +125°C, and working voltages of 200 D.C.

As a pioneer in the concept of standardization, Nytronics maintains large volume inventories of these two products, as well as of many other standardized high quality components: inductors, delay lines, and resistors. Write for complete engineering data.

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CIRCLE NO. 34 ON INQUIRY CARD

NEW PRODUCTS

ELECTRONIC KEYBOARD

An electronic keyboard system features a solid-state encoder, actuated by a set of keyboard switches which are similar in feel and travel to electric typewriter keys. For each key pressed, the encoder generates a corresponding code for entry into a computer, tape punch, information retrieval system, or other data handling or display system. All switch action occurs on the downstroke, allowing faster typing speeds. The encoder can easily be adapted to virtually any application which requires digital encoding of alphabetic, numeric, or other characters. The keyboard system will accommodate any code up to eight levels. Transistor Electronics Corp., Minneapolis, Minn.

Circle No. 218 on Inquiry Card

AUTOMATIC DRAFTING MACHINES

New automatic drafting machine systems work off-line with a computer or can be manually programmed. The Mark II Model 1215 offers speeds of 200-400 imp and accuracy of ±0.002" to ±0.004", using a standard 4' x 5' drafting table. A special table gives 0.001" accuracy at speeds of 100-260 imp. Optional equipment includes a magnetic tape input unit, photo exposure head designed for use in the production of integrated circuits; a 90-symbol printing head and revolving turret allowing 6 pens to be indexed and controlled by control units; an integrated digitizer unit allowing both digitizing and drawing; and a vacuum chuck arrangement to hold paper on table surface. Storage capacity is 1048", using tape code 8 channel punched tape, 300 character reading per second. Automatic and semi-automatic operation is provided for with reverse movement of direction, error detection, and coordinate switching. Baldwin Kongsberg Co., Cincinnati, Ohio.

Circle No. 217 on Inquiry Card

RUGGED TAPE READER

New bi-directional photoelectric tape reader was designed to meet military applications where severe environmental conditions are not present, but where high performance and reliability must be maintained. Designated Model 500 RF/10, the new reader is designed for such military use as non-portable checkout and test equipment, or for commercial requirements such as numerical control applications where a higher degree of reliability is required than can be met by standard readers. Unique features of the new reader include: tape movement controlled by closed loop servo utilizing single capstan printed motor; variable speed capability (from 100 to 500 char/sec); proportional reel servos; two 10½ inch spoolers mounted within frame of standard 19 inch rack requiring maintenance with no adjustments. Photocircuits Corp., Tape Reader Div., Glen Cove, N.Y.

Circle No. 206 on Inquiry Card

SPACE MEMORY

A militarized memory no larger than a thirteenth of a cubic foot was designed for airborne and space applications. Called the Severe Environmental Memory System (SEMS 5), it is said to have the optimum combination of high speed and minimum power, weight, and size. It consumes less than 60 watts of power at its maximum operating speed, and 10 watts on standby. Maximum speed is 700 nanoseconds access and 2 microseconds cycle time. The system weighs less than 7 pounds and has a volume of only 128 cubic inches. It stores 4,096 words of 32 bits each. It is also available with storage capacities of from 256 to 16,384 words, from 8 to 32 bits. Integrated circuitry is used for logic, sense amplifiers, address decoders, data, and address registers. Both clear/write and read/restore are standard modes. Logic interface is TTL positive true. Electronic Memories, Hawthorne, Cal.

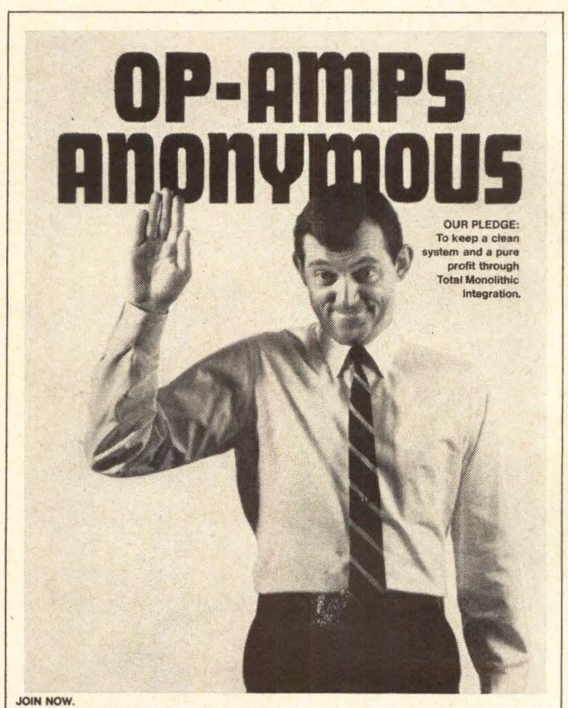
Circle No. 219 on Inquiry Card

IC TEST SOCKETS

A new series of dual in-line IC test sockets were designed to accept packages with up to 24 wire, flat or rolled leads, interchangeable. The contact design of the new series is said to allow extremely easy device insertion and withdrawal. No special extraction tool is required. The new series offers a choice of four standard entry patterns for 0.200 or 0.300 centers or a single unit combination of the two. The sockets are equally well-suited for hand test or for burn-in. Their low profile allows high density placement for multi-socket installations. Socket body material is temperature and abrasion-resistant polysulfone. Contact material is tempered beryllium copper gold-plated. Minimum lead length accepted is 0.1″ and standard termination may be dipped or hand soldered. The socket may be either riveted or screw-mounted to a PC board. Textool Products, Inc., Irving, Texas.

Circle No. 204 on Inquiry Card

Join today. Get your free poster.



A simple inquiry makes you a member of Op-Amps Anonymous. You get a free 24″ x 31½″ poster plus a complete Linear Integrated Circuits Data Kit (data sheets on all Fairchild Linear Integrated Circuits, specs on new circuits, circuit designs, cost-performance comparisons and information on how to simultaneously cut costs and upgrade analog systems). Hurry, while the supply lasts.

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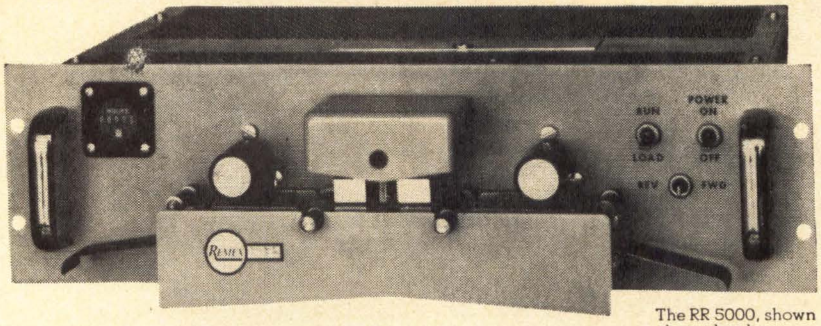

The RR 5000, shown above, has been selected for future Surveyor shots.

109,534 commands without a single error.

For just one little trip to the moon, custom-made Remex tape readers processed all instructions, mid-course corrections and camera direction for the Surveyors. And never made a mistake. That's what we mean by predictable accuracy. And it's built into every Remex reader and spooler. It means a lot in the down-to-earth world of electronics.

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CIRCLE NO. 36 ON INQUIRY CARD

NEW PRODUCTS

PERFORATOR TAPE

Expanded line of Mylar reinforced, opaque perforator tapes includes thicknesses from 0.0043″ to 0.0015″, suitable for both photoelectric and electromechanical readers. The company states that its exclusive laminating process gives the tape exceptional strength and dimensional stability. When perforated, the tapes can be read indefinitely. There is no deformation or elongation of code or signal holes. The tape is available in 11/16″, 7/8″ and 1″ widths in a full range of standard colors; wound on 2″ I.D. cores in measured lengths without splices. The line includes paper/Mylar/paper, Mylar/foil/Mylar and metalized Mylar combinations. Arvey Corp., Chicago, Ill.

Circle No. 215 on Inquiry Card

CONTROL MODULES

High-speed, noise-sensitive computer electronics or awkward relays impose limits in all kinds of process control design. These limits affect the simplest transfer as well as the most sophisticated numerically controlled system. A new low speed, noise-immuned family of industrial control logic circuit modules is said to push back those limits. The modules' upper frequency range is 100-KHz with provision for reduction to 5KHz for maximum noise immunity. English (non-inverting) logic or NOR logic can be built with the modules. The hardware has been specifically designed for standard NEMA enclosures. According to the manufacturer check-out and trouble shooting is easy. Every system input and output has an indicator light at its screw terminal. A special test probe provides its own local illumination and built-in indication of transients, as well as steady states. Every point in the system is a test point, and consistent pin assignments reduce the need to consult prints. Digital Equipment Corp., Maynard, Mass.

Circle No. 207 on Inquiry Card

OPERATIONAL AMPLIFIER

A high-speed FET operational amplifier with differential input offers the combination of fast settling time (less than 1.5 μs) and extremely high input impedance (10^{11} ohms). This combination is said to make the unit very attractive as a buffer for A/D and D/A converters and solid-state multiplexers. The unit's lightweight (2.0 oz. maximum) and small size (1.2″ x 1.8″ x 0.6″) are additional advantages in using high-density packaging. Other specifications include an output voltage and current of ±10 v and ±20 ma; input bias current of less than 100 pa; voltage drift of ±15 $\mu v/°C$ maximum; unity gain bandwidth of greater than 10 MHz; and a slewing rate of 30v/μsec (min). Burr-Brown Research Corporation, Tucson, Ariz.

Circle No. 209 on Inquiry Card

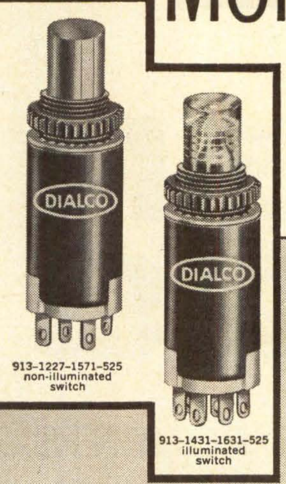
IC CARDS

Stock 4″ x 4″ glass epoxy module cards for integrated circuit prototype construction are intended to help the designer prove out his circuitry ideas with a minimum of time and expense. Sold primarily as a designer's tool, the cards are adaptable to some small production runs. Four socket patterns are currently in manufacture, including dual in-line. Circuit patterns available, in addition to the dual in-line, are: 8 pin TO-5; 10 pin TO-5; and flat pack (customarily for military usage. The same models with power connections in place are optionally available. A partial list of applications includes counters, shift registers, adders, subtractors, and other digital and linear assemblies. In use, the required integrated circuits are soldered to the printed circuit board, and interconnecting leads soldered in holes provided. Terminators (44 total) are standard 22 position double read-out edge tabs to accept standard receptacles and connectors. Contacts are gold plated with standard 0.156″ spacing. There is a copper ground plane on the component side. Elgin Electronics, Inc., Erie, Pa.

Circle No. 244 on Inquiry Card

NEW 913 SERIES ILLUMINATED

MOMENTARY ACTION SWITCH



913-1227-1571-525 non-illuminated switch

913-1431-1631-525 illuminated switch

For Computer, Data Processing and Automation Industries

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Here's another new Switch Series from Dialco—foremost manufacturer of indicator lights!

This series offers S.P.S.T. double break, N.O. or N.C.; or S.P.D.T. double break (one N.O., one N.C.) switching; with or without non-replaceable neon lamp and required resistor.

For use with low currents at higher voltage—or for dry circuits, ratings are: 0.1 amp, 125V AC; 0.1 amp, 30V DC (non-inductive). Life is over one million operations (approx.). Terminals are gold plated.

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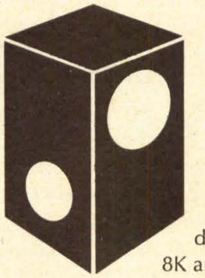
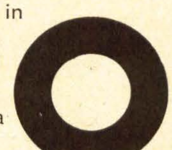
Two Ways to Remember



BIAX® AND CORE MEMORIES FROM RAYTHEON COMPUTER

Raytheon Computer now makes DRO core memories as well as NDRO BIAX memories. The new 300 Memory System is a 900 nanosecond, 2½ D core memory for large capacity, high-speed random access storage. Systems come in 8K and 16K modules with word lengths to 72 bits and are delivered complete with power supply and built-in self-tester. If you need an 8K or 16K memory with 28 bits or less, we can ship you a system in just a few weeks.



Since the first of this year, engineering sales representatives throughout the U.S. and Canada have been primed on both core and BIAX memories. If you'd like fast answers on prices, technical details and delivery, call any one of them today. Raytheon Computer, 2700 S. Fairview St., Santa Ana, California, 92704 • (714) 546-7160

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and SYSTEMS

CAPABILITY

The four largest manufacturers of computers and several related equipment manufacturers are using Welch Allyn fiber optics systems. These products include: card and tape read heads, mark-sense and special reflective devices, and light pens for graphic display systems. Welch Allyn draws upon fifty years' experience in producing precision illuminated medical instruments.

CAPACITY

Production of over a quarter million fiber optic units in the last five years has made Welch Allyn a leader in the fabrication field. We have the capacity—right now—to meet your fiber optic requirements by the hundreds or thousands.

CREATIVITY

We offer you the ability to design complete glass or plastic fiber optics systems including Welch Allyn-made lamps and sockets. Our unique fiber optic encapsulation processes offer you uniform, element-proof, and less expensive products. Our engineering and prototype department is anxious to solve your fiber optic requirements.

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CIRCLE NO. 39 ON INQUIRY CARD

NEW PRODUCTS

THUMBWHEEL SWITCHES

A line of thumbwheel switches for use in single-pole double-pole, or 4-pole switch applications offers convenient preset control of digital information. Visual indication of the setting is by easily-read characters on the thumbwheel. The switches may be used for binary decimal coding or decoding, or for straight decimal circuitry. They are also available for special functions. A built-in decoding diode gate in the rotor eliminates the need of mounting small diodes and running extra equipment leads on the part of the user. The use of four independent wipers makes them readily adaptable to individual circuit requirements. For modular mounting, standard facades are available to accommodate from 1 to 9 switches in cascade on ½" centers. The A. W. Haydon Co., Waterbury, Conn.

Circle No. 201 on Inquiry Card

MIDGET POWER SUPPLIES

A new line of "midget" power supplies is said to offer a high degree of voltage regulation at low cost. The new units provide regulation within 0.01% and sell for under $100.00. They cover a range from 0 to 50 volts and 100 to 300 ma. Both notch units and wide-range programmable models are available. The slim profile and small size (1⅞ x 3-7/16 x 4¾ in.) of the units are said to make them especially suitable for IC applications. They can be mounted on either of two faces to permit mounting within a 2 in. or 3½ in. space. The units also feature a new dual-purpose connector that allows connection either by soldering to terminals or by plug-in to PC connector which may be removed and mounted to user's chassis. ACDC Electronics, Burbank, Cal.

Circle No. 224 on Inquiry Card

AUDIO RESPONSE UNIT

Film-drum audio response system is capable of reciting as many as 189 different words in any sequence on computer or manual command. It is said to have unlimited multiplexing capability. The new equipment operates with no physical contact between the recording surface and sensing means. Heart of the system is a photographic film memory drum with the required vocabulary pre-recorded on it. A light source and aperture provide a narrow light beam that is directed through the rotating memory drum. This light beam is modulated by the pre-recorded audio information on each track and detected by silicon photocells inside the memory drum. The unit has one cell for each recorded track on the film. The output of the photocells is then amplified to a level compatible with the associated audio systems or fed directly to telephone lines. This method is said to result in very high audio fidelity with frequency response within 3 db from 300 Hz to 4 kHz. Models include binary decoding matrices and logic for digital message selection. In addition to the normal message tracks, each drum contains a "once-around" timing pulse track. Cognitronics Corp., Briarcliff Manor, N.Y.

Circle No. 248 on Inquiry Card

THERMOCOUPLE COMPENSATION

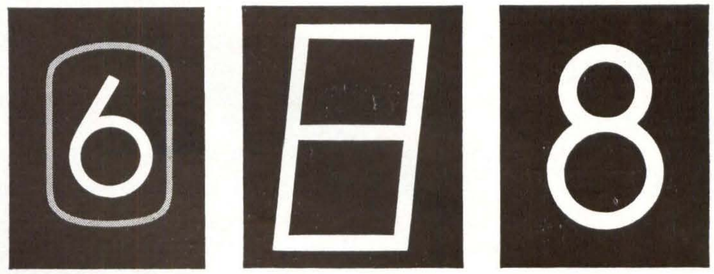
New thermocouple cold junction compensator was designed to mount on a printed circuit card. Essentially, the unit is half of a Wheatstone Bridge. When matched with the other part of the bridge in a typical instrument circuit, it compensates voltage to provide a measurement reference at the cold junctions of thermocouple. The device weighs 5 grams and consumes only 50 microwatts of power when made for chromel-alumel thermocouple wire. It warms up instantly, provides a nominal output reference of 11.0 mv, and operates in ambient temperatures of −55C to +125C. Compensation accuracy is ±50 mv. Consolidated Ohmic Devices, Inc., Carle Place, L.I., N.Y.

Circle No. 259 on Inquiry Card

READOUTS

We also make indicators, switches, keyboards, panel displays, in-line displays and CRT displays.

WHICH TYPE FOR YOU?



NEON DISPLAY TUBE SEGMENTED DISPLAY PROJECTION DISPLAY

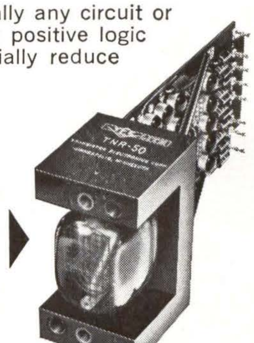
NO MATTER...TEC-LITE DRIVERS CONTROL THEM ALL!

TEC-LITE Digital Readouts (the type is up to you) offer almost limitless circuit flexibility to fit your needs. For integrated or discrete component circuitry. Usually designed to operate from decimal input or from 8-wire or 4-wire 1, 2, 4, 8 binary coded decimal input. Nearly all input codes can be accommodated.

Solid state gated memory available to fit virtually any circuit or system requirement, accommodating negative or positive logic and strobe pulses. Special techniques substantially reduce assembly time—and prices.

TNR SERIES—Transistorized Digital Readout and NIXIE® Tube

Pick the quality to fit your specs: TNR-10 and 30 Series are completely enclosed, military quality devices with metal can transistors; TNR-40 and 50 Series —computer quality—offer same functions, but simplified design and epoxy/ceramic encased transistors reduce price 40%; TNR-41 and 51 Series control low cost side viewing NIXIE tube. TNR Readouts are priced as low as \$23.51 with tube in 100-299 quantities.



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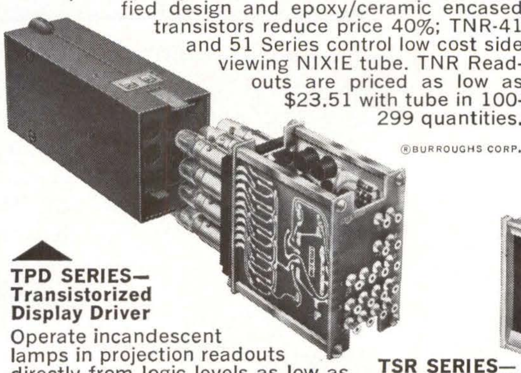
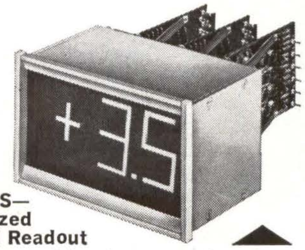


TPD SERIES—Transistorized Display Driver

Operate incandescent lamps in projection readouts directly from logic levels as low as 1 ma.—special relays, level converters or power amplifiers not required. Fast, silent, highly reliable. Does not create transients on signal lines normally found with relay-type lamp control devices. Drivers priced from \$41.25 in 100-249 quantities.



TSR SERIES—Transistorized Segmented Readout

From the front, side, above or below—better, brighter digital display. Greater wide angle visibility with bright no-gap characters. High, constant illumination level. Priced from \$32.25 in 100-299 quantities.

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Nobody has made custom power supplies longer than Varo.

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Funny?

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VARO

CIRCLE NO. 41 ON INQUIRY CARD

NEW PRODUCTS

IC LOGIC MODULES

A new line of integrated circuit logic modules is based on NAND logic. High system packaging density is achieved through use of a 62-pin connector allowing more functions per board and simplified gating rules. This is said to result in simplified wiring, fewer modules, low noise, and lower cost. The utilization of unique function grouping and gating rules (a "Logic Primer" outlining the essentials of logic implementation is available) result in the most economical logic implementation. Designated the 13-Series the logic modules operate from a single power supply providing +6 vdc; logic levels are +6 v true and O v false. Other specifications of the 13-Series line are operating speed of 5 MHz (10 MHz possible with one-level gating), standard load unit of 1.8 ma at 25C, and a noise rejection greater than 1 volt. A complete line of companion equipment can also be supplied. Canoga Electronics Corp., ADC Digital Products Div., Chatsworth, Cal.

Circle No. 223 on Inquiry Card

SOLID TANTALUM CAPACITORS

Solid tantalum capacitors are available in three different case sizes with a total of 41 ratings ranging from 0.0047 MFD at 35 WVDC to 68 MFD at 2 WVDC. Dissipation factor has been reduced to 6% and maximum leakage of case size CT has been reduced to .05 microamps. The capacitors are of entirely dry construction which means no electrolyte leakage. Components, Inc., Biddeford, Me.

Circle No. 208 on Inquiry Card

PRECISION RESISTORS

A new series of ceramic-encased, oil-filled, precision wire-wound resistors is said to be applicable anywhere precision resistance values, long-term stability, low temperature coefficient of resistance, and precision retrace capability are needed. The ceramic case of the new resistors yields high stability (within ±2 ppm per year). A special vacuum oil-filling technique achieves a temperature coefficient of resistance as low as 0 ±1 ppm and retrace capability characteristics within 0.0005%. Resistance Research Co., Pasadena, Cal.

Circle No. 216 on Inquiry Card

DIGITAL TEST RECORDING

A digital accessory for its Visicorder oscillographs and a companion converter unit that presents digital data in serial format have been characterized as two major advances in direct-print recording technology. The new printer makes it possible to record, with a single galvanometer, a column of digital data simultaneous with analog records. The companion converter gives users of the printer an optional mode for presenting the digital information. A key feature of the printer is the unique dual-beam principle employed to record digit characters with a single galvanometer. Using standard high-frequency galvos, printing rates of up to 2000 lines per second are possible. The converter unit is capable of converting six channels of parallel data into one channel of serialized output data to the printer. Only one galvanometer is used to record a 6-digit number. Integrated circuit logic is used extensively in both the printer and converter unit. The galvoprinter has built-in memory circuits to accept data of a minimum 1-microsecond duration. The print command signal may range from 200-nanosecond pulse to dc. Less than 1.0 microsecond is required to start the print cycle after command is given. Both data and print signals are locked out during the printing cycles. The printer accepts standard 8-4-2-1 BCD inputs and can be easily modified for other BCD codes. Honeywell, Inc., Test Instruments Div., Denver, Colo.

Circle No. 205 on Inquiry Card

CIRCLE NO. 42 ON INQUIRY CARD →

This is the vintage year for BURGUN-D™ connectors.

These sparkling new Mark IV D-Subminiatures are *low-cost* connectors with *rear release, crimp snap-in* contacts. They're intermateable and intermountable with existing D-Subminiatures. The wine-colored insulators we selected enhance the connector as well as your equipment.

Robust BURGUN-D Mark IV connectors operate in temperatures up to 250°F. They are ideal for plug-in module applications, cable-to-cable and cable-to-panel installation, computers, business machines and many other commercial applications.

Value analysis will tell you they're low in price because of highly developed pin and socket contacts. The contacts are available in two sizes (which accommodate 18 through 24 AWG stranded wire) and may be ordered separately. Contacts are rear inserted and extracted with a simple expendable plastic tool that's shown above. Closed-entry socket insulators correct any misalignment of pins during engagement.

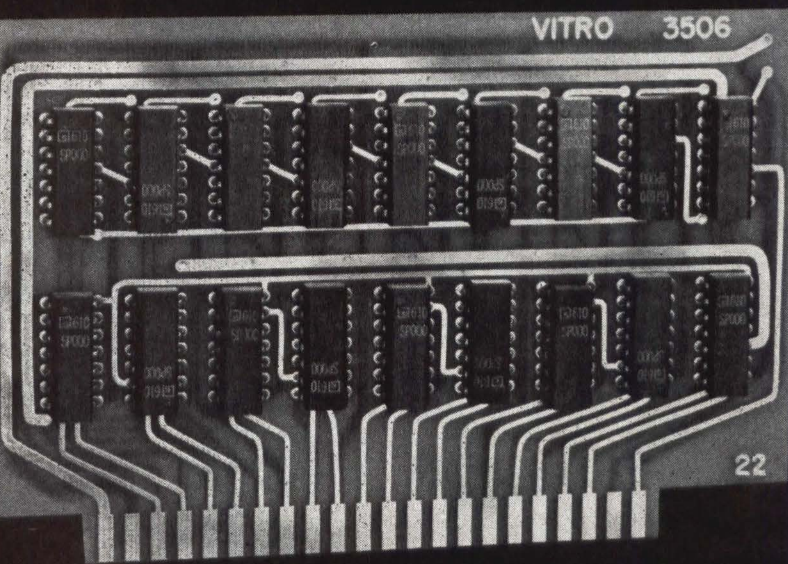
Buy them off the shelf now along with a complete line of accessories from your nearest factory authorized distributor. For our new catalog, write to ITT Cannon Electric, a division of International Telephone and Telegraph Corporation, 3208 Humboldt Street, Los Angeles, California 90031.

CANNON PLUGS

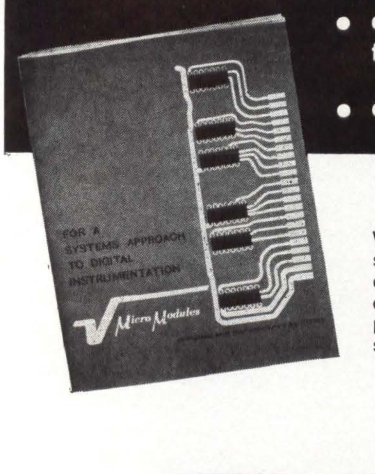
CANNON ITT

VITRO

Micro Modules



- all-new, highly competitive prices
- built-in drivers, inverters and buffers eliminate most interconnecting wiring
- up to 18 microcircuits per card enable high density and lower costs
- boards designed to meet MIL- and NASA standards
- boards keyed to assure proper mounting
- dual in-line packages easily replaced for ease of maintenance
- off-the-shelf delivery



WRITE for this FREE 36 page catalog describing our complete line of card-mounted digital microcircuits. Brochure contains logic diagrams, connections, performance data, power supplies and card drawers. NEW price sheet is also included.

V-31

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CIRCLE NO. 43 ON INQUIRY CARD

NEW PRODUCTS

READ-ONLY MEMORIES

Modular read-only memory systems is said to combine the ancient art of weaving and the modern technology of high-speed switching to produce a braided transformer memory of unique characteristics. Since the system is naturally hard to radiation, it is expected to be used extensively in space and military applications. Other obvious commercial applications are as look-up tables for industrial control, radiation patterns for phased-array antennas, function generators in special purpose computers, hyphenation memories for computerized type setting, numerical control, complier programs storage, etc. There are three compatible modules for interrogation and a unique memory package for storage, all at standard DTL levels. As presently made, the basic braided memory unit has a capacity of 65,536 bits, but any number of these modules can be used to fulfill a particular requirement. Memory Technology, Inc., Waltham, Mass.

Circle No. 211 on Inquiry Card

PRECISION TRIMMER

A half-inch round multiturn precision trimmer with a shear-proof patented stop mechanism offers ±5% resistance tolerance and ±0.5% linearity tolerance. The precision wirewound device is said to provide a stop system up to four times stronger than competitive models. It can withstand a torque of better than 100 oz. in. The patented design uses a helical guide on an undercut portion of the shaft to move a floating key slug along a groove inside the bushing collar. The helix ends, affixed to shoulders at the end of the undercut portion, positively stop further axial movement of the slug. IRC, Inc., Philadelphia, Pa.

Circle No. 203 on Inquiry Card

PRINT IDENTIFICATION

A new automatic identification unit provides a means for supplying BCD data to a printer. It identifies the coincidental test data being printed and automatically displays ascending serial numbers from 0000 to 9999 and provides matching 4 column 1248 BCD output. When connected to a printer control, the identification unit serially advances after each print. Any desired starting identification number (such as "0001" or "0268") can be preset. The number displayed will be printed during the next print cycle. Each column of numbers can be set by individual pushbuttons. The identification unit and instrument with a printer provide a complete data acquisition system printing "Test No. and Voltage" or "Test No. and Temperature" for a large number of voltage or temperature readings. United Systems Corp., Dayton, Ohio.

Circle No. 220 on Inquiry Card

LOGIC LABS

Two new universal "Logic-Lab" instruments are available for digital problem-solvers. The Model LL-350 accepts integrated logic cards, and the Model LL-150 accepts either silicon or germanium discrete cards. The instruments can be used for digital computation; code, word, and format checking and generation; interface problems; prove-out of system timing; automatic checkout systems; classroom training devices; and computer teaching units. The basic frame includes an instrument cover, a removable patch-board, one patch-cord kit, 14 rear terminals and 10 front terminals, and 14 card connectors such that each model will accept any mixture of cards. The Logic-Lab comes complete with an applications manual. Price for the basic frame is $1240.00 with $250.00 for power supply. Computer Logic Corp., Santa Monica, Cal.

Circle No. 225 on Inquiry Card

FERRITE CORE MEMORIES

Available in various physical configurations to suit individual customer requirements, new compact and modular ferrite core memories provide storage capacities ranging from 64 to 4096 words and word lengths from 2 to 36 bits. Access time is 2 microseconds and full cycle time is as fast as 5 microseconds. The memories consist of input/output data registers, digit drivers, sense amplifiers, current drivers, and address switches. Borders Electronics Mfg. Co., Incorporated, Pennsauken, N.J.

Circle No. 227 on Inquiry Card

RESISTIVE NETWORKS

Individual precision resistors, wound in Manganin or nickel chromium alloy, are available in four standard forms, each having leadout wires in a variety of positions. The time constant for individual resistors between 1 and 99 ohms is better than 0.5 microseconds and, typically, a resistor of 100 ohms and above will have a time constant between 0.1 and 0.01 microseconds. These resistors are built up into networks to suit customers' requirements. Temperature coefficients are available within the normal range of the materials used and are selectable to customers' requirements. Muirhead Instruments, Inc., Mountainside, N. J.

Circle No. 270 on Inquiry Card

IC CLOCK OSCILLATOR

Integrated circuit clock oscillator is a 0.16 cubic inch package with a digital output for computer, missile guidance, and other digital applications. It features a low aging, high reliability "Koldweld" crystal combined with integrated circuitry for 450 ppm stability over −55C to +90C in frequencies from 701 to 1000KC. Output voltage at load is logic zero +0.2±0.2vdc, logic one +2.8vdc minimum. Wave form is square with 50/50 ±15% symmetry and 20 nanosecond typical rise time. Current drain is 15 ma. The unit measures 0.5 x 0.625 x 0.5 inch and is encapsulated. Monitor Products Co., Inc., So. Pasadena, Cal.

Circle No. 202 on Inquiry Card

ENGINEERS:
UNIVAC and you:
words to program
a career by . . .

"flip flop"

"FLIP-FLOP" (verb).

In the "USA Standard Vocabulary for Information Processing" this word means one thing. But in terms of your career it could mean changing jobs too frequently; or changing from one career dead-end to another. So we encourage scientists and engineers and skilled programmers to ask any and all questions which can acquaint them with every aspect of a proposed move to UNIVAC.

Just for example, here are some of the positions we now want to fill . . .

- **Advanced Electronic Circuit Studies**
- **Integrated Circuits and Thin Film Studies**
- **Ultra-High Speed Integrated Circuit Interconnections**
- **Computer Manufacturing Engineering**
- **Industrial Engineering & Cost Analysis**

To make sure a change is a real step ahead, not a mere "flip-flop," write and tell us all about your experience, your desires, your hopes for the future. Include any questions about UNIVAC. We'll write back, as completely as we can. Write: John D. Hallenberg, Employment Manager, Dept. 508.

Write today and make an appointment with tomorrow.

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LITERATURE

Isolation Relay

Booklet diagrams 28 circuits to build liquid level control, burglar alarm, weather detector, trick circuits, fire alarm, and other design ideas using a "shock-free" 95 v to 125 vac isolation relay. The design booklet has been prepared to assist engineers and experimenters who work with relay devices and circuits. Alco Electronic Products, Inc., Lawrence, Mass.

Circle No. 328 on Inquiry Card

Readout Catalog

44-page catalog on single-plane rear-projection readouts provides complete details on the principles of operation for a line of readouts from the microminiature units through units capable of displaying 3⅜" high characters. Specifications are also given for assemblies, accessories, lamps, and driver/decoder modules. Industrial Electronic Engineers, Inc., Van Nuys, Cal.

Circle No. 322 on Inquiry Card

Reversible Counters

"Using a Reversible Counter" is the title of a 44-page manual that surveys some of the remarkable varied applications for reversible counters. These are counters which have two inputs and can count backwards as well as forwards. Among other things, this means that they can measure differences between their two inputs. There is also an excellent treatment of transducers for converting length, angle, flow rate, etc., to electrical signals suitable as inputs to the counter. Transducers covered include laser interferometers, optical gratings, tachometers, and several types of flow meters. An extensive list of references is given. Hewlett-Packard, Palo Alto, Cal.

Circle No. 329 on Inquiry Card

Voltage Regulators

A 28-page brochure describes the applications of a voltage regulator to industrial and military needs. Typical installations shown are radar systems, computers, microwave, rectifiers, induction heating, variable-speed drives, precipitation equipment, and regulated load centers. A complete description of the regulator and selection data and ratings for automatic, motor-driven, hand-operated, and liquid-filled units — both single and three-phase — are also included. General Electric Co., Voltage Regulator Business Section, Pittsfield, Mass.

Circle No. 309 on Inquiry Card

Microminiature Connectors

A 20-page publication combines all existing catalog information on a company's line of microminiature connectors into one convenient source. Test information, product descriptions, and specifications are condensed and located in the front section. A "Special Design" section focuses on the problem-solving capacity of the company in developing specially-designed connectors. ITT Cannon Electric, L. A., Cal.

Circle No. 308 on Inquiry Card

Multilayer Board Checklist

A new checklist has been developed to guide the engineer and designer in specifying a multilayer circuit. A series of 20 basic check points range in scope from such elementary information as size, quantity needed, conductor thicknesses per layer, dielectric materials to be used, hole sizes and tolerances to the final test standards the resulting circuit must satisfy. Methode Electronics, Inc., Printed Circuit Div., Chicago, Ill.

Circle No. 330 on Inquiry Card

Read-Only Memory Systems

An informative four-page brochure and technical data sheet describe a company's unique braided transformer memory system which has been made practical through development of an unusual logic loom. The combining of ancient weaving techniques and modern high-speed diode-transistor logic are said to have resulted in a practical fixed memory system with many desirable features: high speed, low cost, systems simplicity, and good reliability. The present basic memory unit has a capacity of 65,536 bits, but any number can be used in a particular application and can be organized into a read-only system of any number of words or bits per word. A 8192-bit memory unit will also be available in the near future. Memory Technology Inc., Waltham, Mass.

Circle No. 325 on Inquiry Card

Switching Matrix

Bulletin on a switching matrix describes how unit is used to select individual or multi-input points at random for testing electrical parameters in ground support, high and low level data acquisition, input-output, and a variety of communication systems. The panel-mounted switching matrix accepts 600 inputs. McKee Automation Corp., No. Hollywood, Cal.

Circle No. 323 on Inquiry Card

Electronic Counters

A 4-page brochure discusses a new electronic counter series which consists of 15 different models. The counter comes either in full or half rack size, with 4, 5, or 6 digits. It has a counting speed of 10 kHz, and features compact modular solid-state design. Standard models are totalizing counters and predetermining counters (with either single or dual preset). Output is either relay or transistor — as specified. The Rowan Controller Co., Oceanport, N.J.

Circle No. 320 on Inquiry Card

INFORMATION SYSTEMS SCIENTISTS AND ENGINEERS

Bendix Research Laboratories has excellent career opportunities for B.S., M.S., and Ph.D. graduates with 2 to 15 years experience in one or more of the following key areas:

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- **AUTOMATIC CONTROLS,** information theory, control theory, circuit and servo analysis, correlation techniques.
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CIRCLE NO. 900 ON INQUIRY CARD

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ADVERTISERS' INDEX

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- Smallest side-viewing tube in low cost category
- Pins directly solderable to PC boards
- Smallest sockets for every type of mounting
- Ultra long life and high reliability characteristics
- Built-in "keep alive" for rapid ionization - particularly useful in strobe applications (optional)
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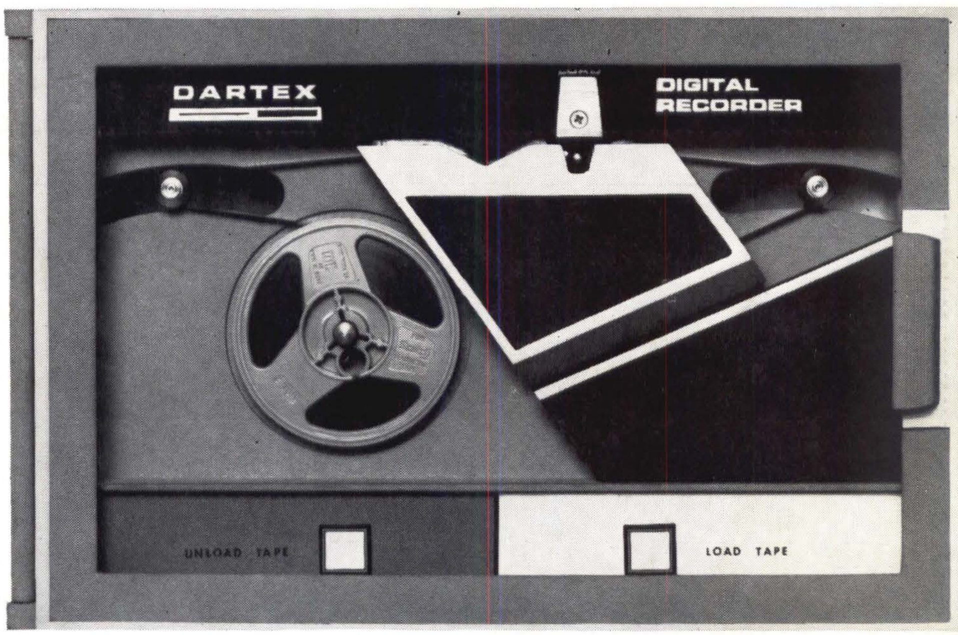
CIRCLE NO. 44 ON INQUIRY CARD

Tally-Ho!

Introducing the highly reliable Dartex 1020 incremental digital mag tape transport.



Operating in either an asynchronous read/record mode at random rates up to 120 characters per second or in a continuous read/record mode of 1600 characters per second, the new Dartex 1020 read/write transport features the ability to accept eight bit parallel characters from various slow input devices for fast output.

Using an advanced tape drive technique, the 1020 features a single capstan that engages the tape constantly, thus wear to the tape and transport mechanism is minimized. Capacity is up to 240,000 characters on each reel of tape.

The compact size of the low cost Dartex 1020 allows easy mounting into a console, rack mount, or desk top enclosure. Other features include gentle tape handling, precise control of tape motion, backspace and re-record, and a design which minimizes and simplifies maintenance. A broad line of interfaces is available—from basic tape transport through telephone line and typewriter options.

Applications for the Dartex 1020 include data transmission, data logging, numerical control of machine tools and graphic arts machines, low cost computer input/output, and auxiliary storage for digital displays. The development of the Dartex 1020 is just one more step in Tally's plan to provide peripheral equipment using the right media at the right time for the right cost.

For complete information, please write Tom Tracy, Tally Corporation, 1310 Mercer Street, Seattle, Washington 98109. Phone: (206) MA 4-0760. In Europe and the U.K., address Tally/APT, Ltd., 6a George Street, Croydon, Surrey, England. Phone: MUN 6838.

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