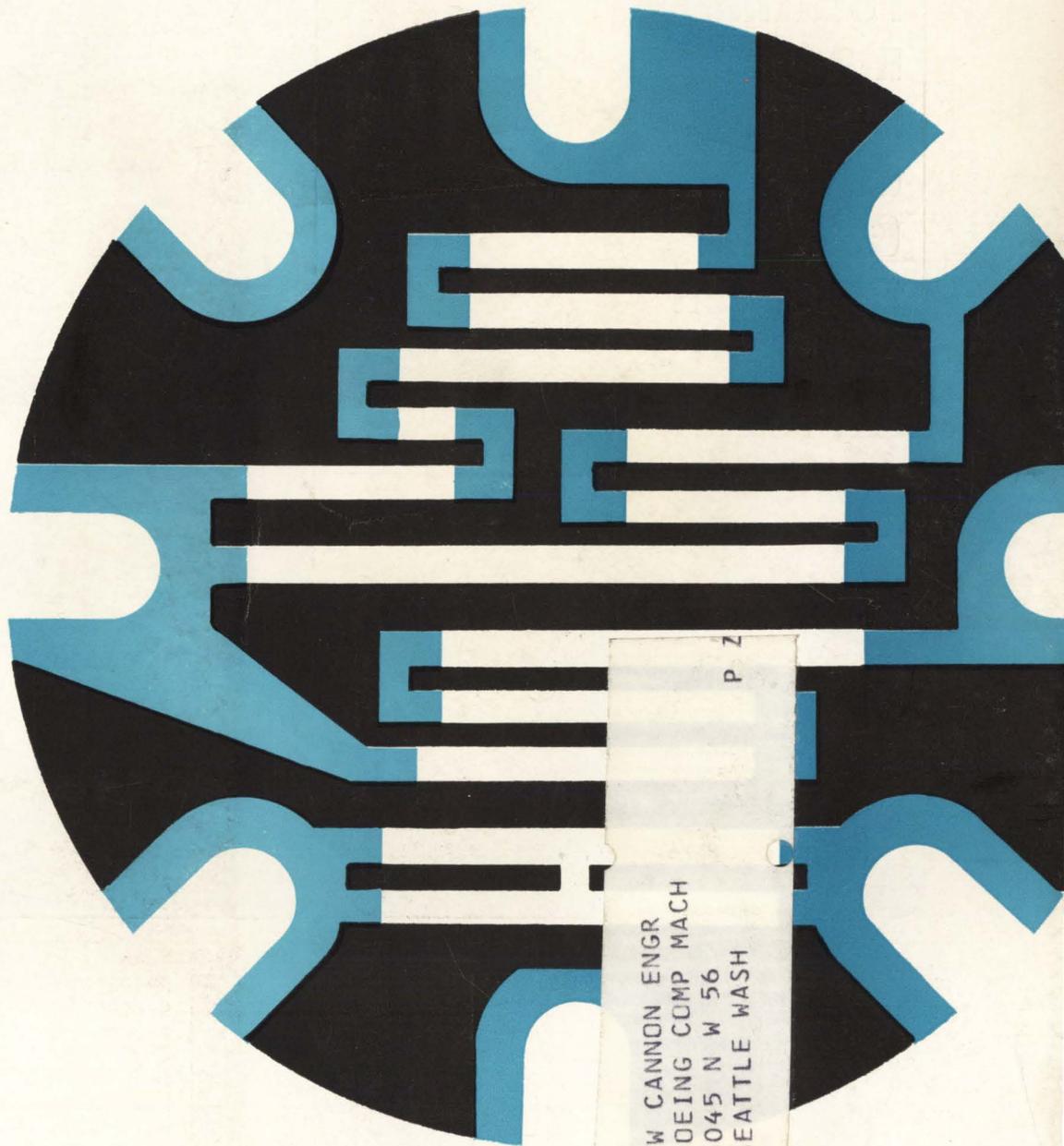


computer design

OCTOBER 1963

design and application of digital circuits, equipment and systems in computing, data processing and control

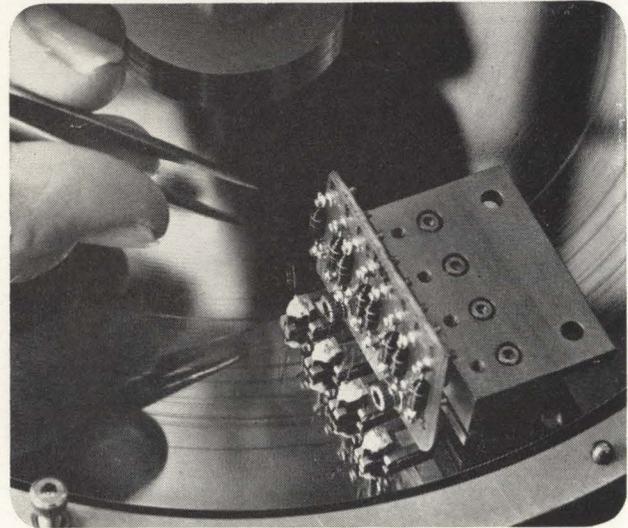
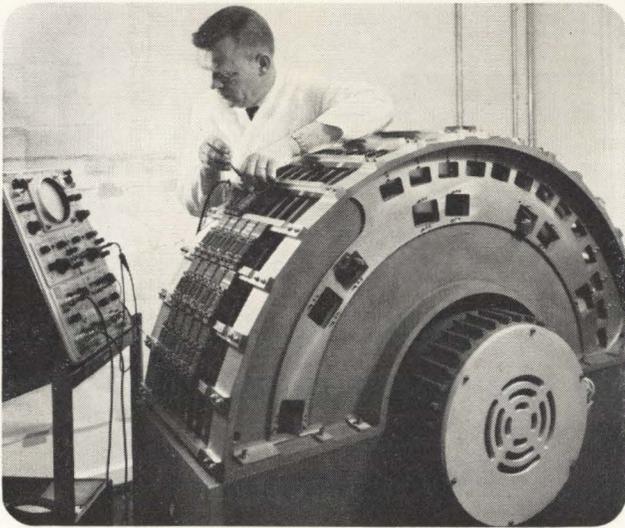
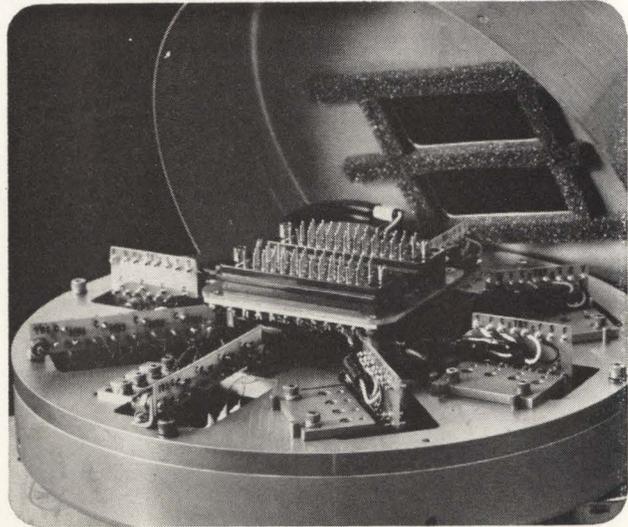


THE IMPACT OF INTEGRATED CIRCUITS

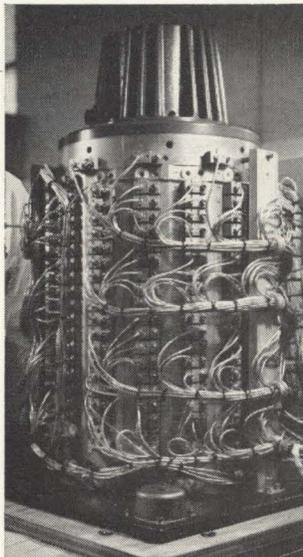
Highlights of the Coming
1963 FJCC

Computer and Data System Designers:

rotating magnetic memory devices from General Precision



DISCS—Many computer and data system designers are turning to the high storage capacity of magnetic discs. For example, General Precision Random Access Magnetic Discs furnish storage up to 7,680,000 bits per disc. "Flying" heads permit high packing density of 400 bits/inch. Exclusive GP-produced plated-cobalt disc coating gives exceptionally high resolution. Excellent thermal shock resistance. Heads replaceable without special tools or danger of disc surface damage. Ultra-precision Grade 9 bearings give a service life of 10 years at 3600 rpm. Meets MIL-E-4970A. DRUMS—Pick the magnetic drums with a proved history of reliable



performance in electronic computing systems designed for Navy, Air Force, NASA, business, engineering, and educational applications. Send for full information on drums and discs, from Commercial Computer Division, Information Systems Group (Librascope Division/Commercial Computer Division) General Precision, Inc., 100 East Tujunga Avenue, Burbank, California. □ TWX BRB 9884, Phone 849-6061.

For Series L100 and L200 discs (all models):

Maximum bits per inch: 400. Head inductance: 25 to 150 microhenries. Type of recording: phase modulation. Recording surface: plated cobalt coating. Playback: 50 millivolts (under most conditions). Write currents: 40 to 100 milliamperes. Ambient temperature: 32°F to 149°F limits. Thermal shock: ΔT ambient in 10 seconds. Vibration: 15 to 55 cps (0.015 db amp., 3 directions). Mechanical shock: 4-inch edge test (4 drops).

SERIES L100 SINGLE DISCS (ONE-SIDE MAGNETIC MEMORY)

Model No.	Disc Diameter	Maximum Tracks	Max. Bits per Track	Total Bit Capacity	Rotational Speed (rpm)
L104	4"	8	2400	19,200	3600-12,000
L106	6"	16	3600	45,600	1800-12,000
L108	8"	32	4800	153,600	1800-12,000
L111	11"	64	6600	422,400	1200- 8000
L116	16"	128	10,000	1,280,000	900- 3600
L124	24"	256	15,000	3,840,000	900- 3600

SERIES L200 DOUBLE DISCS (TWO-SIDE MAGNETIC MEMORY)

Model No.	Disc Diameter	Maximum Tracks	Max. Bits per Track	Total Bit Capacity	Rotational Speed (rpm)
L208	8"	64	4800	307,200	1800-12,000
L211	11"	128	6600	844,800	1200- 8000
L216	16"	256	10,000	2,560,000	900- 3600
L224	24"	512	15,000	7,680,000	900- 3600

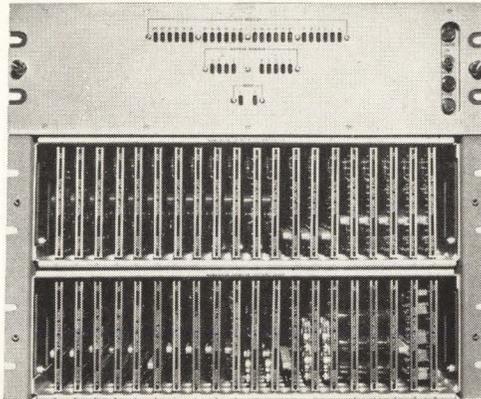
COMMERCIAL COMPUTER DIVISION



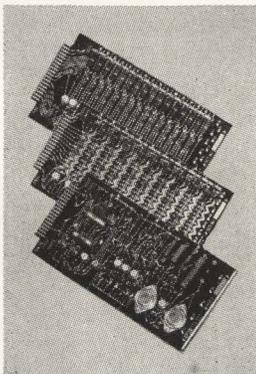
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CIRCLE NO. 1 ON INQUIRY CARD

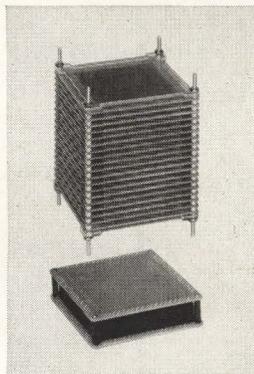
DESIGN FLEXIBILITY GIVES YOU A CUSTOMIZED MEMORY SYSTEM



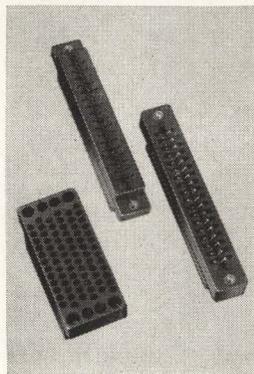
FROM THESE STANDARD, IN-STOCK IGC MODULES



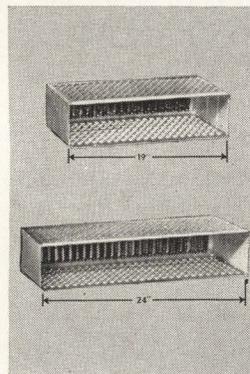
Printed Circuit Cards — Standardized circuitry fits memory systems having wide range of speeds and capacities. Cards clearly titled and coded. Convenient test points.



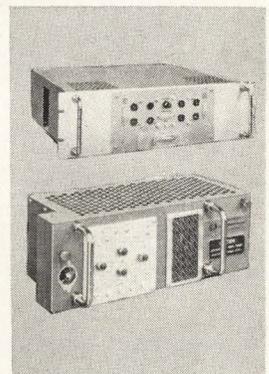
Memory Stacks — Microstack, printed circuit, or temperature controlled stacks. Coincident current speeds down to $2\mu\text{s}$, word organized to $1\mu\text{s}$. Capacities virtually unlimited.



Connectors — All cable and card connectors are solderless and gold plated. Card connectors furnished in two types: standard computer grade and bifurcated, bellows type.



Mounting — Memory systems can be packaged in 19-inch or 24-inch unitized relay racks, or in a cabinet. Unique design gives maximum air flow for cooling, extends component life.

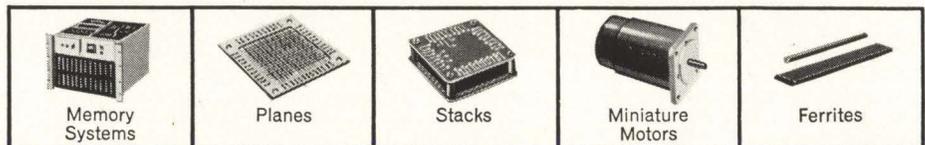


Accessories — Rear mounted or remote power supply . . . indicator lights . . . built-in test and parity modes . . . custom input and output voltage levels . . . ruggedized packaging.

Indiana General offers you a complete line of high dependability, standardized, commercial memory systems . . . available with a wide range of optional features. **Magnetic Storage Systems Are Our Business.** Profit from our unequalled design experience and production capabilities. Call or write today to Indiana General Corporation, Electronics Division, Keasbey, New Jersey. Ask for bulletin 38-J.

See us at Booth 135-136 — Fall Joint Computer Conference

INDIANA GENERAL



CIRCLE NO. 2 ON INQUIRY CARD

Editorial Notes

INTEGRATED CIRCUITS

This issue's feature article, entitled "The Impact of Integrated Circuits", is based on what is probably the first comprehensive, objective evaluation-study on just what effect integrated circuits will have on the industry. In conducting this year-long study, the researchers used the following as a definition of an integrated circuit: "An electronic circuit whose components are made essentially at the same time in or on the same piece of material". The study covered the two most popular approaches — thin-film and solid semiconductor circuits. Present-day production of thin-film circuits involves the addition of discrete active elements; however, deposition of active elements is under development, and working devices have been demonstrated.

The study predicts that by 1975, integrated circuits will represent 22.8% of the total circuit value produced. The report also shows that integrated circuits are, and will be, primarily used in digital equipment — which probably is no surprise to readers of COMPUTER DESIGN.

However, it is interesting to note the statistical correlation between the above 22.8% figure and the various industry sales forecasts we have seen, predicting that digital equipment will represent, by 1970, $\frac{1}{4}$ to $\frac{1}{3}$ of the total amount of electronic equipment produced.

To bring you up-to-date, we have supplemented the main text of the article with "picture-caption" descriptions of typical "integrated circuits" currently available from manufacturers. For your convenience, we have keyed each picture-caption with an inquiry card number from which you can obtain literature describing in detail each manufacturer's capability in this area. We recommend that you have a complete set on file. From what we have seen, the available manufacturers' literature constitutes an excellent reference on the subject.

S. Henry Sacks
EDITOR



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computer design

For Engineering Personnel Responsible for the Design & Application of Digital Circuits, Equipment, and Systems in Computing, Data Processing, Control and Communications.

FEATURES

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16 THE IMPACT OF INTEGRATED CIRCUITS

Based on a comprehensive, year-long study conducted by members of Harvard University's Business School, this article translates the relative advantages and disadvantages of integrated circuits into a detailed projection of their expected applications - forecasting dollar sales volumes through 1975. The article also examines what effects the use of these circuits will have on the industry with respect to traditional supplier/user relationship, personnel, education, and standardization of circuits. Photos and brief descriptions of integrated circuits, currently available from manufacturers, supplement the text.

6 THE 1963 FALL JOINT COMPUTER CONFERENCE

Highlights of the coming 1963 FJCC include a brief summary of technical papers which will be presented at the Las Vegas Convention Center on November 12-14.

DEPARTMENTS

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Circulation
over 20,000



INDUSTRY NEWS

A CONTRACT FOR CONTINUED PROCESSING OF DATA transmitted by NASA's Orbiting Solar Observatory satellite was awarded to the Martin Co. The contract to Martin's Electronic Systems & Products Division at Baltimore brings to \$1.3 million the total funds provided the firm for putting in useful form the information transmitted to earth by the satellite. OSO orbits the earth about every 95 minutes in a near circular orbit at altitudes between 550 and 589 miles. Information is transmitted by radio on 136.744 mc to ground stations in the Western Hemisphere, and is recorded on magnetic tape. The tapes are sent to Martin to be processed through large computers which put the data in usable form for scientific studies. The information is returned to NASA on punched cards, magnetic tape, or charts and graphs.

A CONTRACT, IN EXCESS OF \$100,000, to develop and deliver an airborne severe environment memory system has been awarded to Electronic Memories, Inc. of L.A. by Sperry Rand Corporation's Sperry Utah Division. The random access memory will deliver 1024, 26-bit words, with a 4 microsecond read/write cycle. It is being built to MIL-E-5400 specifications.

A HIGH-SPEED DIGITAL COMPUTER SYSTEM has been ordered by Beech Aircraft Corp., Wichita, Kansas, from the Advanced Scientific Instruments Division of Electro-Mechanical Research, Inc. The system to be delivered to Beech by ASI will include an ASI 210 central processor, magnetic tape equipment, line printer, and input/output typewriter. The ASI 210 will be used by the Beech engineering department for engineering and scientific computation and, in this application, will perform tasks which previously required two computer systems.

DEVELOPMENT AND MASS-PRODUCTION OF SILICON, EPITAXIAL PLANAR TRANSISTORS AND DIODES FOR HIGH-SPEED SWITCHING has been announced by the Japanese firm, Fujitsu, Ltd. Fujitsu officials believe computers equipped with their new semiconductors are capable of making computations five to ten times faster than conventional computers. The new semiconductors will be used in computers which are being jointly-developed by the Nippon Electric Co., Oki Electric Industry Co., and Fujitsu, Ltd. Fujitsu has already begun to mass-produce silicon transistors and diodes at a monthly rate of 70,000.

A \$550,000 CONTRACT FROM ELGIN AIR FORCE BASE for elements of the Air Force's Gulf Test Range Electromagnetic Test and Evaluation Data System has been received by the Electronic Engineering Company of California. The equipment includes five radar digitizing systems and one central radar data processing system. The digitizing systems convert radar test data into a digital format for transmission over telephone lines to a central location. The data is entered in real time directly into an IBM 7094 computer.

A NEW PROGRAMMING SYSTEM THAT ENABLES A COMPUTER to "draw" a flowchart automatically in about 15 seconds was recently introduced by IBM. Use of the new system, called "Autochart", requires no extensive programming experience. A conventional rough, hand-drawn layout of the flowchart can be coded by clerical personnel using coding sheets which locate and define each symbol and all the text on the chart. From these code sheets, a deck of cards is punched and processed on the computer to produce the Autochart. It is written on magnetic tape for off-line printing. Autochart is available, without charge, to users of an IBM 7070/7074 data processing system.

A PROTOTYPE OF A NEW METAL BASE TRANSISTOR which may make it possible to print an entire thin-film microcircuit was recently developed by Philco Corp.'s Lansdale Division. According to J. P. Spratt, research physicist, applications of the metal base transistors should be feasible within a year. The important advance in this technique, he added, is that in addition to passive components, active components showing characteristics substantially identical to transistors can be evaporated as thin-films. In addition to other devices in this area, Philco is working in the development of thin-film metal transistors using graded zinc cadmium sulphide films. The zinc cadmium sulphide films are produced by evaporating from separate sources controlled amounts of zinc sulphide and cadmium sulphide. The control systems used allow the deposition rate of each component to be varied during deposition, if desired. Philco researchers found that highly asymmetric diodes can be produced by grading the film composition from 100 percent cadmium sulphide at the ohmic contact to some intermediate concentration at the rectifying contact. Such diodes show forward I-V characteristics indicative of thermionic flow at low forward biases and of space charge limited flow at high biases. Pronounced effects on the I-V characteristics were also observed when the work function of the metal at the rectifying barrier was changed.

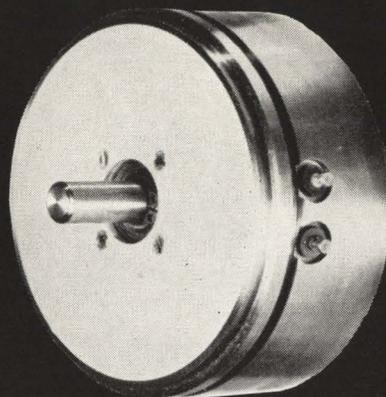
U.S. AIR FORCE REVEALED PLANS TO INSTALL COMPUTERS AT EVERY MAJOR AIR FORCE BASE THROUGHOUT THE WORLD for processing the payroll for over 800,000 military personnel. The vast computer network will utilize from 160 to 174 NCR "390" data processing systems manufactured by the National Cash Register Co. The computers will be installed at approximately 105 bases in the United States and 25 bases overseas. Robert S. Celman, chairman and president of NCR, said the Air Force program is among the most extensive ever undertaken in the electronic data processing field and represents the largest single computer order which the Dayton, Ohio business machines manufacturer has received to date.

TWO LARGE DATA ACQUISITION SYSTEMS WILL BE DEVELOPED

by Systems Engineering Labs Inc., Fort Lauderdale, Fla., for the new Manned Spacecraft Center at Houston, Texas. The contract valued in excess of \$180,000 was awarded to SEL by NASA. Delivery of the first system is scheduled for early November and the second for mid-December. The SEL equipment, described as 50-channel, low-level data acquisition systems, will aid in NASA's environmental research by scanning numerous sensing elements 15,000 times every second to collect measurements of such physical phenomena as temperatures, pressure, and stress. These measurements are then converted into "computer language" and recorded on magnetic tape for processing by IBM data processing systems.

THE DESIGN AND FABRICATION OF A FEASIBILITY MODEL of a Weather Data Storage and Retrieval System will be undertaken by the Information Systems Dept. of LFE Electronics, under a contract awarded by the Federal Aviation Agency. To be used as part of the FAA's over-all National Airspace System, the subsystem will receive, store, and display—in words, numbers, and pictures—current and future weather data needed by pilots, air traffic controllers, and other aircraft operational personnel. The equipment will provide both television-like display and printed form output of the operational aviation weather.

PAPERS FROM OUTSTANDING TECHNICAL SPECIALISTS will highlight the Digital Equipment Corp.'s Computer Users Society (DECUS) Annual Meeting on November 18 and 19, at Lawrence Radiation Laboratory, Livermore, California. Noteworthy speakers include Dr. J. C. R. Licklider, Assistant Director for Behavioral Science for Command/Control Research, Advanced Research Projects Agency—Headquarters Pentagon; and Prof. John McCarthy of Stanford University. Topics of papers cover: Innovations for the Programmed Data Processor-1 Computer; A Display System Oriented Toward Use of a Digital Computer; Hybrid Systems; New Assembler/Compilers; Computer Aids to Number Theory; Time Sharing and Debugging.



Actual size

MODEL 23 OPTISYN HIGH RESOLUTION OPTICAL SHAFT ENCODER

Featuring

HIGH Resolution, 0.025%

HIGH Signal Levels, 260 mv. min.

HIGH Counting Rates, 100 kc

Long Life, Six Years

Mean-Time-To-Failure

LOW Friction Torque, 0.05 in-oz max.

LOW Shaft Inertia, 35 gm-cm² max.

LOW Cumulative Error, ± 0.278 count

Wide-Aperture Optics

Optional Zero Reference

Applications

Model 23 OPTISYN is an optical incremental shaft encoder, utilizing a rotating moiré pattern to provide high accuracy by means of **optical gearing**.

Packaged in a convenient synchro-type housing, Model 23 OPTISYN produces up to 4096 digital pulses per turn of the input shaft.

Because Model 23 offers ruggedness and long life, it is now standard equipment for angular position measurement and angular rate control.

Military applications include the use of OPTISYN as an angle digitizer and rate generator for gimbal systems, accelerometers, gyros, memory drums and gyro rate tables. Industrial applications include pickoffs for lead-screw drives, generation of digital data for display or transmission, and testing of accurate rotary components. Model 23 can also be used as a precision tachometer.

Two sinusoidal output signals, in quadrature phase relationship, are provided by the OPTISYN. Through the use of appropriate amplifier and logic circuitry, these output signals are used to develop bidirectional counting pulses. This same circuitry also increases the basic encoder resolution by a factor of 2 or 4. An optional Zero Reference System provides an output pulse as the input shaft is rotated through the zero reference position.

Dynamics Research Corporation specializes in inertial guidance sub-components and digital control, and develops hybrid systems to meet particular requirements. Standard electronics are available in separate plug-in modules.

Write or call us if you would like to obtain literature concerning our Technical Bulletins with specifications of all standard Optisyns (Models 11, 23, 27, and 35) and electronic modules (15-EL-4, 15-EL-5). Special OPTISYNS, designed to customer's specifications, are also available.

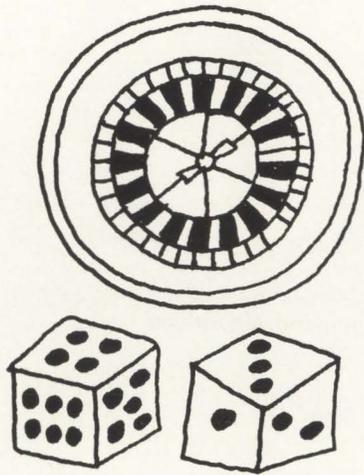


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CIRCLE NO. 3 ON INQUIRY CARD

COMPUTER DESIGN/OCTOBER 1963



1963 FALL JOINT COMPUTER CONFERENCE

NOVEMBER 12-14
CONVENTION CENTER
LAS VEGAS, NEVADA

The beautiful Convention Center in Las Vegas, the site of this year's FJCC, was also host to the last heavyweight championship boxing match; however, the conference promises to last a little longer. This 3-day meeting is expected to draw the largest JCC attendance yet. Some new and interesting working hardware will be on display in the exhibit area. Over 60% of the 38 papers, which will be presented at the 15 technical sessions, cover the design and application of computer hardware.

For the first time at a JCC, the conference will provide a means for organizing special interest discussion groups. These groups will be held each evening from 8-10 P.M., depending upon demand. (There may not be much of a demand the first evening but it will provide something for the "losers" to do the following two evenings.) Example of such discussion topics might be multi-processing, information retrieval, decision tables, mass memories, logic, and compilers. A special bulletin will be located in the registration area where attendees may either suggest topics or sign up for previously suggested groups. Each group will be headed by a recognized leader in the particular field of interest. Anyone wishing to organize such a session in advance should contact: Saul Yochelson, Lockheed Missiles & Space Co., Van Nuys, Cal.

The titles of all the papers to be presented are listed below with brief summaries of some of the papers (those that were available at press time). What promises to be of unusual interest is Session 15 on "Computers as a Social Force", particularly a paper by Dr. Louis Fein entitled "Computer-Oriented Peace-Research". Dr. Fein advocates establishment of a large-scale, non-national, comprehensive, and expensive peace research project. In his paper, he describes a hypothetical organization along these lines which he designates as PERC - Peace on Earth Research Center. A more detailed description of his paper is included below.



SUMMARY OF TECHNICAL PROGRAM

Tuesday, November 12 2:00—5:00 P.M.

SESSION I

PROGRAMMING — EXPERIMENTAL

AN EXPERIMENT IN NON-PROCEDURAL PROGRAMMING

J. H. Katz and W. C. McGee, Thompson Ramo Wooldrige

SIMULATION OF AN ASSEMBLY OF SIMPLIFIED NERVE CELL MODELS ON A DIGITAL COMPUTER

R. E. Sears and S. M. Khanna, IBM Federal Systems Div.

CYCLOPS-1: A SECOND GENERATION RECOGNITION SYSTEM

T. Marill, A. K. Hartley, D. L. Darley, B. H. Bloom, D. M. Park, T. P. Hart, and T. G. Evans, Bolt Beranek and Newman Inc., and M.I.T.

CYCLOPS-1 is a working recognition system that can recognize all hand-printed alphabetic and numeric characters; there are virtually no restrictions on the manner in which the characters may be printed. It can analyze complex visual inputs consisting of an arbitrary number of characters present simultaneously; the characters may be of different sizes and orientation; they may overlap, or be inside of one another; they may be superimposed on arbitrary backgrounds consisting of meaningless lines or spots or geometric shapes. The repertoire of items recognized by the system may readily be enlarged to include shapes other than alphabetic or numeric characters. New items may be added without affecting the recognition of those already in the repertoire.

SIMULATION OF A TURING MACHINE ON A DIGITAL COMPUTER

R. W. Coffin and Walter R. Stahl, Oregon Regional Primate Research Center and H. E. Goheen, Oregon State University

This paper describes a new program for a digital computer that performs the logical function of a Turing Machine at rates up to 3,000 Turing Table entries per

second. The Turing Machine is a special type of computing system which was developed in 1937 by Alan M. Turing, a distinguished British mathematician. For many years the Turing Machine was considered to be inefficient and impractical but recent work has revealed that it is very useful for algorithmic simulation. The main advantage of the Turing Machine is that it is not limited by the conventions of any particular computer language or formal logic. The described program is a means by which any algorithm written as a Turing Machine may be "debugged" and run on a conventional computer, thereby preserving the original Turing logic but taking advantage of the high speed of the computer. The importance of the work is that it presents a very versatile algorithmic tool, which has already been used for such diverse applications as the simulation of the reasoning involved in medical diagnosis, simulation of the operation of a biological cell system and other non-numeric algorithms.

SESSION 2

COMPUTER MEMORIES

THE ROPE MEMORY: A PERMANENT STORAGE DEVICE

Peter Kuttner, Burroughs, Electronic Instrument Division

A powerful way of increasing the capability and flexibility of digital systems is through the use of permanent (read-only) memories. The rope memory is a scheme for realizing permanent storage using standard bobbin or ferrite cores in which each core stores one word. The principle of operation, methods of organizing ropes, operating characteristics and applications of rope memories are discussed.

A 300 NANOSECOND SEARCH MEMORY

C. A. Rowland and W. O. Berge, UNIVAC, Division of Sperry Rand Corporation

Search or associative memories are useful in sorting, cataloging, information retrieval, translating, and searching. This relatively new type of computer memory simultaneously compares an incoming data word with all the stored key words contained in the search memory. A search memory which employs thin magnetic films of nickel alloys and cobalt alloys has been built which is capable of doing a complete search in 0.3 of a millionth of a second and has a reasonable potential of being able to do a complete search in 0.1 of a millionth of a second.



MULTIPROCESSOR COMPUTER SYSTEMS**GENERALIZED MULTIPROCESSING AND MULTIPROGRAMMING SYSTEMS***A. J. Critchlow, IBM Corporation***ORGANIZING AND PROGRAMMING A SHIPBOARD REAL-TIME COMPUTER SYSTEM***G. G. Chapin, UNIVAC, Division of Sperry Rand Corporation*

New techniques used in programming the Naval Tactical Data System (NTDS) are described in the paper. The NTDS, now operational aboard ships, required the use of multiple units of a standard computer, the UNIVAC-developed AN/USQ-20, for each installation. The programs which operate these computers at each site represent the first successful attempt at using multiple computers to share a real-time problem.

A MULTIPROCESSOR SYSTEM DESIGN*Lt. M. E. Conway, USAF, Directorate of Computers, L. G. Hanscom Field***A PROBABILISTIC ANALYSIS OF COMPUTING-LOAD ASSIGNMENT IN A MULTI-PROCESSOR COMPUTER SYSTEM***Masanao Aoki, Gerald Estrin, and Richard Mandell, University of California***A NEW TECHNIQUE FOR USING THIN MAGNETIC FILMS AS A PHASE SCRIPT MEMORY ELEMENT***B. A. Kaufman and Eduardo Ulzurrun, National Cash Register Company***LAMINATED FERRITE MEMORY***R. Shahbender, C. Wentworth, K. Li, S. Hotchkiss, and J. Rajchman, Radio Corporation of America*

Computer memories capable of storing up to 500 times more information per square inch than conventional memories and of processing up to 10 million bits per second may result from a new, low-cost technique employing laminated ferrite sheets. Feasibility of the new technique has been proven with an experimental laminated-ferrite memory less than a quarter inch square which stores 128 bits of information in a 16-word, 8-bits-per-word format. Time required to write a bit of information into and read it out of this memory is only 100 billionths of a second. Laminated-ferrite memories with cycle times in the millionths-of-a-second range are also under development. These would not be as fast as the above, but would require far less electronic circuitry and much less power to operate. As a result, ferrite memories with total storage capacities in excess of ten million bits would appear technically and economically feasible.

A LARGE CAPACITY CRYOELECTRIC MEMORY WITH CAVITY SENSING*L. L. Burns, D. A. Christiansen, and R. A. Gange, Radio Corporation of America*

Compact, all-electronic computer memories with the information storage capacity of electro-mechanical devices such as magnetic drums and tapes are closer following development, under Air Force sponsorship, of a thin-film superconductive memory plane that can store 16,384 bits of information in an area only two inches square.

FIXED, ASSOCIATIVE MEMORY USING EVAPORATED ORGANIC DIODE ARRAYS*M. H. Lewin, H. R. Beelitz, and J. A. Rajchman, Radio Corporation of America*

An experimental "associative" memory (one that has information not only stored but cross-filed according to content) has been built using 4" x 4" plastic cards incorporating interconnected arrays of solid-state organic diodes. The number of words in the memory is determined by the number of cards in the file, and the number of bits per word by the number of diodes on each card. As presently fabricated, cards can accommodate one word consisting of up to 128 bits. Each diode in the memory has a common cathode and two independent anode connections, and all cards are interconnected electrically along their edges.

Wednesday, November 13 10 A.M.-1:00 P.M.

SESSION 4

INFORMATION RETRIEVAL**A DISCRIMINATION METHOD FOR AUTOMATICALLY CLASSIFYING DOCUMENTS***J. H. Williams, Jr., IBM Federal Systems Division, Bethesda, Maryland***THE DIRECT ACCESS SEARCH SYSTEM***I. A. Warheit, IBM Corporation*

Indexes generally have been organized as either serial or inverted files. Each arrangement has some advantages and some limitations, depending on the file size, storage medium, number of descriptors and the formulation of the search question. By making use of random access files and by including both inverted and serial file arrangements, the index organization proposed offers all the advantages of both, and permits selection of the best search strategy for each request for information stored in the files. It is especially efficient for searching such large indexes as are required for insurance companies, medical records, large libraries, police records, etc. The paper confines itself to describing the underlying principles and does not present any operational data. The program is, however, at present being written for a specific application.

A FLEXIBLE DIRECT FILE APPROACH TO INFORMATION RETRIEVAL ON A SMALL TO MEDIUM SIZE COMPUTER

Jane Olmer, Applied Physics Laboratory, Johns Hopkins University

EXPERIENCE WITH A GENERALIZED INFORMATION PROCESSING SYSTEM
M. Kosakoff and D. L. Buswell, U. S. Naval Ordnance Laboratory

SECTION 5

COMPUTER ORGANIZATION

A SEARCH MEMORY SUBSYSTEM FOR A GENERAL PURPOSE COMPUTER
A. Kaplan, UNIVAC, Division of Sperry Rand Corporation

THE LOGICAL ORGANIZATION OF THE PB 440 MICROPROGRAMMABLE COMPUTER
E. O. Boutwell, Jr. and E. A. Hoskinson, Packard Bell Computer

This paper describes the Packard Bell PB440 Digital Computer whose major innovation is use of two memories instead of the conventional computer's simple memory. In the PB440 the logical elements of the computer — the elements that do the adding, subtracting, multiplying and other computing functions — can be linked together in an endless variety of arrangements somewhat like the human brain. This in contrast to conventional computers which have their logical elements wired together in a way that provides a limited — although certainly useful — number of combinations.

APPLICATION OF PUSHDOWN-STORE MACHINES
R. J. Evey, IBM Corporation

SESSION 6

EXPOSITORY SESSION — SOFTWARE FOR HARDWARE TYPES

THE PROGRAMMER — ROLES AND MISSIONS
W. F. Bauer, Informatics Inc.

SOFTWARE TODAY
W. A. Ramshaw, United Aircraft Corporation

COMPILERS TODAY
T. B. Steel, Jr., System Development Corporation

PROGRAMMERS AND HARDWARE DESIGN
R. E. Porter, Control Data Corporation

THE FUTURE OF SOFTWARE
J. W. Carr III, University of Pennsylvania

SESSION 7

HYBRID ANALOG-DIGITAL COMPUTATION

EFFECTS OF DIGITAL EXECUTION TIME IN A HYBRID COMPUTER
Takeo Miura and Junzo Iwata, Hitachi, Ltd.

Two problems pointed out on a hybrid computer are computer assignment between digital and analog parts and effects of digital execution time. In the parallel hybrid computing system in which the above-men-

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CONFERENCE TIMETABLE

TUESDAY NOVEMBER 12

Opening Session Welcome and Keynote Address
Keynote Speaker:
General Bernard A. Schriever
Commander, USAF Systems Command
Andrews Air Force Base
EXHIBITS 11:30 a.m. - 5 p.m.
SESSIONS 1-3 2 p.m. - 5 p.m.
MOVIES 2 p.m. - 5 p.m.
COCKTAIL PARTY 5:30 p.m. - 7 p.m.
(at Riviera Hotel)

WEDNESDAY NOVEMBER 13

SESSIONS 4-7 10 a.m. - 1 p.m.
MOVIES 10 a.m. - 1 p.m.
EXHIBITS 10 a.m. - 6 p.m.
SESSIONS 8-11 2:30 p.m. - 5:30 p.m.
MOVIES 2:30 p.m. - 5:30 p.m.
PANEL SESSION 8 p.m. - 10 p.m.
The Use of Computers to Study
Games of Chance and Skill

THURSDAY NOVEMBER 14

SESSIONS 12-14 10 a.m. - 1 p.m.
MOVIES 10 a.m. - 1 p.m.
EXHIBITS 10 a.m. - 5 p.m.
CONFERENCE LUNCHEON 12:30 p.m.
Speaker:
Dr. A. M. Zarem, Pres.
Electro-Optical Systems, Inc.
Pasadena, Cal.
SESSION 15 3 p.m. - 5 p.m.

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1963 FJCC (continued)

tioned digital part operates in parallel with the analog computer, essential time delay required for the digital computation is of prime importance and, in many cases, the computation assignment can not be determined without considering the effects of it. This paper describes theoretical and experimental investigations on these problems.

CORRECTED INPUTS — A METHOD FOR IMPROVING HYBRID SIMULATION

Robert Gelman, General Electric Company

This paper describes a method for surmounting some of the difficulties normally encountered in hybrid simulations. In recent years, a number of computer facilities have tied together analog and digital computers in order to use the advantages of both in a single problem. Actual operation of such a hybrid requires the transfer of data between computers. This data transfer limits the effectiveness of a simulation for two reasons: the data transfer takes time; and the analog variables change continuously, whereas the digital calculates in steps. The method of corrected inputs describes how the generation of a simple auxiliary function on the analog can bypass these problems by moving them out of the main portion of the simulation. This is somewhat analogous to the use of logarithms to convert multiplication to addition. This method can make the use of hybrid techniques much more widespread, particularly in the areas of navigation, controls, stability studies, and real time simulations.

A HYBRID ANALOG-DIGITAL DIFFERENTIAL ANALYZER SYSTEM

John V. Wait, University of California

This system is similar to the one proposed by H. Skramstad in 1959, but differs in several respects. It may be regarded as an incremental DDA whose truncation and round-off errors are eliminated through interpolation with repetitive analog computing elements. The prototype system utilizes four digital bits and a one per cent analog channel to achieve a nominal accuracy of approximately 0.1 per cent of half-scale at a maximum full-range computing speed of about 8 cps.

Wednesday, November 13 2:30-5:30 P.M.

SESSION 8

MASS STORAGE SYSTEMS

REVIEW AND SURVEY OF MASS MEMORIES

L. C. Hobbs, Hobbs Associates

INVESTIGATION OF A WOVEN SCREEN MASS MEMORY SYSTEM

J. S. Davis, Thompson Ramo Wooldridge

By using novel fabrication techniques — weaving entire magnetic planes like ordinary window screen mesh — the TRW-developed “woven screen” design can provide random access at microsecond speeds to computer

memories 20-50 times as large as conventional magnetic core units now in existence, Davis says. Davis predicts that TRW's woven screen technique may be the most practical way to produce very large memories containing as many as 100 million bits of information, because of the difficulty of interconnecting that number of individual magnetic cores, as would have to be done if conventional techniques were used. TRW woven screen memories can be fabricated automatically. The TRW memory systems do not contain any moving parts, so they should be inherently much more reliable and economical to maintain than conventional large storage systems.

A NEW HIGH DENSITY RECORDING SYSTEM: THE IBM 1311 DISK STORAGE DRIVE WITH INTERCHANGEABLE DISK PACKS

J. D. Carothers, R. K. Brunner, J. L. Dawson, M. O. Halfhill, R. E. Kubec, IBM General Products Division

AN ENGINEERING DESCRIPTION OF THE BURROUGHS DISK FILE

R. W. Jack, R. G. Groom, R. A. Gleim, Burroughs Corporation

This unit's large storage capability and high speed will reduce to a minimum the processing costs for many applications. The unit's modular design provides for incremental storage of 9.6 million characters, and when installed on a Burroughs B5000 Computer, a maximum system can store up to 960 million characters of information. This storage capacity is twice that required to store the names, addresses and phone numbers of all subscribers in the combined cities of Los Angeles, New York, Chicago, Philadelphia, and Detroit. The revolutionary speed of this unit is such, that any single name, address and phone number can be located in an average time of 1/50th of a second.

A MULTIPLE-ACCESS DISK FILE

I. L. Wieselmann, R. Stuart-Williams, and D. K. Sampson, Data Products Corporation

The paper describes a recently announced large capacity, high performance, mass memory system. Based on the already field proven components, this new system has a typical access time of 90 milliseconds to more than 130 million alphanumeric characters. The system can read and/or write in any two areas of the file simultaneously. In addition, the use of independent positioners for each disk allows for as many as four positioners to be moving at the same time. In high performance data processors the ability to move to the next position, while continuing to process the file data, is a powerful tool.

SESSION 9

NATURAL LANGUAGE PROCESSING

SYNTACTIC ANALYSIS OF ENGLISH BY COMPUTER — A SURVEY

D. G. Bobrow, Bolt Beranek & Newman

THE COMPUTER-STORED THESAURUS AND ITS USE IN CONCEPT PROCESSING

C. A. Shepherd, UNIVAC, Division of Sperry Rand Corporation

SYNTACTIC STRUCTURE AND AMBIGUITY OF ENGLISH

S. Kuno and A. G. Oettinger, Harvard University
A TAPE DICTIONARY FOR LINGUISTIC EXPERIMENTS

J. L. Dolby and H. L. Resnikoff, Lockheed Missiles & Space Company and E. MacMurray, Statistical Tabulating Corp.

SESSION 10

EXPOSITORY SESSION — HARDWARE FOR SOFTWARE TYPES

PHYSICAL REALIZATION OF DIGITAL LOGIC CIRCUITS

Arthur W. Lo, IBM Corporation

FUNDAMENTALS AND IMPLICATIONS OF INTEGRATED CIRCUITS

Robert A. Kudlich, AC Spark Plug Division, General Motors Corporation

PRINCIPLES, STATE OF THE ART, AND FUTURE OF COMPUTER MEMORIES

Jan A. Rajchman, RCA Laboratories

INTRODUCTION TO ALL-MAGNETIC LOGIC

Hewitt D. Crane, Stanford Research Institute

INTERACTION-ORIENTED INPUT-OUTPUT DEVICES

Benjamin M. Gurley, Information International, Inc.

SESSION 11

REAL-TIME SIMULATION

HYBRID SIMULATION OF AN AIRCRAFT ADAPTIVE CONTROL SYSTEM

P. W. Halbert, Electronic Associates, Inc., Princeton, New Jersey

A COMPUTER DRIVEN SIMULATION ENVIRONMENT FOR AIR TRAFFIC CONTROL STUDIES

E. A. Robin, R. S. Pardee, D. L. Scheffler, F. C. Holland, TRW Computer Division and A. G. Halverson, F.A.A.

A Computer Driven Simulation Environment (CDSE) to study advanced air traffic control concepts is described. The environment is built around a large-scale computer and designed to operate with complete flexibility in real-time. Keyboards for entering information into the computer, and displays for presenting information from the computer are used by air traffic controllers and simulator pilots for man-machine communication.

HYBRID TECHNIQUES FOR REAL-TIME RADAR SIMULATION

Roger L. Boyell, Pennsylvania Research Associates, Inc. and Henry Ruston, The Moore School of Electrical Engineering, University of Pennsylvania

A DIGITAL COMPUTER FOR REAL-TIME SIMULATION

Max Palevsky and J. V. Howell, Scientific Data Systems, Inc.

Described is a digital computer which can operate at sufficient speed to replace analog computers. Further,

in order to make the transition as easy as possible, this digital computer operates in many important respects like an analog computer. Since trained personnel are difficult to find, this organization of the new computer permits analog personnel to operate the computer directly.

Thursday, November 14 10:00 A.M.-1:00 P.M.

SESSION 12

MEMORY-ORIENTED COMPUTERS

SYSTEMS IMPLICATIONS OF NEW MEMORY DEVELOPMENTS

Sullivan G. Campbell, Xerox Corporation

A MODIFIED HOLLAND MACHINE

W. T. Comfort, IBM Corporation

MASS FABRICATION, HIGHLY PARALLEL SYSTEMS AND ASSOCIATIVE LOGIC

R. R. Seeber and A. B. Lindquist, IBM Corporation

SOME APPLICATIONS FOR CONTENT-ADDRESSABLE MEMORIES

R. H. Fuller, General Precision, Inc. and G. Estrin, University of California

In this paper, the authors describe uses for a digital computer memory which is addressable by content rather than cell location. Availability of this addressing mode makes possible optimization of space-vehicle control, recognition of handwritten and printed characters, and solutions of field equations arising in nuclear reactor design and long-range weather forecasting. Use of content-addressable memories permits performance of these tasks at rates two to several hundred times faster than is possible with conventional memory addressing. The paper reveals methods for using content-addressable memory to solve these problems efficiently.

SESSION 13

PROGRAMMING — APPLIED

A COMPUTER AID FOR SYMBOLIC MATHEMATICS

L. C. Clapp and R. Y. Kain, Consultant, Bolt Beranek & Newman

STOCK MAINTENANCE BY TELEPHONE — ONE STEP TOWARDS INTEGRATED MANUFACTURING CONTROL IN A MULTI-SHOP MANUFACTURING COMPLEX

George P. Lewett and S. Choolfaian, Western Electric Company

INFORMATION HANDLING IN AN ARMS CONTROL INSPECTION ENVIRONMENT

Lt. Colonel L. F. Mathison, USAF, U. S. Arms Control and Inspection Agency

SESSION 14

INPUT-OUTPUT EQUIPMENT

USING INEXPENSIVE SOURCE TO COMPUTER COMMUNICATIONS

COMPUTERS AS A SOCIAL FORCE

Claude A. R. Kagan and Ronald Tevonian, Western Electric Company

More efficient use of computers to reduce costs as a result of improved scheduling and control of manufacturing operations is made possible through the availability of timely, accurate, and complete information. The requirements for timeliness and accuracy can best be satisfied by obtaining data from the lowest level of operations. The lowest level is also the most dispersed, hence, any devices provided for automatic collection of data must be low cost, small in size, and easy to use. The method being developed at Western Electric for in-house use is that of a data collection concept which provides versatility through the use of variety of modular subassemblies from which specific systems may be assembled. Low cost is achieved through extensive use of components and materials produced in large volumes for the communications industry. Simplified operation and reduced size are achieved through extensive use of coding techniques, thereby minimizing the volume of data entered by the operators.

ENGINEERING CHARACTERISTICS OF CYLINDRICAL THIN FILM PARAMETREONS FOR USE IN DIGITAL SYSTEMS

B. A. Kaufman, W. G. Pfeiffer, V. K. Randery, A. J. Kolk, National Cash Register Company

SINGLE CAPSTAN TAPE MEMORY

R. A. Kleist, M. A. Lewis, and B. C. Wang, Ampex Computer Products

This paper deals with a new digital tape drive mechanism utilizing a single capstan and a unique system. The advantages of this type of drive will be specifically covered, including extreme simplicity, gentle tape handling, and methods to precisely control the start and stop characteristics. This technique utilizes a single capstan without contacting pinch rollers and exploiting a low friction tape path. An interesting application is the method in which the tape is in continuous contact with the capstan through employment of uniform tape tension that is derived from vacuum columns. The tape path, as will be described, utilizes four guiding elements with no mechanical adjustments.

THE EVOLUTION OF AN ARMY-NAVY MILITARIZED DIGITAL MAGNETIC TAPE SYSTEM FOR FIELD COMPUTER APPLICATIONS

Daniel J. Morrison, Navy Bureau of Ships, David H. Tyrrell, CCIS70 Systems Office, USAELRDL, Jack J. Staller, Sylvania Electronic Systems

IBM 7340 HYPERTAPE DRIVE

R. A. Barbeau and J. I. Aweida, IBM Data Systems Division

THE COMPUTER IN EDUCATION: MALEFACTOR OR BENEFACTOR

Robert L. Egbert, System Development Corporation
A MORE RATIONAL SYSTEM OF JUSTICE THROUGH INFORMATION PROCESSING

Richard F. C. Hayden, Superior Court Judge of Los Angeles County

COMPUTER APPLICATIONS AT THE FRONTIERS OF BIOMEDICAL RESEARCH

W. Ross Adey, M.D., Professor of Anatomy and Physiology, Brain Res. Institute, UCLA, Cal.

COMPUTER-ORIENTED PEACE-RESEARCH

Louis Fein, Consultant

Arguing that computers are among our best intellectual resources, a physicist and computer expert suggests that computers be put to work on the problem of world peace. Dr. Fein points out that each person has private convictions about what actions will lead to peace, including strengthening or abolishing the U.N., embracing capitalism or communism, democracy or totalitarianism, religion or atheism, moral rearmament, etc. The problem, according to Dr. Fein, is that while many of these convictions may be dearly held and even pursued by governments, they are little more than subjective viewpoints. Further, he notes, the fact that we have not yet had a nuclear war does not mean that we have sufficiently reliable information on how to continue to avoid one. To develop this knowledge, Dr. Fein advocates establishment of a large-scale, non-national, comprehensive, and expensive (billion dollar) peace research project. In his paper he describes a hypothetical organization along these lines designated as PERC — an acronym formed from Peace on Earth Research Center. Dr. Fein identifies the two principal objectives of PERC as ascertaining the conditions under which people of the world would live in peace with each other and determining ways of getting from the present world conditions to conditions ensuring peace. PERC would begin, Dr. Fein suggests, by testing all available hypotheses of roads to world peace, therefrom deriving stratagems most likely to lead to world peace. The task, he admits, is formidable; he also notes that some will claim it to be impossible. However, he argues, it may be suicidal not to attempt such a study. All nations would have access to what Dr. Fein refers to as the "pedagogic, not coercive" results of PERC's study. He hopes that the results would be so intellectually persuasive that no nation would reject them, but instead follow them of their own free will. Present-day peace research projects, Dr. Fein notes, are handicapped because they are isolated, narrow, under-financed, uncoordinated, empirical, or development (as opposed to research) programs. In particular, he notes, since the existing projects sprang up at random, their results cannot be fitted into any over-all scheme. He suggests instead that the first need is for a single master peace-research plan.

1963 NEREM

*Commonwealth Armory and Somerset Hotel
Boston, Massachusetts
November 4, 5, 6*

Usually attracting from 17,000 to 20,000 attendees, the Northeast Electronics Research and Engineering Meeting (NEREM) offers a highly diversified technical program reflecting this year's significant R&D progress.

Several million dollars' worth of the latest in electronic equipment will be displayed in over 400 booths by more than 300 exhibitors. This huge exhibition will be held in the Commonwealth Armory in Boston.

Over 100 papers in 22 fields will be presented at both the Somerset Hotel, conference headquarters, and the Armory. All IEEE registrants will receive, at no additional fee, a copy of the NEREM Record, a conference report covering all of the papers.

A summary of some of the papers which promise to be of most interest to the digital designer is presented below.

Monday, November 4, 1963..... 2:30 - 5:00 P.M.

Session 3, entitled "Space Electronics", will be held at the Somerset Hotel and will include a paper on NASA Ground Support Networks by J. T. Mengel of the Goddard Space Flight Center. He will describe interstation communications systems and associated computing and data processing systems. Under the title, "NASA Guidance and Control", Col. C. H. Gould will detail the present state-of-the-art plus future guidance and control problems and possible solutions.

Tuesday, November 5, 1963

10:00 A.M. - 12:30 P.M.

In Session 7, "Transistor Circuit Design-Status Report", D. F. Hilbiber, of Fairchild Semiconductor, will discuss solid-state dc amplifiers outlining the improved devices and circuit techniques that have contributed substantially to precise methods of amplifying microvolt dc signals. W. Peil and L. J. Ragonese, of General Electric, will evaluate the performance of high-speed, transistor switching circuits and determine the limiting speed factors on both circuit and system levels. J. C. McDonald of Sylvania Electric will discuss the use of transistor blocking oscillators as nanosecond pulse generators with emphasis on the difference between past theory and practice.

Wednesday, November 6, 1963

10:00 A.M. - 12:30 P.M.

One of the most important sessions for the digital designer is Session 16, Microelectronics Technology. R. Alberts, of Wright-Patterson AFB, will start off this session with a review of the status of microcircuit ap-

plications in military systems. T. A. Longo, of Sylvania Electric, will present the philosophy behind the development of silicon monolithic integrated circuits tracing the progress to date and examining advanced design concepts.

S. M. Stuhlborg, of P. R. Mallory & Company, will report on the "pellet" approach to microelectronics showing examples of pellet microcomponent applications, and explaining the relative merits of various intraconnection techniques. H. Gunther Rudenberg, of Arthur D. Little, will give an analysis of performance figures of merit for integrated circuits. His study will appraise a number of parameters that can be used to assess performance and the related costs of obtaining such performance. F. Plemenos and W. McMorran, of Raytheon Company, will describe the design and packaging of miniaturized digital equipment. They will discuss the design compromises that arise when deciding on which type of integrated circuit is to be used, citing examples based on actual system requirements.

Wednesday, November 6, 1963 2:30 - 5:00 P.M.

In this time period, two sessions of interest to digital designers are scheduled. In Session 19, called Information Technology, Col. A. Debons, of Air Force System Command at Hanscom Field, will describe design methodologies for large command and control systems. A. Rosenfeld, of the Budd Company, will present a survey of techniques for encoding pictorial information, processing of images, and pictorial pattern recognition. D. P. Petersen, of United Aircraft Corp., will survey the design of smoothing and differential operations for digital processing of data derived from discrete measurements of random space/time fields. E. E. Nelson, S. S. Viglione, and H. F. Wolf, of Astropower, Inc., will discuss the data processing capabilities of a recently-developed electronic neuron model. They will examine the use of neuron networks for logic functions, pulse storage, analog-to-digital conversion, and the recognition and classification of time-varying signals.

In Session 20 entitled "Microelectronics Applications", E. A. Blanchette and J. A. Narud, of Motorola Semiconductor Products, will outline the problems of device design peculiar to integrated circuits, with particular reference to Motorola's MECL logic gate. They will detail the final performance figures for a high-speed MECL gate relating the analysis to the basic physical properties of PN junctions. T. V. Sikina and S. A. Idzik of Philco Corp., will report on an investigation being conducted to demonstrate the feasibility of using DCTL integrated circuits in a pattern-recognition system. Problems encountered in applying these circuits to a paraproagation pattern classifier will also be discussed. J. Hohmann and A. Bramble, of Fort Monmouth's USASRD, will describe a unique tone recognition circuit for use in telephone and telegraph equipment where discrete tones below 3000 cps are used for signalling or information transmission. This microminiature circuit is expected to eliminate the bulky and heavy LC filters that are normally used for these low frequencies.

END

SORT MERGE TECHNIQUES

Use Of Eight-Century-Old Fibonacci Numbers Eliminates A Tape Unit

An interesting use of a numerical progression, the Fibonacci series discovered nearly eight centuries ago by an Italian mathematician, was demonstrated at the recent Data Processing Management Association Convention in Detroit. Using their B280 magnetic tape computer, Burroughs demonstrated how a program based on the Fibonacci series requires the use of only three magnetic tapes, instead of the customary four, in sorting a mass of random data into an ordered sequence. The technique permits a savings to users of \$700 a month, the lease price of a magnetic tape unit.

Fibonacci, also known as Leonardo of Pisa, published his discovery in 1202. A series of numbers in which each term is the sum of the two previous numbers, the progression looks like this:

1, 1, 2, 3, 5, 8, 13, 21, 34, 55, 89, 144, 233 . . .

Mathematicians have long been fascinated by the amazing relations which can be obtained between the numbers in this series, but computer experts have been especially interested in their usefulness in sort-merge routines. Customary four-tape sort-mergers involve a complicated juggling of data between tapes, passing it back and forth in ever longer "strings" until an ordered sequence is arranged

for the whole mass of data. The sort-merge technique based on the Fibonacci series involves a similar juggling of data but with only three tapes. Here's how it works. Assume a large mass of randomly arranged data — say 5,000 retail customer account transactions — must be set into some numerical order before the customer accounts can be updated. These 5,000 data are contained in random order on one reel of magnetic tape.

Data is drawn by the computer from this random mass and assembled in the form of "strings". Each string lists a small number of transactions. These transactions are placed in the desired sequence in the computer's central memory, after which the now-ordered strings are read into the other two tapes in the B280 system so that the number of strings on the tapes is always in accord with the Fibonacci series, as the chart below shows:

STEP	TAPE A	TAPE B	TAPE C
	(all data)	0	0
1		1	1
2		2	3
3		5	8
4		13	21

This process continues until all data has been read out of tape A and contained on strings of data lodged in tapes B and C in accord with the Fibonacci progression. When this transfer has been accomplished, the merge

phase can begin. For demonstration purposes, let's assume 233 strings — much fewer than would be likely in any actual instance — are allotted in this fashion: 89 on tape B and 144 on tape C. The order of merge would look like this:

STEP	TAPE A	TAPE B	TAPE C
1	0	89	144
2	89	0	55
3	34	55	0
4	0	21	34
5	21	0	13
6	8	13	0
7	0	5	8
8	5	0	3
9	2	3	0
10	0	1	2
11	1	0	1
12	0	1	0

The process charted above begins by the computer drawing 89 strings of data from tape B, another 89 strings from tape C and merging them, string-by-string, onto tape A. As step 2 above shows, this results in 89 longer strings on tape A and 55 strings on tape C. Tape B is then empty. The process is repeated. Fifty-five strings are drawn from tapes A and C, merged string-by-string and stored on tape B. In the same fashion the process is repeated over and over.

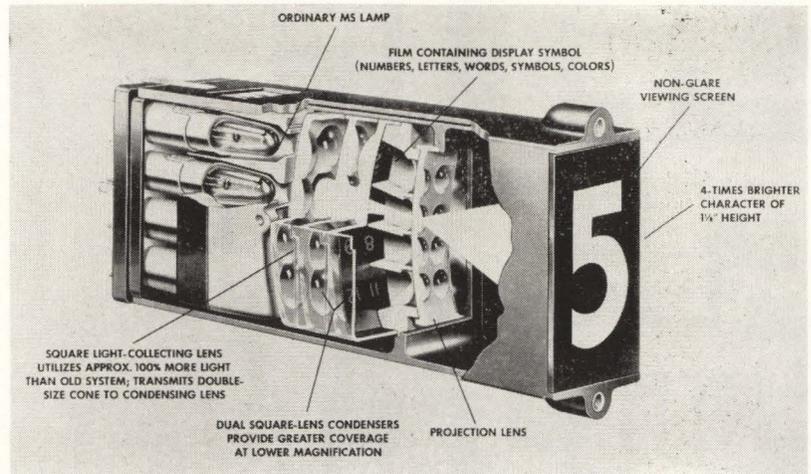
The end result is one huge string of ordered data which lists all 5,000 transactions in the desired numerical sequence. Note that the descending order is simply the Fibonacci series in reverse. That particular progression enables programmers on the B280 and other computers to work towards unity — that is, one long string of ordered data — employing only three tape units and with a minimum of data juggling. **END**

Coming in COMPUTER DESIGN

- *Teletypewriter fundamentals*
- *Cryogenic memories*
- *Survey of shaft-angle encoders*
- *Digital process control*
- *Components for digital circuits*

Digital Readouts

A new rear-projection one-plane readout equipped with a patented brightness-building lens system was introduced recently by Industrial Electronic Engineers, Inc., North Hollywood, California. Since the lenses and not the lamps provide the increased brightness, the new Series 10 readouts use conventional MS lamps operated strictly at rated voltages. For example, the new readout, when used with 6.3 volt lamps, provides character brightness exceeding 100 foot-lamberts, or four times the brightness of older models using identical lamps at rated voltage. As an optional fringe benefit, users not requiring the fourfold increase in brightness may obtain double brightness of older units while increasing life expectancy of lamps ten times. This is accomplished by operating the lamps below rated voltage. Thus, a 6.3 volt lamp, operated at 5 volts, will give more than 50 foot-lamberts of brightness and an increase in lamp life from 3,000 to 30,000 hours.



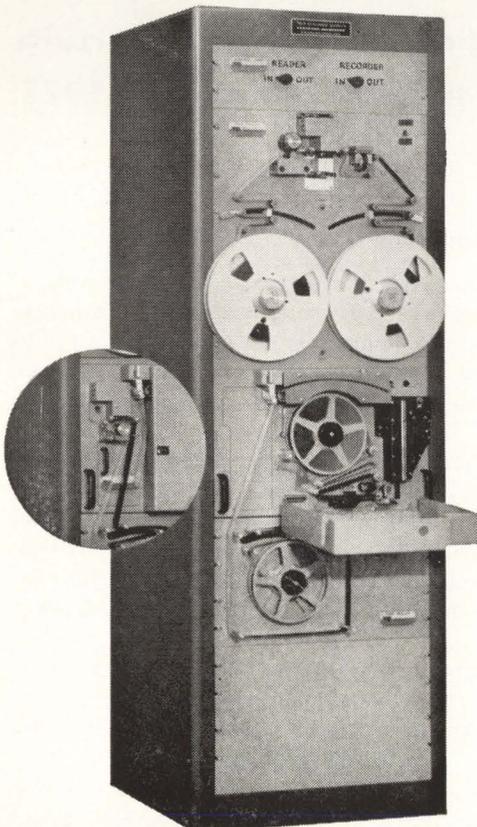
Conventionally, lenses are circular; the new lenses are basically square to permit greater usable lens area within the limited space. This increase in lens size utilizes two factors almost equally in quadrupling brightness. First, brightness is doubled because the larger lenses collect twice the amount of light from source. The second doubling of brightness takes place inversely through an approximate 50% reduction in magnification

requirements.

For operational purposes, the new Series 10 readouts are identical to older models and are completely interchangeable. They come in a metal case which is 2.25" H, 1-9/16" W, 5 3/4" D, including terminals. The new unit is priced at \$18.00 with decreasing scale for quantity. Bezels and mounting assemblies are available for in-line mounting.

Circle No. 204 on Inquiry Card

FASTEST PAPER TAPE SYSTEM



At 300 to 1000 characters per second of five to eight bits, the Tele-Dynamics system is the fastest paper tape presentation available for retrieving from and reading information into a digital computer or communications link. Printing electrostatically, it produces a permanent recording of coded information without mechanical punching, chemical processing, or paper burning. The reflected light reader reads both punched and electrostatic tape.

Building as the job grows is fully practical since printer, reader, and accessory units are modular in construction. Speed can be adjusted simply by changing pulleys and/or adding standard printed circuit cards. Edge-printed alphanumeric presentation of the coded character can be attained by plugging an additional chassis into the printer. Parallel-to-serial conversion is available as standard plug-in cards. Code conversion is accomplished by connecting an additional chassis. Either the recorder or reader can be procured separately.

This standard electrostatic equipment has a wide range of usefulness in data handling and communications systems to provide high speed recording with slow or high speed playback. (Inset—low speed reader may be combined in the same chassis as high speed printer to buffer speed for input to mechanical page printer.) Typical applications include computer input/output message speed buffering, message routing by torn tape, and digital data communications systems. Write today for detailed information.

TELE-DYNAMICS

DIVISION

AMERICAN BOSCH ARMA CORPORATION

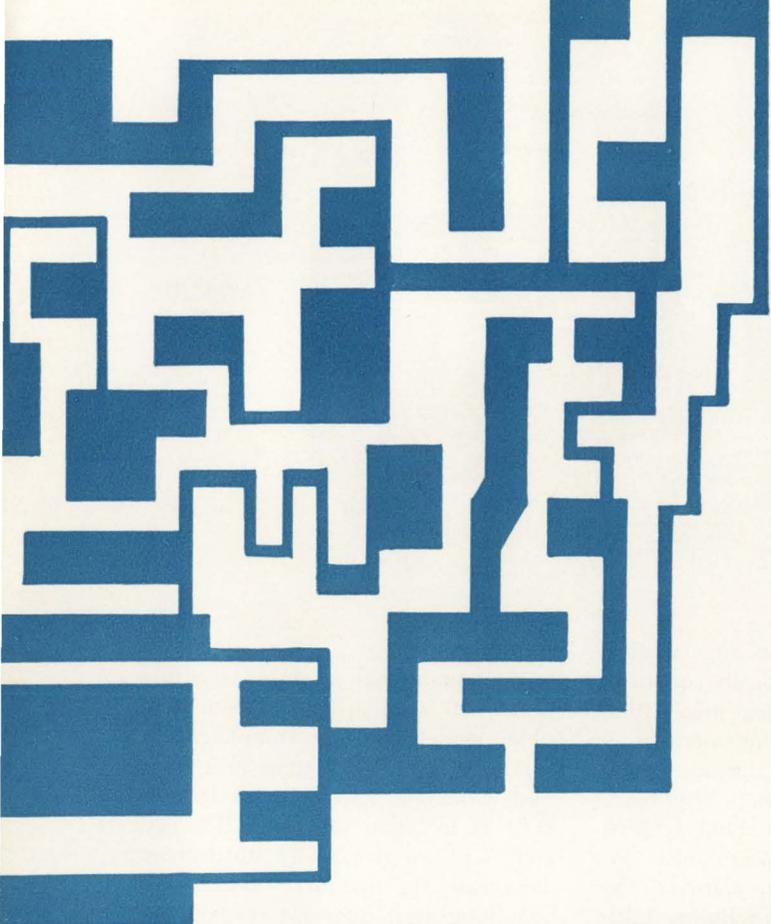
6000 Parkside Avenue, Philadelphia 31, Pa.

CIRCLE NO. 5 ON INQUIRY CARD

9127

COMPUTER DESIGN/OCTOBER 1963

15



The Impact of

INSIGNIFICANT OR PROFOUND?

Expert opinions on what effect the use of integrated circuits will have on the industry have ranged from "insignificant" to "more profound than the transistor". This report, based on a comprehensive year-long study, predicts that integrated circuits will take over 20% of the circuit market by 1975.

From all indications, integrated circuits are capable of replacing a significant portion of existing circuitry. Present integrated circuits have this capability within a broad multi-dimensional spectrum with defined limits of power, frequency, noise, etc. Present limitations preclude integrated circuits' replacement of all portions of circuits in existing devices, such as high power applications; however, given the present stage of development, the outlook for the near future is very bright.

Given the limitations that exist, integrated circuits will follow the evolutionary footsteps of the transistor — initially appearing in military and space applications and then appearing in industrial and consumer applications. As with the transistor, future developments will tend to push back the boundaries, and the number of functions that can be accomplished with integrated circuits will multiply.

In attempting to foresee the application of integrated circuits, the electronics market has been conveniently divided into three general classifications: government, industrial, and consumer markets.

Government Applications

The earliest applications of integrated circuits were in the government market. These applications were in various forms of digital computers. The digital computer consists of many repetitive circuits, the active elements of which can have almost any type of transfer function, just so long as "on" and "off" states are clearly defined. These factors make use of the most favorable characteristics of the integrated circuit while capitalizing on the efficiencies of volume in manufacture. This natural fit between digital computers and integrated circuits has been recognized by military planners, and the military has contributed to the financing of integrated circuit development.

The significant aircraft, missile, and space fields have been important to the integrated circuit. In these fields, a useful rule of thumb is that an additional pound of payload will require eight to ten pounds of supporting structure in a modern aircraft and a thousand pounds of fuel and structure in a space vehicle. Thus, the value gained

Integrated Circuits

A little over a year ago, members of Harvard University's Business School initiated a comprehensive study to determine what effect integrated circuits is having and will have on the industry. The objective of the study was to investigate this new development both from the technical and business standpoint and link these two aspects in a meaningful fashion.

In making the year-long study, the researchers reviewed basic textbooks, trade magazine articles, company reports and literature, conference papers, and other written material. Over 100 manufacturers were interviewed including a visit to almost every major integrated circuit manufacturing facility.

Part of the results of this work is presented here, however, the complete study is now available as a textbook which, although just recently published, is already recognized by many as the most thorough treatment of the subject to date. The book successfully fulfilled the authors' objectives which were:

- To summarize the present state of integrated circuit technology and fabrication processes
- To predict what the resulting industry will look like

- To analyze and evaluate critically the relevant factors such as size, weight, tolerances, flexibility, reliability, and costs in relation to alternative approaches
- To determine to what uses integrated circuits will be put and in what time perspective
- To examine from all aspects the impact of integrated circuits on the industry.

Based on a detailed review of the integrated circuit state-of-the-art from both design and manufacturing viewpoints, which is presented in the first few chapters, the book develops a manufacturing investment and unit cost analysis, and a thorough market analysis which includes a detailed sales volume projection through 1975.

Entitled "Integrated Circuits - A Technical Review and Business Analysis", the complete study contains 130 pages and is priced at \$18.50. For more information on the book, circle No. 106 on our reader service inquiry card or write to:

INTEGRATED CIRCUITS ASSOCIATES
P. O. Box 131
No. Cambridge, Massachusetts 02140

through a significant reduction in weight can be substantial. In these applications, circuit cost becomes much less important than circuit size and weight. Therefore, economic justifications of a total aerospace package have outweighed the higher cost of integrated circuits alone.

Current and proposed digital computer uses of military integrated circuits in the space field include a funded guidance computer for the Minuteman Missile, the central computer for the Grumman AEW aircraft, and the central computer in the forthcoming Apollo project. For each of these projects, the reliability of the integrated circuit - as well as size and weight - has been judged

superior to conventional circuits. Although the size and weight advantage was the first great impetus for integrated circuits in the military and space market, the potential of greater reliability has become the dominant reason the government is turning more and more toward the integrated circuit.

Airborne and spaceborne communications and electronic counter-measure systems, particularly the passive variety, have the additional requirements of high frequency capability and receiver sensitivity. Once the signal has passed these initial stages, however, it has been sufficiently amplified and shifted in frequency to the point where

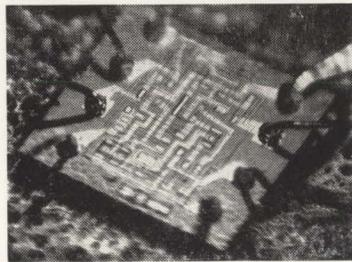
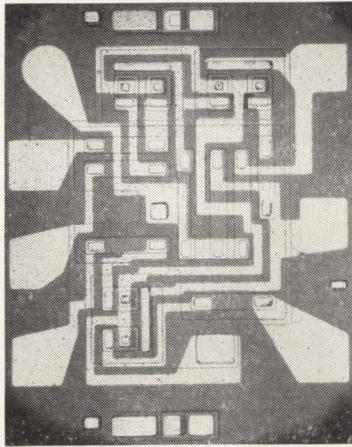


Fig. 1 Introduced at the recently-held Wescon show, Fairchild Semiconductor's "EPITAXIAL MICROLOGIC" integrated circuits are reported to be faster, more rugged, and less expensive than its predecessor — non-epitaxial "Micrologic" circuits. The difference between the two involves both process and performance improvements. Available in production quantities, the new epitaxial silicon microcircuits are more immune to extraneous computer noise, more stable throughout the temperature range of -55 to $+125^{\circ}\text{C}$, and they exhibit improved saturation characteristics. Briefly, the differences in the two production processes are: a P-type silicon crystal for epitaxial vs. the N-type used as the starting material for non-epitaxial; and relatively thicker, less fragile wafers ($0.005''$) can be used in epitaxial techniques giving added finished strength and also resulting in lower wafer loss dur-

ing manufacturing. The remaining steps in the processes are similar except that an N^+ region must be diffused within the P substrate of the epitaxial circuit and after that, the next step is the growth of the epitaxial layer. The thickness and resistivity of this epitaxial layer contribute to the increased speed and improved saturation characteristics of the finished device. The Epitaxial Micrologic circuits can share the production line with Fairchild's silicon Planar transistors, since the processes are identical from dicing through final seal. A photomicrograph of an "H" half-adder element of Epitaxial Micrologic is shown at top and below is a photomicrograph of an Epitaxial Micrologic counter adapter element bonded to a TO-5 header showing leads.

For more information on Fairchild Semiconductor's integrated circuitry:
Circle No. 51 on Inquiry Card

integrated circuits can be utilized in order to realize weight reductions. A military shift toward digital communications and telemetry should result in a more rapid use of integrated circuits in this field. Several units utilizing integrated circuits that fulfill the operating requirements of the military have been proposed.

Not all of the telemetry, communication, and electronic counter-measure functions are achieved by use of integrated circuits, however. In those functions that require a transmitter, conventional circuits are required except in hybrid applications. The introduction of integrated circuits into transmitting functions can be expected to lag introduction into receiving functions for some years to come.

The use of the integrated circuit for airborne radar — either search, track, or navigate — will be limited to the circuits associated with the control and data processing functions. The use of high power and high frequencies combine to eliminate the use of the circuits in these radar functions.

As currently envisioned by military planners, the integrated circuit will make possible the throw-away concept in equipment maintenance. Realization of the throw-away concept would reduce the need for many highly skilled technicians, since the technical training required to diagnose and repair an electronic fault in a system would be considerably less than that required to locate a single bad component. Furthermore, the number of failures would be reduced because of the greater reliability. Hence, it should eventually become less costly to maintain integrated circuit equipment because of lower labor maintenance costs and improved reliability.

In summary, the integrated circuit will replace conventional circuits in the military and space markets as

soon as the combination of initial costs and continued maintenance become obviously better than for conventional circuits. The replacement will be made sooner in those applications where size, weight, reliability, and repairability become the overriding factors. It is logical to assume that once development has occurred and equipment has been proved in the field, adoption of integrated circuits in a greater number of applications will rapidly follow. Acceptance of integrated circuits by each of the three military services is assured, although the different services have supported different approaches to circuit miniaturization.

Industrial Applications

Industrial acceptance of integrated circuits can be expected to lag government acceptance because in industrial applications cost is generally more important than size and weight, and it is more difficult to prove maintenance savings. Therefore, manufacturers of industrial equipment tend to concentrate on reducing original manufacturing and installation costs.

There are any number of exceptions to the generalization about costs, the most notable instance being the computer industry. To a great extent, computer manufacturers do not sell products so much as they sell service. As such, their responsibilities do not terminate with the sale, but continue to include the maintenance and repair functions. With the expense in these areas being borne by the manufacturer, the reliability and repairability takes on greater significance. Computer manufacturers have begun extensive work on design and even fabrication of integrated circuits for use in business machines. The obvious purpose of this move is to improve computer relia-

bility and reduce the downtime for repairs, which upset the user's business activities. While size and weight of present computers have not been a drawback, further size and weight reductions would mean additional space and power savings for end users. Therefore, as in the military market, the integrated circuit will find its initial industrial acceptance in computer applications.

The computer-associated field of industrial controls also presents an important potential market for integrated circuits. However, the use of integrated circuits in this field will come slower than in the computer field since there are fewer repetitive circuits.

Commercial and private aircraft navigation, air traffic control, and landing aids such as Doppler navigators, Radar altimeters, and ILS are a potential market for integrated circuits, but only after their slow introduction into hybrid systems. As in most industrial applications, cost is often more important than size or weight and until widespread application is apparent, it is unlikely that these fields will rush to integrated circuits. This is also true in communications equipment for aircraft.

Other scattered industrial applications offer potential, particularly applications in which portability is important. For example, radioactivity counting-rate meters could become both more portable and more flexible with integrated circuits. The digital circuits could be expanded with additional counting-rate channels without increasing size and weight. The increased cost would appear to be less than proportional to increased capability. In addition, there is tremendous potential for integrated circuits in many medical applications. Tiny electronic equipment, such as a heart-pacer, can be used to replace worn-out parts of the human body, or to aid in delicate operations. The integrated circuit will help stimulate advancements in medical electronics.

At the other end of the portable equipment spectrum, various meters, oscilloscopes, vacuum tube volt-meters, signal generators, and signal analyzers offer limited market potential for integrated circuit manufacturers at this time. In most such equipment, a reduction in size is not critical; however, linearity is critical, and at this time, linearity is not one of the integrated circuits' outstanding characteristics.

Finally, portable communications equipment which could benefit from size and weight reductions might offer a limited market for integrated circuits; the greatest potential would exist for personal communications equipment, such as wrist radios, rather than in mobile units mounted in cars. The obvious exception is in applications where reliability could be improved and cost reduced.

In summary, it appears that integrated circuits will replace conventional circuits in the industrial market much slower than in the military market because of the more importance placed on cost in the industrial market. It will be several years before integrated circuit prices can compete effectively except in computer or specialized applications; however, once the prices become competitive with conventional circuits, the integrated circuit will become a big factor in the rapidly expanding industrial electronic market.

Consumer Applications

The consumer market has been completely unaffected by the development of the integrated circuit to date. As

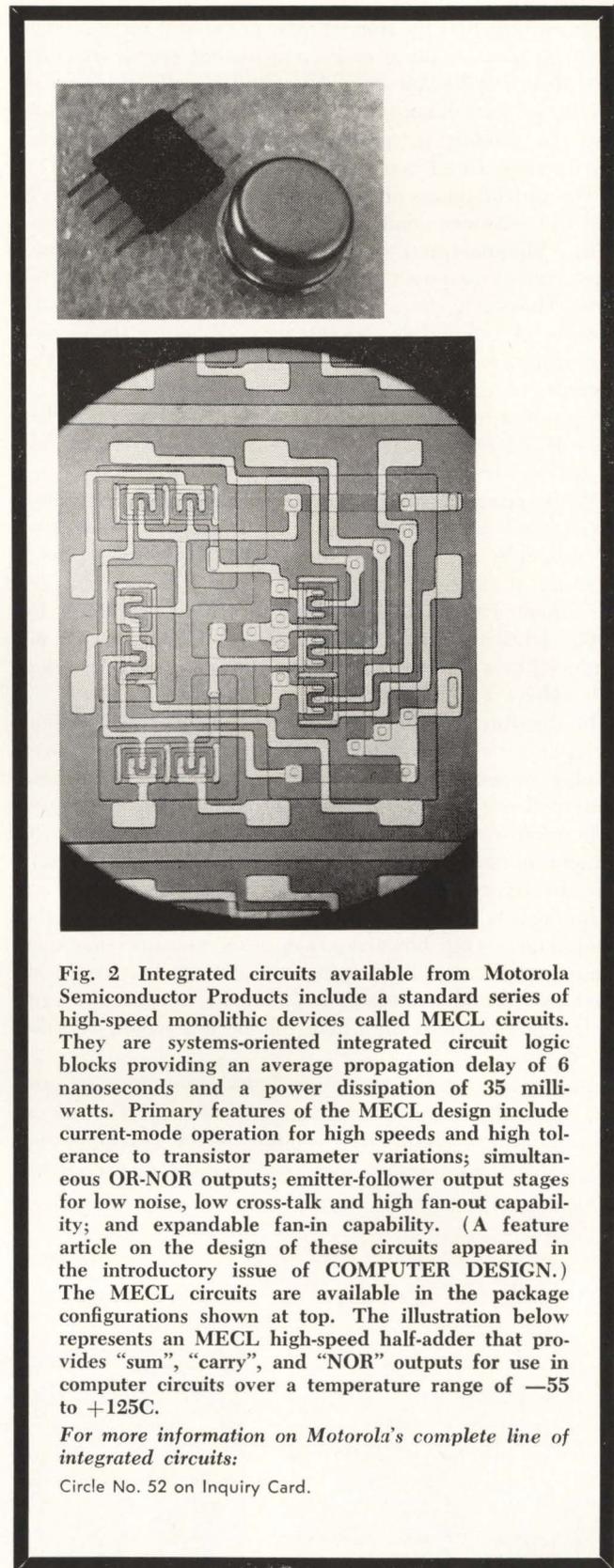


Fig. 2 Integrated circuits available from Motorola Semiconductor Products include a standard series of high-speed monolithic devices called MECL circuits. They are systems-oriented integrated circuit logic blocks providing an average propagation delay of 6 nanoseconds and a power dissipation of 35 milliwatts. Primary features of the MECL design include current-mode operation for high speeds and high tolerance to transistor parameter variations; simultaneous OR-NOR outputs; emitter-follower output stages for low noise, low cross-talk and high fan-out capability; and expandable fan-in capability. (A feature article on the design of these circuits appeared in the introductory issue of *COMPUTER DESIGN*.) The MECL circuits are available in the package configurations shown at top. The illustration below represents an MECL high-speed half-adder that provides "sum", "carry", and "NOR" outputs for use in computer circuits over a temperature range of -55 to $+125^{\circ}\text{C}$.

For more information on Motorola's complete line of integrated circuits:

Circle No. 52 on Inquiry Card.

with most new developments, the initial cost of adopting a technical change precludes introduction in price-conscious consumer goods.

Consumer goods manufacturers have two primary criteria for evaluating technical developments in advance of

their introduction by competitors: (1) *Could the development be used in place of a conventional circuit in order to realize a reduction in cost without a noticeable loss in quality of performance?* (2) *Would the development enable the product to perform a function so much better that increased cost could be passed on to the buyer?*

The unwillingness of the consumer to pay a premium is said by consumer goods manufacturers to extend to reliability. Manufacturers say the consumer prefers lower purchase prices to possible maintenance savings in the future. Moreover, consumers are said to discount longevity because of rapid style obsolescence. Whether these generalizations are accurate is a matter of conjecture, and the strength of the generalization is probably dependent on the product being discussed. However, to the extent that price is a factor, the use of integrated circuits is precluded for the time being.

With reduction in the cost of integrated circuits, consumer applications appear to offer a potential market of considerable magnitude. The advantages of volume manufacture of standard units and infrequent design changes are expected to bring down costs to competitive levels by 1966. Until that time, these circuits will probably be introduced in a few specialized applications such as hearing aids, where a market for reduced size exists.

In the future, integrated circuits are expected to find a significant market in television sets only if a low power display screen is developed. It is anticipated that these units will not require the high power functions now used with picture tubes, functions beyond the capability of present integrated circuits. Certainly, the audio circuits are already capable of accepting this transition.

Radio sets also represent a significant market for the integrated circuit; however, as in other consumer markets, the introduction of basic integrated circuits that could be used by several manufacturers may be necessary to get costs down to the point where the circuits would be salable items.

Unless the circuits are either reduced in price or possess improved power handling capabilities, their use in phonographs or high fidelity equipment seems temporarily limited. As with radios and television, standard circuit

functions adopted by several manufacturers may hasten introduction.

In the future, home computer applications may result in integrated circuits entering the home. In addition, integrated circuits will make possible the development of many portable consumer devices, such as wrist radios and miniature television sets comparable to portable radios. However, the development of these applications appear distant and depend upon the consumer demand for new electronic devices and the cost to manufacturer them.

EXTENT OF USE

The introduction of integrated circuits into electronic equipment has begun on a small scale, with the great preponderance of applications centered in military and computer uses where size, weight, and reliability advantages are crucial. However, with time, as integrated circuits applications are developed, their costs will fall. Similarly, as competitive pressures increase and more engineers develop experience in the associated design techniques, the rate of growth of circuitry integration will accelerate. More types of end uses and more categories of equipment will accept integrated circuits to replace the more vulnerable types of conventional circuitry.

In order to project integrated circuit dollar sales volume through 1975, any one of several methods could have been used. Nevertheless, predicting circuit sales in a growth industry such as electronics, where information is not always available or consistent, presents a difficult task because of the diverse types of markets the industry serves. In attempting to arrive at meaningful estimates for factory value of integrated circuits over the forthcoming twelve years, a multistage decision procedure was employed.

The first step was the derivation of projected factory sales for each of 126 equipment categories, subdivided into consumer, military and space, and industrial markets. The basic approach used in projecting the major equipment categories in each of the market segments was the two-step, or round-about approach; i.e., the most closely related segment of the G.N.P. was projected through 1975 and then a trend of the past relationship between the

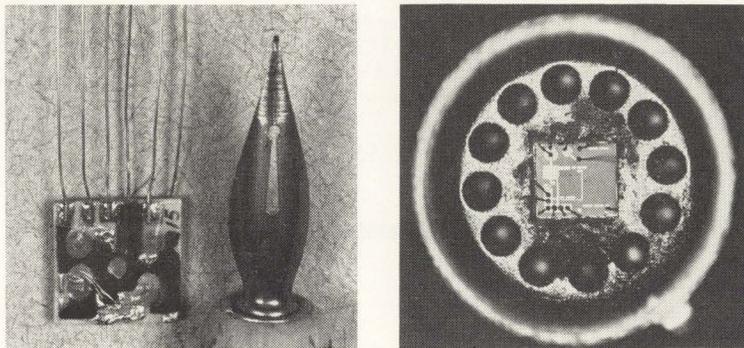
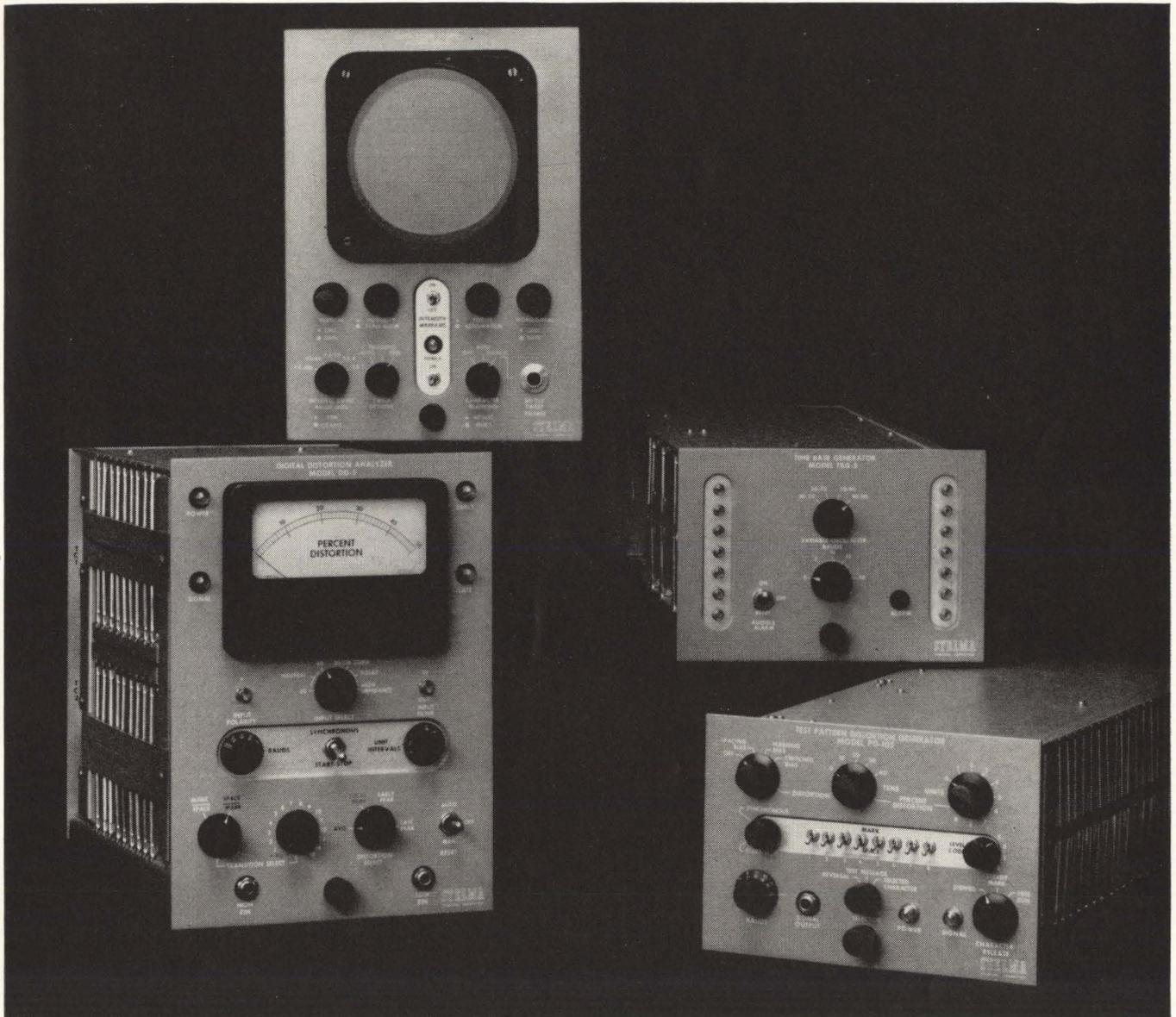


Fig. 3 A typical thin-film circuit made by Sprague Electric is shown on the left, overshadowed by a pen nib. Used in a precision oscillator network, this thin-film circuit, tradenamed CERACIRCUIT, contains 14 metal film resistors, 3 ceramic capacitors, 2 solid tantalum capacitors, and 3 transistors. While the component density computes to an astronomical figure of 3 million parts per cubic foot, this must be used with caution since the figure does not take into account the volume occupied by interconnections with other plates. Shown on the right is an integrated NOR gate microcircuit developed at Sprague's Research Center for use in computers of the future. Contained on a silicon die, which is an 0.080" square, are 8 diodes, 1 transistor, 4 resistors, and 1 capacitor. The actual diameter of the TO-5 can in which the circuit is housed is 0.290".

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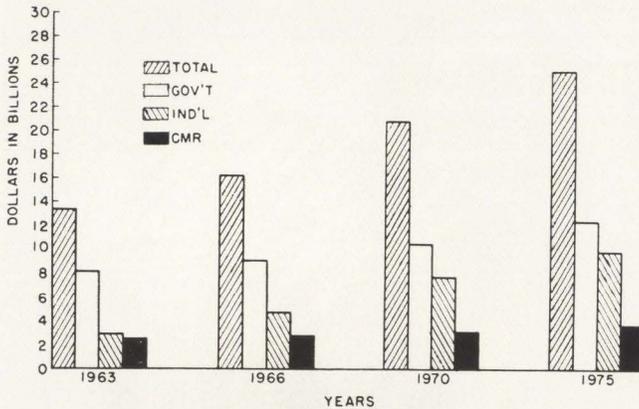


TABLE 1

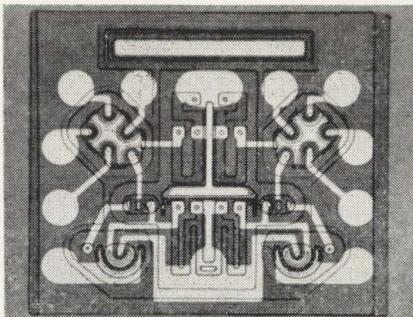


Fig. 4 Siliconix, Inc., offers a line of load-compensated diode-transistor logic circuits in single chips of silicon. The logical operation of the circuits is identical with conventional DTL circuits, however, a unique emitter-follower diode-clamp arrangement is added to provide high-speed switching with high gain and low power operation. The dual NAND/NOR gate, shown here, features a low power-speed product of 60 picowatt-seconds. The circuit operates from a single power supply with a typical propagation delay time of 12 nsec; a typical power dissipation of 5 milliwatts; and a high fan-out of 5 at -55 to $+125^{\circ}\text{C}$. The dual gate is available in a modified 12-lead TO-5 package and also in a flat package.

For more information on Siliconix' integrated circuit line:
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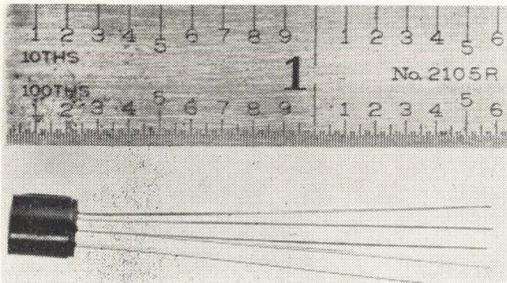


Fig. 5 Numerous diode, resistor, capacitor combinations are available in TO-18 or TO-5 packages from MicroSemiconductor. These integrated circuits are said to provide the optimum in microcircuit performance, reliability, and cost. The circuits operate over broad current and voltage ranges, frequencies in excess of 20 megacycles and over a temperature range of -55 to $+150^{\circ}\text{C}$. Typical circuits include input gates and flip-flop steering gates.

For more information on MicroSemiconductor's integrated circuitry:
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equipment sales and the closest G.N.P. segment was applied to this projection. For example, since consumer electronic equipment sales are related to Personal Disposable Income, Personal Disposable Income was projected through 1975 and the trend relationship, expressed as a ratio between consumer sales and Personal Disposable Income, was applied. A ratio was used in order to smooth out the long-range trend and eliminate cyclical fluctuations that occur in electronic equipment sales. The Producers' Durable Equipment segment of the G.N.P. was related to industrial electronic equipment sales and National Defense Expenditures to military and space electronics. Once the 19 major categories were established, the individual equipment categories which comprise the major classes of equipment were projected on the basis of other electronic industry projections and continued growth trends exhibited in the past. A summary of equipment sales for the three major market segments is shown in Table I.

An elaborate projection of sales of 126 different equipment categories was made because the sales of integrated circuits are conditional upon the estimated sales of equipment. The second step in the projection of factory value of integrated circuit was, thus, to estimate the dollar value of conventional circuitry that integrated circuits would replace. This was accomplished, first, by determining the portion of equipment factory sales representing the value of the conventional circuit for each of the 126 categories. These percent-circuitry estimates were based upon industry experience, electrical engineering knowledge, and information gained through interviews or questionnaires. Second, the maximum potential portion of conventional circuitry that could be integrated was determined for each category, given the assumptions noted earlier as to costs over time, reliability, and relative operating characteristics. These maximum percent-integrable estimates were also based on information gathered through interviews or questionnaires. By multiplying the percentages determined above, one can derive the ultimate percentage of the equipment sales dollar which can be replaced by integrated circuits, or its proportional potential, given present and projected trends in cost, size, weight, reliability, performance, and other operating characteristics.

Third, after this determination of potential applicability, the year in which integrated circuits would be introduced in each of the equipment categories was estimated, as was potential which would be integrated by 1975. These estimates define the end points for the projected growth of integrated circuits over the forthcoming twelve year period. The percent of maximum potential circuits that can be integrated for the years between the date of introduction and 1975 were determined by the use of natural growth curves and information gathered through interviews. The effect of these percent estimates is to maintain the rising growth trend of integrated circuits introduced late in the period, and to decelerate the growth of integrated circuits' exploitation of potential in their earlier introductions. After a period of increasing growth as the most vulnerable conventional circuitry is supplanted, integrated circuits will meet increasing resistance, while sales growth evolves about the introduction of new forms of equipment designed around integrated circuits. Hence, the final steps act, first, to establish a demand figure sufficiently far in the future (1975) to be free of the in-

itial problems of introducing integrated circuits, such as user inertia and re-design delay periods; and, second, to normalize the effects of these problems over the industry as a whole.

After having thus determined the above percent figures, they are multiplied together to determine the value of conventional circuitry that will be replaced by integrated circuits. In other words, $IC_R = (S_E) \times (P_C) \times (P_M) \times (P_A)$ for a given type of equipment:

where

- IC_R Dollar value of conventional circuits that will be replaced by integrated circuits.
- S_E Dollar sales of the given equipment type
- P_C Circuitry as percent of dollar sales of equipment
- P_M Maximum percent of conventional circuitry that can be integrated
- P_A Percent of maximum (or P_M) attained in the given year.

Table 2 shows a summary of equipment sales and integrated circuit replacement value for the 19 major types of equipment. It should be noted that integrated circuits are projected to replace only \$28.6 million in 1963, but this will rise to \$2.04 billion by 1975. The vast majority of replacement, will occur in the Industrial and Military and Space markets, particularly in computer systems.

Calculation of the dollar value of conventional circuits that will be replaced by integrated circuits is not, however, the same as the factory value of integrated circuits, because the price of conventional circuits differs from that of integrated circuits. The third step in the derivation of factory value of integrated circuits is, therefore, to deflate the total integrated circuit replacement value by an average price deflator. Calculations for deflated integrated circuit values for 1963, 1966, 1970, and 1975 are shown in Table 3. It can be seen that the deflated factory value of integrated circuits will rise from \$68.6 million in 1963 to \$814.6 million in 1975. These deflated figures are significantly different from the replacement values because of the large drop in integrated circuit prices predicted through 1975.

In order to gain some perspective in analyzing this large projected growth in integrated circuits, a comparison with total circuit value is useful. This comparison is depicted in Table 4 which shows graphically that integrated circuits as a percent of total circuit value will rise from 2.7% in 1963 to 22.8% in 1975. This represents a substantial growth in the use of integrated circuits over the next twelve years, which should have a sizable impact upon the industry.

It appears that the integrated circuit has tremendous potential through 1975 and will enjoy a rapid growth rate in factory value, both in absolute terms and as a percentage of total circuit value. Most of the sales of integrated circuits will come from the computer and communications equipment in which many repetitive circuits are used. After 1975 it appears that the growth of integrated circuits will begin to slow as new devices, such as functional blocks, are invented and put into use.

TOTAL IMPACT

Integrated circuits represent an increasing percent of total circuit sales, going from less than 3% in 1963 to over 22% in 1975 as shown in Table 4. This percent rep-

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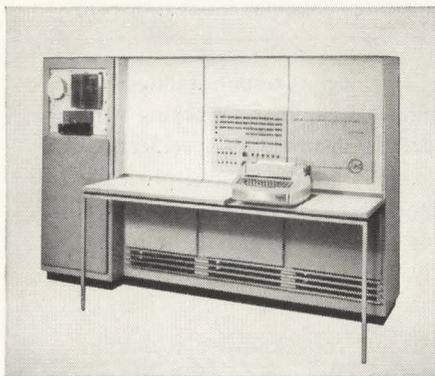
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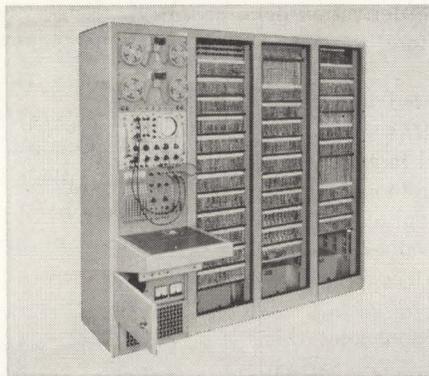
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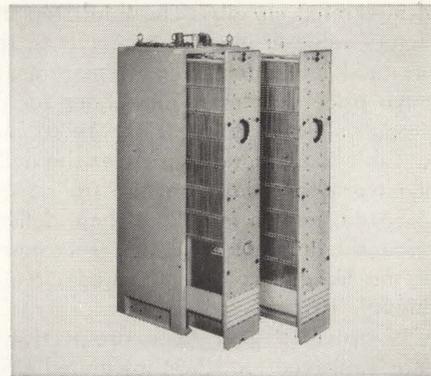
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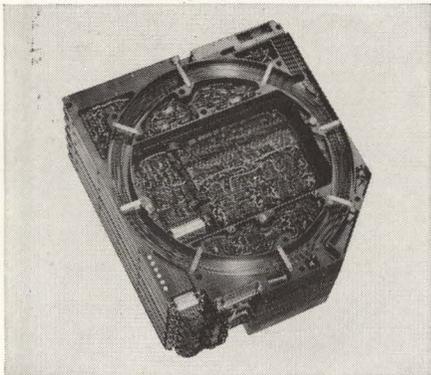


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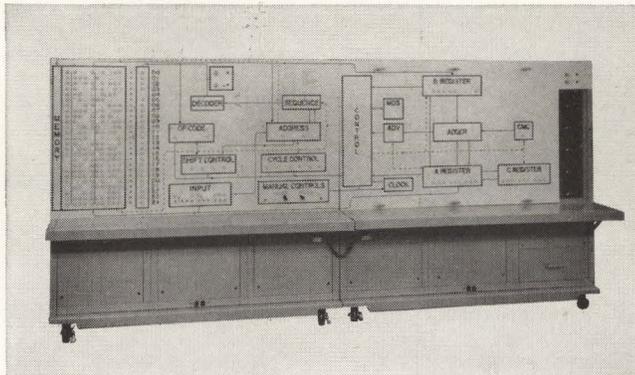
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SUMMARY OF EQUIPMENT SALES AND INTEGRATED CIRCUIT REPLACEMENT VALUE
FOR THE MAJOR EQUIPMENT TYPES

	Equipment Sales (\$Million)				Integrated Circuit Replacement Value (\$Million)			
	1963	1966	1970	1975	1963	1966	1970	1975
Consumer Electronics								
Television	\$ 1,020	\$ 1,130	\$ 1,270	\$ 1,430	-	\$ -	\$ 1.0	\$ 10.8
Radio	365	403	459	535	-	3.1	17.2	51.4
Phonograph, Radio-Phono	409	442	503	588	-	-	2.8	12.7
Hi-Fi (Amplifiers & Tuners)	47	61	80	111	-	-	-	5.0
Records	275	306	349	407	-	-	-	-
Miscellaneous	319	389	483	605	-	.7	5.7	25.3
Electronic Organs	101	117	143	177	-	-	1.1	10.6
Dictating Devices	61	78	98	122	-	-	-	-
Tape Recorders	52	65	84	110	-	-	.9	4.2
Amateur Equipment	43	52	63	76	-	-	-	-
Hearing Aids	33	38	45	57	-	.6	3.0	7.9
Kits	28	39	50	63	-	.1	.7	2.6
Total Consumer Electronics	\$ 2,435	\$ 2,731	\$ 3,144	\$ 3,676	-	\$ 3.8	\$ 26.7	\$ 105.2
Industrial Electronics								
Test & Measuring Equipment	\$ 450	\$ 732	\$ 1,150	\$ 1,560	\$ -	\$.0	\$ 1.6	\$ 10.4
DP & Industrial Controls	1,450	2,587	4,491	5,560	.7	84.9	450.4	777.8
Computers, Systems	1,230	2,200	3,800	4,330	.7	84.8	447.0	759.0
Teaching Machines	10	40	125	250	-	-	.3	10.0
Industrial Controls	210	347	566	980	-	.1	3.1	8.8
Communications & Broadcasting	845	1,230	1,750	2,210	.4	6.1	34.1	112.0
Nuclear Instruments	52	57	108	197	-	.0	.5	3.2
Medical Equipment	107	134	231	388	-	-	1.7	8.7
Total Industrial Electronics	\$ 2,904	\$ 4,740	\$ 7,730	\$ 9,915	\$ 1.1	\$ 91.0	\$ 488.3	\$ 912.1
Military & Space Electronics								
Test & Measuring Equipment	\$ 2,210	\$ 3,070	\$ 3,730	\$ 4,300	\$ -	\$ -	\$ 9.8	\$ 166.2
Search & Identification	2,300	1,820	2,500	2,920	-	.5	5.1	26.0
Computers, Systems	1,720	2,000	2,100	2,150	23.1	127.0	420.0	583.0
Communications	1,430	1,660	1,890	2,420	4.4	33.4	119.8	242.9
Electronic Warfare	260	245	270	286	-	-	-	-
Trainers, Simulators	100	114	140	166	-	-	-	-
Nuclear Instruments	86	95	100	115	-	.1	.3	1.2
Medical Equipment	37	38	73	109	-	-	.0	.5
Total Military & Space Electronics	\$ 8,143	\$ 9,042	\$ 10,523	\$ 12,466	\$ 27.5	\$ 161.0	\$ 555.0	\$ 1,019.8
Total Electronic Equipment	\$ 13,394	\$ 16,253	\$ 20,863	\$ 25,225	\$ 28.6	\$ 255.8	\$ 1,070.0	\$ 2,037.1

TABLE 2

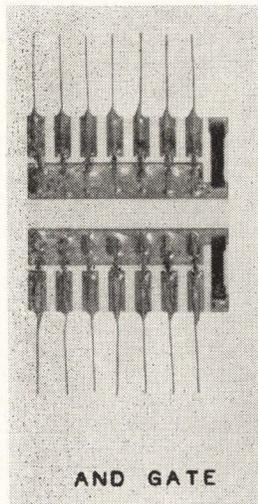
resents a substantial portion of the market. Such a large replacement of existing forms will undoubtedly have a profound impact on the industry. This impact will now be discussed in four areas: standardization of circuits, technology and applications, structure of the electronic market, and education and personnel.

Circuit Standardization

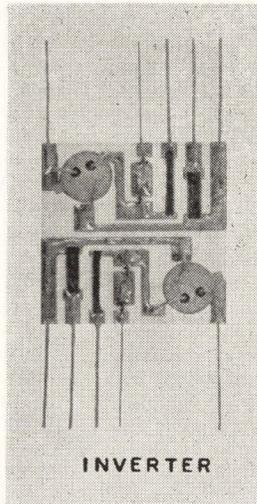
At the present time, standardization of circuits appears to be impractical with the thousands of different types, shapes, and sizes offered on the market. One major reason for this is the millions of component combinations that can be formed. A second major reason arises from the fact that, because of the competitive situation in the electronics market, many equipment manufacturers sell their

equipment on the basis of the uniqueness of circuit design. In order to sell, a manufacturer finds he must offer something different than his competitor in order to stay away from competition based on price alone. Of course, this is a major generalization and does not apply to all situations, but the equipment manufacturer, or user of integrated circuits, feels he cannot afford to give up his circuit design capability because it is one of his competitive strengths.

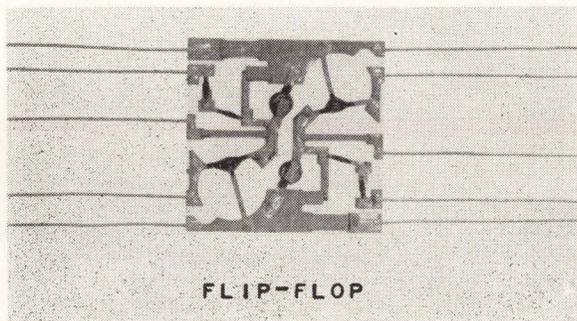
It should be pointed out, however, that many manufacturers, particularly in the computer, radio, and television fields, do purchase standard circuits that are used throughout their field. They compete on other factors, such as price, marketing strength, distribution strength, equipment design, production strength, etc. Moreover, the military has not only been pushing for standardization in



AND GATE



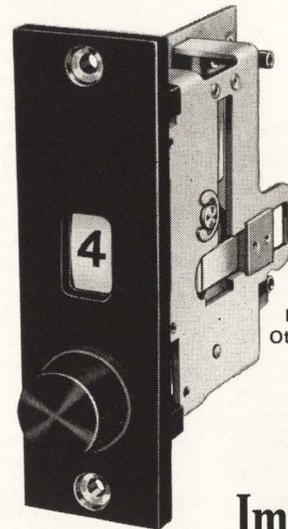
INVERTER



FLIP-FLOP

Fig. 6 These typical integrated circuit packages manufactured by CTS of Berne, Inc., are made entirely to customer specifications to perform nearly any circuit function. Tradenamed CERAFER, these circuits utilize thin-film cermet resistors and capacitors with conductive paths fired onto various substrates to which are added necessary transistors, diodes, and filter capacitors. Circuit characteristics remain constant into the megacycle frequency range with a minimum of interelement stray capacitance and leakage. Resistor and capacitor materials are entirely inorganic, highly stable, and inherently reliable. They are fired in air at temperatures in excess of 600C and need not be protected against such environmental conditions as oxidizing atmospheres up to 500C, high vacuum, liquid helium, thermal shock, solvents, potting compounds, nuclear radiation, and high humidity. CERAFER resistive material is available in values from 10 ohms to 1 megohm in short, straight paths. Power rating is approximately 5 watts per square inch of substrate at 100C derated to zero at 175C. The CERAFER capacitor has a wide capacitance range up to 8,000 pfd per single layer per 1/2" square maximum size. Rating is 75 vdcw and insulation resistance exceeds 100K megohms at 50 vdc over -65C to +125C temperature range. Standard tolerances are $\pm 10\%$ over 25 pfd and $\pm 25\%$ under 25 pfd with special tolerances of $\pm 2\%$ and $\pm 5\%$ available at 50 pfd and over. Capacitors can be stacked one on top of each other on the same substrate to save space and increase the capacitance or complete circuit wafers can be stacked close together and incorporated into a system having an extremely high component density. Platinum-gold compositions are used to terminate the resistors and capacitors and to provide the conductive pattern to which other components in the circuit can be connected. External lead connections can be made to conductive tab terminations at edges of substrate by soldering, welding, or thermocompression bonding.

For more information on the integrated circuits available from CTS of Berne, Inc.:
Circle No. 56 on Inquiry Card.



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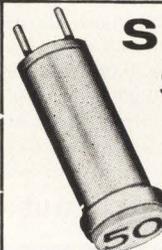
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COMPUTER DESIGN/OCTOBER 1963

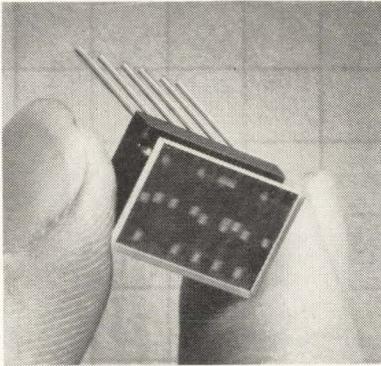


Fig. 7 A full line of INTELLUX digital circuit modules from Intellux, Inc., are hybrid thin-film and semiconductor devices. Passive components are deposited on the surface of a glass substrate, hermetically-sealed with a fused glass superstrate, and interconnected with a superposed, photo-etched, gold-plated, copper wire pattern. The resistors and capacitors are terminated along the long edges of the $\frac{3}{8}$ " x $\frac{1}{2}$ " x 0.065" substrate via suitable lands to which the leads of a 13-lead header are permanently soldered. The header is cemented to the glass substrate with epoxy resin and the leads are bonded to the header so that the electrical connection between the passive chip and the leads is unaffected by thermally or mechanically induced stresses. The header securely holds the TO-18 or TO-46 packaged transistors, provides a modest heat sink for the semiconductors, and a suitable structural form for the module. Since all components are hermetically-sealed, there is no need for final potting. The transistors

and micro-diodes are connected to the lead assembly by means of welding and the entire assembly is dip coated with polyurethane to provide leakage protection. The completed module can be affixed to etched circuit or multilayer boards by conventional manufacturing techniques. Typical of the types of digital modules available from Intellux are the NOR gate and buffer module shown here. For use as high-speed medium power logic elements, 15 of these modules can be mounted on a company-made interconnecting multilayer circuit the size of a business card. Termination pins on 0.075" centers are designed for insertion and dip soldering to the interconnecting board. The boards reflect the ultimate in reliability as the entire circuit is electro-formed from copper. There are no plated-through holes, conductive pastes, or electroless copper in the circuitry.

For more information on Intellux's integrated circuitry:

Circle No. 57 on Inquiry Card.

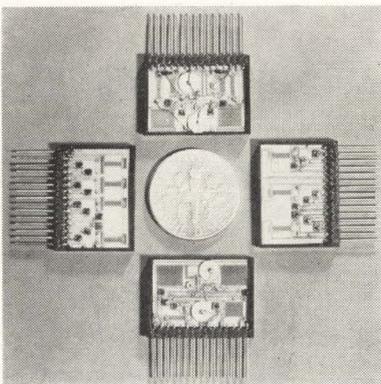


Fig. 8 The Special Products Div. of Varo, Inc., makes a standard line of high-speed digital circuits (50 mc logic) in which passive elements are vapor-deposited thin-films combined with discrete active components. Typical passive element parameters include a 10 to 500K ohm range, $\pm 10\%$, $\pm 5\%$, and $\pm 2\%$; 5 to 1000 mmfd range with nominal accuracy of $\pm 10\%$. Standard packages, such as those illustrated here, come in sizes 0.065 x 0.070 x 0.085" and 0.800 x 0.600 x 0.085 with 0.016" diameter on either 0.060" or 0.050" centers. Taking one circuit as an example, Varo's Model 8200

microcircuit flip-flop combines the thin-film passive elements with silicon planar epitaxial active devices which operate as saturated switches. Connected as a binary counter, the Model 8200 can operate at speeds in excess of 50 mc. This flip-flop utilizes clamped outputs to define output voltages and includes versatile internal gating which permits interconnection of flip-flops for application as counters and serial or parallel shift registers without external gating requirements.

For more information on Varo's integrated circuit capabilities:

Circle No. 58 on Inquiry Card.

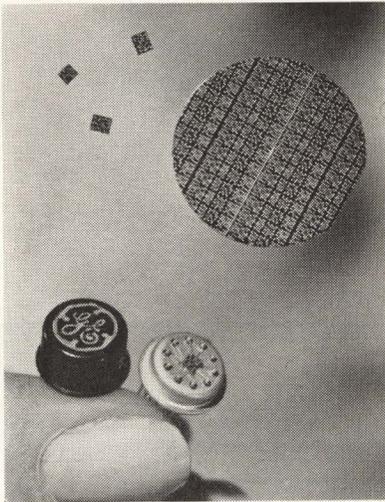
TABLE 3 • FACTORY VALUE OF INTEGRATED CIRCUITS (\$ MILLION)

Integrated Circuit Replacement Value in:	1963	1966	1970	1975
Consumer Equipment Market ¹	0	3.8	26.7	105.2
Industrial Equipment Market ¹	1.1	91.0	488.3	912.1
Government Equipment Market ¹	27.5	161.0	555.0	1019.8
Total ¹	28.6	255.8	1070.0	2037.1
Integrated Circuit Value Price Deflator Multiplier (per Figure 5-5)	2.40	.80	.47	.40
Deflated Factory Value of Integrated Circuits ²	68.6	204.6	502.9	814.8

1. From Table 2.

2. Product of the Total Integrated Circuit Replacement Value and the Price Deflator.

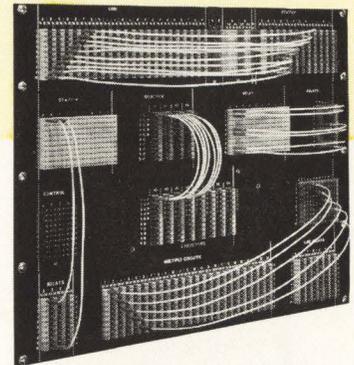
Fig. 9 General Electric's matrix approach to integrated circuitry allows the formation of many different circuits simultaneously on the same wafer. As many as 18 transistors and 66 tapped resistors are available on a single chip in a TO-5 case. The first step in G.E.'s matrix approach is the production of a wafer which consists of approximately 4200 resistors and 1100 transistors. This wafer is called the M1 Matrix. At this point, the wafer is uncommitted as no connections have yet been made. Since the surface has been passivated, the wafer can be stored in its "uncommitted" state indefinitely. Exact copies of the matrix, magnified 100 times on drafting paper, are used by the customer to lay out his particular circuit within the constraint of subsequent manufacture. On a single wafer as many as 100 different



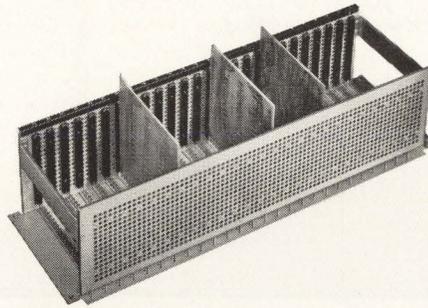
circuits can be laid out, or to the other extreme, the same circuit can be reproduced 100 times. To complement the M1 Matrix technique, G.E. has developed its own logic system called emitter-coupled transistor logic. (A feature article in the introductory issue of *COMPUTER DESIGN* described this logic scheme in detail.) Advantages of emitter-coupled transistor logic include: elimination of current hogging encountered during fan-out in DCT logic; common mode noise rejection due to differential drive; only transistors and resistors are required; low power consumption for a given computing rate (0.3 megacycles/mw); non-critical component values; and 2 mc clock rate over -55 to $+125^{\circ}\text{C}$ range.

For more information on G.E.'s integrated circuitry:
Circle No. 59 on Inquiry Card.

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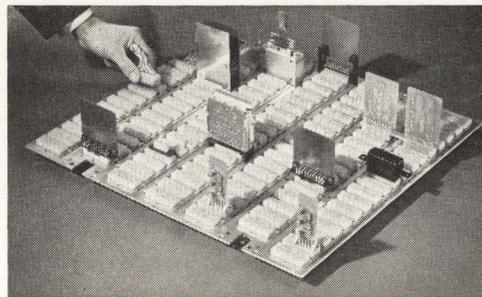
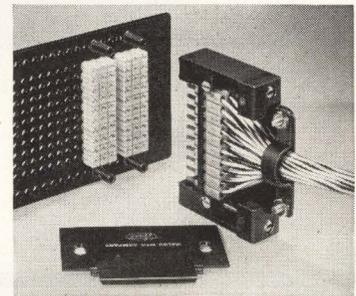


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TABLE 4 ● INTEGRATED CIRCUIT VALUE AS A PERCENT OF TOTAL CIRCUIT VALUE

	<u>1963</u>	<u>1966</u>	<u>1970</u>	<u>1975</u>
(1) Total Circuit Value ¹ (unadjusted)	\$2489.2	\$3420.6	\$4349.9	\$4799.2
(2) Less: Circuit Value Replaced by Integrated Circuits ²	<u>28.6</u>	<u>255.8</u>	<u>1070.0</u>	<u>2037.1</u>
(3) Total Circuit Value Excluding Integrated Circuits	\$2460.6	\$3114.8	\$3279.9	\$2762.1
(4) Plus: Deflated Integrated Circuit Value ²	<u>68.6</u>	<u>206.4</u>	<u>502.9</u>	<u>814.8</u>
(5) Total Circuit Value	\$2529.2	\$3321.2	\$3782.8	\$3576.9
(6) Integrated Circuit Value as a Percent of Total Circuit Value (4)/(5)	<u>2.7%</u>	<u>6.2%</u>	<u>13.4%</u>	<u>22.8%</u>

1. "Unadjusted" refers to the fact that factory value of integrated circuits were included at conventional circuit prices.
2. From Table 3.

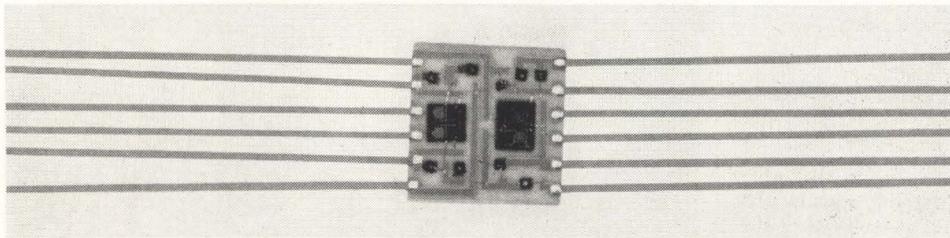


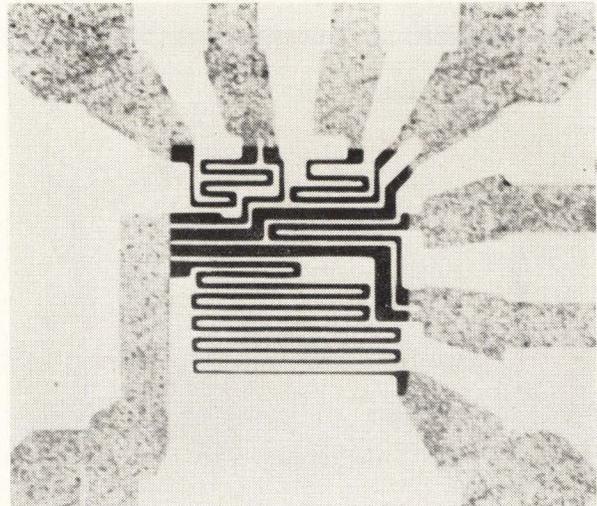
Fig. 10 A broad range of both custom and standard microcircuits utilizing a multi-chip approach is available from General Instrument's Semiconductor Div. High performance digital microcircuits with clock frequencies up to 20 megacycles are designed to customers' exact requirements. In addition, 12 off-the-shelf standard, high-speed digital circuits, using planar epitaxial passivated technology are available. Five General Instrument's standard digital circuits have been converted to a more highly integrated construction using resistor-capacitor networks on single silicon chips. These are: NC-8, a flip-flop; NC-9, a steering gate; NC-10, a NOR gate; NC-11, a NAND gate; and NC-12, a buffer amplifier. The NC-8, one of the typical partially-integrated circuits, is a bi-stable multivibrator (flip-flop) which operates from a 12-volt supply and presents 5-volt logic levels. A suitable

steering gate can be provided to trigger the flip-flop. The circuit shown here is a 20 mc RST flip-flop, PC-13, which is a combination of the circuitry of the NC-8 flip-flop and the NC-9 steering gate with a direct reset diode added for additional circuit application flexibility. Also available from General Instrument is a fully integrated microcircuit, a NAND gate, designed as a building block in medium speed, lower power digital systems. Based on diode transistor logic (DTL), this device provides a maximum clock rate of 5 mc under full load fan-out of 5, while dissipating nominally 8.5 mw. The advantage of this logic system is that it can be readily adapted to present systems.

For more information on General Instrument's integrated circuitry:

Circle No. 60 on Inquiry Card.

Fig. 11 Thin-film microcircuits from Corning Electronics are based on the company's years of experience in materials technology. The bulk of Corning's work in this area is custom-made thin-film resistor-capacitor networks on alumina ceramic substrates glazed with glass. Corning normally chooses glazed alumina since the composite material combines the smooth surface of glass, necessary for precise control, with the thermal conductivity of a ceramic, often necessary for dissipating heat. Corning heats the substrate in a chamber and sprays it with a precise solution of tin and antimony. Diffusion begins immediately in the hot chamber, the tin and antimony forming oxides. Some of the oxygen atoms combine with the substrate material resulting in a tin oxide film chemically bonded to the entire exposed surface. The film is about 12 microinches thick. Conductor patterns are produced by plating portions of the tin oxide pattern with electroless copper using a proprietary process which eliminates failure through delamination by chemically bonding copper to the tin oxide which is chemically bonded with the substrate. Capacitors are added by vacuum-evaporating aluminum; silicon monoxide is evaporated to form the dielectric. Corning recently reported that thin-film resistor networks have shown better stability than some types of discrete resistors in a test covering over more than 800,000 resistor-hours. The test data, which covers nearly a year in time, shows no failures and maximum



resistance change of over 0.57%. Shown here is a close-up of a NOR gate resistor network illustrating control over line width to less than a mil.

For more information on Corning's microcircuits:

Circle No. 61 on Inquiry Card.

its equipment in order to reduce costs, but also has begun requiring second sources which requires several manufacturers to offer duplicate circuits. This effort by the military has not brought about a revolution, but has helped to point out the possibility for more circuit standardization. The topic of standardization is a much discussed subject in the industry with both the EIA and the IEEE holding conferences, studies, etc.

Although the integrated circuit will not bring about complete circuit standardization, it will help move toward more standardization. This hypothesis is based on the following several assumptions and arguments:

First, the integrated circuit offers a tremendous cost advantage over conventional circuits, but only if produced at high volumes. Unless orders in excess of several thousand solid integrated circuits or thin-film circuits (containing very cheap active devices) are placed, economies will not be realized and prices will be high. Therefore, a purchaser who must use integrated circuits but can only afford a small order must either pay more for his special circuit requirements or use a more standardized form that the manufacturer can produce in large volumes and sell off-the-shelf. This is apparent at the present time with conventional circuits, but will have a greater effect with the integrated circuit because of the high fixed cost associated with masking. Several integrated circuit manufacturers at the present time offer semi-standard circuits which contain several components that can be interconnected to form many circuit combinations; this is an attempt to make small purchases economical. However, this semi-standard circuit does not get around the added

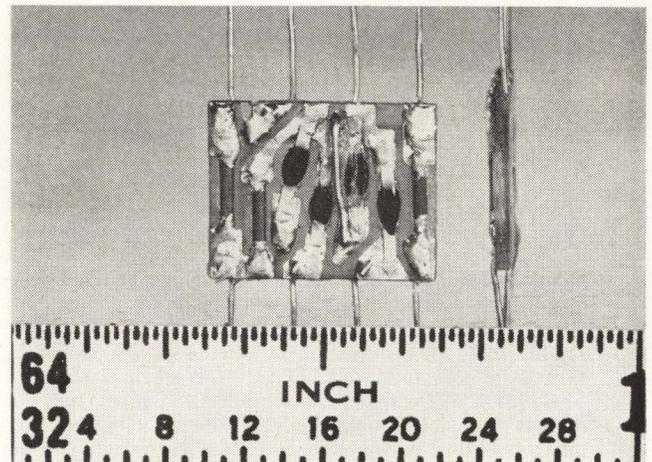


Fig. 12 "Integrating" integrated circuits along with micro-components and other elements into a substrate is the specialty of Cleveland Metal Specialties Co. By what they call the MICRAM technique, integrated blocks and active or passive elements are inlaid within a substrate. Exterior mountings of small components can also be made. The company reports that this technique is being adapted to multi-layer circuitry as an additional feature for making complex interconnecting schemes. The substrate can also be made as a single stage, such as a flip-flop, using available microcomponents such as dots and pellets. Shown here is a NOR gate, made by the MICRAM technique, which includes 4 diode inputs, 1 transistor, and 3 resistors.

For more information on Cleveland Metal Specialties' circuits:

Circle No. 62 on Inquiry Card.

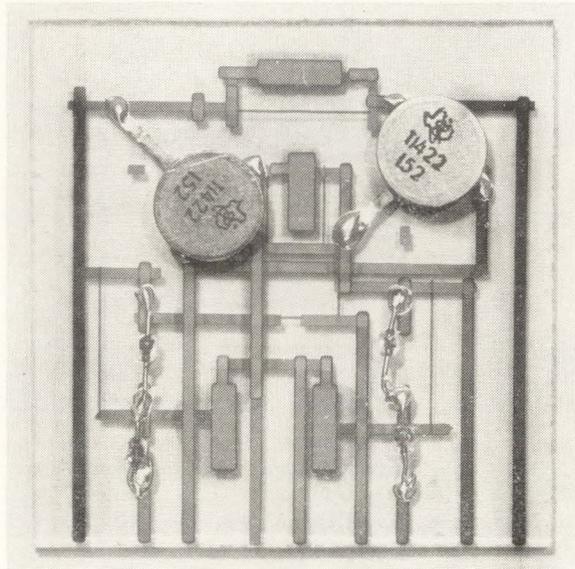
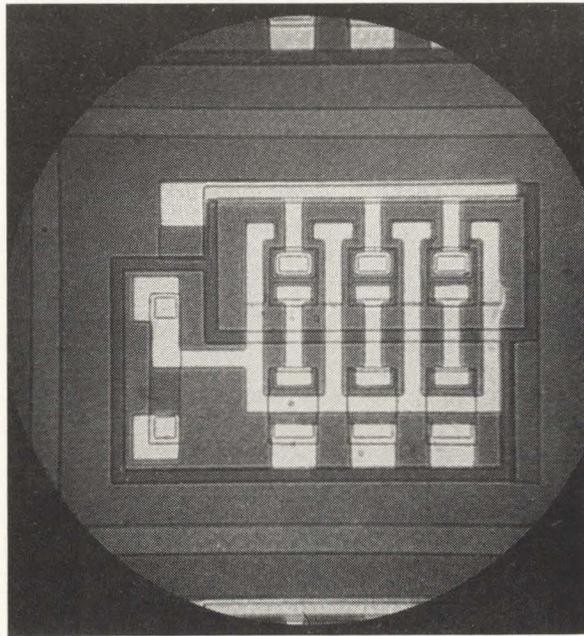


Fig. 13 A typical thin-film circuit fabricated by Alpha Microelectronics Co. (A.M.E.). All passive circuitry including resistors, capacitors, and interconnections are produced in one operation — the total circuit is evaporated in one pull-down of the vacuum system. A.M.E. offers substrate materials of glass, glazed ceramic, Mylar, etc., in areas up to 10 square inches. Resistor specs: up to 5 Megohms per square inch; tolerances — $\pm 3\%$ untrimmed and $\pm 10\%$ trimmed; dissipation — 12 watts on alumina; T.C. — 200 ppm/ $^{\circ}\text{C}$; and drift — less than 1% after 10 K hours. Capacitors with $\pm 5\%$ tolerance can be fabricated up to 0.02 microfarads per square inch. Up to 50 mc circuits are available with delay times in the order of 15 nanoseconds.

For more information on A.M.E.'s integrated circuitry:
Circle No. 63 on Inquiry Card.

Fig. 14 During the past year Transiron Electronic Corp. has applied its silicon planar technology, developed for its single semiconductor devices, to the fabrication of silicon monolithic integrated circuits. Design and development of a DCTL three input NOR gate, a photomicrograph of which is shown here, was accomplished and resulted in a circuit compatible with previous units already on the market. Production of this circuit is now in active operation and the remaining basic DCTL logic circuits (flip-flop, half shift, buffer, half adder, counter adapter) are being developed, with availability estimated at three months. The NOR gate has a typical propagation delay of 20 nanoseconds, saturation voltages under 350 mv and minimum fanout of 8 at room temperature. Beyond the DCTL production, development is underway at Transiron to make a four input NAND gate for use in TTL logic. This circuit will employ a multiple emitter input, buffered output, epitaxial material, and will be designed for optimum operating performance over the entire temperature range from -55°C to $+125^{\circ}\text{C}$. Prototype quantities should be available within several months. Recognizing the desirability of custom circuits for individual high volume applications, Transiron has made it a practice to work closely with such customers in the design and development of special circuits. They found it necessary to restrict the custom design effort to those circuits which are compatible with existing materials and processes, and which have a relatively high probability of success. Otherwise, they report, the cost and time duration of the custom design becomes prohibitive. Summarizing their activities with integrated circuits, Transiron disclosed that they are now actively producing DCTL logic circuits, developing TTL circuits, evaluating a unique linear amplifier, work-



ing closely with several customers on individual design requirements, and performing the R&D work necessary to maintain a state-of-the-art technical position.

For more information on Transiron's integrated circuits:
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COMPUTER DESIGN/OCTOBER 1963

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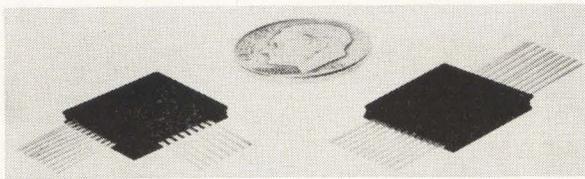


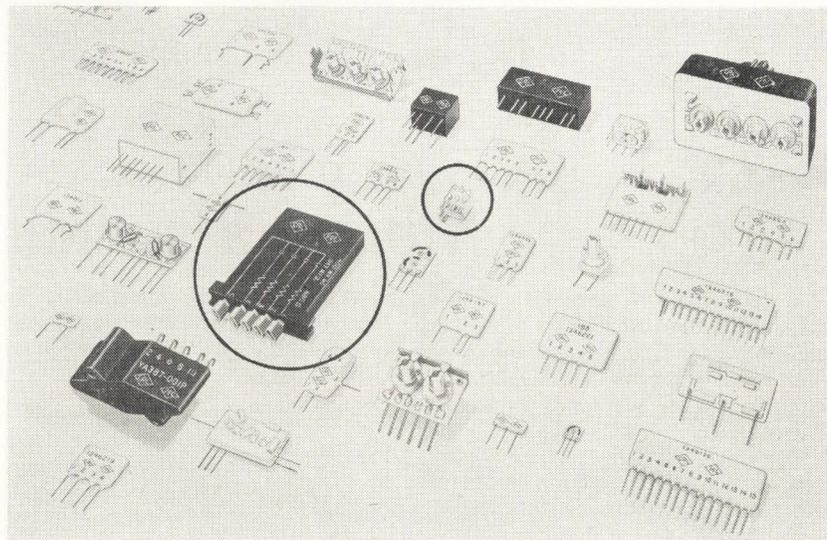
Fig. 15 These two new circuit packages from the Burroughs Corp's Electronic Components Div. have not been previously announced to the industry. The unit on the left is the BIP-5513, a 40-silicon diode decoder module. It is designed to decode binary-coded decimal information to decimal form. Selling price of the unit is \$22.00 in the 100 quantity or slightly over 50¢ per diode fully wired in a functional circuit. These units will be available for delivery on October 15. Typical diode characteristics are: breakdown voltage 50 vdc min.; forward current 10 ma min. The diodes are enclosed within a flat pack which is 0.560 inches square and has a maximum thickness of 0.125 inches. The BIP-2004, shown on the right, is a transistor amplifier package containing 10-silicon planar transistors connected in a common emitter configuration. This unit sells for \$18.00 in the 100 quantity. The transistors are high voltage types suitable for operating Burroughs' NIXIE indicator tubes directly from low voltage signals. BV_{ce} is 65v min. with an H_{fe} of 15 min. The body of this unit has the same size and shape as the diode package. For more information on these and other circuit packages from Burroughs:

Circle No. 65 on Inquiry Card.

cost of designing the circuit interconnection masks and placing these interconnections on the substrate, which is not very significant for large orders. Hence, the fact that small equipment manufacturers will have to either pay more or accept standardization to remain competitive should influence the acceptance of more standardization. This standardization should also force the small equipment manufacturers, who are now competing on the uniqueness of their circuit design, to rely even more heavily on the uniqueness of their systems design or other competitive factors.

Second, and related to the above argument of the economy in large production runs, the integrated circuit manufacturers themselves will probably help bring about more standardization. They can sell integrated circuits at a much cheaper price, given high volume operation, because of the high fixed costs in such things as mask making. Thus, integrated circuits manufacturers can afford to sell circuits that perform the desired functions better than required if the production run for the better circuit is long enough. This is not possible today with conventional circuits because the better the circuits, the better the components and interconnections and, thus, the higher the cost. Therefore, stimulus to standardization will come from both the manufacturers and users of integrated circuits; however, due to the many complexities in the industry this movement toward standardization will be slow.

Fig. 16 The principle of screening capacitors, interconnections, and resistors to a ceramic substrate is the basis of Centralab's highly successful approach to integrated circuitry. Tradenamed PEC, Centralab's integrated circuits are custom-designed and are available in production quantities. Designers can choose just about any finished size or shape, as illustrated in the photograph showing some of PEC circuits that have been produced by Centralab. Ceramic surface area can vary from 0.02 to 10 sq. inches. Transistors, diodes, rectifiers, fixed or variable resistors, capacitors, inductors are available in almost any standard component value or tolerance. Typical digital circuits include a gate circuit in cubic form, shown circled in the photograph, with 6 diodes and 5 resistors in a total size of 13/32" X 13/32" X 5/8"; and a high reliability arc-suppression circuit (the flat package shown circled in the photograph) which is potted in a case, 1 1/2" X 2 1/8" X 1/4". This R-C suppressor contains 4 resistors and 4 capacitors and was built for a minimum of 20,000 hours of continuous operation. Flip-flops and other digital circuits have been produced by Centralab using their PEC tech-



nique. Recently, Centralab reports, IBM put 2700 PEC circuits in a feasibility study for an advanced computer design. In 1400 hours of continuous operation, according to the report, not one PEC failed — this is equivalent to 36,936,000 hours of PEC operation without failure.

For more information on Centralab's integrated circuits:

Circle No. 66 on Inquiry Card.

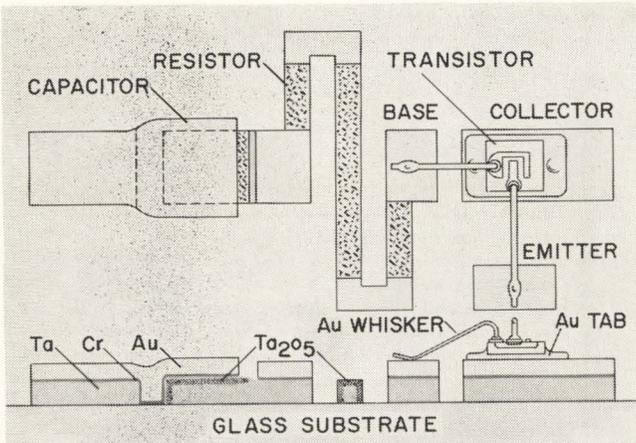
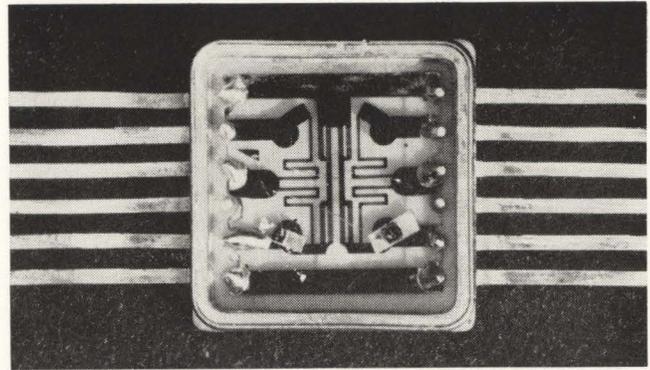


Fig. 17 The photo on the left is a cross-section and planar view that illustrates Philco Corp.'s tantalum thin-film circuit technology. One of basic tantalum thin-film circuits, shown on the right, is a resistor-transistor logic (RTL) flip-flop in a 2-D assembly. Philco's Lansdale Division uses sputtered tantalum as the basic material for the integral fabrication of resistors, capacitors, and conductors in thin-film circuits. Chromium-gold is deposited on the tantalum to enhance the conductivity of the conductors and to provide land areas suitable for interconnecting to the package and active elements added in the form of pre-tested chips. According to Philco, the use of a single basic material for resistance, capacitance, and interconnections gives simplicity of fabrication, high reliability, and low cost. Other advantages of the tantalum thin-film approach, the company reports, include high component density; precisely-adjusted components through the formation of Ta_2O_5 ,



a refractory oxide; protection against corrosion which increases stability and reliability; low sensitivity of circuit components to temperature and voltage changes; good radiation resistance and high power handling capacity provided by refractory materials; optimum circuit performance by elimination of isolation problems, by free selection of active elements, and by use of both lumped and distributed parameter circuit elements; and optimum heat dissipation through flexibility in topographical layout. Philco's Lansdale Division also makes silicon integrated circuits using the planar process. In addition, the division has started tooling for production lines that will produce Fairchild's Micrologic Circuits under a license agreement.

For more information on Philco's integrated circuitry:

Circle No. 67 on Inquiry Card.

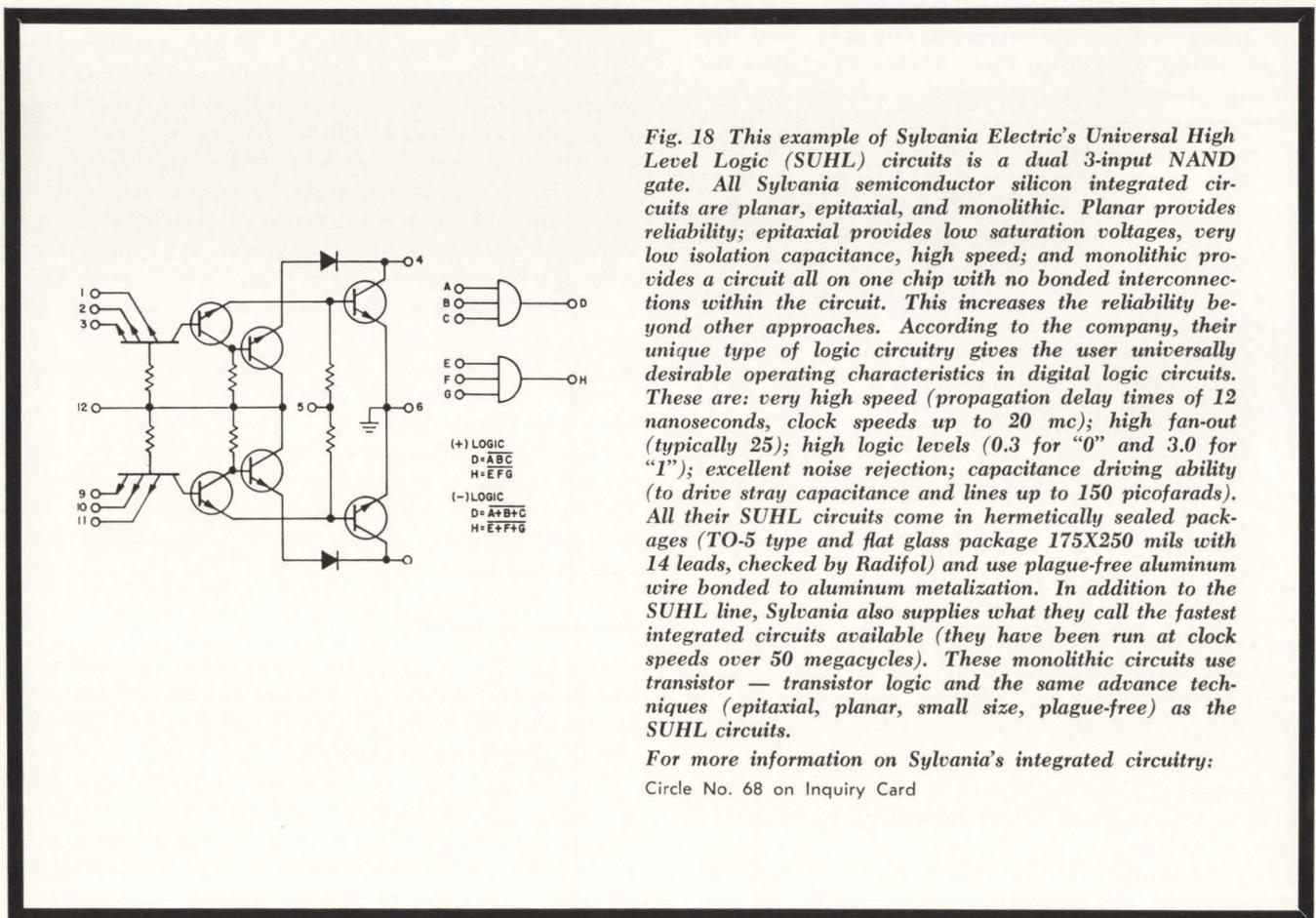


Fig. 18 This example of Sylvania Electric's Universal High Level Logic (SUHL) circuits is a dual 3-input NAND gate. All Sylvania semiconductor silicon integrated circuits are planar, epitaxial, and monolithic. Planar provides reliability; epitaxial provides low saturation voltages, very low isolation capacitance, high speed; and monolithic provides a circuit all on one chip with no bonded interconnections within the circuit. This increases the reliability beyond other approaches. According to the company, their unique type of logic circuitry gives the user universally desirable operating characteristics in digital logic circuits. These are: very high speed (propagation delay times of 12 nanoseconds, clock speeds up to 20 mc); high fan-out (typically 25); high logic levels (0.3 for "0" and 3.0 for "1"); excellent noise rejection; capacitance driving ability (to drive stray capacitance and lines up to 150 picofarads). All their SUHL circuits come in hermetically sealed packages (TO-5 type and flat glass package 175X250 mils with 14 leads, checked by Radifol) and use plague-free aluminum wire bonded to aluminum metalization. In addition to the SUHL line, Sylvania also supplies what they call the fastest integrated circuits available (they have been run at clock speeds over 50 megacycles). These monolithic circuits use transistor-transistor logic and the same advance techniques (epitaxial, planar, small size, plague-free) as the SUHL circuits.

For more information on Sylvania's integrated circuitry:

Circle No. 68 on Inquiry Card

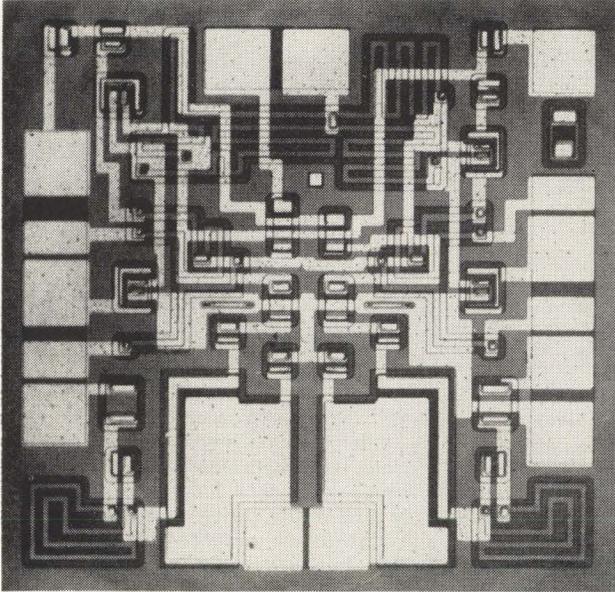


Fig. 19 This DTL Binary Element manufactured by Signetics Corp. has been described by the company as probably the most complex circuit ever to be integrated on a single chip and offered as a standard off-the-shelf item. Designed for counting and shifting applications to 10 mc, this element incorporates 4 transistors, 10 diodes, 10 resistors, and 2 metal-over-oxide capacitors on a monolithic silicon substrate. Features include a fan-out of 8, direct as well as clocked set-reset inputs, and operation over the full mil range from -55 to $+125^{\circ}\text{C}$. Signetics Corp. manufactures a full line of integrated logic circuits. In addition, Signetics makes a line of integrated component groupings, called preFEBS, which provide the designer with a fast, flexible means of making breadboard studies of proposed integrated circuits designs in a manner that will adequately simulate the performance of the final, completely integrated circuits.

For more information on Signetics' integrated circuitry: Circle No. 69 on Inquiry Card

Technology and Applications

The second area in which the integrated circuit will have an impact is in the technology and the related applications of electronic circuits. The integrated circuit is a big step toward getting away from the conventional engineering approach of combining components selectively to form desired circuit functions and is a step toward the "black box" or functional approach. Integrated circuits will force the equipment manufacturer to think more in terms of the desired function instead of how this function is performed, as he gradually relinquishes his circuit design capabilities. Eventually, equipment manufacturers will accept integrated circuits as they accept conventional components today.

This acceptance of functions, instead of how the functions are performed, will have an effect on the circuit technology through the acceptance of new electronic devices based on other than electron transfer to perform electronic functions. Integrated circuits have already encouraged new materials studies, particularly in silicon and thin-film vs. bulk material properties. New devices using such phenomena as the insulated gate field-effect, wave guide mechanisms, thermal propagation, photon effect, etc. have recently been introduced, showing something of a trend toward the true molecular circuit. However, these new developments will probably be used to complement the solid and thin-film integrated circuits rather than replace them and, thus, slowly be integrated into the circuit field. The integrated circuit is the first real evidence of this molecular or functional ideal, except for the quartz crystal, and is giving impetus to further research in this new area.

In giving further stimulus to the functional approach and bringing on new devices, integrated circuits will help to bring new electronic circuit devices on-stream faster. As greater acceptance of the integrated circuit is achieved,

the greater will be the incentive and, hence, the discovery of new devices and phenomena effects. Moreover, with the acceptance of the functional approach, the equipment manufacturer will not be as interested in what makes the circuit work as he will be in how well it performs the job he wants done. This will pave the way for faster development of new devices, such as these based on thermal propagation, because it will become unnecessary to educate the users to all the workings of the circuits.

Another effect resulting from the integrated circuit development will be an introduction of new consumer and industrial electronics business through new applications. Although new applications are probably several years away, such things as wrist radios and home computers now appear to be feasible because of the potential size, weight, reliability, and cost advantages that integrated circuits offer. New and smaller applications will also force the miniaturization of other components, such as inductors and transformers. Once the present consumer electronics market is saturated with televisions, radios, hi-fi's, etc., private industry must look for new ideas and markets. Integrated circuits will be a stimulating influence in this area.

Structure of Industry

The third area in which the integrated circuit will have an impact is the structure of the electronics industry; i.e., the number and make-up of the companies in the industry and the user-buyer relationships.

The integrated circuit represents a radical departure from the present philosophy and form of the electronics industry. Traditionally, one group of manufacturers has made components and the other designed and assembled circuits to go into electronic equipment. This gave rise to the natural separation of component and equipment manufacturers. With the integrated circuit, however, the

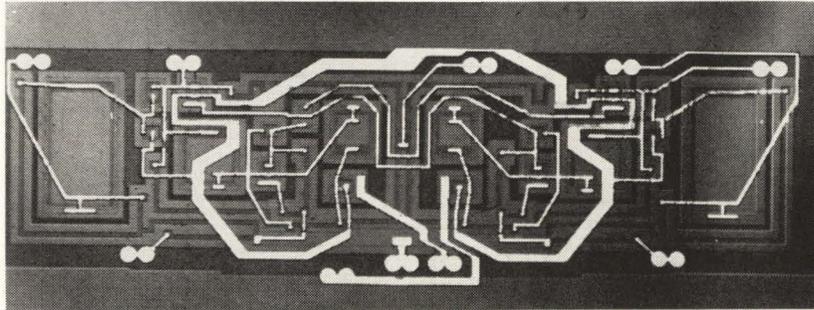


Fig. 20 This photomicrograph of a flip-flop circuit represents one of many standard digital "molecular" circuits produced by Westinghouse Electric's Molecular Electr. Div. These integrated circuits are fabricated on monolithic silicon substrates. Typical size is 0.375" square by 0.40" thick. As an example of Westinghouse's cap-

ability in the field, they have produced, for use in the improved Minuteman Missile System, a flip-flop containing 40 active and passive elements on a single chip of silicon, 0.065" by 0.195".

For more information on Westinghouse's integrated circuits:

Circle No. 70 on Inquiry Card

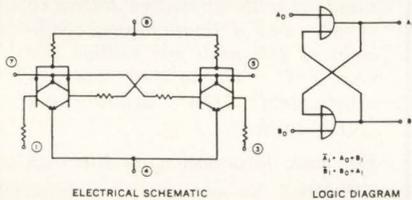


Fig. 21 Fabricated on monolithic silicon substrates, integrated circuits from Amelco Semiconductor are fully

passivated digital circuits with low saturation voltages. As evidenced by the schematic diagram of their Type F flip-flop, shown here, these circuits feature unique dual collectors which together with precise process control provide high fan-out, low power, and high speed. Basic fan-out is 10 over a temp. range of -55 to +125C.

For more information on Amelco's integrated circuitry:

Circle No. 71 on Inquiry Card

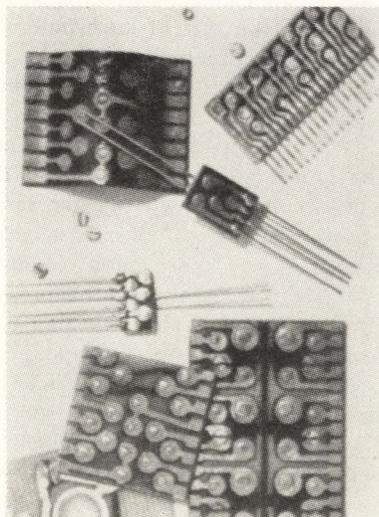


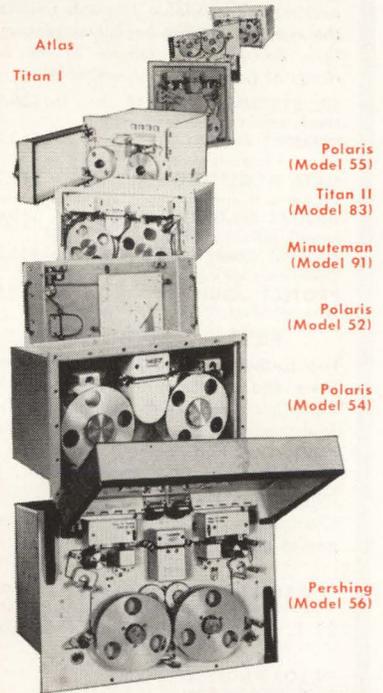
Fig. 22 These typical microminiature circuits from Hughes Semiconductor are not "integrated circuits" but flat, conventionally etched "circuit boards" in which all the active and passive components, in either "dot" or "pellet" form, are imbedded flush with the top and bottom surfaces. However, Hughes Semiconductor plans to have thin-film passive circuits ready for production by the middle of 1964. Silicon integrated logic circuits are scheduled to go into production at Hughes in the first quarter of 1964. Hughes also anticipates that all thin-film integrated circuits will be practical production devices; however, it is too early in the program for them to predict when they will be available.

For more information on Hughes' circuit packages:

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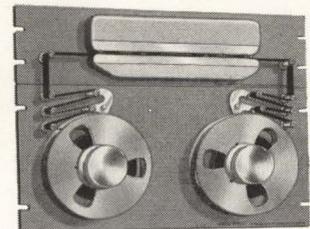
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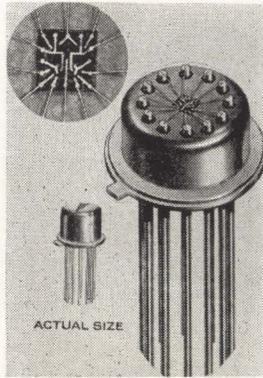


Fig. 23 A full line of integrated logic circuits using transistor-coupled logic is available from Pacific Semiconductors, a subsidiary of Thompson Ramo Woolridge. Their logic modules are fabricated from a single substrate of semiconductor material. Shown here is a dual NAND gate consisting of two 3-input AND gates followed by inverting stages. Multiple emitter transistors are used for the input gating in order to minimize loading and driving requirements. Propagation delay across this input gate is negligible. The circuit operates at frequencies up to 5 mc over a temperature range from -55 to 125°C .

For more information on Pacific Semiconductors' integrated circuits:

Circle No. 73 on Inquiry Card

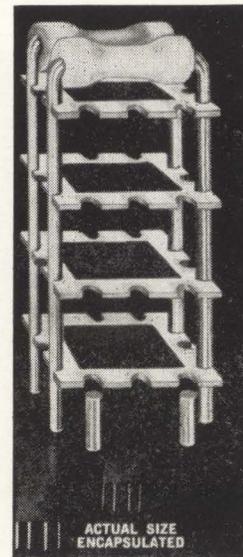


Fig. 24 Electra Mfg. Co. manufactures thin-film metal resistive microelements on ceramic substrates. As shown here, the ceramic wafers can be stacked and combined with capacitors and active elements. Resistive values from 10 to 100-thousand ohms are standard with a resistive tolerance of 2% and a temperature coefficient of 100 parts per million per degree C. The wafers are approximately $5/16$ " square and 0.010" thick.

For more information on Electra's circuits:

Circle No. 74 on Inquiry Card

components and circuits are fabricated at the same time by the same manufacturer, thus indicating the possible elimination of one of the groups. However, this will not be the case because there will always be some need and market for conventional components in the foreseeable future. As mentioned earlier the percent of total circuits that are predicted to be integrated by 1975 amounts to 22%, thus leaving a substantial market for conventional circuits.

On the other hand, even though there will not be a wholesale elimination of electronic firms, it appears that a relatively small number of firms will emerge in the integrated circuits industry. This is a direct result of the economies of scale required to be price competitive, the large investment required to get into the integrated circuits industry, and the large annual research and development expense needed to remain abreast of technology. In other words, the integrated circuit industry is not as attractive to a small firm to jump into as was the transistor industry. Moreover, most of the large electronics firms, both component and equipment manufacturers, have already entered the field and will strive to keep the transistor experience from happening again.

By the same token, integrated circuits will eliminate the need for a great many component and equipment companies that are making relatively simple circuits; they will be priced out of the market. With approximately 13%

of the market to be taken over by integrated circuits by 1970, the inefficient conventional component companies will be eliminated by the tremendous competition that will develop. There will be little room for the small inefficient circuit manufacturer. However, this shakeout of inefficient circuit and components people will not be overwhelming; instead, it will be part of an evolutionary process that occurs as any industry matures.

In addition to pushing the inefficient companies out of business, integrated circuits will also help make the big companies bigger. The big companies are in a better position to obtain the lowest prices because they deal with larger volumes of circuits that will put the circuit manufacturers down on the flat part of their cost curves. Hence, the bigger companies can order more circuits at one time, obtain the lower prices, and put the pressure on the smaller volume user. Another effect the big users will have is to put more power in the user's hands. This is already apparent with conventional circuits since the large users have bargaining power, but it is especially true with integrated circuits since circuit manufacturers need higher volumes to be profitable than they do with conventional circuits.

The integrated circuit will also tend to make the user-maker relationships closer. In order to obtain the business from the big users, the circuit manufacturers will have to offer service, and work closely with the users. It will

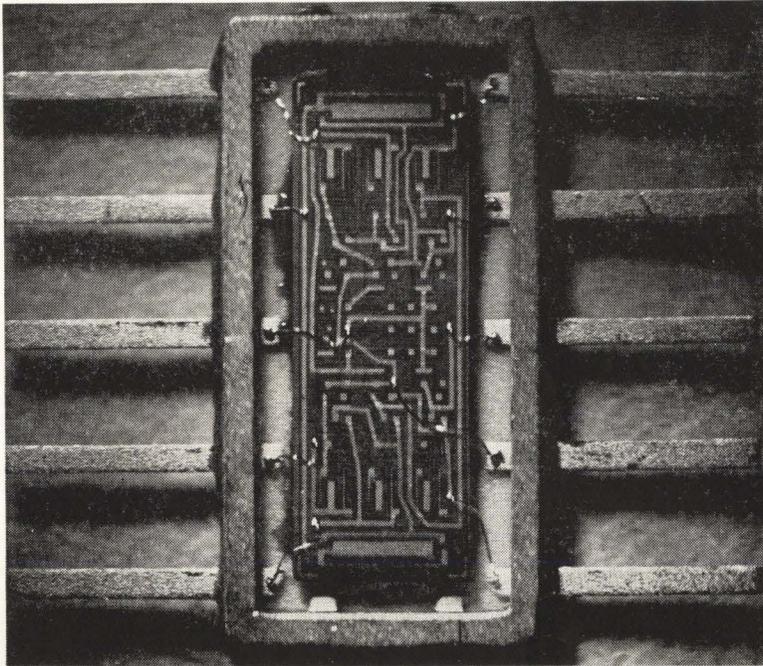


Fig. 25 Texas Instruments believes that their "master slice" design concept is the best economical answer to custom integrated circuits. During the past three years, Texas Instruments has produced catalog or totally custom semiconductor integrated circuits, tradenamed "Solid Circuits". However, the company felt that a catalog line may not give the designer the desired flexibility, while on the other hand, a totally custom approach involves too much lead time or cost. This "master slice" concept was developed to overcome these limitations. Briefly, here's how it works. First, standard "master slice" silicon wafers — complete except for interconnections — are taken from established, high-volume production lines. Second, a special interconnection pattern and mask is prepared from the user's circuit. Third, this special interconnection pattern is

photo-etched on the "master slice". Since the only custom step involved in obtaining a circuit variation is the design and preparation of a single interconnection pattern, the user gets, according to the company, a customized circuit quickly and at minimum expense. The photo shows a typical "master slice" circuit after it is cut into a separate bar and mounted for individual packaging prior to the hermetically-sealing operation. Texas Instruments looks to 1964 as the year that prices of semiconductor networks will be economical for the industrial market, and between 1966 and 1968 for the consumer market. The latest pricing for their Series 51 "digital functions" circuits is an approximate 20% reduction over 1962.

For more information on Texas Instruments' semiconductor networks:

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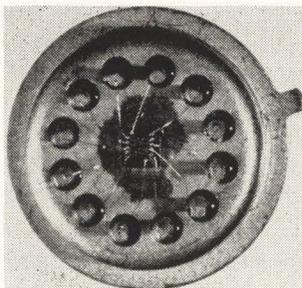


Fig. 26 Shown here is a typical integrated microcircuit from International Resistance Co. Interconnecting conductive paths and passive and active elements are fabricated on a single silicon wafer by a series of successive epitaxial and

diffusion processes. International Resistance also makes, as standard production units, hybrid microcircuits, which are not strictly integrated circuits, but offer great reductions in size and marked improvement in reliability. These hybrid circuits have conductive and resistive paths fused to a ceramic base. Semiconductor chips are fused to a conductor path and all elements are enclosed in TO-5 hermetically-sealed cans. A typical digital hybrid circuit has a fan-in of 3, a fan-out of 4, and operates to 1 mc, over a temperature range of -55 to 125C.

For more information on circuits from International Resistance Co.:

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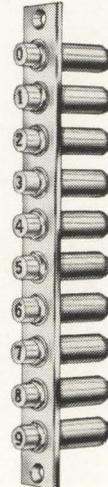
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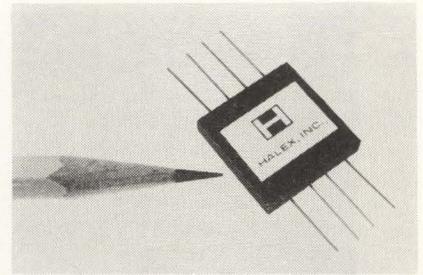


Fig. 27 Halex, Inc. of El Segundo, Cal., is producing thin-film microcircuits in quantity. An integrated network of passive components and interconnections of thin metal films are deposited onto substrates such as glass or ceramic. Typical of the thin-film circuits available from Halex is their Model 1010FF Flip-Flop shown here. The encapsulated circuit contains vacuum deposited nichrome film resistors, capacitors with thin-film silicon oxide dielectrics, and microsize silicon diodes and transistors. Specifications include: supply voltage of 5 volts $\pm 10\%$, 7 milliwatt power consumption, maximum operating frequency of 2 megacycles, and operating temperature range of -55 to $+85^\circ\text{C}$. Actual size of the encapsulated flip-flop is $0.8 \times 0.8 \times 0.120$ ".

For more information on Halex, Inc.'s thin-film circuitry:

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also be imperative for the integrated circuit manufacturers to work closely with potential buyers in the near future in order to determine who will retain the circuit design responsibility. Integrated circuits manufacturers must overcome the user's reluctance to use new circuits through close relationships and constant service. Therefore, the user-maker relationships that already exist should be strengthened somewhat.

Education And Personnel

Although the integrated circuit will not have a profound effect on the education of engineers, chemists, etc. or personnel requirements in the industry, it will be an added stimulus to the trends that have already started in these areas. With the development of the transistor and other devices based on molecular structure, there has been a definite trend toward training the engineer in basic studies rather than for a specific job. Massachusetts Institute of Technology and the California Institute of Technology Undergraduate Schools have taken the lead in this direction, giving their engineers more of the fundamentals in physics, chemistry, and math, while leaving the specific training up to the companies or to graduate work. The integrated circuit, with its emphasis on material study and molecular structure, will give further impetus to this development.

In addition, the integrated circuit will foster the need for electrical engineers trained to work with functions rather than components. With the development of

molecular or "black box" devices, universities will need to develop studies along this line.

In the area of personnel in the industry, the integrated circuit will give more emphasis to the skilled, patient worker who is willing to work with a microscope. However, most of the production techniques in both thin-film and solid integrated circuits are similar or exactly the same as presently in use in transistors. Therefore, no unusual personnel problems are anticipated.

In conclusion, the integrated circuit will have a big impact on the electronics industry but it will not have as profound an effect as did the transistor. Although the impact will not be as great as some expect, it will be sizeable on standardization of circuits, technology, structure of the industry, and education and personnel. The total impact will be in line with the stimulus already created by the invention of the transistor. With the integrated circuit expected to take over 20% of the circuit market by 1975, it cannot help but be the biggest electronic breakthrough since the transistor. END

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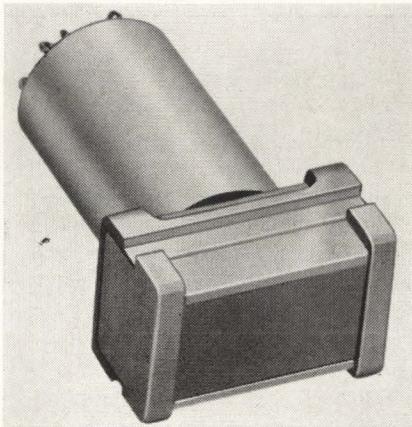


NEW PRODUCTS

STANDOFF TERMINALS

A subminiature "Press-Fit" Teflon standoff terminal features a three-turreted lug separating the areas for wire soldering. Designated as ST-SM-27-TUR, the new terminal is designed for insertion into a 0.238" (± 0.002 ") diameter hole countersunk 60° for metal chassis 0.040" or thicker; for chassis under 0.040" thickness — an 80° countersunk hole 0.260" (± 0.010 " -0.000") in diameter. The ST-SM-27-TUR terminal has an overall height of 0.531" making it ideal for use in miniaturized chassis. Seal-electro Corp., Mamaroneck, N. Y.

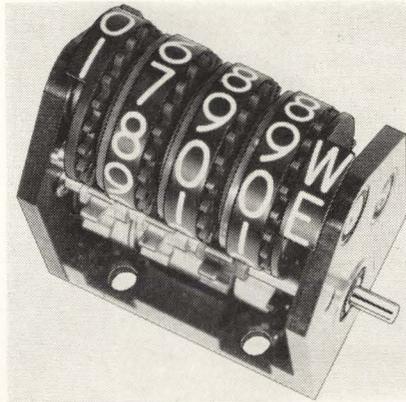
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MULTI-LAMP PUSHBUTTON SWITCH

A new multi-lamp, lighted pushbutton "Lit-Switch", Model-807, can be individually or gang mounted and is available in a single row lock, or interlock, or in several rows vertically and horizontally in matrices, locked and interlocked, between rows and switches. Available with 1, 2, 3, or 4 color lenses and from 1 to 4 poles double throw the model can be sealed and RFI shielded. Featuring front removable bulbs with terminal connections at 1 point, the unit may be mounted to any size panel up to 5/16". Sloan Co., Sun Valley, Cal.

Circle No. 163 on Inquiry Card.



REVERSING COUNTER

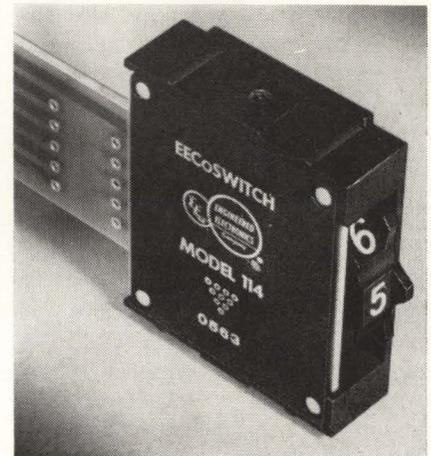
Three new designs were described as representative of a new series of reversing counters. The reversing design eliminates need for two sets of counter drums oriented on two parallel reading lines which are ordinarily required for "X-O-X" (a term used to indicate that readings can represent virtually any unit of measure) reading sequences, without change of shaft rotation. Other inherent advantages are reduced size, weight, and panel space requirement. Type X-2822 is a five-drum, longitude indicating unit, providing readings declining from 179°59' to 00°00' in 1' increments; and increasing back to 179°59'. A two-position flag transfers between E and W reading positions. The shaft rotates in the same direction throughout the sequence, but the counter drums reverse at the 0° and 180° reading positions. Another unit, X-2823, has four drums and provides latitude indication to 89°59' either side of a 00°00' reference, in 1' increments; a two position flag transfers to N or S position designation. Type X-2824 provides E and W variations up to 179.9° in 0.1° increments, and has an E-W two-position flag. Both units operate with the same shaft rotation throughout their reading sequence, reversing their drums at 0 and maximum readings. Bowmar Instrument Corp., Fort Wayne, Ind.

Circle No. 142 on Inquiry Card

METALLIC-PLATED MEMORY DRUMS

A new series of metallic-plated memory drums is reported to have twice the bit storage capacity of comparable sized, oxide-coated units. Recording surfaces are electrolytically-plated with a cobalt alloy which provides extremely stable and reproducible characteristics. In addition, the wear-resistant plating protects the surface from accidental physical damage. Units are designed to operate for 40,000 hours (continuous duty) at 3,600 rpm, with cylinder concentricities as low as 0.000008". According to the company, a unique double bit density permits running drums at half the speed required by conventional units, thereby giving longer life to the bearings. Designated Series 1200, these memory drums are 13" in diameter, with heights from 11.375" to 21.875". Storage capacities range from 50,000 to 3,500,000 bits. Drum speeds: 900 to 12,000 rpm. Metwood Mfg. Co., Gardena, Cal.

Circle No. 146 on Inquiry Card.

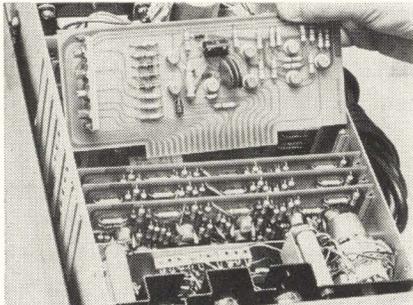


THUMBWHEEL SWITCH

A rotary thumbwheel switch has a 1-2-4-8 BCD output and provision for the installation of diodes on its circuit-board termination. The unit is made entirely of military-quality materials and has a rated life of 100,000 revolutions. A special detent prevents accidental hang-up between positions. Characters on the thumbwheel are engraved and filled for legibility and elimination of glare. Switches are available from factory stock at a unit price of \$12.00. Engineered Electronics Co., Santa Ana, Cal.

Circle No. 188 on Inquiry Card.

NEW PRODUCTS



DIGITAL VOLT-OHM METER

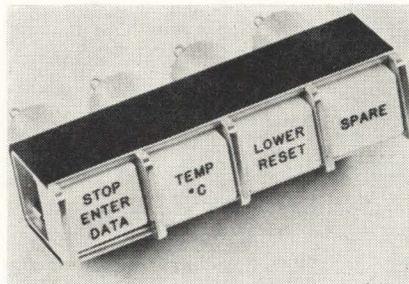
Said to represent a major achievement in the development of a high-accuracy digital volt-ohm meter, a new instrument contains completely solid-state circuitry. A unique regenerative voltage comparator combines the functions of precision ramp generator, voltage comparator, and memory circuits into a single circuit of simplicity, reliability, and accuracy. According to the company, this circuit arrangement eliminates the need for many circuits normally used in instruments of this type. Voltage sensitivity is available to 1 mv., and each voltage scale has an accuracy of $\pm 0.1\%$ of full scale, ± 1 count, not only at the maximum scale reading, but also 10% beyond the scale setting. This feature offers the user the advantage of overlapping scales and the ability to obtain a four digit reading on a three digit instrument. Also, a special switch may be used automatically to blank all indicators when the selected range scale is exceeded. This error-free feature is invaluable for production use, since it commands the operator's immediate attention. Other outstanding features include fully automatic polarity switching and indicating; automatic ohm indication; tracking illuminated decimal point; and high over-voltage protection on both the resistance and voltage scales. One model, called the Reporter 35, incorporates all needed BCD outputs to enable direct systems construction with the volt-ohm meter used as a basic A-D converter. Lowest price model costs \$395. Harman-Kardon, Data Systems Div., Plainview, N.Y.

Circle No. 179 on Inquiry Card

LOW-FREQUENCY OSCILLATOR

Designed for specialized computer, telemetry, and communications applications, high precision crystal controlled oscillator, designated Model VO-3610, is available in any given frequency, pre-set at the factory from 5kc to 50kc with high stability and precise control over a wide temperature range. The device is accurate to 1 part $\times 10^{-7}$ and produces a clean output signal. Harmonic distortion is less than 5%. At mid-range frequencies, the frequency source will withstand 100 G's shock at 11 milliseconds duration and vibration of ± 10 part per million at a level of 10 G's over 10 CPS to 2,000 CPS. Unit meets all military ground equipment specs MIL-E-5400, MIL-E-4970A, and MIL-E-5272. Frequency Control Div., Valpey Crystal Corp., Holliston, Mass.

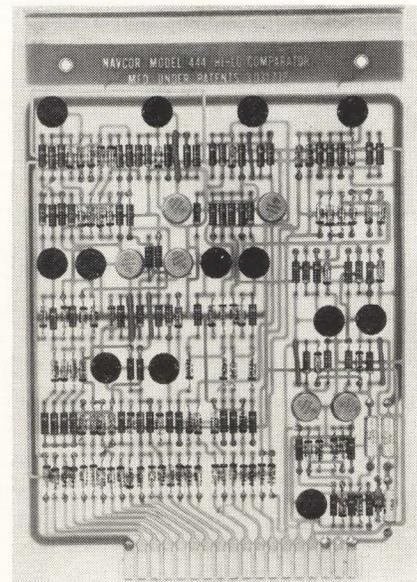
Circle No. 184 on Inquiry Card.



GANG SWITCH ASSEMBLIES

Any combination of individual switchlights, up to 12, can be used in each gang switch assembly, with a choice of 9 different types of mechanical locking, interlocking, and lockout action between pushbuttons. The new Series II assemblies, containing satin-finish metal barriers between pushbuttons, are mounted without screws in panels up to $\frac{1}{4}$ " thick. Switchlights, barriers, and latching mechanism are installed in interior channel section, which is inserted in panel from the front. Black exterior section is installed from, and butts up against, rear of panel. It holds complete assembly firmly in place by means of screws through the base of each section. Maximum depth behind panel is $2\frac{1}{4}$ ". Single-station assemblies can also be supplied in order to provide uniform panel appearance whenever both ganged assemblies and individual switchlight positions are required. Pendar, Inc., Van Nuys, Cal.

Circle No. 166 on Inquiry Card



HIGH-LOW COMPARATOR

Available as part of a complete line of system functions, a Model 444 High-Low Comparator incorporates all of the individual logic elements, such as AND gates, OR logic and inverting amplifiers, to detect equality between a known and an unknown binary number; and to give outputs which show whether the unknown number is higher or lower than the preset number. The unit can be the heart of a tape or drum address search system, where the known number can represent the address command, and the unknown number can be the address that is being searched. Logic levels are -6.8 volts for "One" and 0 volts for "Zero". Outputs are clamped with a Zener supply located on each card, so that the only voltages required are -12 volts and +12 volts. Propagation time is a maximum of 1 microsecond per 5-bits, which allows a full 10-bit word to be compared at a 300 kc rate. Navigation Computer Corp., Norristown, Pa.

Circle No. 170 on Inquiry Card

LOW VOLTAGE VARISTORS

A new series of low voltage varistors are made of silicon carbide mixed with ceramic binders, molded and fired at high temperatures. Classified in 10 current ranges at voltages of 12, 24, and 48 volts, units are available in $\frac{1}{4}$, $\frac{1}{2}$, 1, and 3-watt sizes as flat discs with metal sprayed faces or with tinned leads and dip coated. Carbone Corp., Boonton, N. J.

Circle No. 187 on Inquiry Card.

SILICON RESISTOR KIT

Design kit for temperature-sensitive circuits contains twenty-two 1/4-watt molded silicon resistors covering resistance values from 10 ohms to 10 kilohms. Also included are detailed specification sheets and applications literature on circuits ranging from simple amplifiers to sophisticated multiplex high-speed flip-flops. The complete kit, which costs \$49.50, is designed as a permanent laboratory working tool to assist the designer in the evaluation, checkout, and improvement of his breadboard circuits. Silicon resistors, called Sensitors, are thermally sensitive devices with a unique high positive temperature coefficient of approximately 0.7%/C. They are used to compensate for the negative TC of other components in transistorized circuitry and in temperature-sensing applications. Texas Instruments, Inc., Dallas, Texas.

Circle No. 196 on Inquiry Card.

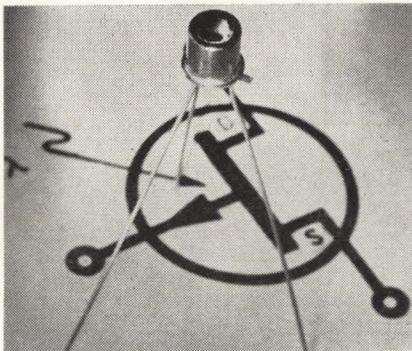


PHOTO FIELD-EFFECT TRANSISTOR

The P-102 Photofet, a photosensitive field-effect transistor, consists of a diffused, passivated, silicon photodiode functionally integrated with a high-impedance, low noise preamplifier in a windowed TO-18 package. A specific detectivity of 10^{10} cm-cps^{1/2}/watt (equivalent input noise power of 10^{-12} watts/cps^{1/2} at 1 kc) can be obtained with the output of the detector operating into a 2 K to 10 K ohm load for optimum coupling to standard transistor amplifiers. The use of a high-quality field-effect structure provides premium service and flexibility. This photodetector is said to be ideal for high-impedance, high-output transistor systems. Other applications include log or integrating response, adjustable threshold, and low-drift dc operation. Siliconix Inc., Sunnyvale, Cal.

Circle No. 133 on Inquiry Card

REED RELAYS

Constructed with their reeds and coils floated in resilient "RTV" for maximum resistance to shock and vibration, a new line of magnetically-shielded reed relays conform to MIL-R-5757-D. Operate time of these dry reed types is 1.2 milliseconds nominal; fastest operate time is approximately 0.8 millisecond. Units are made to meet either temperature Class A or Class B operation standards. With a maximum of 125 volts or 0.5 amp, contact rating is 4 watts dc or 10 volt-amperes ac. Maximum coil resistance is 6,000 ohms. Average operating power required is 15 milliwatts per Form A contact. Minimum power is approximately 5 milliwatts for 1 Form A. Furman Electric Co., Brooklyn, N.Y.

Circle No. 191 on Inquiry Card.

CURRENT-LIMITING DIODES

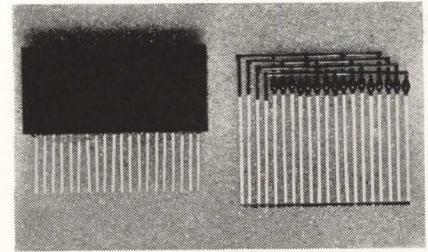
Kits incorporating current limiting diodes, called "CURRECTORS", permit a wide selection of current cut-off levels and other characteristics for experimental and development work. The kits include 6 Currectors, and are offered with different combinations of unit series and in different current ratings of the same series. Units available include silicon high temperature series; germanium general purpose types; miniature germanium series; and low current (0.1 to 1.0-ma) types. According to the company, the incorporation of a Currector in a circuit will often greatly simplify design work and eliminate a number of components. CircuitDyne Corp., Laguna Beach, Cal.

Circle No. 180 on Inquiry Card.

D/A CONVERTER

Accepting a 14-bit binary code (or 13 bits and sign), a new digital-to-analog converter produces an output voltage to 0.01-percent accuracy. Full-scale output is ± 5 v. The digital number can be changed at a 100-kc rate, and the settling time of the output is 1 usec for a 10-volt change. Optional equipment includes a binary storage register, output amplifier, and binary display. Other converters are available in BCD code, various accuracies and numbers of bits, conversion rates, and voltage ranges. Abacus, Inc., Santa Monica, Cal.

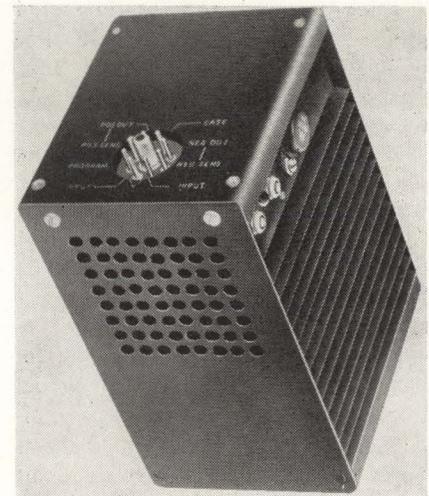
Circle No. 201 on Inquiry Card.



CORE DRIVER ASSEMBLIES

Silicon micro diode assemblies for core driver and other high current computer applications are available with pulse current as high as 1.5 amps and recovery times as low as 0.002 microseconds. Inverse operating voltages are said to be exceptionally high with junction capacity as low as 2 picofarads. Assemblies are capable of meeting or exceeding MIL-S-19500C and MIL-STD-750 requirements. Versatility in packaging dimensions and circuit variations permit ready insertion into memory planes and stacks. Size of a 10 diode common cathode or anode array is only 0.5" x 0.150" x 0.060" thick. Prices range from \$6.00 to \$25.00 each at the 100 quantity level. MicroSemiconductor Corp., Culver City, Cal.

Circle No. 123 on Inquiry Card

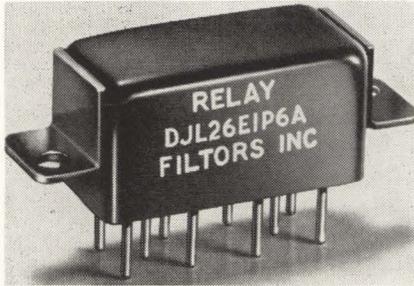


PROGRAMMABLE DC POWER

New series of precision programmable transistor power modules are remotely or internally adjustable to 0.01%. Five voltage and current ranges are offered from 0-12 volts at 1.5 amps to 0-50 volts at 0.4 amp. The power modules are protected electronically and may be programmed remotely at 1000 ohms/volt or may be adjusted from zero to full voltage with a built-in multi-turn potentiometer. ACDC Electronics, Inc., Burbank, Cal.

Circle No. 141 on Inquiry Card

NEW PRODUCTS



LATCHING RELAY

A new half-size crystal-case magnetic latching relay is two-coil and is said to be the smallest two-ampere latching relay on the market today. It is sealed with a new electron-beam welder which welds without contaminating flux in a near-perfect vacuum. Specs include: temperature range of -65 to 125°C ; dielectric strength of 1,000 volts rms, 500 volts rms between contacts; contact resistance (max.) of 0.05 ohm initial, 0.10 ohm after rated life; contact rating of 2 amps resistive, 4 amps overload; operate time of 4 milliseconds max., and release time of 4 milliseconds max. Filters, Inc., East Northport, N. Y.

Circle No. 190 on Inquiry Card.

REPORT CONVERTER SYSTEM

A report converter system permits unskilled personnel to prepare data for computer entry by simply filling out printed forms in the field, factory, office, or elsewhere. The printed sheets are inserted in the photoelectric report reader where they are scanned and answers are converted to a punched paper tape in computer format. Manual entry keyboard permits the operator to insert information directly such as date, serial number, computer routine number, etc., as desired. An unskilled operator can process 1500 sheets an hour with each sheet containing up to 25 answered questions. Use of this equipment completely eliminates the need of the preparation of tab cards and the verification operation. Datascan Inc., Clifton, N.J.

Circle No. 139 on Inquiry Card

PRECISE POWER SUPPLIES

Designed for use in business machines, computers, digital data and logic devices, and other equipment where precise voltage regulation is required, a line of dc voltage power supplies offers, according to the company, load regulation that is substantially better than previously available "open-loop" devices. Depending on output voltage specs, load regulation ranges from less than 1% to 4% with output voltage maintained at $\pm 1\%$ for $\pm 15\%$ input voltage variation. The "Power-guard" dc supplies are designed so that there are no "hot" leads or terminals above the chassis, except for the terminal block. The units are therefore especially well-suited for bench operation and provide increased safety in routine maintenance of rack-mounted units. A total of 18 different units are available with power rating from 50 to 300 watts. Output voltages range from 6vdc to 250vdc, with nominal 117 vac inputs. Stancor Electronics, Inc., Chicago, Ill.

Circle No. 189 on Inquiry Card.

MAGNETIC TAPE VIEWER

Precision instrument, which makes visible the data recorded on magnetic tape without damaging the tape, has been developed by the 3M Company, producer of the "Scotch" brand of recording tapes. The "Scotch" brand magnetic tape viewer No. 600 can be used to check recorder head alignment, track placement, pulse definition, interblock spacing, and drop-out areas in computer and instrumentation work. The viewer was under development for three years. One of the first proto-types was used to align pieces of an airplane recorder tape which provided the clue to the cause of a military aircraft explosion. The tape had been broken and scattered over a wide area by the explosion. In another early case, the viewer was used to determine that a defect in an aerospace telemetry tape was due to a faulty recorder. The viewer is a quality, but delicate, instrument which requires no exterior chemicals and no preparation to use. It costs \$50, and is covered by a six-month guarantee against defective materials and workmanship. 3M Company St. Paul, Minn.

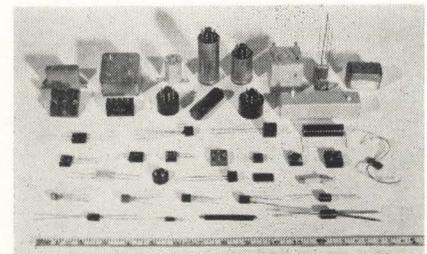
Circle No. 174 on Inquiry Card.



TINY THERMAL SWITCH

Claimed to be the only miniature, snap-acting thermal switch that combines the functions of a thermistor and its electronic circuitry in a unit no larger than the thermistor alone, a new thermal switch is said to respond five times faster than any comparable unit and to replace, at lower cost, thermistor systems used for direct sensing and switching in computers, memory systems, printed circuit boards, and other equipment. Designated the KLIXON 4BT "Tiny-Stat", this SPST, all welded, Class A hermetically-sealed device is small enough to be placed anywhere in a system; weighs only 0.2 grams; has an operating temperature range of 0°F to 350°F (temperature exposure -80°F to 400°F) and is available in an encapsulated version for electrical insulation. Metals & Controls, Texas Instruments, Attleboro, Mass.

Circle No. 132 on Inquiry Card



MULTI-CIRCUIT MODULES

New encapsulated circuit configurations include stack rectifiers, bridge rectifiers, ring modulators, AND gates, NOR gates, or various combinations of functional and logical elements. Frequency response ranges from dc to gigacycles and connections may be made by means of flexible leads, solderable terminals, plug-in terminals, or a combination of these methods. Prices range from fifty cents to fifty dollars and up. National Transistor, a subsidiary of ITT, Lawrence, Mass.

Circle No. 145 on Inquiry Card

FLUORINATED CAPACITORS

High capacitance disc ceramic capacitors formerly rated at 50 volts dcw have been up-rated to 100 volts dcw by a fluorination process which electrically hardens the ceramic dielectric, making it highly resistant to degradation. In addition to allowing higher voltage, fluorination also permits continuous operation at high temperatures. Designated Type H, these capacitors have a range of 0.005 mfd to 0.1 mfd and operating temperature range of $+10^{\circ}\text{C}$ to $+85^{\circ}\text{C}$ which meets EIA temperature characteristics Z5V. Diameters range from 0.350" to 0.625". Up to and including 0.05 mfd, thickness is 0.156"; greater than 0.05 mfd, thickness is 0.200". Cornell-Dubilier Electronics, Newark, N.J.

Circle No. 175 on Inquiry Card.

PLUG/JACK ASSEMBLIES

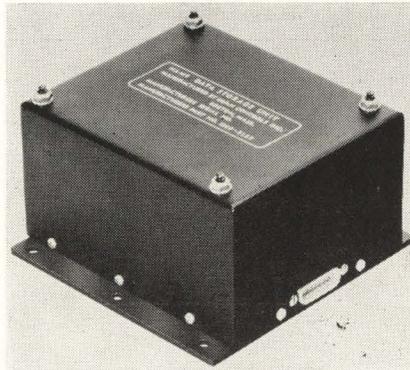
Combination plug-jack and jack assemblies were designed for the growing number of applications for 0.040" patching in computers, programming, control instrumentation, and systems communications — particularly where high reliability and low contact resistance are required. The 0.040" jacks and plugs have a beryllium copper spring insert that provides exceptional reliability. Parts with this captive insert can be expected to withstand over 65,000 insertions and extractions without failure or excessive contact resistance. Cambridge Thermionic Corp., Cambridge, Mass.

Circle No. 177 on Inquiry Card.

ULTRA-SMALL DELAY LINE

Miniaturized so that 60 sections occupy only one cubic inch, new lumped-constant delay lines are hermetically-sealed, possess a temperature stability of 50 parts per million per degree C., operate throughout a temperature range of -55°C . to $+85^{\circ}\text{C}$., and are designed to meet environments specified in MIL-STD-202. A typical delay line of 48 sections would exhibit a delay time of 1.8 microseconds, a characteristic impedance of 500 ohms, and a rise time of 0.1 microsecond maximum. Gudeman Co. of California, Inc., Visalia, Cal.

Circle No. 162 on Inquiry Card.



SUBMINIATURE MEMORY

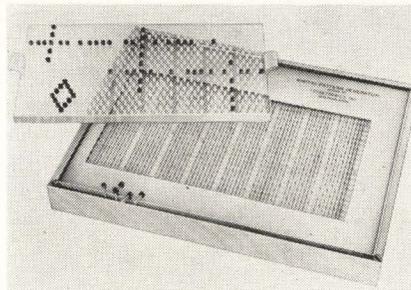
Designed for aerospace data storage and retrieval systems, new, subminiature 30,096-bit sequential access memory, is just 40 ounces and occupies less than 70 cubic inches. The new MSA-1A-INT-30096 is a coincident current core memory with internal addressing and counting. It utilizes ultra-reliable solid state magnetic drive and control circuitry, with no internal heating or temperature control required. Data input and output are asynchronous — one bit at a time at any rate up to 20,000 bits per second. Clear/write or read/restore modes of operation. Temperature range: -20°C to $+95^{\circ}\text{C}$. A 20 ounce, 10-, 296-bit memory is also available. DI/AN Controls, Inc., Boston, Mass.

Circle No. 172 on Inquiry Card.

TWISTOR MEMORIES

A new memory element, the twistor, is composed of a fine copper wire and a flat molybdenum-permalloy tape. It has square-loop magnetic properties and fast switching characteristics which enable it to be used advantageously as a memory element. When compared with a conventional ferrite core memory, the advantages of the twistor, the company reports, are considerably lower cost per "bit", faster switching speed, smaller temperature variations, and greater ease of fabrication. The twistor is made by helically wrapping a flat molybdenum-permalloy tape around a fine copper wire. The tape is wrapped at an angle of 45 degrees with the longitudinal axis of the wire. The wire has a diameter of 0.003 inches and the tape is approximately 0.003 inches thick by 0.004 inches wide. The finished twistor has a diameter of about 0.004 inches. A "bit" of information can be stored in a length of one-tenth of an inch of twistor wire. For temporary type twistors: H_c is 3.5-4.0 oersteds, and Br/B_m is greater than 0.90. For Permanent type twistors: H_c is 2.5-3.5 oersteds and Br/B_m is greater than 0.80. Arnold Engineering Co., Marengo, Ill.

Circle No. 149 on Inquiry Card.



DIGITAL PATTERN GENERATOR

Major element of a pattern generator is a magnetic peg board that controls ten separate outputs, each with 64 serial bits individually selected by small permanent-magnet plugs inserted in the peg board according to the desired pattern. Setting up or changing a program is accomplished rapidly and easily by plugging in or re-arranging the magnets. By selective repetition, each output can have as

many as 512 serial bits. The entire program can be filed for future use by simply removing the peg board. A new program can be readily obtained by merely inserting another pre-plugged peg board. Triggering can be either internal or external, with a maximum serial repetition rate of more than 250kc. The unit can be used for one-shot or continuous operation. The normal output levels are ground and -5v . This pattern generator is especially useful wherever program changes are frequent. Typical applications are in the testing and simulation of digital systems; code-conversion and cryptography; input-output simulation; digital-circuit design; and checking of data-communication systems. The device can also be used as a random-access fixed storage. Cybetronics, Inc., Waltham, Mass.

Circle No. 195 on Inquiry Card.



Racks and Consoles

Catalog contains 44 pages of illustrations, detailed engineering drawings, technical specifications, descriptions and prices of modular cabinet racks and consoles, together with appropriate accessories. Illustrations give the engineer examples of how these cabinets and consoles can be used singly as well as in multiple assemblies. A cut-away drawing gives precise specs of all parts which have a bearing on the rigidity of the racks. Component group check list enables reader to specify console units more easily than previously. Par-Metal Products Corp., Long Island City, N.Y.

Circle No. 130 on Inquiry Card

Edge Connectors

Product bulletin on low-cost laminated edge connectors provides dimensional data and complete electrical specs on the six styles that are available with up to 56 contacts per connector. According to the bulletin, the advantages of these connectors include lower costs, quick and easy assembly to printed cards, contact float, elimination of moisture traps, and positive connector operation over a wide range of board tolerances. Body materials are available for either commercial or military applications. Cinch Mfg. Co., Chicago, Ill.

Circle No. 181 on Inquiry Card

Tape Recorder/Reproducer

Capabilities of predetection magnetic tape recorder/reproducer are described in a four page bulletin. The Model VR-3600 is a wide bandwidth, multichannel system which can be used for data storage in the 400 cps to 1.5 mc frequency range with high signal-to-noise and low distortion characteristics. Seven and fourteen channel machines, available as standard equipment, feature modular construction to provide greatest system flexibility and utility. Consolidated Electrodynamics Corp., Pasadena, Cal.

Circle No. 183 on Inquiry Card

Memory Testing

Eight page brochure describes equipment for testing memory cores, planes, stacks, and automatic equipment for testing multiaperture ferrite memory and logic plates. A complete line of logic modules and accessory equipment for systems designing is also described. RFS Engineering Co., Philadelphia, Pa.

Circle No. 192 on Inquiry Card

Printed Circuit Components

Information on a variety of connecting devices for use with printed circuit boards is contained in a new 24-page catalog. Listed are 77 types of transistor, tube, and nuvistor sockets, 4 types of multiple circuit connectors, and 9 types of edge connectors. Detailed dimensional drawings and electrical specs are given on all products. Cinch Mfg. Co., Chicago, Ill.

Circle No. 124 on Inquiry Card

Automatic Circuit Checkout

A 4-page brochure covers new system for automatic production-line checkout of circuit modules. The test system can operate at a production rate of 1400 computer circuit modules per 8-hour day. Digital Equipment Corp., Maynard, Mass.

Circle No. 168 on Inquiry Card

Cooling Module

A new thin-profile thermoelectric cooling module, 1.125" wide x 1.440" long x 0.270" deep, is said to offer substantial cost savings and is available as an off-the-shelf item. Designed for 115vac/12vdc power systems, the Model 424 draws a maximum of 8 amps at 2.4vdc. A technical monograph is available. Jepson Thermoelectrics, Inc., Chicago, Ill.

Circle No. 169 on Inquiry Card

Hybrid Computer System

A 16-page brochure describes the Series 350 Digital Operation System which is the digital portion of a hybrid digital/analog computer. The brochure includes a detailed description of the computer and describes its capabilities in the economical solution of a wide range of advanced scientific problems. It also outlines the modular computing components used in the computer and describes how these can be used as building blocks to add flexibility and the feature of progressive expansion toward a complete hybrid computing system. Electronic Associates, Long Branch, N.J.

Circle No. 129 on Inquiry Card

Digital Counter Printer

Full description and specs on a solenoid-operated digital counter printer are given in a new bulletin. The printer, panel or portable style, contains a counter for totaling sequential input pulses, on either one or two channels, up to 600 per minute with printout on 3-inch paper tape. Texas Instruments Inc., Industrial Products Group, Houston, Texas.

Circle No. 165 on Inquiry Card

Phase Modulations Methods

How and why phase modulation of information storage offers advantages of economy, reliability, and low noise level operation are described in a technical bulletin. The technique insures a minimum of one distinct flux reversal per bit in storage. LFE Electronics, Computer Prods. Group, Boston, Mass.

Circle No. 164 on Inquiry Card

Computer Grade Capacitors

A 24-page catalog covers aluminum electrolytic capacitors designed for applications requiring high reliability and long life. Typical applications include computer equipment, telephone network use, and industrial electronic and other equipment. Mounting dimensions, ordering information, performance specs, typical performance curves, and bracket information is provided in detail. Aerovox Corp., New Bedford, Mass.

Circle No. 122 on Inquiry Card

High Frequency Pulse Generator

According to data sheet, the price of a high frequency pulse generator has been reduced from \$1350 to \$960. Known as Model PG-10, the pulse generator offers such features as a frequency range from 1 to 20 megacycles, less than 5 nanosecond rise time, and an 8 nanosecond minimum pulse width at high frequency. General Applied Science Labs, Westbury, L.I., N.Y.

Circle No. 200 on Inquiry Card

Standby Power System

A new solid-state standby power system, called ConstAC, assures continuous, precision ac power to critical loads such as those in computer, guidance, telemetering, control, data-processing, and other types of operations which are adversely affected by any power irregularity. ConstAC assures a load of continuous uninterrupted power, with no break in the sine wave, when line power falters or fails. ConstAC also prevents wild power overshoots from reaching the load when power returns or when rotary type supplies start operating. The system normally "rides along", synchronized with line power, but does not supply power to the load until line power falls above or below pre-set limits. An additional feature is that ConstAC can automatically charge the battery pack, eliminating the need of a separate battery charger. Four-page brochure is available. Parametrics, Costa Mesa, Cal.

Circle No. 136 on Inquiry Card

Double Regulated Supplies

Five models of dc power supplies are described with complete electrical and physical specifications, theory of operation, and outstanding features. Curves charting output current vs. ambient temperature, and input voltage vs. output voltage are also included. These double regulated supplies feature 0.01% regulation, 0.05% stability over 24 hours, and complete indestructibility, since they can operate indefinitely into a dead short. They are furnished with a 10,000-hour warranty. Powered from 105 to 125 volt input, at from 57 to 2000 cps, the five models offer outputs of 4-18 vdc at two, four, and eight amps, and 4-35 vdc at two and four amps. Power Devices, Inc., Chatsworth, Cal.

Circle No. 198 on Inquiry Card

Diode Reference Guide

Two new subminiature glass diode reference guides give the characteristics and test specifications for over 400 diodes currently registered by EIA. Arranged in simple numerical order, according to their registered type numbers, the guides make it a simple matter to locate the characteristics of any diode. One guide covers germanium and the other silicon types. Characteristics covered include, PIV, forward current and voltage, reverse current and voltage, high temperature reverse current, reverse recovery time, test circuit, and capacity. National Transistor, a subsidiary of ITT, Lawrence, Mass.

Circle No. 140 on Inquiry Card

Modular Counters

Features, specifications, and prices of a new line of modular digital test instruments are listed in a 6-page technical brochure. Series 800 "Digi-Twin" instruments described consist of a basic chassis containing power supply, oscillator, readout and related circuitry, and two plug-in spaces—one for frequency range and one for function modules. Computer Measurements Co., San Fernando, Cal.

Circle No. 126 on Inquiry Card

Silicon Readout Cells

Advantages of using silicon photovoltaic readout cells in tape readers, punch card systems and control applications are described in a 4 page brochure. Illustrated graphs and charts are included. The readout cells response time is in microseconds while the output power is said to be 8 to 10 times that of selenium cells with the same area. The cell's low output impedance is ideally suited for matching input networks. Solar Systems Inc., Skokie, Ill.

Circle No. 137 on Inquiry Card

Computer Products

Covering a complete line of computer products, an eight page catalog describes cores, arrays, stacks, tape transports, read-write electronics, and tape. Applications, features, advantages and specifications are listed. Ampex Corp., Redwood City, Cal.

Circle No. 197 on Inquiry Card

Feather Fans

Complete technical information on new "Feather Fans" includes detailed data on applications, materials, mounting, temperature, and acoustical curves. Described as a precisely-engineered air moving device, the fan delivers up to 270 cfm of air and measures 7" in diameter by 2-7/16" thick. Weight is only 1.5 pounds. Rotron Mfg. Co., Woodstock, N.Y.

Circle No. 193 on Inquiry Card

Thin-Film Capacitors

Data sheet describes a unique multi-application thin-film screened capacitor which has exceptional reliability due to the inherent stability of its inorganic construction. Capacitance range is up to 8,000 pfd per single layer per 1/2" square maximum size on flat alumina substrates. CTS Corp., Elkhart, Indiana.

Circle No. 135 on Inquiry Card

Hall Effect Generators

Comprehensive 4 page product data bulletin describes Hall effect generators that are thin-film, solid-state, flexible, and totally non-magnetic. Included are the history and classical diagrammatic representation of the Hall effect phenomenon, complete specifications of the micro-thin line of Type HA devices, and application data that indicate how the generators can perform a wide variety of electronic circuit control, computer and transducer functions. American Aerospace Controls, Farmingdale, N.Y.

Circle No. 199 on Inquiry Card

Lighted Pushbutton Switches

Lighted pushbutton switches cut control console costs by combining indicating and manual switching functions in a single compact package. The same pushbutton that serves as a color or legend coded panel indicator actuates one or more subminiature snap-action switches. This single component replaces conventional systems of separate panel lights and pushbutton or toggle switches. A 4-page brochure gives complete information on various types. Licon Div., Illinois Tool Works, Chicago, Ill.

Circle No. 128 on Inquiry Card

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	2N2955		2N2956		2N2957		Units
	min	max	min	max	min	max	
$BV_{CEO} @ I_C = -100 \mu A$	40		40		40		Volts
$BV_{EBO} @ I_E = -100 \mu A$	3.5		3.5		3.5		Volts
$BV_{CEO} @ I_C = -10 \text{ mA}$	25		20		18		Volts
$h_{FE} @ I_C = -50 \text{ mA},$ $V_{CE} = -1 \text{ V}$	20	60	40	120	100		
t_{ON}		55		45		40	nsec
t_{OFF}		80		90		95	nsec

For additional information on Motorola's new 2N2955 series of high-voltage germanium transistors, or for information concerning any requirements for germanium computer transistors, call your nearest Motorola District Representative or Motorola Semiconductor Distributor, (see complete listing on opposite page) or write:

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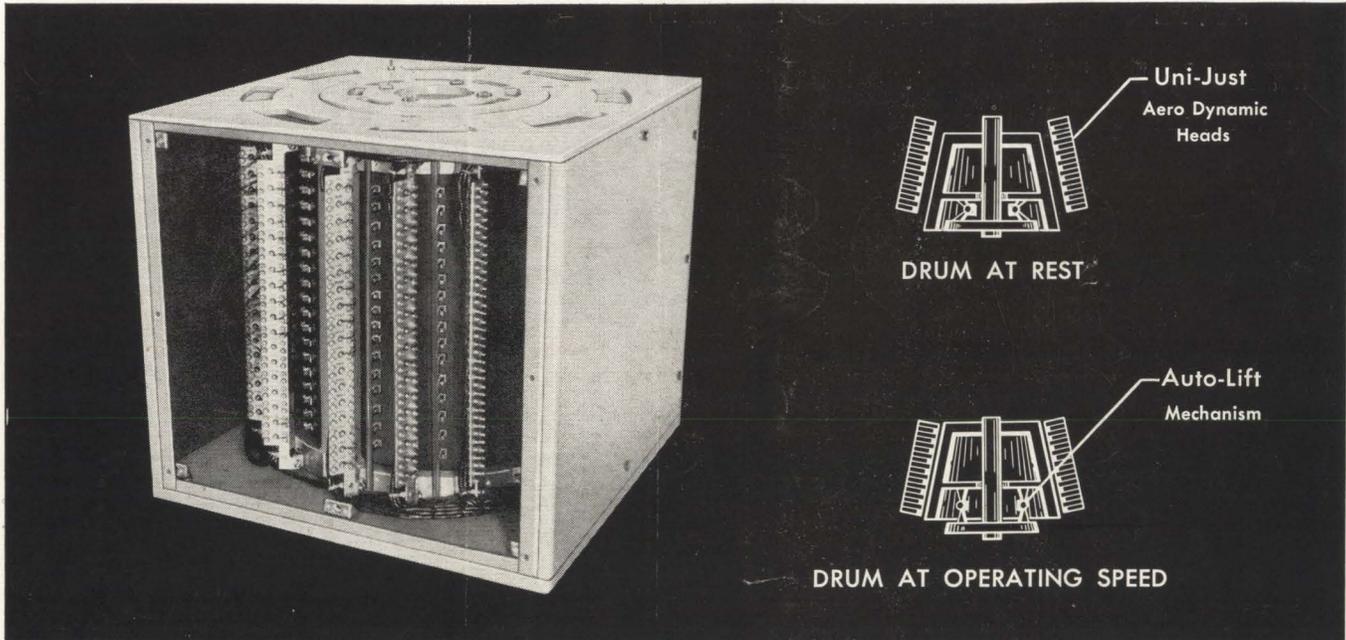
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HERE'S RELIABILITY AND MAINTAINABILITY

Bryant Auto-Lift* Drums with Uni-Just* Aerodynamic Heads



AUTO-LIFT DRUM FEATURES:

- No head-drum contact.
- Centrifugal lift raises tapered drum to heads at operating speed.
- Tapered drum retracted axially on stop cycle.
- One simple, fail-safe Auto-Lift regardless of number of heads.
- Auto-Lift maintains fixed adjustment of heads.
- Auto-Lift is automatic, requires no external power, controls or adjustment.
- Auto-Lift unit unaffected by temperature, shock, or vibration.
- Full range of standard sizes and speeds in production.
- Interchangeable production parts throughout.
- All drums expandable to full capacity in field.
- Motor and bearings field serviceable without loss of data.

UNI-JUST AERODYNAMIC HEAD FEATURES:

- True aerodynamic heads fly continuously — no skipping or bouncing.
- Negligible playback envelope modulation.
- Fail-safe individual adjustment to match playbacks.
- Individual heads replaceable without loss of data.
- Head adjustment and replacement with drum running.
- Full range of frequency and pulse density satisfied by production heads.
- Unlimited recording modes.

*Trademarks

STANDARD SPECIFICATIONS

MODELS:

- Series 5000 — 5 inch diameter — 4710 bits/track**
- Series 7500 — 7.5 inch diameter — 7080 bits/track**
- Series 10000 — 10 inch diameter — 9240 bits/track**
- Series 18500 — 18.5 inch diameter — 17400 bits/track**

CAPACITIES:

Up to 16.5 megabits at 300 BPI with single bit alteration. Higher capacities available using NRZ, block format.

AVERAGE ACCESS TIME:

2.5 to 33.3 milliseconds depending on drum size.

MOTORS:

900 to 12,000 RPM, Induction or Synchronous.

MAGNETIC MEDIUM: hard oxide coating.

READ-WRITE HEADS:

Individually adjustable, true aerodynamic heads.

ENVIRONMENT:

Storage: -65°F to +160°F.

Operating: +32°F to +140°F.

Thermal shock: Drum with covers in place will withstand 50°F step change in operation.

Altitude: Operating to 15,000 feet.

Humidity: to 95% RH.

Shock: 5 G's any plane with standard mounts.

Vibration: 0-10 CPS 5 mils excursion.

10-250 CPS 2 mils excursion.

25-50 CPS 1 mil excursion.

Over 50 CPS 0.5 mil excursion with maximum acceleration of 2 G's.

Military Auto-Lift Drums are also available to meet these typical specifications: Mil-E-5400, Mil-E-4970, Mil-E-4158, and Mil-E-16400.



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