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Special: portable digital instruments

JUNE 1978 THE INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS, INC.

VOLUME 15 ☐ NUMBER 6 JUNE 1978

IEEE spectrum

Design Director Taylor selected pieces from a portable service processor (Omnicomp, Inc.) to produce this semiliteral representation of the type of test gear described in the article "New philosophies for portable digital instruments," p. 32.

articles

departments

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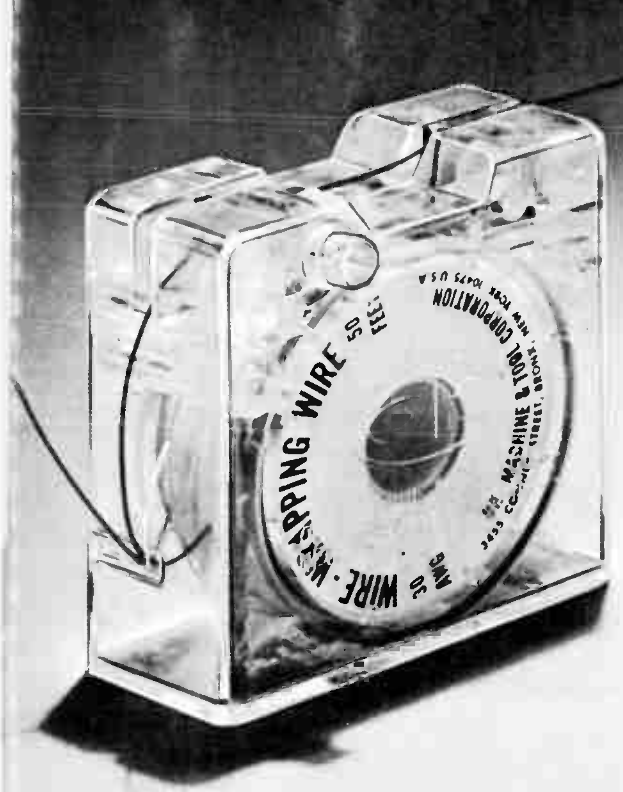

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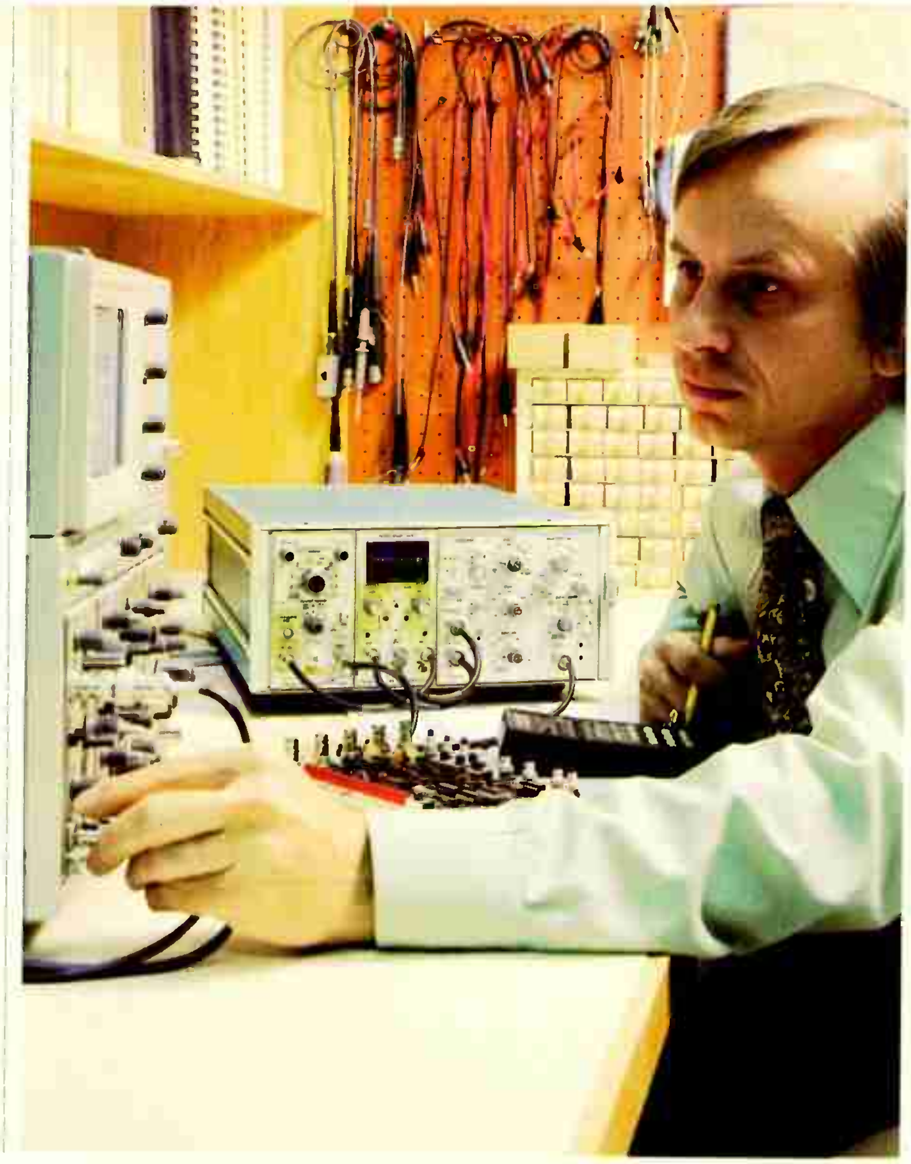

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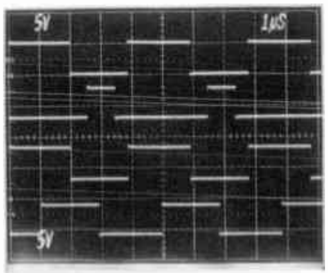
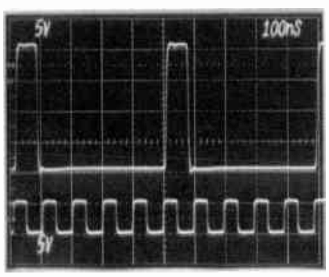


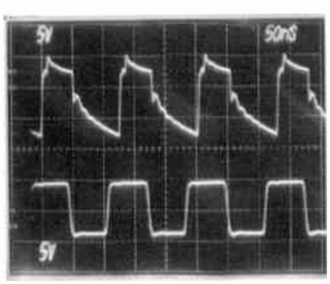
Biphase Clocks

When working with mixed logic systems, two-frequency synchronous clocks operating at different frequencies and different logic levels can be configured.



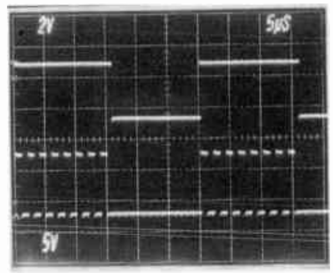
Two Frequency Synchronous Clocks

Also, this instrumentation provides translation capability between common logic families; CMOS to ECL or TTL to CMOS, for example. A unique pulse restoration or superbuffer capability, with high or low input impedance and 50Ω output impedance, helps you produce low aberration signals in unterminated lines.



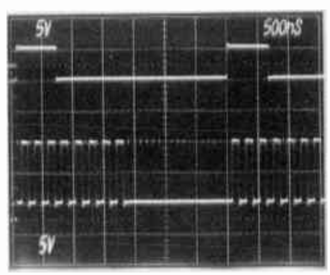
Pulse Restoration

Dual pulse generation within one unit provides self contained burst generation. In this mode, burst rate and width, and pulse rate and width within each burst can be individually controlled.



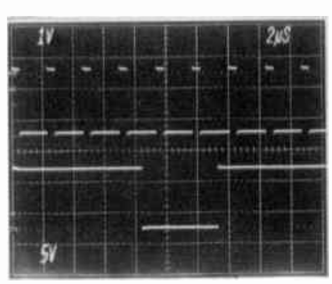
Self Contained Burst

A counted burst feature, with thumbwheel switches, gives exact control when selecting pulses for use with shift registers, CCD delay lines and data transmission. With this instrumentation it is not necessary to reset burst control if width and duration is changed within the burst. When working with a large number of pulses, more stability and ease of resolution is assured.



Counted Burst

When desired, two pulse generators are operable as independent instruments. Both outputs provide true and complement pulses, and other types of mixed pulses. Both outputs are controlled by independent high and low dials.



Independent Pulse Generation

Frequency capabilities are 50 MHz at 20V for MOS and CMOS logic and 250 MHz at 5V for ECL and Schottky TTL. Square wave trigger outputs can be viewed when narrow pulses decrease scope visibility, and simplify counter triggering.

Tektronix has designed a TM 500 pulse generator system capable of these functions and more. Two pulse generators (PG 508 and PG 502) and an independent digital delay (DD 501), packaged together in a versatile mainframe, meet a wider range of applications.

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If you prefer a bench set-up the three plug-ins (PG 502-PG 508-DD 501) can be installed in a TM 500 mainframe to sit conveniently and neatly on a bench top. When your needs demand a portable test unit, the three plug-in modules can be packed in the small-as-a-suitcase TM 515 Traveler Mainframe.

In addition to this mechanical configurability, your pulse generator unit can be combined with other TM 500 modules to expand your present test and measurement library.

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Calendar

For additional information, write or call the listed contact; or IEEE Conference Coordination, 345 East 47 St., New York, N.Y. 10017; (212) 644-7895.

IEEE-sponsored meetings

Power Engineering Society Summer Meeting (S-PE) July 16-21, 1978. Hilton Hotel, Los Angeles, Calif. Contact: G. A. Davis, Southern Calif. Edison Co., P.O. Box 800, Rosemead, Calif. 91770

Nuclear and Space Radiation Effects (S-NPS) July 18-21, 1978. University of New Mexico, Albuquerque. Contact: B. L. Gregory, Sandia Labs., Dept. 2140, Albuquerque, N.Mex. 87115 (505) 264-1912

4th WVU Conference on Coal Mine Electrotechnology (S-IA) Aug. 2-4, 1978. Lakeview Inn Country Club, Morgantown, W.Va. Contact: Dr. M. D. Aldridge, W.Va. University, Morgantown, W.Va. 26506 (304) 293-6371

Intersociety Energy Conversion Engineering Conference (S-ED, S-AES) Aug. 20-25, 1978. Town & Country Hotel, San Diego, Calif. Contact: G. P. Townsend, Hamilton Standard Div., United Technologies Corp., Windsor Locks, Conn. 06096 (203) 623-8723

International Conference on Parallel Processing (CompSoc) Aug. 22-25, 1978. Shanty Creek Lodge, Bellaire, Mich. Contact: Prof. T. Y. Feng, Dept. of Elect. Comp. Eng., Wayne State University, Detroit, Mich. 48202

COMPCON Fall (CompSoc) Sept. 5-8, 1978. Washington, D.C. Contact: COMPCON Fall, P.O. Box 639, Silver Spring, Md. 20902 (301) 439-7007

* **International Optical Computing Conference** (CompSoc) Sept. 6-8, 1978. Imperial College, London, England. Contact: S. Horvitz, Box 274, Waterford, Conn. 20901 (301) 439-7007

OCEANS '78 (OEC, MTS) Sept. 6-8, 1978. Sheraton Park, Washington, D.C. Contact: Myra Binns, Marine Tech. Soc., 1730 M St., N.W., Washington, D.C. 20036 (202) 659-3251

Joint Power Generation Technology Conference (S-PE; ASME, ASCE) Sept. 10-13, 1978. Contact: C. J. Wylie, Duke Power Co., P.O. Box 2178, Charlotte, N.C. 28242 (704) 373-4438

* **Petroleum and Chemical Industry Technical Conference** (S-IA) Sept. 11-13, 1978. Camelot Inn, Tulsa, Okla. Contact: T. Shaw, Phillips Petroleum Co., 6 Al Phillips Bldg., Bartlesville, Okla. 74004 (918) 661-4516

Western Electronic Show and Convention—WESCON (Los Angeles & San Francisco Councils; ERA) Sept. 12-14, 1978. Los Angeles Convention Center, Los Angeles, Calif. Contact: W. C. Weber, Jr., 999 N. Sepulveda Blvd., El Segundo, Calif. 90245 (213) 772-2965

* **Automatic Support Systems for Advanced Maintainability—Autotestcon** (S-AES, San Diego Sect.) Sept. 12-14, 1978. Contact: Robert Aguais, General Dynamics Elect. Div., Mail Stop 7-98, P.O. Box 81127, San Diego, Calif. 92138 (714) 279-7301, ext. 3975

***Asterisk denotes new listing**

* **International Conference on Very Large Data Bases** (CompSoc) Sept. 13-15, 1978. Berlin, F.R. Germany. Contact: Anthony Wasserman, Medical Information Science, Rm. A-16, University of California, San Francisco, Calif. 94145 (415) 666-2951

* **Cyclotron Conference** (S-NPS) Sept. 18-21, 1978. Bloomington, Ind. Contact: R. F. Pollock, Cyclotron Facility, Indiana University, Bloomington, Ind. 47401

Interactive Techniques in Computer-Aided Design (CompSoc; ACM) Sept. 21-23, 1978. Palazzo dei Congressi, Fiera di Bologna, Italy. Contact: Dr. B. Herzog, Computer Center, Univ. of Colorado, Boulder, Colo. 80303 (303) 492-6501

Convergence '78 (IEEE; SAE) Sept. 25-27, 1978. Hyatt Regency Hotel, Dearborn, Mich.

Ultrasonics Symposium (G-SU) Sept. 25-27, 1978. Philadelphia, Pa. Contact: F. S. Welsh, Bell Telephone Labs, Allentown, Pa. 18101

Electronics and Aerospace Systems—EASCON (S-AES) Sept. 25-27, 1978. Sheraton National Hotel, Arlington, Va. Contact: Bette English, At-Your-Service, Inc., 821 15th St., N.W., Suite 636, Washington, D.C. 20005

Industry Applications Society Annual Meeting (S-IA, Toronto Sect.) Oct. 1-5, 1978. Royal York Hotel, Toronto, Ont., Canada. Contact: W. Harry Prevey, 4141 Yonge St., Willowdale, Ont. M2P 1N6, Canada (416) 222-3067

* **Joint Engineering Management Conference** (S-EM) Oct. 16-17, 1978. Regency Hotel, Denver, Colo. Contact: Henry Bachman, Hazeltine Corp., Greenlawn, N.Y. 11740 (516) 261-7000

* **Conference on Canadian Communications Power** (Reg. 7, Montreal Sect.) Oct. 18-20, 1978. Queen Elizabeth Hotel, Montreal, Que., Canada. Contact: Jean Jacques Archambault, CP/PO 757 Succ. "C," Montreal, Que. H2L 4L6, Canada

* **Digital Satellite Communications** (Reg. 7) Oct. 23-25, 1978. Montreal, Que., Canada. Contact: Marcel Perras, Teleglobe Canada, 680 Sherbrooke St. W., Montreal, Que. H3A 2S4, Canada (514) 281-7976

* **Frontiers in Education** (G-Ed; ASEE) Oct. 23-25, 1978. Dutch Inn, Lake Buena Vista, Fla. Contact: E. R. Chenette, Dept. of EE, University of Florida, Gainesville, Fla. 32611 (202) 632-5881

* **Biennial Display Research Conference** (S-ED; Society for Information Display) Oct. 24-26, 1978. Cherry Hill Inn, Cherry Hill, N.J. Contact: Thomas Henion, Palisades Inst., 9th Flr., 201 Varick St., New York, N.Y. 10014

* **Computer Arithmetic** (CompSoc) Oct. 25-27, 1978. Miramar Hotel, Santa Monica, Calif. Contact: Prof. M. D. Ercegovac, 3732 BH, Computer Science Dept., University of California, Los Angeles, Calif. 90024 (213) 825-2660

* **International Conference on Telephone Energy—INTELEC** (ComSoc) Oct. 25-27, 1978. Sheraton Park, Washington, D.C. Contact: J. J. Suozzi, Bell Labs, Rm. 5D-178, Whippany, N.J. 07981 (201) 386-2381

* **Semiconductor Laser Conference** (QEC) Oct. 30-Nov. 1, 1978. Sheraton-Fisherman's Warf, San Francisco, Calif. Contact: T. L. Paoli, Bell Labs, 600 Mountain Ave., Murray Hill, N.J. 07974 (201) 582-2903

Other meetings of interest

Symposium on the Transfer and Utilization of Particular Control Technology (U.S. Environment Protection Agency) July 24-28, 1978. Stouffer's Denver Inn, Denver, Colo. Contact: F. P. Venditti, Denver Research Institute, University of Denver, P.O. Box 10127, Denver, Colo. 80208 (303) 753-2241

* **Radiation Safety in NDT** (ASNT, BRH) Aug. 1-3, 1978. Fairmont Hotel, San Francisco, Calif. Contact: D. J. Walter, The American Society for Nondestructive Testing, Inc., 3200 Riverside Dr., Columbus, Ohio 43221 (614) 488-7921

* **Symposium on Time and Frequency** (URSI) Aug. 1-4, 1978. Helsinki, Finland. Contact: Dr. H. Hellwig, Tire and Frequency Div., National Bureau of Standards, Boulder, Colo. 80302 (303) 499-1000, ext. 3277

* **2nd World Hydrogen Energy Conference** (International Assoc. for Hydrogen Energy) Aug. 21-24, 1978. Zurich, Switzerland.

* **10th Conference on Solid-State Devices** (Japan Society of Applied Physics) Aug. 29-30, 1978. Tokyo, Japan. Contact: T. Sugano, EE Dept., University of Tokyo 7-3-1, Homgo, Bunkyo, Tokyo, 112 Japan

* **International Conference on Large High-Voltage Electric Systems** (CIGRE) Aug. 30-Sept. 7, 1978. UNESCO Conference Building, Paris, France. Contact: L. J. Mulligan, U.S. National Committee—CIGRE, c/o EBASCO Services, Inc., 125 Jericho Turnpike, Jericho, N.Y. 11753

* **International Conference on Information Theory and System Theory in Digital Communications** (IEEE German Sect.) Sept. 18-20, 1978. Berlin, Germany. Contact: Dr. Ing. F. Coers, Stresemannallee 21, VDE-Haus, D-6000 Frankfurt/Main 70, F.R. Germany

* **Microprocessors in Automation and Communication** (U.K. & Rep. of Ireland Sect.; IERI, IEE) Sept. 19-22, 1978. University of Kent, Canterbury, England. Contact: M. S. Birkin, British Railways Tech. Centre, Derby, England

* **Automatic Test Equipment Conference and Exhibition—ATEX** (Automatic Test Equipment Assoc.) Sept. 26-28, 1978. Hynes Auditorium, Boston, Mass. Contact: William Hickey, Golden Gate Enterprises, 1307 South Mary Ave., Suite 210, Sunnyvale, Calif. 94086

* **Fifth International Electric Vehicle Symposium** (EVC, UNIPEDE) Oct. 2-5, 1978. Sheraton Hotel, Philadelphia, Pa. Contact: E. A. Campbell, Electric Vehicle Council, 90 Park Ave., New York, N.Y. 10016

* **16th Annual Allerton Conference on Communication, Control, and Computing.** Oct. 4-6, 1978. Allerton House, University of Illinois. Contact: Allerton Conference, c/o Prof. M. B. Pursley, Coordinated Science Lab., University of Illinois, Urbana, Ill. 61801.

* **National Electronics Conference and National Communications Forum** (NEC) Oct. 16-18, 1978. Hyatt Regency O'Hare, Chicago, Ill

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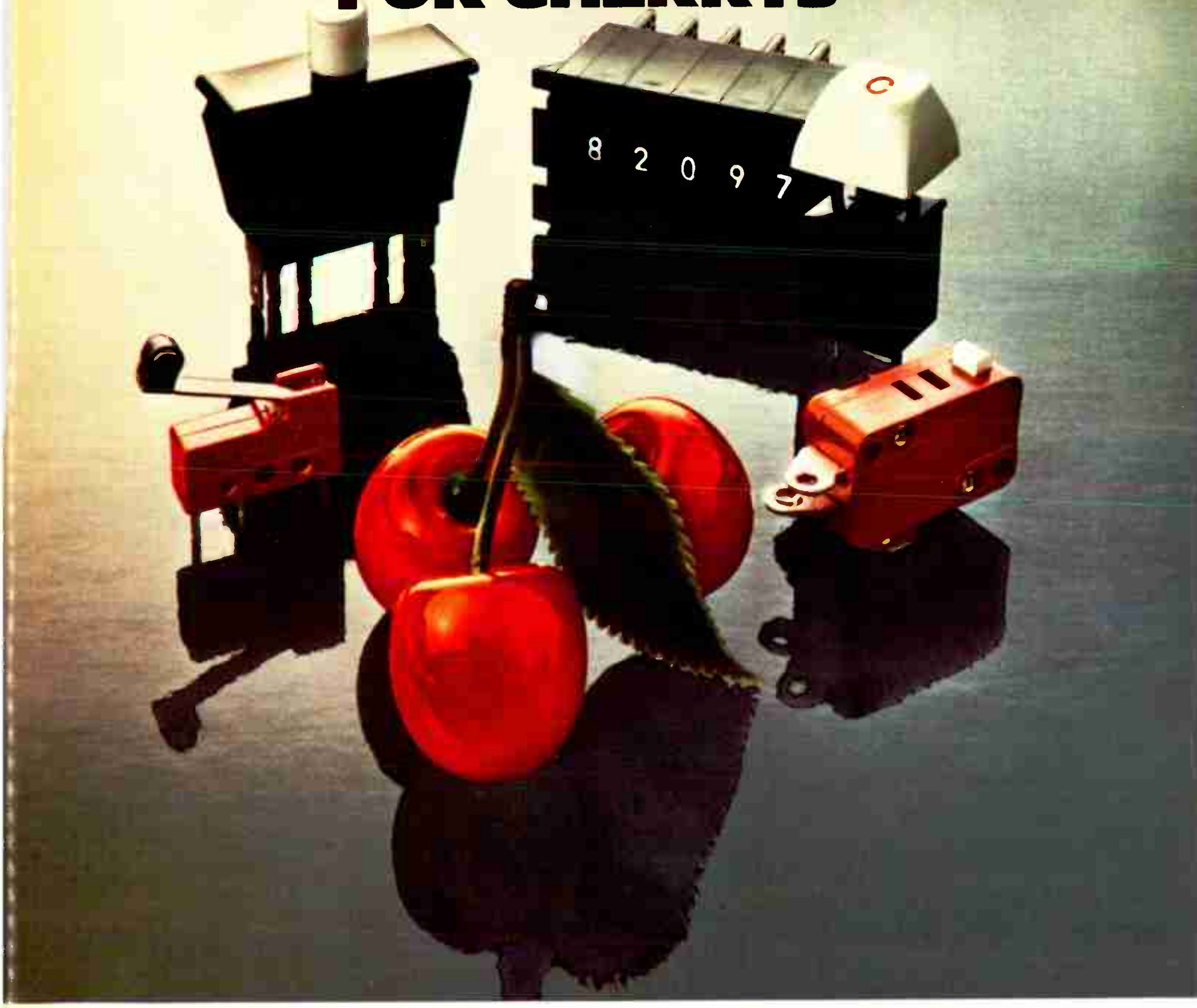

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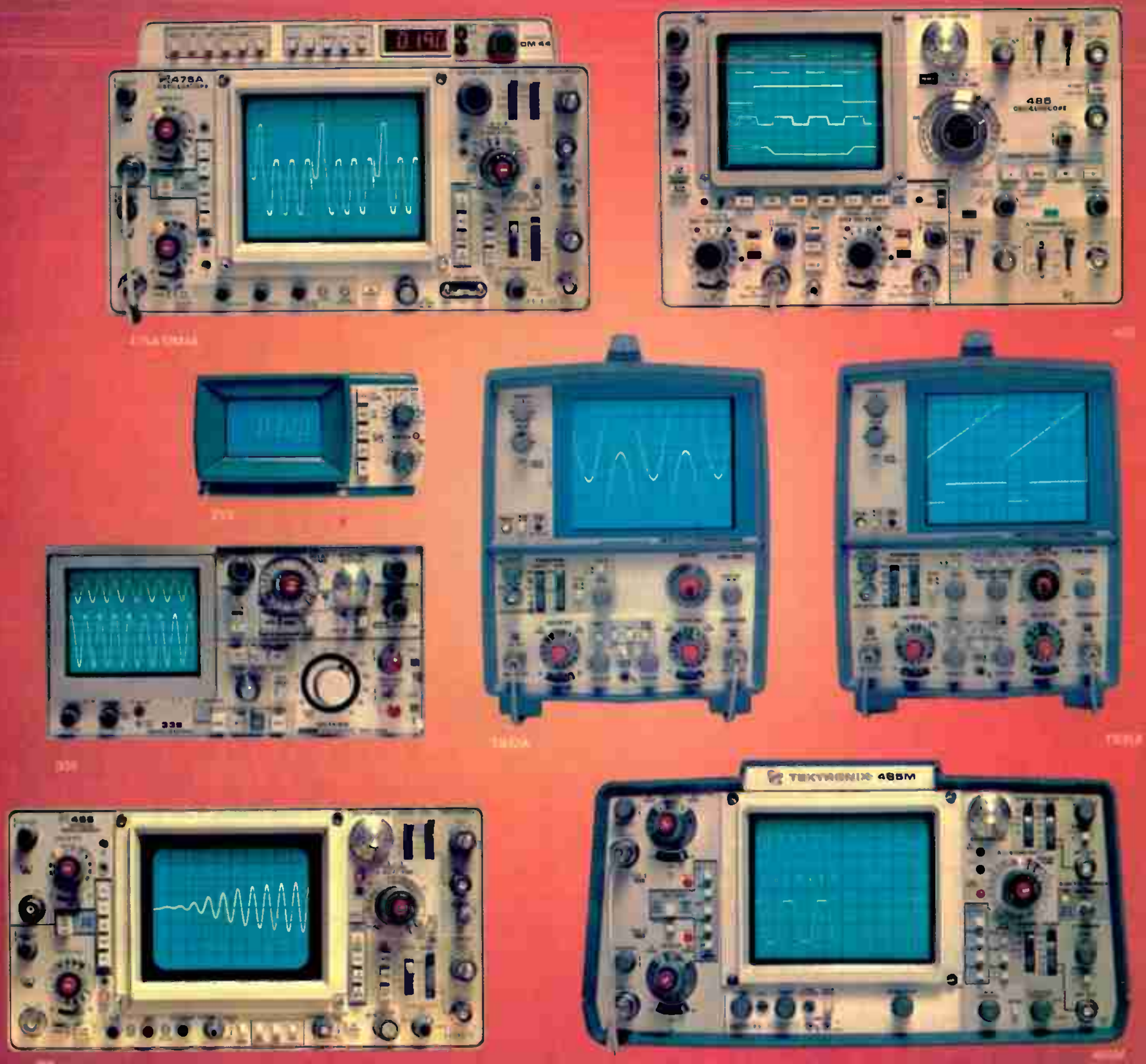

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	434	25 MHz @ 10 mV/div	yes		20 ns/div	Split screen storage	[illegible]
	314	10 MHz @ 1 mV/div	yes		100 ns/div	Only 10.5 lbs (4.8 kg)	[illegible]
	214	500 kHz @ 10 mV/div	yes		1 μs/div	Only 3.5 lbs (1.6 kg)	[illegible]
	T912	10 MHz @ 2 mV/div	yes		50 ns/div	Low cost bistable storage	[illegible]
Nonstorage Models	485	350 MHz @ 5 mV/div	yes	yes	1 ns/div	Widest BW in a portable	[illegible]
	475A	250 MHz @ 5 mV/div	yes	yes	1 ns/div	High performance 250 MHz portable	[illegible]
	475	200 MHz @ 2 mV/div	yes	yes	1 ns/div	Highest gain BW in a portable	[illegible]
	465	100 MHz @ 5 mV/div	yes	yes	5 ns/div	Cost effective for 100 MHz BW	[illegible]
	465M	100 MHz @ 5 mV/div	yes	yes	5 ns/div	Tradeoff standard 100 MHz scope	[illegible]
	455	50 MHz @ 5 mV/div	yes	yes	5 ns/div	Cost effective for 50 MHz BW	[illegible]
	335	35 MHz @ 10 mV/div	yes	yes	20 ns/div	Only 15.5 lbs (7 kg)	[illegible]
	326	10 MHz @ 10 mV/div	yes		100 ns/div	Internal battery	[illegible]
	323	4 MHz @ 10 mV/div			500 ns/div	Only 7 lbs (3.2 kg)	[illegible]
	221	5 MHz @ 5 mV/div			100 ns/div	Only 3.5 lbs (1.6 kg)	[illegible]
	213	1 MHz @ 20 mV/div			400 ns/div	DMM Oscilloscope @ 3.7 lbs (1.7 kg)	[illegible]
	212	500 kHz @ 10 mV/div	yes		1 μs/div	Low cost for dual trace & battery	[illegible]
	T935A (New)	35 MHz @ 2 mV/div	yes	yes	10 ns/div	Variable trigger holdoff and differential	[illegible]
	T932A (New)	35 MHz @ 2 mV/div	yes		10 ns/div	Delayed sweep and differential	[illegible]
	T922	15 MHz @ 2 mV/div	yes		20 ns/div	Low-cost dual-trace scope	[illegible]
	T922R	15 MHz @ 2 mV/div	yes		20 ns/div	Rackmount version of T922	[illegible]
	T921	15 MHz @ 2 mV/div			20 ns/div	Lowest cost TEKTRONIX Portable	[illegible]
Time Interval Readout	DM44	Optional, factory installed, direct numerical readout of time intervals and DMM functions for the 464, 465, 466, 475, and 475A					[illegible]

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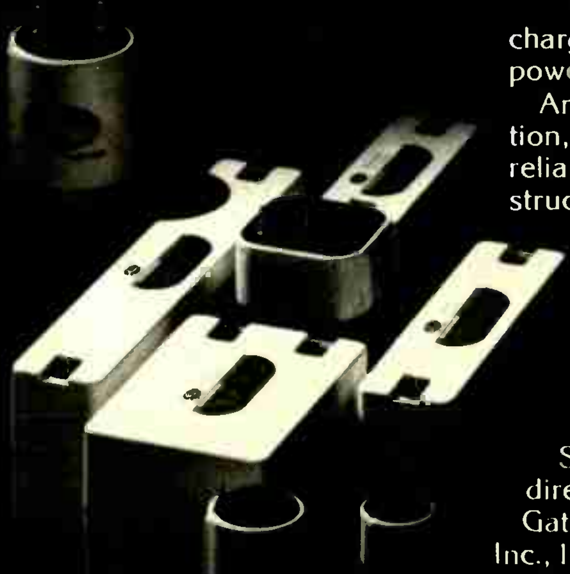

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DEBATE CONTINUES ON CURBING EXPORT OF TECHNOLOGICAL KNOW-HOW

The Carter Administration continues to wrestle with proposals to restrict the export of technological know-how that might be of strategic value to the Soviets. Initially recommended by the Defense Science Board in a 1976 report, the proposed curbs--which focus on processes rather than end products--have been the subject of a long and grueling interagency study that, as of this writing, is yet to arrive at any common agreement. While the Defense Department wants to curtain off certain critical technologies in which the U.S. holds a lead over the Soviets, the State Department and the Commerce Department are urging the adoption of a flexible policy that would permit the technologies to be used as a bargaining chip in general dealings with the U.S.S.R.

Meanwhile, Philip Handler, president of the National Academy of Sciences, which administers U.S. scientific exchanges with the Soviets, has recommended that Soviet requests for an expansion of the program be turned down, pending a Soviet response to the Academy's appeals for lenient treatment of dissident scientists. In his report to the annual meeting of the Academy membership, Dr. Handler noted that several such inquiries had gone unanswered, and said, "I consider that we would be ill-advised to respond affirmatively to proposals for an increase (in)...exchange activity."

CHINESE SEEK EXPANDED TIES WITH WESTERN RESEARCHERS

In a reversal of the Maoist policy of restricting contacts between Chinese and Western research organizations, the new Chinese leadership has issued a strong appeal for an expansion of East-West scientific exchanges. Speaking at the recent National Science Conference in Peking, Party Chairman Hua and Vice Chairman Teng candidly acknowledged China's scientific backwardness, and stressed the value of close contacts with the West as part of a long-range plan to bring Chinese research up to world standards by the year 2000. A timely example of the new philosophy was the May 5-29 visit, hosted by IEEE, of a delegation of 12 from the Chinese Electronics Society. Their itinerary included ELECTRO in Boston, as well as stops in San Francisco, Los Angeles, Washington, and New York.

NSF SURVEYS INDUSTRIAL HIRING

Industry is likely to increase the proportion of doctoral-degree holders on its R&D staffs because of "the growing complexity of industrial technology and the fairly ready availability of new Ph.D.'s," according to a recently issued study of the National Science Foundation. Projecting ahead "for the next five to ten years," the NSF analysis states that some firms may decline to enlarge their hirings of Ph.D.'s because of the availability of "lesser trained and cheaper staff," or "because of a belief that Ph.D.'s are not well suited by virtue of their training to work in a profit-oriented environment." However, the report goes on to speculate that "if there is a further decline in the salary differential earned by Ph.D.'s in relation to baccalaureate and master's graduates, probably some of those firms not now planning to accelerate Ph.D. hiring will do so." Copies of the study are available without charge. Request NSF 78-301 from the Division of Science Resources Studies, National Science Foundation, 1800 G Street, N.W., Washington, D.C. 20550.

Energy report

Last year set a record for nuclear power in the United States, with the nation's 65 nuclear plants producing approximately 250 billion kWh, or about 12 percent of all electricity generated. A recent report from the Edison Electric Institute (EEI) shows that nuclear plants achieved a capacity factor of 62.4 percent of designed maximum-output ratings, an improvement of 5 percent over 1976. Total output increased by 31 percent over 1976 while total electric generation from all sources rose 4 percent last year to just over 2.1 trillion net kWh. A nuclear kWh costs, on the average, a total of 1.5 cents, about the same as in 1976. In contrast, a coal kWh costs 2.0 cents, up from 1.8 cents in 1976, and an oil kWh costs 3.9 cents as compared with 3.5 cents in 1976. Thus, the electricity generated by nuclear power is demonstrably cheaper, and within five years such power should become the second largest source of electricity, provided the nuclear construction program is permitted to take its scheduled course. Coal remained the largest source of electricity in 1977, or about 47 percent, followed by oil and natural gas, 17 and 14 percent respectively; hydro accounted for about 10 percent.

Construction of the first electrical generating plant in the U.S. to be powered directly by solar energy is expected to begin this year and to be completed by 1981. A 10-MW central receiver pilot power plant near Barstow, Calif., will use a field of 1500 to 2000 sun-tracking heliostats to concentrate sunlight onto a receiver/boiler. The receiver will be mounted on a 100-meter (330-foot) tower located slightly south of the center of the field of the heliostats and the boiler will pump steam to a conventional turbine to generate enough electricity to meet the needs of a community of about 6000 people. The U.S. Department of Energy will provide the solar portion of the plant at a cost of more than $100 million and the state and utilities will provide the site and utility network and will be responsible for operating the plant at a cost of about $20 million. The project will offer the first opportunity for industry and utilities to gain experience integrating solar hardware into an existing power system.

A new type of power plant that, unlike other fossil-fuel plants, can produce electricity without combustion is under study by the General Electric Company for the Electric Power Research Institute. The plant will use second-generation fuel cells to convert the chemical energy present in coal or oil directly into electricity. Problems of fabrication and performance of cell electrolytes and corrosion of seals and other structural components have not been resolved as yet. However, once such problems are overcome, the second-generation fuel system is expected to yield a 75-percent efficiency advantage over conventional combustion turbines.

Power-factor control is the function of a small device invented by Frank J. Nolla, a space engineer at NASA's Marshall Space Flight Center. The device can continuously determine the load being carried by the motor to which it is attached by monitoring and detecting changes in the magnitudes of and the relationship between voltage and current flowing to the motor. By regulating the voltage level and current flow to the minimum required, the amount of wasted power in the form of heat loss is markedly reduced. The device can work on either single-phase or three-phase motors and can be applied to many existing household and industrial electric motors. The inventor points out that some 64 percent of all electricity generated in the U.S. goes to operate electric motors and estimates that 10-20 percent of this amount could be saved by applying his device.

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Forum

Readers are invited to comment in this department on material previously published in IEEE *Spectrum*; on the policies and operations of the IEEE; and on technical, economic, or social matters of interest to the electrical and electronics engineering profession. Short, concise letters are preferred. The Editor reserves the right to limit debate on controversial issues.

The right to reproduce

IEEE is a publishing house, at least in the sense that it prints and distributes the journals of its technical Groups and Societies. Our Group/Society and membership dues, together with the voluntary page charges that are requested of authors, guarantee that the publishing arm of the IEEE will not go broke. Thus, I strongly object to the copying fee that the Institute now collects under the new copyright law ("Spectral lines," Jan., p. 23).

Why should a fee be charged to individuals who choose further to disseminate information for which the not-for-profit publishing costs have already been met? Provided that a proper source citation accompanies each copy, the further circulation of a paper can only benefit both IEEE and the author by increasing the exposure the paper will receive. Why should the Institute have a continued financial interest in the publication?

The "cryptic" code (*sic*) referred to in "Spectral lines" should have read: 0018-9235/78/0100-0023$FREE. Why can't all of the IEEE codes read that way from now on?

David K. Bernhardt
Schenectady, N.Y.

Mr. Bernhardt's thoughtful letter provides a good opportunity to illuminate some little appreciated aspects of journal economics and photocopying. First, membership dues and author page charges by no means guarantee solvency. They cover less than 40 percent of publication costs. Most people don't realize that the preponderance of journal income, about 60 percent, comes from libraries. Library usage, therefore, is the single most important factor affecting journal viability and survivability, which is why library photocopying is such a sensitive and important matter.

Second, the new copying fee does not apply to individuals. They can continue to make single copies for personal use as before. The fee applies only to organizations—and then only in the particular case where an organization is engaged in what the new U.S. copyright law terms as "systematic" copying. Although "systematic" has not been fully defined as yet, it is expected that the impact of the copying fee for the most part will be limited to large industrial libraries. A prohibition against unauthorized, unlimited systematic copying was adopted by the Congress because of its potential serious impact on journal subscriptions, which is an area of vital concern.

It should be noted that IEEE's basic philosophy is to permit copying on request without fee. Of the 1000 reprint permission requests we receive annually, only 1 to 2 percent involve a fee. These are special situations related to commercial resale of IEEE published articles.

Now, with the new copyright law, a fee has been added for systematic copying. (The money IEEE expects to receive as a result of this fee will be returned to the sponsoring publication.) When the volume of photocopying from a single subscription reaches the level of thousands of copies per year, which it now does under systematic copying, it is not unreasonable that the beneficiaries should help pay for the cost of providing the technical information they are systematically utilizing in such great abundance. Indeed, the heads of two major affected libraries have said that IEEE's fees and copyright policies are not only reasonable, but exemplary.

E. K. Gannett
Staff Director
IEEE Publishing Services

Chinese technology

Herbert Sherman's report on "Electrotechnology in China" (Feb., pp. 60-66), which came out of a three-week visit to that country by a group of IEEE members, reflects the successful efforts by both the delegation and its hosts to improve mutual understanding and communications between U.S. engineers and those of the People's Republic.

It should be noted that most of the technologies Dr. Sherman discusses—ICs, telecommunications, computers, data communications, radio, television—have significant defense applications; defense plays an important role in the development of these technologies in all countries, but particularly in a socialistic country such as China. Moreover, it is common knowledge that China's defense industries, which were managed by independent Government ministries, were little—if at all—affected by the Great Cultural Revolution or the influence of the "Gang of Four." Thus, it seems reasonable to conclude that the technical competence and level of modernization in these areas are much more advanced in China's defense-related industries than in their civilian counterparts. Here, the danger exists that an evaluation of electrotechnology in China based on tours of the facilities that are open to visitors can lead to underestimation of the country's true capabilities.

Dr. Sherman also states that "the words for motor and generator are the same in Chinese and so the name Shanghai Motor Factory means that the plant makes both..." Apparently, this is a misunderstanding, because the language does provide separate terms: *Fa Tien Chi* for generator, or machine sends out electricity; and *Tien Tung Chi* for motor, or machine moved by electricity. From the author's description, it appears that the factory visited by the delegation must be the Shanghai Electrical Machinery Factory, since it is the only one in China (known to the outside world, at least) that produces 300-MW double water-cooled generators. And in Chinese, electric machinery (*Tien Chi*) is defined to include generator, motor, and transformer. However, that factory does not make steam turbines. These are manufactured nearby in the Shanghai Steam Turbine Factory, which also has been visited by Western groups.

Lawrence Lam
Chinese-American Institute of Engineers
San Francisco, Calif.

Negative feedback

I feel obliged by the nature of H. S. Black's article on "Inventing the feedback amplifier" (Dec. 1977, pp. 54-60) to dig back again into the history of this important development. It is granted that Dr. Black made a very clear statement of the principle in 1927, but the nostalgic remembrances of its discovery—"in a flash"—engender a bit of skepticism.

The possibility of prior conception by others was broached in an article (or letter) by Rote Greber in the *Proceedings of the IRE* in July 1959. At the time, I wrote to the *Proceedings* and to Dr. Greber, nominating Stuart Ballantine as the first to suggest negative feedback in his Patent No. 1 723 719, filed January 9, 1923. In it, Ballantine stated in regard to "an audio frequency bias voltage in phase with or *exact opposite* to...a correcting bias of substantially the same wave form as the audio frequency wave...may be applied to an audion or other amplifying circuits for the purpose of reducing or eliminating distortion..."

This patent became a reference for the development of the Ballantine Laboratories Model 300 Electronic Voltmeter, which was the first commercial instrument to capitalize on the principle of negative feedback to stabilize its performance. It was an enormous success. It is remarkable that the Western Electric Company never approached Ballantine in the matter of licensing under any of its patents, specifically the Black patent, No. 2 102 671.

Edmund Osterland
W & G Instruments, Inc.
Livingston, N.J.

Harold Black's article is a very interesting contribution to the history of electronics. However,...it seems worth mentioning that the invention of the negative feedback amplifier is a nice example of an idea originated independently and almost simultaneously by two different people working in different parts of the world: Harold S. Black with Bell Laboratories in New York and K. Posthumus with Philips Research Laboratories in Eindhoven, the Netherlands (see the survey article by B. D. H. Tellegen in *Philips Technical Review*, vol. 2, p. 289, 1937). Patents have been granted to Posthumus in several countries for his invention of what was then termed the "inverse feedback" amplifier (British Patent 323 823, for example, and Dutch Patents 28 871 and 33 318).

G. Diemer
Philips Research Laboratories
Eindhoven, the Netherlands

Clarke comments

I have just seen the *Spectrum* correspondence referring to my work (1977 Forum: Apr., p. 12; July, p. 11; Sept., p. 26).

I did not invent the concept of the geostationary orbit—it dates back to the astronautical literature of the 1920s. And, of course, any astronomer after the time of Newton could have pointed out its possibility; I am sure that someone did, especially after the discovery of Deimos in 1877.

When I worked out the comsat idea, in early 1945 (the first reference is in a letter to *Wireless World* in February, which I had long since forgotten until someone discovered it), I am fairly sure that I was not thinking of George Smith's *Venus Equilateral* stories. But as John Pierce pointed out (see my introductions to his *The Beginning of Satellite Communications* and to the new edition of *Venus Equilateral*), it's very probable that I was unconsciously influenced by them.

Mr. Goeller is a bit hard on Samuel Lutz, whose remark that most engineers associate me with science fiction rather than comsats is probably correct, and not at all insulting! Anyhow, I am happy either way...

Recent debates over the ownership of the geostationary orbit prompt me to pass on a joke make at the Prague IAF Congress last year. There's already a UN Committee on the Peaceful Uses of Outer Space. Some wag suggested that we now need one on the Useful Pieces...

Arthur C. Clarke
Colombo, Sri Lanka

On registration

As an IEEE member and a registered professional engineer, I've been following IEEE's...activities in the proposed mandatory professional engineer political arena. The "Spectral lines" discussion, "Registration: a second look' (Mar., p. 29), notes that the Damon committee wants to hear the views of individual members, and so I would like to present mine.

I am proud to be a registered engineer in the states of Pennsylvania and Illinois. I was the 616th person to be licensed by examination in Pennsylvania; one out of three successfully passed the exams at that time. It wasn't easy and I view myself as a member of a select group. I did it on my own—no one required me to do it.

That, however, does not indicate that I have any special capabilities above and beyond those of my peers. I still seek aid and guidance after some 32 years in the business from the several hundred engineers with whom I work; some are registered but probably most are not.

I look to IEEE, as a professional society, for technical professionalism, not as a regulator of the engineering profession and industry.

Second, the requirement for industry to have only registered engineers in responsible positions will make great demands on the licensing agencies and the examinations will become relatively easy to pass. Registration will not enhance an engineer's competence. It does not now, and the concept should not be further weakened.

Furthermore, all engineers in the home appliance industry are in responsible positions. If their supervisors are registered, nothing changes. Where is the evidence that the products of industry need whatever more registered engineers can contribute? (What is expected to happen to home appliances, for example, when all these responsible engineering positions in industry are filled with registered engineers?)

All home appliance manufacturers encourage their engineers to become registered by appropriate training and state. examination. Most of them encourage registration by providing free time for study and financial assistance in addition to their salaries for this study and registration. None, however, want registration to be mandatory.

Business already is overregulated and compulsory engineering registration not only will add nothing of value, but will provide an impediment to holding down costs and inflation.

Herbert Phillips
Association of Home Appliance Manufacturers
Chicago, Ill.

'Rejected' or 'submitted' paper

I read with interest the comments of David Carta (Jan., p. 13) concerning publication of information about rejected papers. As editor of the *IEEE Transactions on Automatic Control*, I have been involved in discussions of this sort...

Mr. Carta's basic idea is that some ...archival record should be made of all papers rejected by a journal, giving enough information so that an interested reader may obtain copies of such papers. Assuming that the journal could afford to devote space to this venture, I believe the idea has little merit because: Who wants to be included in a list of unsuccessful authors? Who has ever seen a bad abstract? How can one determine the relationship between an abstract and the full paper? Does it make sense to have a paper that appears in one journal be included on the rejected list in others? If a paper is rejected because it is technically incorrect, why advertise incorrect results? Why list good papers that are rejected because their subject is inappropriate for a particular journal readership but that eventually will appear elsewhere?

I do not deny that some useful function may be served by timely reporting of topics, authors, and locations of R&D work in a field. One way to do this would be to list titles and authors (and their addresses) of papers submitted to a journal. The main purposes would be to: provide timely information about who is working on what, and where; provide some recognition for the effort required even to submit a paper; speed up a possibly inefficient reviewing process by publicly providing data that could be used to compute how long it takes to get through the process; attract attention to areas of work that never seem to get published in the journal; help identify other works in a given field of interest, whether or not the papers are eventually published; open up editorial processes to public scrutiny; and uncover unknown expertise to help in the reviewing process.

...To be sure, there do exist a variety of editorial review procedures; most are represented in one or another journal published by IEEE. So far, no group experienced in the editorial process has found that the virtues of any such scheme outweigh its disadvantages.

Stephen Kahne
Case Western Reserve University
Cleveland, Ohio

IEES?

"Tradesmen" at the Bonneville Power Administration paid more than engineers ("Engineer at large," Mar., p. 21)? Yes, because they are worth more to the economy. Engineers will be paid more when they are worth more. That will not happen until ECPD revises its mix of curriculum judges to include a majority of practitioners from industry.

As for the bachelor-of-engineering technology degree (*The Institute*, Mar., pp. 4-5)—what's in a name? The B.E.T. degree came about because too many electrical engineering graduates are only scientists and don't know, at graduation, which end of a soldering iron is the hot end. The world needs practical theorists.

The real error seems to be in our retaining the name "engineer" when, in truth, we are scientists primarily. Even our degrees read: a bachelor of science in ... Besides, we at IEEE often treat like dirt those who practice, sell, market, or manage.

Look at "Spectral lines" for March (p. 29) and the quote [from William Hayes]: "This country's economy rests on a strong technical base. The presence of thousands of competent engineers working not just in design, but in sales, marketing, and management, is what makes that base so strong... To exclude them from the engineering profession for not meeting criteria needed by only a few would be very wrong..."

Should we rename ourselves the IEES, for scientists?

Robert B. Angus, Bedford, Mass.

Wiley Highlights for June 1978...

THE SEMICONDUCTOR MEMORY BOOK
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approx. 496 pp. (1-24235-7) **1978** $25.00

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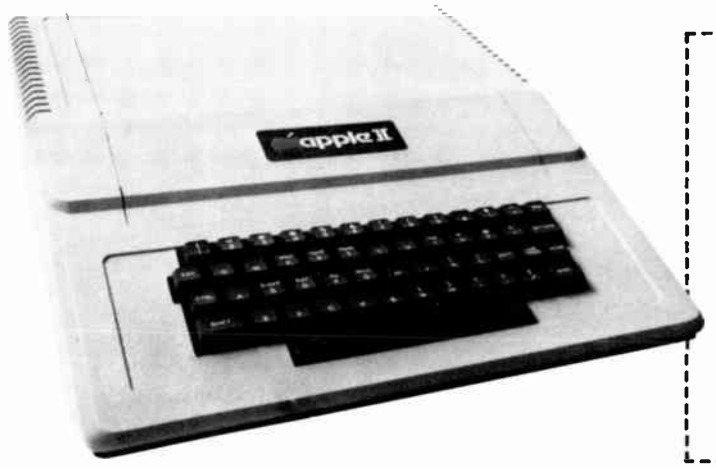

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IEEE 6/78

Circle No. 38

Venerable standard due for update

One of the Institute's most venerable standards—high-voltage testing techniques—is about to be updated in a version due out this month. Tracing its genesis back to the beginning of this century, the current version establishes standard methods of high-voltage measurement and of basic testing techniques so far as they are generally applicable to all present types of apparatus for alternating and direct voltages, lightning and switching impulse voltages, and impulse currents.

As far back as 1899, the subject had been addressed in the earliest standardization report of the American Institute of Electrical Engineers, and two decades later, when the AIEE's standards were reorganized into separate sections, measurement of test voltages became one of the first subjects to be designated for separate publication. The first edition appeared in 1928, and like earlier efforts in this area, bore the imprint of Charles P. Steinmetz, among other early giants in the industry.

IEEE Std 4-1978 is about twice the size of the last revision (about 60 pages in length) published in the late 1960s. Part of the increased space is used to present a textbook-like guide to readers for evaluation of various methods. In addition, the revision contains several features not found in the earlier work.

For example, the standard now contains contamination testing procedures for suspension and support insulators, lightning arresters, and bushings. As the industry has moved to 500-kV and higher-voltage systems, these procedures have played an increasingly important role. In another example, rain-test information may be obtained for rainfall rates that are considerably less than the long-accepted 0.2 inch per minute (5 mm/min.)—which corresponds to so heavy a rainfall that some observers have dubbed it 1 Noah.

The present document is based on standards accepted by the International Electrotechnical Commission. Exemplifying revisions made to ensure conformity with international practice, the standard reference temperature has been changed from 25°C to 20°C. As a result, sphere-gap values (in measurements that apply a voltage to two spheres and determine the distance between them as a spark bridges the two) are now the same as those used by the IEC.

The hardbound document costs $13 to nonmembers and 10 percent less to members. For more information, write to the IEEE Service Center, 445 Hoes Lane, Piscataway, N. J. 08854.

Slide talk features reprographics

An 80-slide presentation covers 12 common drafting shortcuts, such as making revisions, adding repetitive elements, and restoring dog-eared and hard-to-copy drawings—all through the use of photographic methods. The slide-talk show, entitled "Versatility in Reprographics," is given by Eastman Kodak technical sales representatives before reprographics personnel and managers, as well as clubs and association groups.

Cost studies by Kodak shows that redrawing an original costs about $75 a square foot on the average, whereas photographic methods can effect savings in drafting time of from 50 percent to almost 100 percent. The reprographics methods are not intended to replace the skilled draftsman, but rather to allow the master draftsman to utilize photographic methods to perform work faster with greater accuracy at less cost.

Requests for a presentation should be sent to Henry Morgan, Jr., Marketing Coordinator, Graphics Markets Division, Eastman Kodak Company, 343 State St., Rochester, N.Y. 14650.

Magazine reports NBS advances

Designed to inform audiences ranging from scientists to consumers of the latest advances in science and technology at the National Bureau of Standards is *Dimension/NBS*, a monthly magazine published by the U.S. Department of Commerce's physical science and measurement laboratory.

A feature article in the April issue, for example, discusses a lightweight, multilens "fly's eye" telescope, developed by James Faller to detect laser light from the moon. The NBS scientist was a member of a team of scientists that first used laser beams in 1969 to measure the distance from the earth to the moon via retroreflectors placed on the moon by Apollo 11 astronauts.

The fly's-eye telescope, mounted in Hawaii, works in conjunction with a lunar ranging station in Texas. By having two observation posts, scientists hope to be able, among other objectives, to obtain the first "real time" measurements of continental drifts and to determine the position of the North Pole to within a few centimeters.

Other articles in the issue discuss microwave measurement techniques for safety and other applications, how to watch a nuclear reaction up close, and a device for field-testing smoke detectors.

The magazine is available by subscription for $12.50 annually (add $3.15 for mailing outside the U.S.). Orders should be placed with the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

EEs' Tools & Toys

Have wireless, will travel

Fanciers of classic radio equipment planning a trip through Colorado may want to contact the Rocky Mountain Antique Wireless Association. This association boasts a number of interesting antiques, such as a model of the first aircraft radio (a pre-World War I transmitter-receiver) and the first Atwater Kent commercial-broadcast receiver, notable for its pioneering ability to operate from an alternating-current supply. Other vintage units include DeForest audion triodes and spark transmitters. The association reports that all models displayed are operational.

To find out when and where the association plans next to show its wares, or to invite the association to exhibit locally, write to this year's president, Douglas Furney, 11775 W. 14th Ave., Denver, Colo. 80215.

Ultrasonic ranging featured in camera

Photography ranks at the top of most lists of engineers' favorite crafts and hobbies—and so Polaroid's latest camera, the SX-70, should attract a sizable following. Its most distinctive feature is the incorporation of an ultrasonic ranging device that automatically focuses the camera's lens.

Although the new camera is basically the same as the conventional SX-70, its electronic circuitry has been modified to accommodate the ranging device. The camera determines focus distance by measuring the time it takes for sound to travel from the camera to an object and back again. As an automatic system, one that can be converted by switch to a manual system, it is faster and more accurate than the conventional manual focus on present SX-70 units. It focuses in fractions of a second in any light level.

Polaroid plans to have the camera in the consumer marketplace by the end of the year, presumably in time to make the 1978 holiday gift lists. The company anticipates that the camera will sell for less than $400.

Scanning the Institute

New standards catalog available for the asking

The 1978 edition of the *IEEE Standards Catalog* is now in print; copies are available free of charge. The new 32-page catalog lists each of the more than 300 electrical and electronics standards publications under one or more of the 167 subject headings, in addition to a separate numerical listing. The many American National Standards published by IEEE are included.

Standards developed within IEEE cover test methods, practices for electrical installations, units, definitions, graphic symbols, and applications methods. Among the new and newly revised publications listed are the 1977 edition of the National Electrical Safety Code, the *IEEE Standard Dictionary of Electrical and Electronics Terms*, IEEE Std 500-1977, the IEEE Nuclear Reliability Data Manual, and the just-published National Electrical Safety Code Interpretations, 1961–1977.

Single copies of the 1978 *IEEE Standards Catalog* may be obtained upon request to the IEEE Standards Office, 345 East 47 Street, New York, N.Y. 10017.

EE educators favor professionalism programs

Engineering deans and the heads of electrical engineering departments appear to favor the introduction of professional concepts to their students. At least this was the consensus of results of a recent survey by IEEE of U.S. and Canadian colleges and universities. However, as pointed out in analysis of the survey appearing in this month's *The Institute*, few engineering schools currently have programs in this area.

Topics of most interest to those responding were ethics, responsibility to society, identification with the engineering profession, and the "engineering environment" (including political, social, economic, and educational influences). Generally, seminars were chosen as the preferred method of introducing students to these matters. Of those replying, 37 reported that they already have such material.

The survey—which was prepared by the Career Development Committee under the sponsorship of the U.S. Activities Board and the Educational Activities Board—was sent to 271 institutions and 171 of them replied.

Reflector antennas is IEEE Press Topic

The publication of *Reflector Antennas*, a Book of Selected Reprints edited by A. W. Love of Rockwell International, has been announced by the IEEE Press.

The use of reflectors is as old as the radio art itself. In 1888, Hertz used such an antenna to demonstrate the existence of electromagnetic waves. Since then, the technology has made spectacular progress, particularly during the past four decades as radar, microwaves, and radio astronomy have risen to prominence.

This book brings together the 65 most important and most referenced papers published in a variety of journals over a number of years. They are grouped under the following topics: focal region fields; radiation pattern analysis of reflectors; Cassegrain and dual-reflector systems; polarization effects; offset or unsymmetrical reflectors; lateral feed displacement, scanning, and multiple-beam formation; phase errors and tolerance theory; spherical reflectors. The volume should be a valuable companion to the 1978 IEEE Press Book, *Electromagnetic Horn Antennas*, also edited by A. W. Love.

The 440-page book, sponsored by the IEEE Antennas and Propagation Society, is $14.95 for the paperbound member edition. A clothbound edition is $22.45 for IEEE members; $29.95 for nonmembers. It can be ordered postpaid from the IEEE Service Center, 445 Hoes Lane, Piscataway, N.J. 08854. Payment should accompany the order.

Nominations due for '78 Eckman Award

June 15 is the deadline for nominations for the 1978 Donald P. Eckman Award, which goes to outstanding young contributors to the field of automatic control.

The nominees must be less than 30 years old as of July 1, 1978. Their contributions may be in the form of technical or scientific publications, theses, patents, inventions, or combinations of these, accomplished while the nominee was resident in the United States.

Nominations should include complete resumes, reference letters, and supporting documentation (with a full endorsement by at least one responsible supervisor), and must be in English. Send them to William R. Perkins, Chairman, AACC Awards Committee, Coordinated Science Laboratory, University of Illinois, Urbana, Ill. 61801.

The award, consisting of a certificate and cash, will be presented during the 1978 Joint Automatic Control Conference, to be held in Philadelphia, Pa., next October.

Coming in Spectrum

Flat-panel displays. Efforts to make a flat-panel display to compete directly with the cathode-ray tube have fallen short of expectations because of six major problems: matrix addressing, duty cycle, luminous efficiency, uniformity, gray scale, and cost. An examination of these problems and their potential solutions highlight this article.

Speech recognition. The rapidly expanding technology in speech recognition is dedicated to permitting computers or special-purpose machines to identify accurately words, phrases, or sentences spoken by any of a set of talkers over communication links. This article introduces many of the basic concepts involved in computer recognition of speech, discusses in detail some currently popular methods, and summarizes the past, present, and future technology developments in the field.

Power-system control in the year 2000. Major developments and changes in the nature of electric power systems will occur in the future as new types of central station generation, storage, transmission, and distribution facilities are installed. More customer-generation and energy-storage devices are in the offing and more sophisticated control systems will utilize a variety of sensors and computers interconnected via extensive data networks.

Single-sideband transmission. Existing mobile radio bands could be used more effectively to accommodate more traffic in the same bandwidth, according to the authors of this article. From seven to ten times as many channels could be made available in the existing very-high- and ultrahigh-frequency bands, experimental data indicate. The developmental technique combines single-sideband amplitude modulation with analog speech compression to reduce bandwidth. The article presents an analysis of experimental data and results to date.

Energy conservation. Increased fuel costs, shortage of energy resources, and the availability of low-cost computers have all combined to make industrial computer-based energy-management systems an attractive alternative to less flexible schemes. This article outlines the algorithms, instrumentation, and human interaction necessary to create such a computerized system. The cost-effectiveness of this approach is outlined for a pulp- and paper-producing plant, and the results are analyzed for other applications.

Support, theirs.

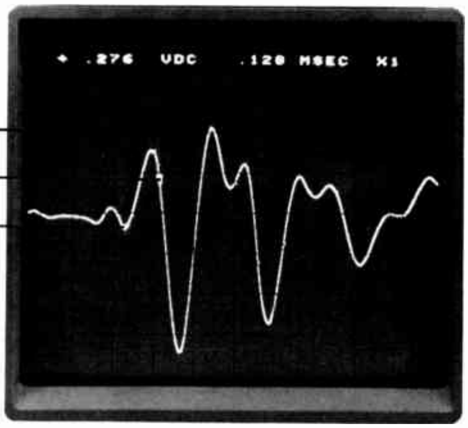
Most CRT controllers require a great many support devices.

We've just introduced the least supported CRT controller ever—the National DP8350. Instead of the bagfull of support devices necessary with current MOS controllers, ours lets you off the hook with just one.

The reason is bipolar technology. It allows high frequency performance with high drive current outputs. So we can shift the functions of extraneous support chips onto the controller chip itself. Functions like dot counter/decode logic, crystal oscillator and high current Tri-State™ memory address bus drivers. The only support required is one crystal.

Since there are fewer components, you get benefits like lower systems cost. Less complexity. Greater reliability. And we made

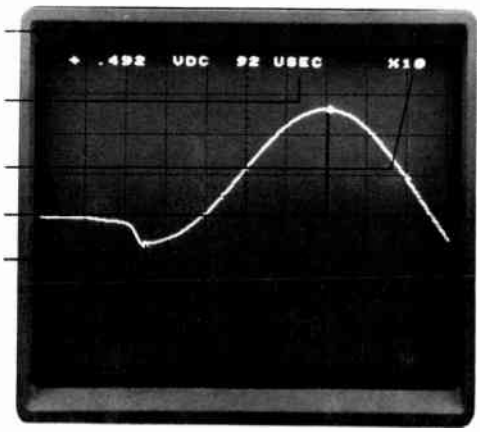
Three ways digital storage makes our 820 a super scope.



1 Capture one-time analog events.

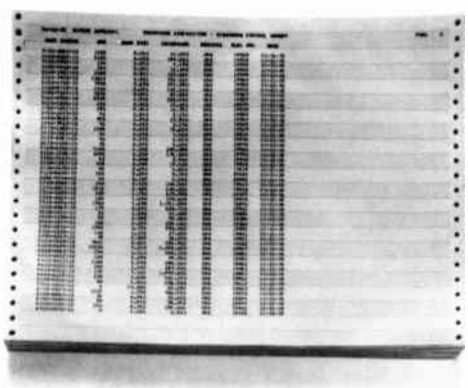
There's no better way to record one-time events than our 820 Digital Storage Oscilloscope. It captures analog signals, converts them to digital data, then stores that data in semiconductor memory.

Digital storage techniques enable us to give you "pre-trigger" recording, a Biomation exclusive. You can actually begin recording a random signal before you know it's going to occur, and apportion the 820's memory to record data both before and after the trigger. And set the trigger level to prevent false triggers.



2 Expand the display for detail analysis.

When you need to analyze the event in detail, you can expand the display 2, 5, 10, 20 or 50x. Movable cursors let you pinpoint the portion of the waveform you want to study. And on-screen digital readout of time and voltage is automatic.



3 Perform computer data analysis.

Digital storage gives you maximum analysis flexibility. You can transfer the data, already digitized, to mag tape, disc or other permanent storage. Or you can read the data out directly to a programmable calculator or computer system.

The 820 is the latest product in our six-year history of using digital storage techniques to help you capture and analyze analog signals. Other Biomation products enable you to convert your scope to a "super scope" by adding digital storage. For more information, or to arrange a demonstration in your lab, call Don Dedinas, (408) 988-6800. Or write us: 4600 Old Ironsides Drive, Santa Clara, CA 95050.

GOULD biomation

Circle No. 201

spectral lines

So you're an engineer. But what do you do?

Isn't it fascinating how over the years certain titles have proven to be so prestigious that they are often appropriated without the approval of officialdom, and, at times, downright misappropriated?

The other day I took my car to the Transmission Doctor. I really don't believe he's a doctor—M.D. or otherwise—but he fixed my transmission. My daughter recently consulted the local Plant Doctor to get a prognosis on her ailing African violet. He gave it a couple of tablets and it perked right up. Yet, when pressed, the "doctor" admitted he doesn't even have an associate degree in plant pathology, or, for that matter, in anything else. On the other hand, not many physicians of my acquaintance seem genuinely disturbed by the proliferation of those "doctors" of transmissions and greenery who flaunt their fictitious titles.

Why is it then that the mere mention of a "domestic engineer" (housespouse) or "sanitary engineer" prompts some in our profession to assume an apoplectic complexion? Could it be they perceive enough similiarity between those jobs and their own that they fear the layman might not make the distinction? Most engineers, like most medical doctors, would chuckle at such imitators as harmless flatterers. On the other hand, the systematic misuse of the title "engineer" could result in serious problems. We shall touch upon these later.

There are those who express doubt about the possibility and desirability of legally reserving the title "engineer," even though about half of the licensing jurisdictions in the U.S. now attempt to prohibit its use by unregistered persons. There is little doubt that abuses abound in the use of "engineer," including use with various adjectives that may merely provide a means to circumvent existing state laws.

It has been noted that 15 definitions of the noun "engineer," under five separate categories, are listed in *Webster's Third New International Dictionary* (unabridged), but that only one of the 15 relates to the definition that certain state laws seek to protect. This leads to a logical question: "Can one legally and practically protect a word in such common and historic use?"

If the title "engineer" is not to be, in fact, reserved by law, then it appears to be incumbent upon IEEE and other professional engineering societies to help distinguish between engineers who are licensed and those who are not. Indeed, some who have studied the problem endorse the legal protection of the title "professional engineer," and deem such endorsement appropriate to the protection of the public. Furthermore, a 1977 report by the National Council of Engineering Examiners indicates that all 55 licensing jurisdictions that responded to a survey do prohibit the use of the title "professional engineer" by an unregistered person.

Beyond clearly identifying those engineers who hold a license, there is good reason to identify subsets of the engineering profession. If this is not done, pollsters may generate statistics on vital matters, such as salaries and employment, that are misleading or useless in the aggregate. IEEE's own surveys underscore significant variations in salary distributions between areas of specialization in electrical engineering.

Even the U.S. Government has contributed to the confusion in titles by issuing obsolete, casually organized, or otherwise inappropriate definitions of engineering jobs. Recently, IEEE provided input useful in producing two Government documents involving engineering job titles: the *Dictionary of Occupational Titles*, fourth edition, published by the U.S. Department of Labor, and the *Standard Occupational Classification Manual* of the U.S. Office of Management and Budget. (The documents, although an improvement over previous versions, still contain inconsistencies across disciplines; i.e., mechanical, electrical, chemical, etc.)

We've emphasized here the functional aspects of engineering titles, but the psychological aspects cannot be overlooked. Most engineers hope the designation "engineer" will not become tarnished through widespread misappropriation. If it is, practitioners of the future may feel compelled to invent new terms. Thus our profession may develop its own equivalent to the medical profession's internist, surgeon, and pathologist. Such new titles may be more descriptive, less ambiguous, and even more glamorous. Until then, we cannot respond to the perennial cocktail party question, "What do you do?" with a simple answer. "I'm an engineer" will not do. We'll still have to say, "I'm a computer designer for IBM," or "I develop equipment to test satellite communications systems for NASA."

A call to 'friends of Edison'

On October 21, 1979, the centennial of the electric light will be celebrated. Already a variety of projects are under way to commemorate the event. For example, a project to organize and preserve the papers of Thomas A. Edison will be undertaken under the joint sponsorship of the Smithsonian Institution, the New Jersey Historical Foundation, and the National Park Service. We at *Spectrum* are interested in hearing from engineers who have personal recollections of Edison. Did you meet him, work with him, or attend one of his lectures? If so, we'd like to hear the details.

Donald Christiansen

Consumer

AM stereo: five competing options

A classic tradeoff among desirable objectives is taking shape as the FCC attempts to select the "best" AM stereo system

The name of the game in consumer audio is stereo. Phonograph record manufacturers dropped monaural products from their catalogs years ago, and music lovers of all persuasions now find the FM band predominantly filled with stereo broadcasts. However, AM radio listeners are still stuck with obsolete monaural sound—not because of lagging technology, but because AM broadcasters showed little initial interest in stereo. The Federal Communications Commission (FCC) tabled AM stereo proposals in the early 1960s to encourage the growth of FM stereo. But the situation is changing dramatically. The AM broadcasters now proclaim they need a stereo option to stay competitive with FM, and broadcast-equipment manufacturers are anxious to oblige. Five competing AM stereo systems are now before the Commission; one of them is likely to be proposed for commercial use later this year. Here's a look at all five candidates...and a challenge: Can you predict which system will be chosen, and why? *Spectrum* will make a summary of your comments public once the FCC has reached its own conclusions on the matter (see box, p. 31).

20 years of waiting

Serious efforts to bring stereo reception to the vast AM listening audience can be traced back to the late 1950s and early 1960s when RCA, Philco, Westinghouse, and Kahn Communications independently petitioned the FCC on behalf of their respective AM stereo systems. However, in January 1962, the Commission decided against all these proposals, encouraging instead the growth of FM stereo broadcasting. Today, FM stereo broadcasters are winning top ratings in several large metropolitan markets, even against AM competition. This is all the more remarkable considering the poor penetration of FM signals into fringe areas (compared with AM), and the multipath/fading problems encountered by many FM listeners, particularly those in automobiles.

The National AM Stereophonic Radio Committee (NAMSRC) was formed on September 24, 1975, "for the purpose of studying AM stereophonic broadcast systems in response to a growing interest by industry, broadcasters, and the FCC." The Committee was sponsored jointly by the Electronic Industries Association (EIA), the National Association of Broadcasters (NAB), the National Radio Broadcasters Association (NRBA), and the Broadcast, Cable, and Consumer Electronics Society of IEEE.

On December 19, 1977, the NAMSRC's efforts culminated in a final report that was published by the EIA and submitted to the FCC. The report contains theoretical analyses and field-test results on AM stereo systems submitted by three different proponents: Belar, Magnavox, and Motorola. Two other AM stereo proponents have submitted proposals directly to the Commission, independent of the NAMSRC—Harris and Kahn Communications.

Prompted by the increasing activity of system proponents, the FCC issued a Notice of Inquiry on June 22, 1977, seeking industry-wide opinion about AM stereo (the official period for submitting such comment closed March 8, 1978). The Commission is now evaluating all submitted documents, and tentatively promises to issue a Notice of Proposed Rulemaking by midsummer.

It should be remembered that a Notice of Proposed Rulemaking will simply open the door for more comments before a final decision is made. And it's possible that none of the five AM stereo systems thus far proposed will get the official nod.

Apples and oranges?

Reading through the documents submitted to the FCC on behalf of all five AM stereo systems is mind-boggling adventure. Each proponent makes skillful use of modulation theory and field-test results to demonstrate the superiority of his system over all the others. Unfortunately, no single body of test data has been run concurrently on all five systems by a disinterested (but technically qualified) third party—which could obligate the FCC to perform its own series of tests (something it prefers to avoid for now) to help resolve conflicting claims.

At this point, we hasten to mention that no evidence of dishonest or otherwise questionable activity has been uncovered or even suggested to us. Instead, there is simply no broad recognition of those performance characteristics that are absolutely vital to AM stereo's implementation and success. Each proponent has his favorites, such as monaural compatibility, good stereo separation, better fidelity (than mono AM), or even low cost. They all might be surprised to learn that AM broadcasters are unlikely to embrace any stereo encoding system that weakens their fringe-area signal, regardless of other redeeming qualities. But reduced coverage, even for monaural listeners, is a definite possibility, according to AM stereo proponents who wish to hold negative-going amplitude-modulation peaks below 100 percent (carrier disappearance can mean momentary loss of the encoded stereo information channel, producing audible noise bursts). If much rms sideband power is sacrificed to avoid this situation, station coverage could suffer noticeably.

System advocates should also heed what automobile-radio manufacturers are saying. They want an indicator light that automatically indentifies AM stereo broadcasts

Don Mennie Associate Editor

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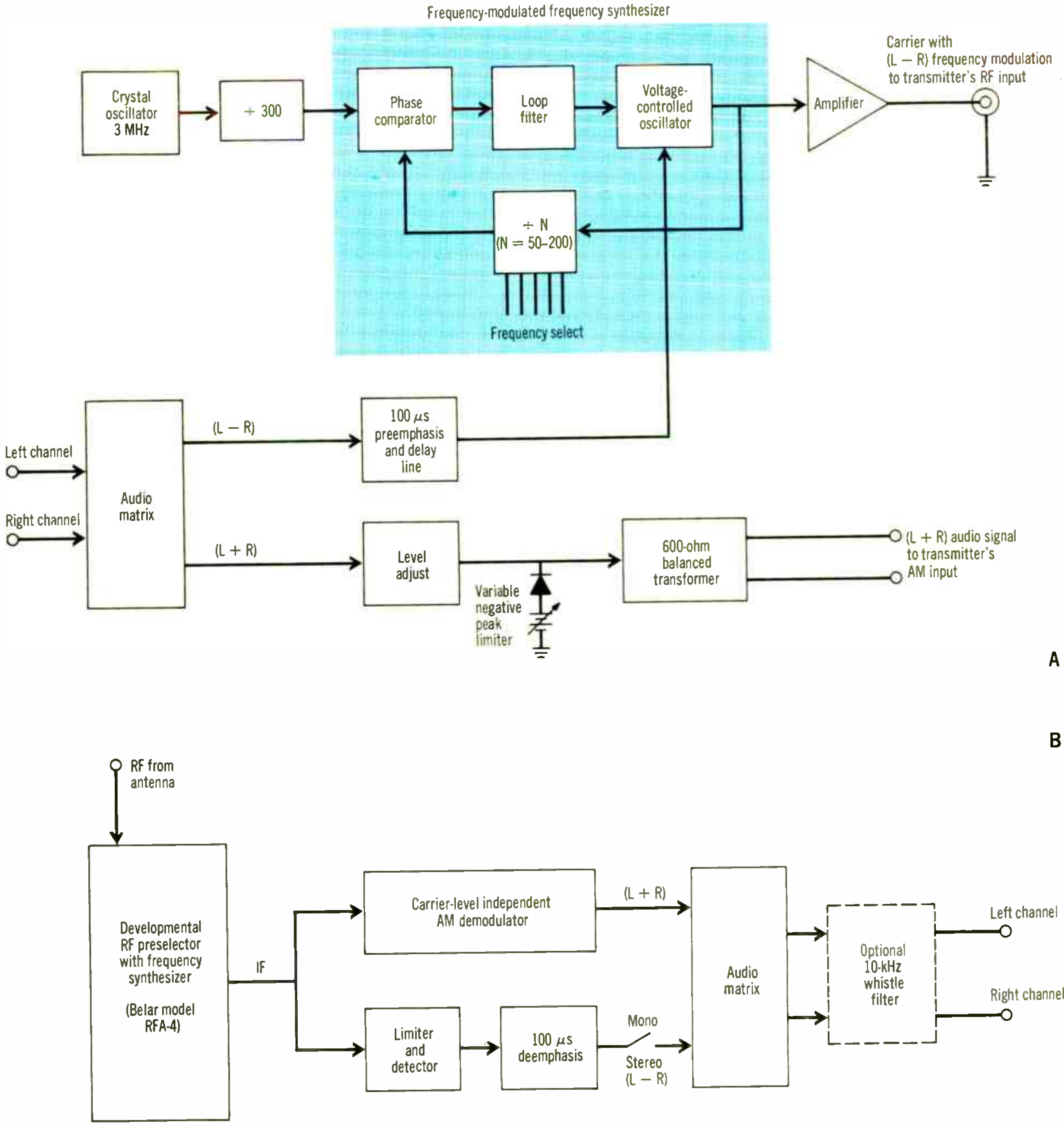


[1] Combined amplitude modulation and frequency modulation comprise Belar's encoding (A) and decoding (B) technique for AM stereo. A laboratory AM/FM source capable of simulating the RF output of either the Belar or the Magnavox system has been developed by Boonton Electronics Corp., Parsippany, N.J. (model 103A/B-S3).

in less than 100 ms. Without this feature, auto makers lose interest because all their potential customers for AM stereo expect visual feedback, based on years of experience with FM stereo. The "feel" of the tuning control is also considered most important. A "tight" automatic gain control (AGC) would make AM stereo sets tune like FM stereo (stations are abruptly captured or lost during dial cruising with little interim transition). Integrated-circuit designers at National Semiconductor say that maintaining a "soft" AGC could create a problem because the stereo image will shift as the operator tunes through each station. Relatively simple "matrix tracking" circuits have been proposed to correct this situation.

It is these kinds of issues, plus the more widely debated importance of adjacent channel interference, stereo reception that requires large signal-to-noise ratio penalties, or audio distortion traceable to sky-wave/ground-wave and multiple sky-wave reception, that will decide the commercial future of AM stereo. What follows is a brief description of the five systems thus far proposed, and a summary of claimed advantages and possible weaknesses as reported to the FCC.

Actually, all five proposed AM stereo systems (Belar, Kahn/Hazeltine, Harris, Magnavox, Motorola) are somewhat similar because each uses conventional amplitude modulation to transmit audio components that are more or less compatible with monaural reception (left + right), and some form of angular modulation (frequency, phase, or modified quadrature) to transmit the stereo information (left − right). But the Kahn/Hazeltine system has asymmetric AM sidebands (lower sideband contains the left channel, upper sideband contains the right channel). When a monaural radio is center-tuned to a Kahn-modulated stereo signal, its envelope detector algebraically adds the left and right sidebands together, giving compatible (*L* + *R*) monaural reception.

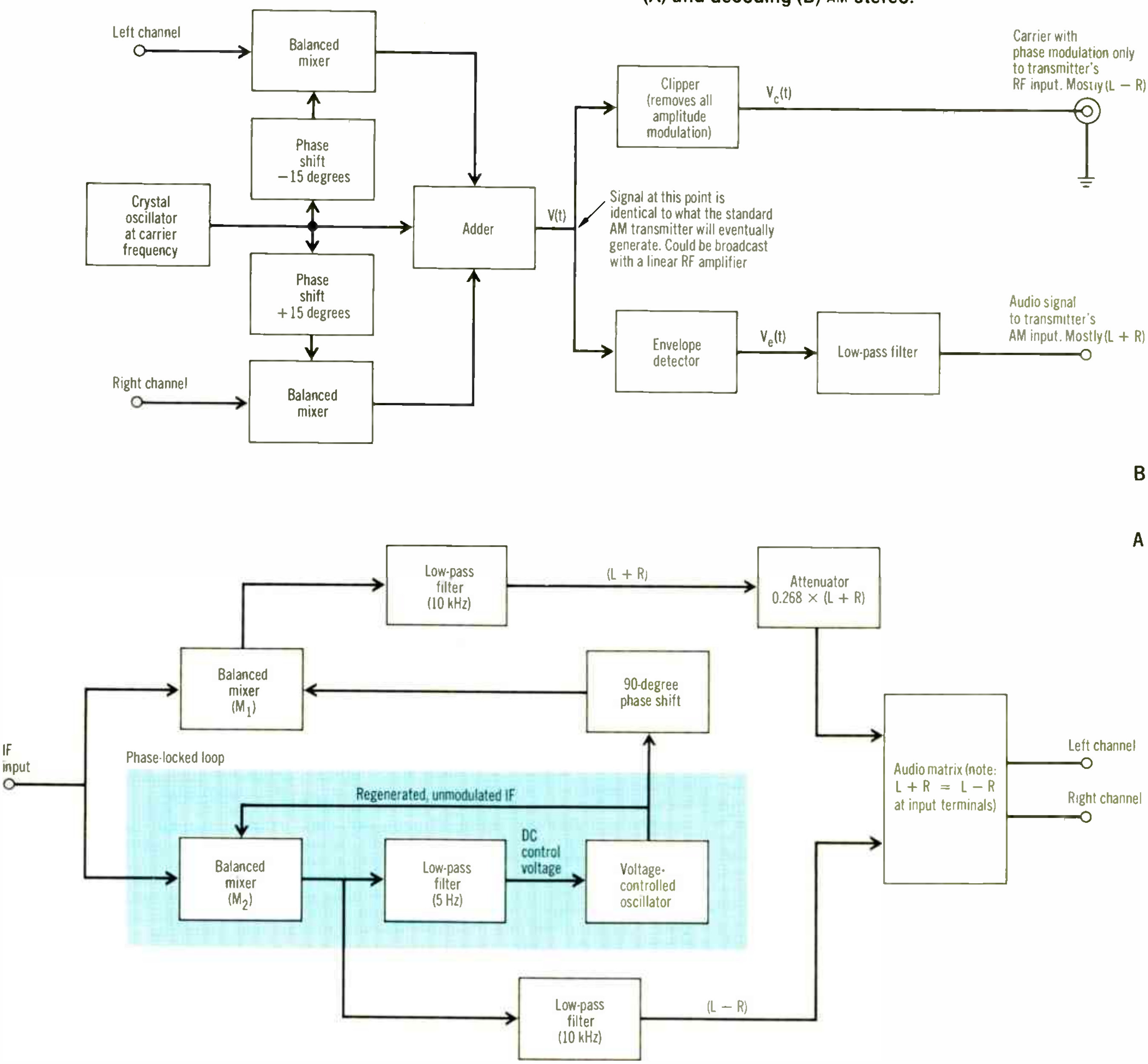
Belar's AM/FM modulation system

A good understanding of how each proposed AM stereo system operates can be obtained by tracing the audio signals as they are encoded, impressed on the carrier, transmitted, received, decoded, and then amplified for stereo listening. With the AM/FM modulation system proposed by Belar Electronics Laboratory, Devon, Pa., the left and right audio signals are first applied to an audio matrix (Fig. 1A). The audio matrix performs the linear addition and subtraction of *L* and *R*, resulting in the formation of (*L* + *R*) and (*L* − *R*) signals. The (*L* − *R*) component is preemphasized with a 100-*m*s time constant, and is routed through a variable-delay line to the FM modulator input, where it frequency-modulates the radio-frequency (RF) drive to the transmitter. The (*L* + *R*) signal then amplitude modulates the carrier in the normal fashion. The (*L* − *R*) modulation constant proposed for this system employs a peak low-frequency deviation of ± 1.25 kHz.

A variable-delay line delays the (*L* − *R*) signal in selectable 2-μs increments, up to a maximum of 40 μs. Delaying the (*L* − *R*) component in this fashion compensates for the delays imposed on the (*L* + *R*) component as it passes through the transmitter modulator, and improves broadband stereo separation at the receiver. The (*L* + *R*) component is level-adjusted and is passed through a negative peak-limiter circuit before being applied to the 600-ohm balanced input of the AM transmitter. The peak limiter is capable of holding negative modulation peaks to any preset value between 90 and 100 percent. For the NAMSRC tests, this circuit was adjusted on program material to limit negative modulation peaks to 95 percent. Positive peaks were allowed to modulate the transmitter well above 100 percent as insurance against a potential loss in "loudness" for monophonic reception.

Belar's prototype AM stereo receiver is actually a developmental AM/FM preselector designed for use with broadcast modulation monitors but its design is indicative

[2] Modified quadrature modulation (dubbed compatible phase multiplex) has been adopted by Harris for encoding (A) and decoding (B) AM stereo.



of the impact that present-day technology might have on future consumer products (Fig. 1B). The RF and intermediate-frequency (IF) stages are typical of conventional AM receiver designs. However, the output of the IF amplifier is split into two separate detection paths. One path is applied to a conventional envelope detector where the AM information [corresponding to $(L + R)$] is extracted.

The other path is applied to a limiting amplifier (which strips off the AM modulation), leaving an FM square wave to be demodulated in a frequency discriminator. The resulting audio signal is deemphasized to restore its original amplitude response and to enhance the signal-to-noise ratio of the $(L - R)$ channel.

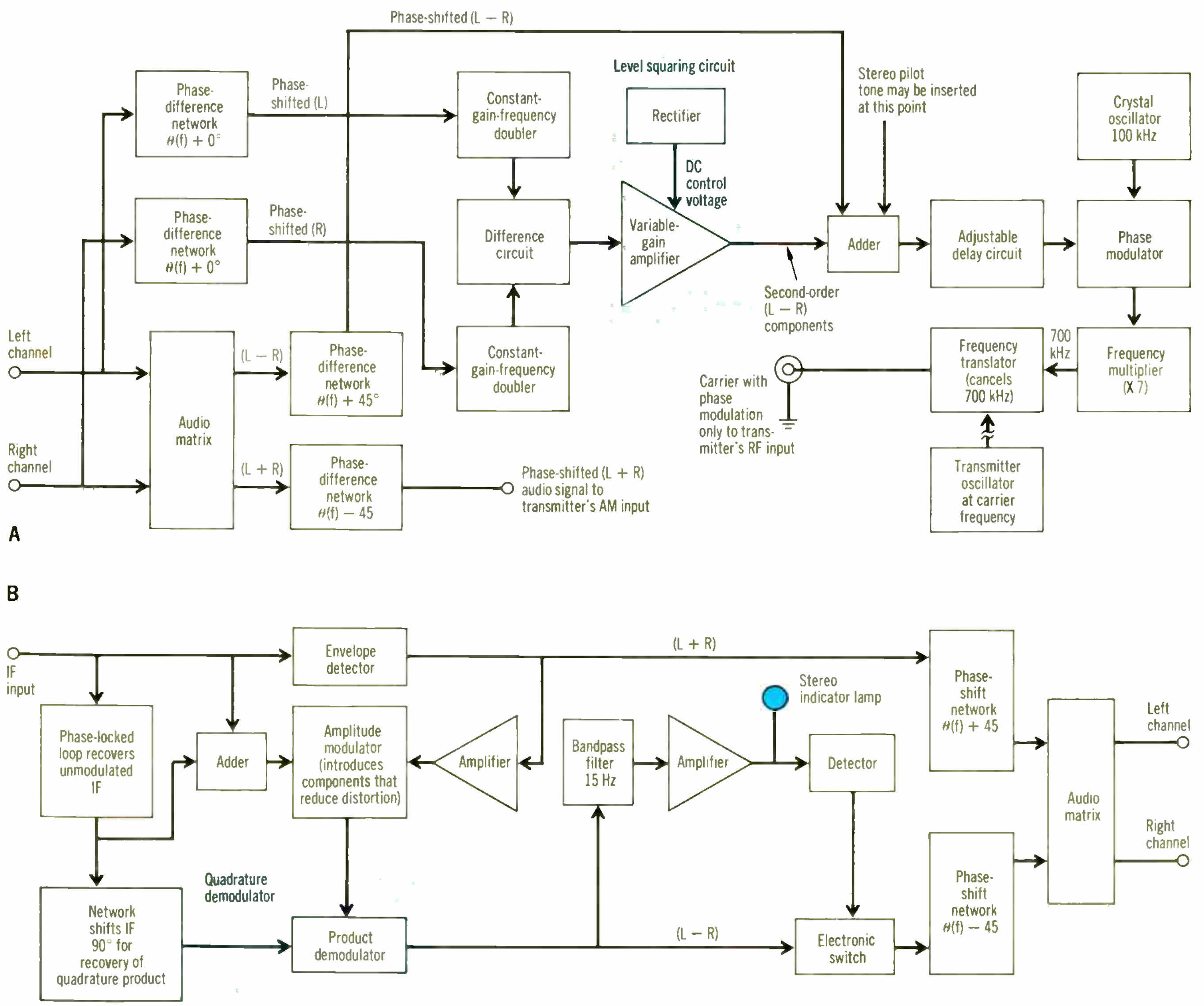
Next, the detected $(L + R)$ and $(L - R)$ components are applied to a simple audio matrix, which performs the linear addition and subtraction required to recover the left and right audio information. If necessary, L and R can also be fed through a 10-kHz whistle filter that removes any adjacent channel interference.

The Harris CPM system

Another AM stereo approach, called the compatible phase-multiplex (CPM) system, has been submitted to the FCC by the Harris Corporation, Quincy, Ill. This design was not completed in time for inclusion in the NAMSRC testing program, so Harris engaged consulting engineers from Carl Jones Associates, Falls Church, Va., to run field trials on CPM. The Harris petition contains a summary of all test procedures used and the data subsequently obtained. Harris estimates that 90 percent of the monaural AM transmitters now in operation could be quickly and inexpensively modified for CPM stereo (new exciters would cost $3000–$5000 each). Updating monaural studio equipment to complement this changeover would run an additional $20 000 per station. Other proponents claim similar cost figures for refitting a monaural station.

The CPM system works by the amplitude modulation of two carrier signals separated in phase by 30 degrees. The left-channel signal amplitude-modulates a carrier lagging the transmitted resultant by 15 degrees, and the right

[3] Independent sideband AM stereo from Kahn/Hazeltine has been field tested at WFBR and XETRA. Encoding (A) and decoding (B) require special phase-shift circuits. The stereo indicator lamp, while not a part of Kahn's June 16, 1976, petition to the FCC, was briefly mentioned in reply comments to the Commission dated March 6, 1978.



channel modulates a carrier leading by 15 degrees. These two signals are linearly combined (added) to form coherent ($L + R$) sidebands that are identical to those of a conventional monaural signal, and ($L - R$) quadrature sidebands that are reduced in amplitude with respect to the ($L + R$) sidebands due to the use of the 30-degree angle. Thus, the CPM system is a "modified quadrature" system, using a technique similar to that employed by color television for transmitting two chroma signals on one subcarrier.

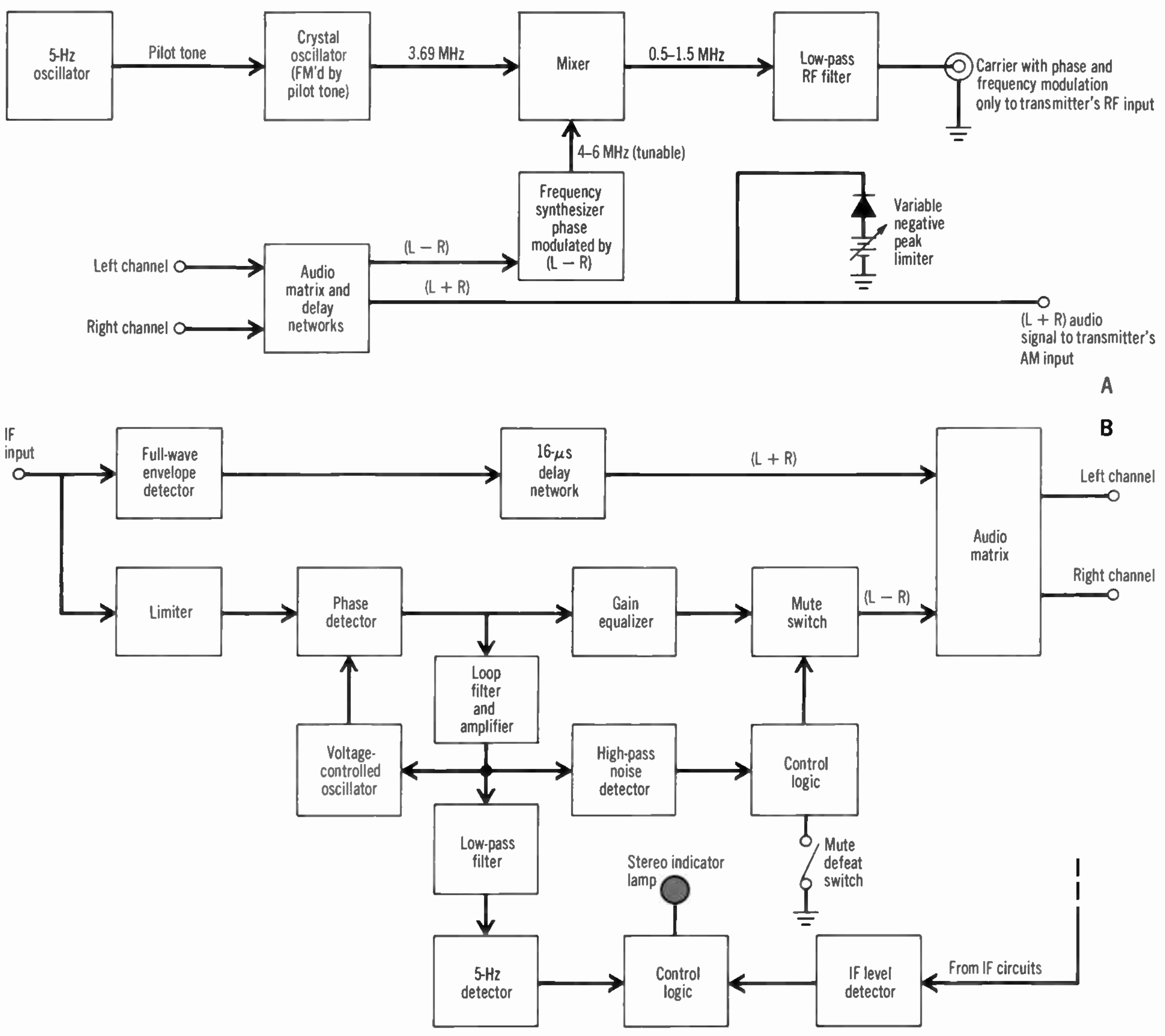
Existing transmitting equipment may be used for CPM. For example, a crystal oscillator can supply the initial unmodulated carrier, which is then phase-shifted plus and minus 15 degrees (Fig. 2A). These phase-shifted RF signals are next multiplied by the left and right channel audio signals in balanced mixers. The mixer outputs are then summed with the unmodulated carrier to yield the CPM signal.

This CPM signal, $V(t)$, must be separated into its envelope components, $V_e(t)$ and phase-modulated carrier components, $V_c(t)$, before it can be transmitted by a conventional AM transmitter. A hard clipper recovers the phase modulation and an envelope detector recovers the amplitude modulation. $V_c(t)$ and $V_e(t)$ are applied, respectively, to the RF input and audio input of the transmitter, which then delivers an amplified CPM signal to the antenna.

Reception of CPM signals can be accomplished in a variety of ways. For example, a conventional superheterodyne receiver can be used up to the point of IF detection (Fig. 2B). A phase-locked loop (PLL) regenerates unmodulated IF from the incoming IF signal. The PLL consists of a balanced mixer M_2 (which serves as a phase detector), a 5-Hz low-pass filter, and a voltage-controlled oscillator (VCO). The incoming modulated IF signal serves as the reference for the phase detector, and the regenerated, unmodulated IF appears at the output of the VCO.

The regenerated, unmodulated IF from the VCO is 90 degrees out of phase with the incoming modulated IF, and thus M_2 directly demodulates the quadrature ($L - R$) information of the CPM signal. A 90-degree phase shift produces unmodulated IF that is in phase with the modulated IF. This signal is combined with the modulated IF signal in balanced mixer M_1 to demodulate the in-phase ($L + R$) information of the CPM signal. Attenuation (tan 15 degrees = 0.268) is inserted in the ($L + R$) channel to make the ($L + R$) channel gain equal to the ($L - R$) channel gain. Then, the ($L + R$) and ($L - R$) signals can be matrixed into the original left- and right-channel audio signals. Stereo separation at audio midband is said to be 30 dB typical, and 15 dB minimum across the audio

[4] Amplitude modulation and phase modulation have been combined by Magnavox to encode (A) and decode (B) AM stereo. Receiver tests employed a 6-kHz/12-kHz IF.



bands. Distortion should be similar to that found in present AM monaural transmissions.

For alerting the listener to stereo broadcasts, Harris suggests transmitting a 20- to 25-Hz sine wave at 9-percent modulation on the $(L - R)$ channel only. This pilot tone requires no reduction of modulation and causes a neglible increase in envelope detector distortion. The tone will not be heard in mono receivers because it is on the $(L - R)$ channel, and the virtual image will cancel between left and right speakers in the stereo listening environment.

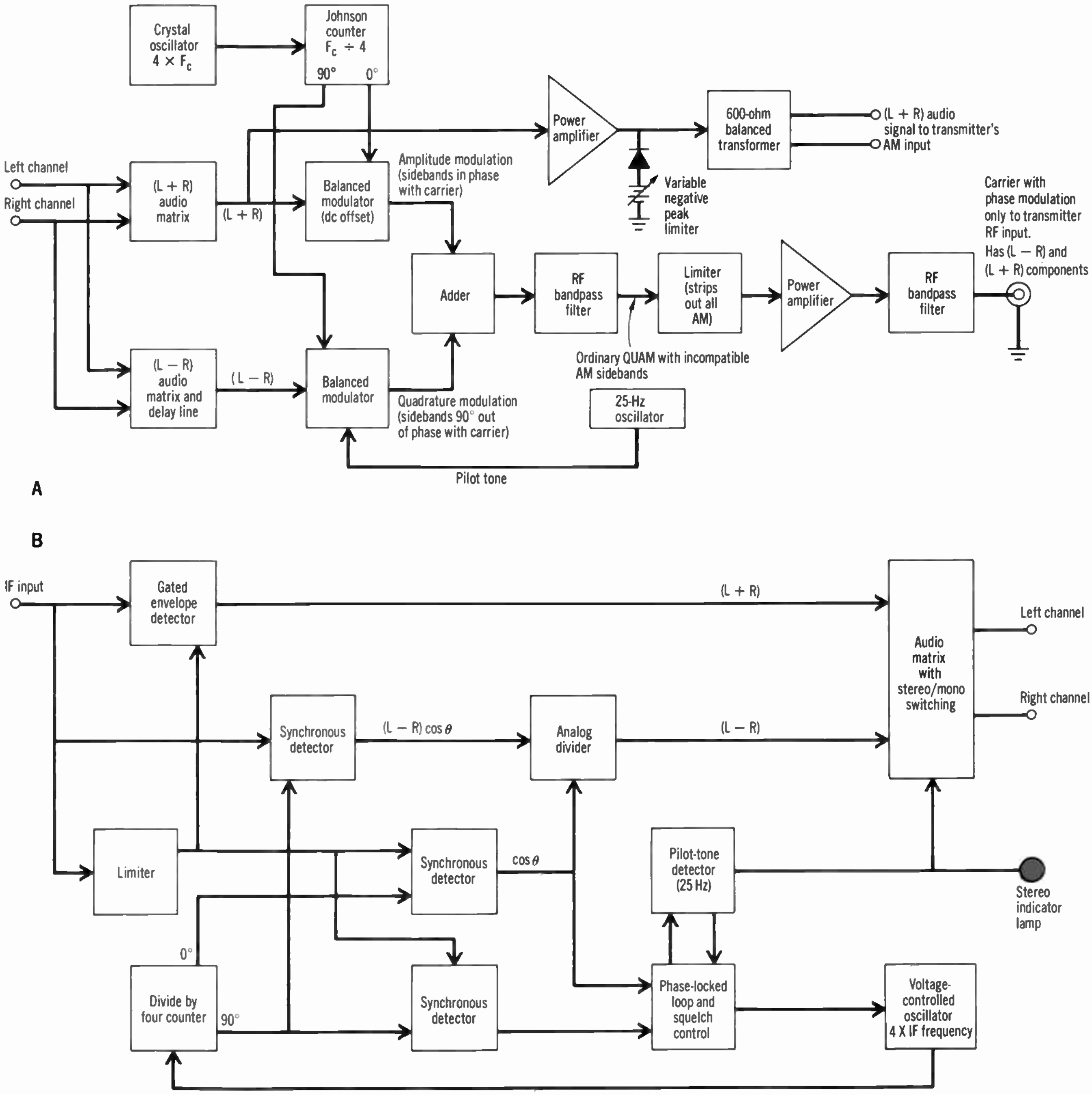
The Kahn/Hazeltine ISB system

Actively looking toward the adoption of AM stereo standards since 1958, Kahn Communications, Freeport, N.Y., has shown remarkable tenacity despite almost 20 years of FCC inaction and postponements. During the early 1970s, Kahn helped sponsor field testing of its independent sideband (ISB) AM stereo system at station WFBR in Baltimore, Md., and XETRA in Tijuana, Mexico, and has used the resulting data to support its current FCC petition. In September 1977, the Hazeltine Corporation joined with Kahn in support of the ISB system.

Kahn, though invited to participate in last year's NAMSRC testing program, did not do so. President Leonard Kahn explains that his small company could not afford to engage in yet another round of tests after investing in the WFBR and XETRA experiments. (The NAMSRC did not exist at the time Kahn ran these independent studies.) Mr. Kahn says unsupervised (by Kahn) technicians at WFBR and XETRA tested ISB system performance. Moderate RF levels, typical of normal reception, were used during the receiver tests.

The audio path through Kahn's proposed AM stereo ex-

[5] Compatible quadrature amplitude modulation (C-QUAM) has been developed by Motorola to encode (A) and decode (B) an AM stereo signal that is also acceptable to envelope detectors.



citer begins where the left and right audio channels are summed and fed through a constant-phase-difference (-45 degrees), constant-amplitude network to produce the $(L + R)$ signal (Fig. 3A). This signal drives the audio input of a conventional AM transmitter. Thus, the envelope modulation produced is a linear sum of the L and R signals, a necessary condition for monophonic compatibility.

Simultaneously with the creation of $(L + R)$, the L and R signals are also subtracted and fed through another constant-phase-difference (+45 degrees), constant-amplitude network to produce the $(L + R)$ stereo signal. At this point, the $(L + R)$ and $(L - R)$ audio components are 90 degrees out of phase with each other.

The $(L - R)$ stereo component feeds a summation circuit and a level squaring circuit. A variable-time-delay network on the output of the summation circuit allows adjustment of time delay in the $(L - R)$ path so that it equals the time delay in the $(L + R)$ path.

Outputs from the time-delay circuit and the standard AM transmitter's crystal oscillator are delivered to a phase-modulator/frequency-multiplier chain, which eventually provides a phase-modulated carrier wave (at the correct frequency) to the standard AM transmitter's RF input. The Kahn exciter delivers about 2 watts of RF drive to the transmitter.

The frequency-translation circuit, as provided in the Kahn exciter, allows the standard AM transmitter's crystal oscillator to determine the center frequency of the exciter's phase-modulation output. This insures that the transmitter's original high-frequency stability characteristics will be maintained.

The system thus far described, while producing a credible AM stereo, has somewhat limited stereo separation. By adding a second-order phase-modulation component, this separation has been improved to about 30 dB. Implementation involves taking the L and R audio components and individually phase-shifting them, relative to the $(L - R)$ component, by -45 degrees. These two phase-shifted audio signals are passed through constant-gain frequency doublers, into a difference circuit, and are finally delivered to a level squaring circuit. Control for the level squaring circuit is provided by the $(L - R)$ signal. This arrangement is said to give excellent stereo separation while sidebands remain within a well-confined spectrum.

Specially designed AM receivers are not required to demonstrate stereo reception from ISB transmissions. Two ordinary AM table radios placed about two meters apart will suffice. While both radios are tuned to the same ISB broadcast, the left-hand dial is set slightly *below* the point of loudest reception, and the right-hand dial is set *above* the point of loudest reception. Adjusted in this manner, the two radios will directly demodulate the lower and upper AM sidebands, respectively, thus producing the left and right audio channels.

Kahn has also developed a single IF AM stereo receiver for picking up ISB transmissions that was used during the stereo AM tests at WFBR (Fig. 3B). This decoder is said to provide excellent stereo separation, to be insensitive to microphonic oscillation problems, to deliver low-distortion audio signals, and can incorporate a stereo indicator lamp.

The Magnavox AM/PM system

The system for AM stereo broadcasting proposed by the Magnavox Company, Fort Wayne, Ind., employs a combination of amplitude modulation and true linear phase modulation. Stereophonic program material is matrixed into $(L + R)$ and $(L - R)$ signals prior to transmission. The $(L + R)$ signal amplitude-modulates the carrier, and the $(L - R)$ signal phase-modulates the carrier. Magnavox also proposes including a 5-Hz FM signal on the carrier to allow for the automatic identification of stereo broadcasts.

A three-step process, capable of producing any frequency in the broadcast band, generates the Magnavox AM/PM signal (Fig. 4A). First, a 3.69-MHz oscillator is frequency-modulated with a 5-Hz stereo identification tone (4-radian phase deviation). Next, a phase modulator adds the $(L - R)$ audio component as phase deviation to the output of a tunable (4-6-MHz) frequency synthesizer [peak deviation contributed by $(L - R)$ is held to one radian]. The two modulated signals are heterodyned (down-converted) to the desired broadcast band frequency, applied to a standard AM transmitter's RF input, and amplified to full carrier power.

This amplified carrier is also amplitude-modulated by the $(L + R)$ audio component using the modulation circuitry already present in the standard AM transmitter. A delay network equalizes the time delays encountered by the $(L - R)$ and $(L + R)$ signals prior to transmission.

Reception of the Magnavox AM/PM signal is implemented in a manner similar to that outlined for the other AM stereo systems thus far discussed (Fig. 4B). Amplitude $(L + R)$ and phase $(L - R)$ variations are detected separately and then matrixed to obtain the left and right audio signals. Detection of the 5-Hz frequency modulation operates an indicator light that identifies stereo broadcasts. Magnavox has also suggested sending digital data (station ID, weather, etc.) by modulating the 5-Hz tone.

The Motorola C-QUAM System

One of the best-known methods of transmitting two signals on one carrier is separately to modulate two carriers of the same frequency, chosen to be in phase quadrature with each other (a 90-degree phase shift exists between the two carrier signals). This is how two separate color signals are separately transmitted on a single subcarrier for color television. The technique's advantages lie in the areas of noise performance and matrixing. Two separate transmitters are not required for practical implementation. Modification of a single transmitter can provide a quadrature signal identical to one supplied by combining the outputs of two transmitters.

The main problem with ordinary quadrature amplitude modulation (QUAM) when used in the broadcast band to transmit stereo is mono capability. When significant amounts of stereo information are present, the audio signal recovered by a monaural radio's envelope detector is not a linear sum of the left and right channels, but instead contains upward of 14-percent intermodulation distortion.

Motorola has addressed this situation by developing an AM stereo exciter that provides compatible QUAM or "C-QUAM." The mathematical explanation is that modulating the in-phase and quadrature components of QUAM by the cosine of the modulation angle (while retaining the full 90-degree phase shift between carriers) will produce a compatible envelope modulation. (Recall that Harris decided that this problem was best handled by reducing the phase shift between carriers from 90 to 30 degrees for

Has AM stereo "arrived"?

Just because implementing an idea is technically feasible, there is no guarantee the marketplace will welcome the resulting product. Quadraphonics comes quickly to mind as a capability (still) in search of a customer. In this perspective, does AM stereo make sense for consumer electronics? Do any of the systems described here impress your engineering "horse sense" favorably?

Spectrum would like your opinion and we have reserved a block of five numbers on this issue's Reader Service Card so you can quickly record a preference (Belar 195, Harris 196, Kahn/Hazeltine 197, Magnavox 198, Motorola 199). Written comments on AM stereo are also welcome. Simply drop us a note or use the space provided at the bottom of the Reader Service Card.

After the FCC concludes its deliberations on AM stereo, *Spectrum* will summarize the Commission's findings and, at the same time, reveal your inputs on the subject. Let's see if *Spectrum* readers and the FCC can independently come to the same conclusion!

its "modified quadrature" CPM system.)

Implementation of a C-QUAM encoder/exciter was designed to be as versatile as possible during the NAMSRC tests (Fig. 5A). Variable-delay lines were used to equalize any group-delay differences found between the audio-modulation system and RF system in the various AM transmitters used for experimental stereo broadcasts.

Audio matrixing of the left and right stereo channels provides Motorola's exciter with $(L + R)$ and $(L - R)$ audio. The $(L + R)$ signal follows two paths. One path simply amplifies and delivers $(L + R)$ to the transmitter's AM modulator, while the other route (through a balanced modulator) impresses a crystal-controlled carrier, Fc, with $(L + R)$ amplitude modulation. Meanwhile, the $(L - R)$ audio is run through a different balanced modulator, which generates pure quadrature modulation.

Next, the $(L + R)$ amplitude-modulated carrier and the quadrature-modulated carrier are added and filtered to become an ordinary QUAM RF signal. This is the signal that, if amplified and broadcast, would give unacceptable distortion when picked up on monaural radios with ordinary envelope detectors.

Finally, the QUAM signal is heavily limited (all incompatible AM sidebands removed), amplified, filtered, and delivered as a phase-modulated carrier to the transmitter's RF input. It is the standard AM transmitter, amplitude-modulating this phase-modulated carrier with $(L + R)$, that actually generates the C-QUAM signal. [Note that prior to being amplitude-modulated in the transmitter, the carrier has both $(L - R)$ and $(L + R)$ phase-modulation components.]

A standard AM radio circuit can be used to receive C-QUAM up to the point of IF detection. Demodulating the stereo information involves breaking the composite IF signal into the desired (L) and (R) audio components (Fig. 5B). The envelope information $(L + R)$ is obtained from a gated detector. Two synchronous detectors are used to demodulate the phase-modulated information quadrature component and the cosine of the phase angle. These outputs are fed to an analog divider, which yields the difference signal $(L - R)$. The envelope detector output $(L + R)$ and the divider output $(L - R)$ are applied to the audio matrix that provides the desired stereo outputs. A fourth demodulator controls the operation of the phase-locked loop and the squelch circuitry.

Some names and claims

Hardware implementations aside, the major difference between each of these proposed AM stereo systems is the mathematical function individual proponents use to modulate the carrier. In effect, proponents have designed systems that boost what they consider to be the "most important" parameter or parameters. Briefly, here is where the five proponents now appear to stand, based on their FCC petitions, telephone interviews with both advocates and critics, and related documents:

- Belar—The emphasis is on implementation. AM stereo must be economic for the consumer, easy to produce for the manufacturer. The Belar petition lacks consideration of a stereo pilot tone, but Belar now claims to have developed a method for directly identifying AM stereo broadcasts that would not require a pilot tone. Possibility of noise problems during 100 percent negative peak modulation conditions.
- Harris—Main concern here is for compatible monophonic transmission quality. Broadcasting a stereo sideband spectrum with no increase in occupied bandwidth is given maximum consideration. Reduced amplitude $(L - R)$ sidebands invite noise problems in stereo.
- Kahn/Hazeltine—Unique feature of independent upper and lower sidebands. Claimed to be the system least delicate to transmission anomalies through the ionosphere (best sky-wave reception), and able to withstand full negative peak modulation. Could be a more costly system to implement because special phase-shift circuits are needed in the single-IF receiver design.
- Magnavox—Again, emphasis is on implementation (like Belar), but their petition includes full information on the generation and detection of a stereo pilot tone. Possibility of noise problems during 100 percent negative peak modulation conditions.
- Motorola—The noise reduction advantages of quadrature modulation are retained, while removing the disadvantage of high distortion in mono receivers with envelope detectors. This approach puts the burden for stereo quality on the receiver rather than the transmitter.

Naturally, it will be for the FCC to decide what is acceptable AM stereo performance. Most likely they will pick a "winner" from among the present crop of petitions. The often conflicting, and sometimes confusing, diagrams, analysis, and data presented in support of each system pose a major headache for any impartial evaluator.

The uncertainties surrounding AM stereo have particularly affected those semiconductor houses that serve the auto radio industry. The radio makers want AM stereo IC decoders available at practically the same moment that an FCC decision is announced, and so parallel bread boarding efforts on all five systems have been undertaken with the knowledge that four such designs must eventually be scrapped. In an attempt to reduce fruitless duplication of effort, Signetics and Sprague have divided up the decoder design task, with the understanding that one "partner" will end up second-sourcing the other, depending on which AM stereo system the FCC eventually endorses. ◆

New philosophies for portable digital instruments

Signature analysis and circuit emulation are exploited in new test equipment to reduce runaway service costs

Paced by a maturing integrated-circuits technology, the costs of data-processing products have been declining steadily, which should be a bright note in the lives of computer and terminal-equipment manufacturers. But there is another, darker side to the coin—the rising cost of service and maintenance as the equipment increases in complexity and sophistication. And the problem is compounded by a lack of skilled service personnel, and by a spreading nontechnical data-processing customer base (banks, brokerage houses, retail outlets) that demands minimum equipment downtimes.

Now, the answer may be at hand in the form of a new generation of field-service instruments to replace, or at least supplement, the traditional board-swapping approach. These instruments are designed to provide service personnel with the capability for making rapid equipment-fault diagnosis and repairs, with minimal technical training. In general, they employ one, or a combination, of two techniques: signature analysis and in-circuit emulation. Instruments are also being designed to effect rapid repairs on the printed-circuit (PC) board or subassembly level, and for servicing down to the component level. Some instruments can do both.

Some major computer manufacturers have tended to favor one or the other of the new techniques by making commitments to purchase specific test instruments, but most have not decided either way. Nearly all, however, are taking a serious look at what's available.

Board swapping—still no. 1

Board swapping has been a traditional service philosophy, and one that provides the quickest repair method. As the name implies, it simply means that the service technician will try to repair a malfunctioning computer system by replacing suspect boards with new ones until the system returns to normal. However, not only does this approach require an enormous investment in PC boards, but, if not managed very carefully, it can create severe problems. The disadvantages of board swapping include:

1. As a result of the "shotgun" board-replacement procedure, many of the PC boards replaced are actually good boards. Thus, a large inventory of good boards is kept "floating" in the field, unused.

2. Intermittent faults that are cleared up in the field when a board is replaced may not show up when that board is tested at a repair depot. As a result, the credibility of the analysis—and the cure—are in question.

3. Many problems that clear up when a PC board is unplugged and replaced by a new one actually are attributable to a faulty mating of the board with the connectors. However, to the serviceman, the replaced board appears to be the culprit.

4. Some PC boards develop problems only when they are used in conjunction with a set of other specific boards. Board swapping here can have a "hit or miss" chance of being effective.

It is for these reasons, and particularly the first one, that large computer companies are investigating methods to control runaway service costs, by using better management techniques and test equipment (Fig. 1). Nevertheless, nearly all computer and terminal-equipment producers still feel that board swapping is the best service method in terms of rapid repair time.

The new test equipment

A number of new-generation test and measurement service tools have been put on the market within the past two years. They employ a wide variety of testing techniques—among them signature analysis, in-circuit emulation, and guided fault probing. Some are multifunction instruments that provide digital displays of such circuit parameters as frequency, voltage, and resistance, whereas others display hexadecimal notations. Many are designed to troubleshoot microprocessor-based circuits, which is a disadvantage to minicomputer and large mainframe computer makers since such instruments cannot be used with their products, particularly the older lines. On the other hand, many new computer and terminal installations are using microprocessors, and their number is growing rapidly. This article will examine some of the more notable instrument developments.

Applying the techniques

About a year and a half ago, Hewlett-Packard introduced its model 5004A Signature Analyzer. Although the concept was not new (it was used earlier for data recording and error detection in automatic test systems), this was the first time that signature analysis had been incorporated into an inexpensive ($990) field-service instrument. The philosophy is simple: A service technician using the Signature Analyzer checks its display of hexadecimal signatures against a list of correct signatures on a schematic or in a service manual, for all circuit nodes probed. In the event of an incorrect match, the technician can backtrack in the circuit until a signature match is made, and thus narrow down the diagnosis to the faulty component. The accuracy of the instrument is reported to be as high as 99.998 percent, for component-level troubleshooting. (See the box on p. 36 for a more complete explanation of signature analysis.)

Roger Allan Associate Editor

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The drawback in using the 5004A is that the signature-analysis concept must also be designed into the product with which it is used, although Hewlett-Packard claims that this disadvantage is far outweighed by its advantages.

Another approach is in-circuit emulation, exemplified in an instrument recently introduced by Intel Corporation, Santa Clara, Calif. This technique involves the use of an external system to imitate a microprocessor system under test and provide a real-time functional diagnosis of its failures.

Intel pioneered this concept in larger, more expensive microprocessor development systems many years ago, but not until about a year ago did the company succeed in incorporating the technique in a $2000 portable instrument it named the μ Scope. However, this instrument can diagnose faults only down to a subassembly level, and it is generally used with socketed microprocessors, since its emulator cable must be plugged into the socket of the system under test. (See box on p. 36 for a more complete explanation of in-circuit emulation.)

Although simple to operate, both the Hewlett-Packard signature analyzer and the Intel in-circuit emulator instruments have been more popular on the production line than for field-service applications because of their circuit limitations.

Synergy of two approaches

More recently, the two concepts—signature analysis and in-circuit emulation—have been combined in a single portable low-cost instrument called the Microsystem Analyzer. The device is the product of Millenium Systems, Inc., Cupertino, Calif., a company that previously had designed and built microprocessor development systems for other companies (Fig. 2). The combination permits both real-time functional testing for module-level fault tracing and signature analysis for component-level diagnosis. This $2475 basic emulator instrument with a hexadecimal readout and a $495 circuit-card signature analyzer option negates the need to have signature analysis designed into a circuit under test. In-circuit emulation is used to generate externally the necessary bit streams used in signature analysis, and thus it is not necessary to break open loops into a circuit. The only requirements are that the clock for the system under test be used (synchronous testing) and that the microprocessor under test be socketed (so that the instrument's emulator cable can be plugged in). The Microsystem Analyzer has proved useful for engineering development and production testing, as well as field-service applications. Currently, the instrument handles 6800 and 8080 microprocessors, with Z-80 and 8085 microprocessors in the planning stage.

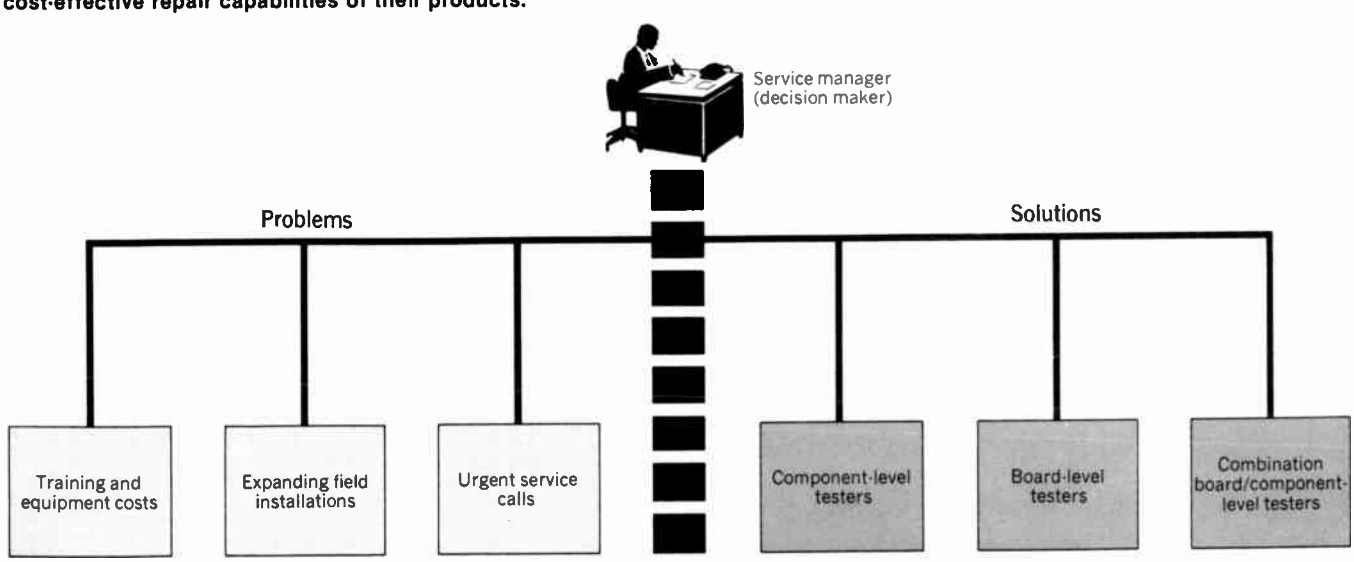
Of course, testing digital circuits involves more than just the digital checks of microprocessor testers. Analog tests and adjustments, such as those of timing signals, are often necessary. And, as explained previously, minicomputer and large mainframe installations—which account for a large segment of field computers—cannot utilize microprocessor testers, which is why the portable oscilloscope is still in wide use for field service of computers. There have been, however, recent service-instrument developments in this area.

The multifunction approach

The idea of combining several instrument functions into one box for universal-circuit testing has been tried by several instrument maufacturers over the past five to six year, with limited success. Many of these early-day multifunction instruments were not optimized for field service, but were designed for the engineering laboratory, an environment that requires the maximum flexibility and high-performance features generally found in single-function instruments.

By early 1976, the Data Test Corporation, Concord, Calif., successfully marketed a multifunction instrument to the Burroughs Corporation, Detroit, Mich., for use by the latter's field-service force of computer repairmen. The $1995 Datatester model 1200 is essentially a combination digital multimeter and counter/timer. It can measure voltage, current, resistance, frequency, time intervals, and transition counts. The transition-counting feature is a form of signature analysis, and is something with which Data Test had early experience (the company originated the TRC or transition redundancy check concept, based on obtaining digital count signatures at important circuit

[1] Computer and terminal-equipment service managers are being barraged from both sides. On one side are the growing service problems of manpower training and equipment costs, greater numbers of products in the field under service, and greater customer demands for quick repair turnarounds. On the other is a host of service-instrument manufacturers, all attesting to the rapid and cost-effective repair capabilities of their products.



nodes and logic boundaries that describe proper system operations).

A key element in the success of the Datatester model 1200 is its simplicity of operation. It is designed for use by service persons with little or no knowledge of the operation of the circuit they are testing, or of the instrument they are using.

Last year, Tektronix, Inc., Beaverton, Oreg., took the multifunction instrument approach a step further with its model 851 digital tester. The instrument, which also is being supplied to the Burroughs Corporation, allows a repair person to perform voltage, current, resistance, frequency, time-interval, and transition-count measurements by a single knob rotation without moving any probes, thanks to a clever function-switch design. Its front panel was designed for ease of understanding by the operator. The model 851 tester also features improvements in a number of its measurement specifications over the Datatester—including input loading and dynamic-accuracy range of peak-voltage measurements.

Both the Tektronix and Data Test instruments may be harbingers of all-purpose service instruments to come, and may cut into the domain of heavier, larger, and more expensive oscilloscopes. For the present, however, the oscilloscope is still a very valuable service tool.

A digital testing oscilloscope

One of the most recent concepts in combining instrument functions was that introduced by Biomation, Cupertino, Calif., in its model DTO-1 digital testing oscilloscope. The device combines the functions of a storage oscilloscope, an automatic go/no-go tester, and a logic analyzer in one package. It was designed for rapid analysis of both PC-board and component-level faults. For go/no-go testing, it displays and compares up to eight logic traces from a system under test (SUT) with previously stored logic traces from a known good system (KGS) on a magnetic cartridge tape plugged into the DTO-1 (Fig. 3). Passing and failed traces are identified automatically by corresponding green and red LEDs on the probe and the unit's front panel. Also displayed are the SUT/KGS trace pair under comparison, as well as a "data error trace"

[2] A new approach in portable test equipment is represented by Millenium Systems' Microsystem Analyzer. By combining the well-known diagnostic capability of in-circuit emulation with that of signature analysis, the instrument allows rapid, down-to-the-component fault isolation in microprocessor-based circuits, externally, without the need to open up circuit loops.

Component- or board-level repairs?

Advocates of both component- and board-level repairs have impressive arguments for their respective approaches. In essence, however, the relative value of the two approaches depends on such things as the type of digital equipment under service, the kind of end user, and the size of the market to be serviced.

Proponents of the component-level repair philosophy feel that it is time for computer companies to rethink their board-level repair approach with its inherently high costs (according to some estimates, at least 15 percent of a PC board's value is involved in the cost of keeping spares). They feel that although it may take a little longer to diagnose and repair a system fault down to the component level with new service instruments, the difference in cost more than makes up for the extra troubleshooting time. Furthermore, this extra time undoubtedly will become shorter as more advanced service instruments become available. Another benefit is the reduction in the need for large PC-board repair pipelines between service centers and central repair depots.

Those arguing against component replacement claim that this technique requires an even larger spare-parts inventory than does the PC-board concept. Moreover, test points would have to be designed into serviced equipment and documentation would be needed. And even assuming that a system fault were diagnosed rapidly, a great deal of time would have to be spent unsoldering defective components and resoldering new replacements, since most components on PC boards are soldered into the boards, not socketed. Although most microprocessors used in the field in such applications as point-of-sale terminals, process control, and desk-top calculators currently are soldered in, a growing number are being socketed, in industrial applications.

Advocates of the board-level repair method correctly point out that many computer companies emphasize better local board testers over portable down-to-the-component instruments, although they might use the latter in certain cases. No one has yet demonstrated a faster repair method than board swapping, and speed is necessary for customers demanding absolutely minimum downtime, such as banks, retail outlets, and brokerage houses.

But one point is not in dispute: Portable component-level testers generally cost $2000 to $3000, whereas board-level testers can easily cost upward of $20 000.

Which way to go? The answer that seems to be evolving among some computer service organizations is to take advantage of both techniques, by using an effective board tester in a central repair depot or local service office, augmented by a powerful component tester in the field.

when a logical disagreement occurs.

For troubleshooting, the instrument can display up to six logic traces or an analog waveform, together with the SUT/KGS trace pair; or a new trace can be retained with the SUT/KGS trace pair, should a trace be present prior to the acquisition of the analog waveform. A number of other trace-signal superimpostions are also possible with the DTO-1.

Instruments optimized for board swapping

Board swapping is still a necessary—albeit expensive—service philosophy for many computer companies, and so these companies have tried to attack those aspects of a board-swapping program that considerably add to the overall costs. One important factor is the huge inventory of PC boards required because of repair pipeline delays between computer-customer sites and a central rework facility where suspect PC boards are repaired. Until recently, most efforts by computer companies to control this problem had centered on streamlining their management operations.

[3] The use of magnetic-tape cartridges for test programs for comparative data analysis, as is done in Biomation's DTO-1 digital testing oscilloscope, is a growing trend in portable field-service instruments for digital circuits.

The National Cash Register Company, Dayton, Ohio, was the first to tackle the problems by attempting to move the central rework facility out to the field—closer to, or at, the service site (Fig. 4). To accomplish this, in 1975 it funded the Omnicomp Corporation, Phoenix, Ariz., to develop a portable piece of automatic test equipment (ATE) that would enable local-office PC board repair, as well as "on-site" repairs where feasible. Omnicomp's efforts resulted in the Portable Service Processor (PSP), a portable bench-top instrument featuring guided-probe fault isolation, interactive test programming in a high-level language (PSP Basic), high-speed dynamic testing of PC boards, and fully programmable driver/sensor pins to test boards with multiple logic families. The PSP displays easy-to-understand diagnostic instructions for the operator in English.

The importance of the PSP is that it brings low-cost ($20 000) ATE sophistication, previously available only to large repair depots in large and expensive (upward of $80 000) systems, down to the local service office as well as to the field. A major advantage of the instrtument is that it minimizes test-program-generation costs (one source reports that it costs anywhere from $5000 to $25 000 per microprocessor-based PC board to have a test program written). Omnicomp has made available language translators that can translate, rapidly and at low cost, test programs written for the most widely used commercial test language to the Basic language used on the PSP.

Measuring the true cost of service

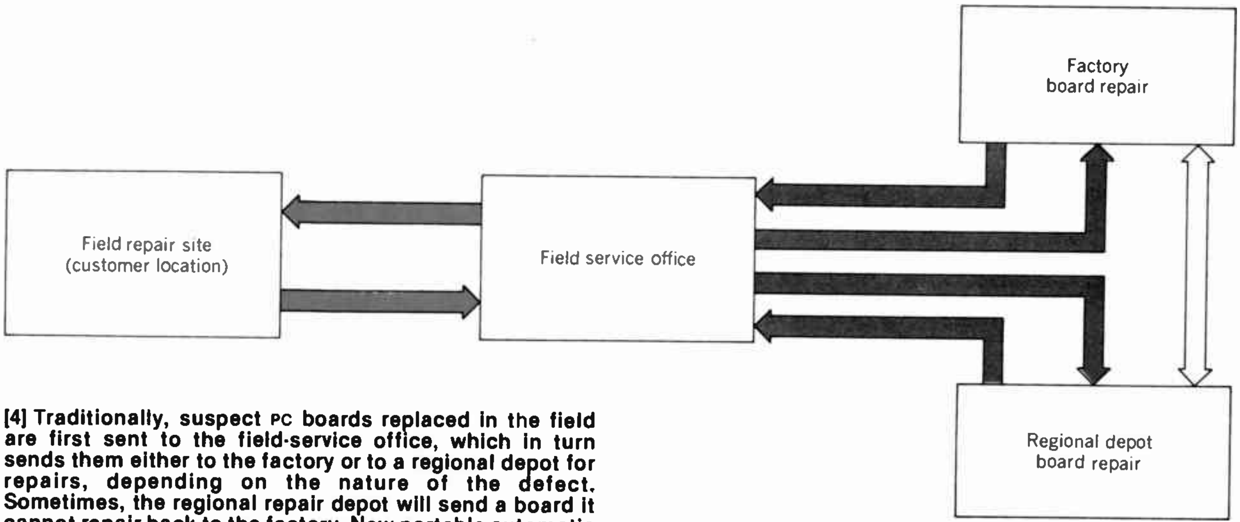
Computer and terminal-equipment manufacturers admit that few of them have a good handle on the true cost of service, given the many complex factors involved. They agree, however, that the service problem is a large one, and that more should be done to provide the highest service quality at the least cost.

In a recent speech to a local chapter of the Association of Field Service Managers, George Harmon, president of the association and vice president and general manager of the Pertec Computer Corporation Service Division, warned that many computer companies, in spite of brilliant new ideas for products, will eventually go out of business for lack of adequate field service. "A data-processing system in a business or governmental application demands the same commitment to service as copying machines and telephones. But it is almost impossible for a small computer company to position a repairman 20 minutes from each customer without going broke." he explained.

"The paradox in this computer business," points out Thomas Cook, corporate director of field engineering for Data General Corporation, Westboro, Mass., "is that a customer can purchase a small computer system for only a few thousand dollars, but then recoil with horror at having to spend nearly as much, or more, over the life of the system, for upkeep and service. While dropping hardware costs are bringing down computer prices, the skill and expertise needed to maintain and service these complex computers are going up."

He adds, "I see us getting away from the black-box instrument for service, particularly for CPUs, where built-in software is available for self-checking. Most major makers of digital systems are doing just that. Black-box service instruments might be used for such things as terminals."

Clifton Clarke, manager of field service administration for Digital Equipment Corporation, Maynard, Mass., agrees with Mr. Cook's paradox, noting that a new customer base for computers presents a challenging dimension to service organizations. "We had one recurrent service problem with one of our computers at a fast-food chain outlet," he says. "We found out that coffee and other liquids were constantly being poured over the computer, accidentally, by inattentive cashiers. We took care of this problem by designing a special internal cover for the computer. This is a common problem that computer service organizations are going to have to deal with more often as greater numbers of less sophisticated customers start using computers."



[4] Traditionally, suspect PC boards replaced in the field are first sent to the field-service office, which in turn sends them either to the factory or to a regional depot for repairs, depending on the nature of the defect. Sometimes, the regional repair depot will send a board it cannot repair back to the factory. New portable automatic test equipment helps minimize "pipeline" delays of boards between the field-service office and the repair depot or the factory, by allowing board repairs at the field-service office. Some automatic test equipment is even available for on-site component troubleshooting and repairs, at the customer location.

Remote diagnostics—a growing trend

In addition to the help they're getting from instrument manufacturers, several computer manufacturers are investigating the use of remote diagnostic routines over telephone data lines. The Digital Equipment Corporation, for instance, announced plans to institute its Remote Computerized Diagnosis, for users of its PDP-11/70 minicomputer, as part of its service contracts (Fig. 5). Originally developed about a year ago for the company's DEC system -10 and -20 minicomputers, the service enables an accurage diagnosis of system malfunctions, including recommendations for repairs, to be done remotely, in advance of a service call. Three elements make up the system: a remote electronic console that replaces the regular PDP-11/70 front panel and is used to initiate operating commands through the system terminal; the 24-hour toll-free telephone service line over which the remote diagnostic signals are sent; and a digital diagnosis center consisting of the host computer, communications equipment, and engineering staff.

In the case of a system malfunction, the user dials a toll-free number for the service-response group, which arranges for remote diagnosis and contacts the appropriate field-service office to schedule a service call. Using configuration files to determine proper parameters and diagnostic procedures for specific systems, the host diagnostic computer normally begins diagnosis within minutes of the customer's call. Following immediate analysis of results, digital diagnosis center engineers notify the service office of the nature of the malfunction and needed replacement parts. The user need furnish only a dedicated, voice-grade telephone line and a telephone-line interface.

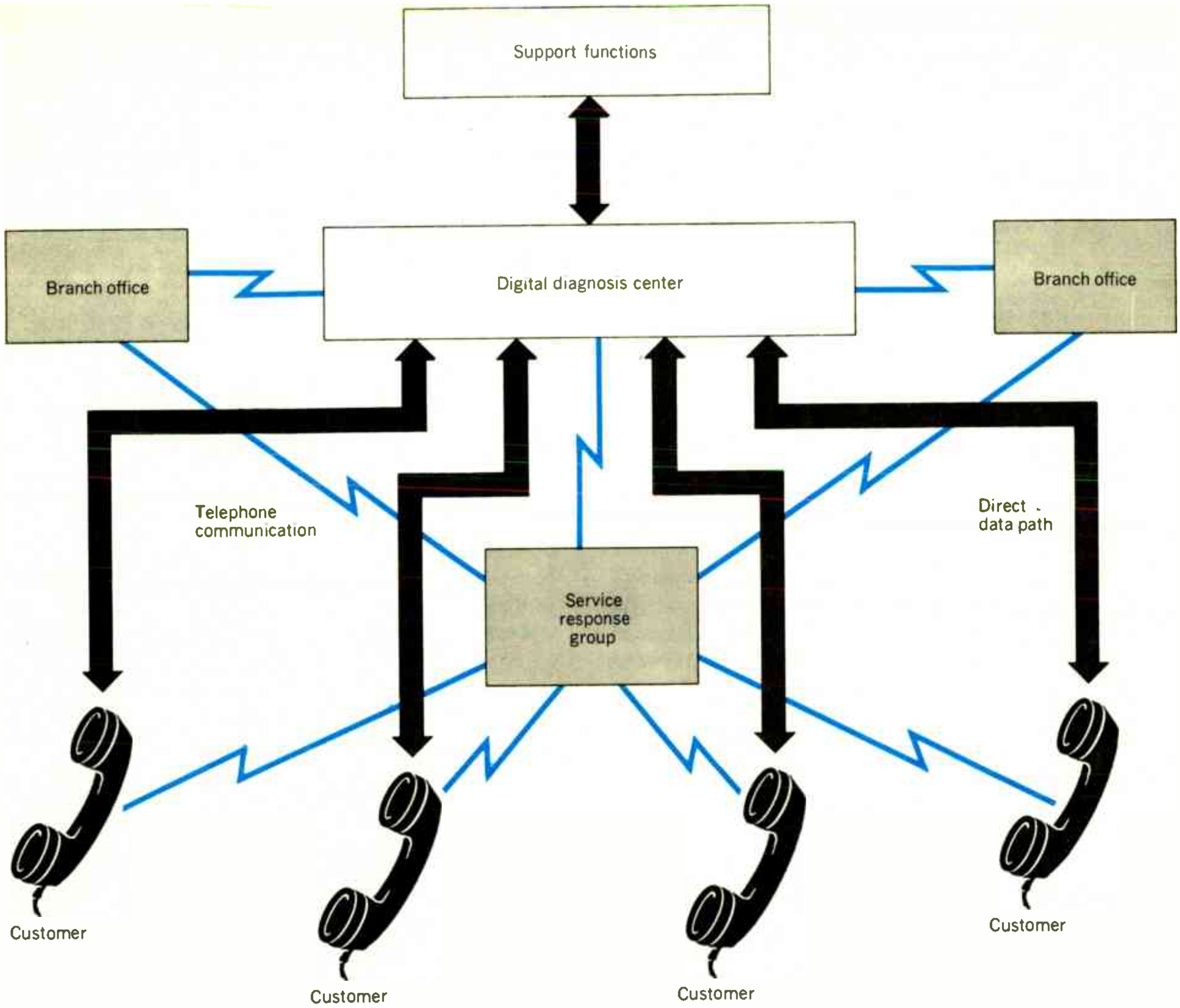
A primer on various testing techniques

A number of testing techniques have been incorporated in field-service instruments; the most prominent of these are in-circuit emulation (ICE), cyclic redundancy check (CRC), better known as signature analysis, and transitional redundancy check (TRC).

Pioneered by Intel Corporation, ICE is a technique in which the functions of the microprocessor in a system under test are imitated by an external device, or "emulator." The emulator usually is attached to the subject system by an umbilical cable into the socket of the microprocessor, which has been removed. In essence, the microprocessor is replaced by an emulator and the system under test operates as if it were still under control of the microprocessor. Since its program is the controller, the emulator allows the setting of hardware breakpoints, stepping through program instructions, and examining, displaying, and alternating CPU registers, memory, and I/O ports. The technique thus allows monitoring as well as control of a system being tested for hardware and software faults.

Popularized in field-service instruments by Hewlett-Packard as signature analysis, CRC is used to detect faulty components in inoperative digital systems, by exercising a system with a stimulus pattern that produces verifiable digital signatures at circuit nodes. The stimulus pattern is generated by using serial shift registers with feedback loops to form polynomial pulse codes. The loops provide the registers with prior and current data. Signature analysis, used in this manner, depends on the clock of the system being tested and necessitates the opening of feedback loops in the circuit under test.

A technique pioneered by the Data Test Corporation, TRC evolved from a serial transmission test technique known as longitudinal redundancy check. This form of signature analysis involves analyzing a logic pattern by counting the number of logic transitions. (CRC is based on logic pulses, not transitions.) The four least significant digits of a transition count are usually stored in memory, and are used as known good signatures (from a known good circuit) and compared with matching signatures at various circuit nodes. Unlike CRC, TRC is based on the use of counters and is asynchronous in operation.



[5] A promising technique to cope with rising demands on digital-field-service organizations is remote diagnostics of computers, such as the Remote Computerized Diagnosis for Digital Equipment Corporation's PDP-11/70 minicomputer users. This service, provided by the company as part of its service contracts, enables accurate diagnosis of minicomputer system malfunctions, and makes repair recommendations remotely in advance of a service call.

Instrument makers have also been anticipating this trend toward remote diagnostics by designing remote-control capabilities into their instruments. For example, Millenium Systems is looking into the possibility of operating its Microsystem Analyzer remotely, by downloading test programs for the instrument over the telephone lines. All a service technician would need to do would be to dial a remote service center and request the latest on a specific test program to be dumped into a blank PROM that the technician would be carrying. The company is also investigating the possibility of total direct control of the instrument, remotely.

Omnicomp's PSP has also been designed for remote diagnostic capabilities. The instrument contains RS232- and V-24-compatible asynchronous and synchronous interfaces for connection to data-processing equipment for test-program transfers An acoustic coupler and modem on the instrument allow telephone communications between the PSP and a central data base for test-program downloading, or between several such instruments. Two PSPs can also be operated in a master–slave mode so that a remote PSP can be controlled by an operator using another PSP.

Serviceability starts with the designer

Simple-to-operate service instruments that permit rapid troubleshooting of downed systems are proliferating. Even the role of test instrumentation in a service organization is increasing. Yet, despite these facts, both instrument and computer-equipment manufacturers almost completely agree on one thing: No single service instrument, no matter how powerful, can do the job alone, particularly if a product was not designed for serviceability at its conceptual stage.

O. Douglas Greenwood, vice president of Data Test Corporation, the oldest automatic test equipment manufacturer in the business, advises that a life-cycle testing philosophy be established. "This means that engineering, production, and service engineers must work together to produce a most serviceable product, backed by compatible and available test equipment and programs," he says.

The recent service-instrument developments suggest that the needs of the computer and terminal-equipment manufacturers have been met only partially, and that many more good answers are needed to satisfy them completely. ◆

Biomedical

For diabetics: an electronic pancreas

A bionic device implanted below the human diaphragm will deliver insulin into the peritoneum and be inductively programmable

My wife and I returned to Albuquerque from San Francisco on a Saturday afternoon at the conclusion of WESCON. We knew that our youngest daughter was ill. Her illness has been diagnosed as a simple viral infection and she had been left in the care of her grandmother. When we saw her, we were shocked. She had lost about 15 pounds, was hyperventilating, the muscles in her face were in convulsion, and she was unable to keep down any food or liquids. We immediately called our physician, who reconfirmed his initial diagnosis and told us not to be alarmed. At about 5:00 a.m. on Sunday, we rushed her to the emergency ward of the local hospital. By this time, she was completely unintelligible. Two hours later, her condition was diagnosed as diabetes with an extremely high blood-sugar level. Immediate treatment with insulin and intravenous fluid injections was begun. It took another 48 hours before our daughter's blood-glucose level began to approach normal and she regained consciousness.

Diabetes is a major health problem for millions of people throughout the world—ten million in the U.S. alone—and a major portion of that problem is the requirement that insulin be delivered into the body periodically to maintain normal blood-glucose levels. Now, as a result of biomedical engineering progress, a solution may be at hand: a miniature, low-power bionic pancreas that should be available within the next three to five years for implantation in humans with diabetes. The device would be programmed to deliver insulin into the peritoneum (the membrane lining the cavity of the abdomen) at a low rate, and would automatically reduce that rate even further during sleep. Higher insulin-delivery rates would be programmable externally to obtain suitable insulin levels following meals.

Two other approaches, nonengineering in nature, are also presently under investigation. The first is based on the assumption that diabetes is a genetically caused disease that may be brought on by a viral infection and that the body's antibodies, in reacting to that virus, attack not only the virus but also the islet cells in the pancreas that secrete insulin. Researchers are seeking to isolate the diabetes virus and develop a serum to kill it. The second approach involves transplantation of islet cells from healthy individuals to the diabetic. Here, the major problem is to keep the diabetic host from rejecting the transplanted cells through immune reactions. Radiation of transplanted cells and chemotherapeutic treatments can help alleviate the difficulty.

The artificial pancreas

A major step forward in controlling blood sugar in diabetics undergoing surgery or childbirth was the development of the artificial pancreas. This work originated in Toronto under A. M. Albisser, and a unit, which has not yet been certified for patient care in the U.S. but is in wide use elsewhere, is being manufactured by Miles Laboratory of Elkhart, Ind.

W. J. Spencer Sandia Laboratories

The system concept of the Miles artificial pancreas is shown in Fig. 1. The device delivers insulin and glucose intravenously while monitoring glucose levels in blood samples drawn from the patient. The blood samples are monitored on a real-time basis. Output of the glucose sensor is fed into a minicomputer that contains algorithms for delivering either insulin or glucose, depending on the blood-glucose levels in the evaluated sample. The algorithms are insensitive to small variations of blood glucose but produce large outputs when the glucose swings away from the normal level of about 100 milligrams per deciliter (100 milliliters). The output of the minicomputer activates either an insulin pump or a glucose pump, depending on the patient's needs.

The artificial pancreas described has enabled diabetics to undergo surgery without the major complications of blood-sugar imbalance and improves the probability of normal children being delivered from diabetic mothers. Experience has shown that the equipment almost always provides insulin rather than glucose.

On the negative side, the equipment is rather unwieldy and can be used only with bedridden patients. In addition, the blood-glucose sensor has a very limited life and must be changed every few hours. (A major effort to develop long-lived, miniature glucose sensors is underway at the Joselin Clinic in Boston under the supervision of J. S. Soeldner.)

Open-loop systems

If one were able to determine a priori what the insulin needs of an individual would be as a function of food intake, exercise, or other activity, the insulin requirement could be preprogrammed, thus eliminating the need for a glucose sensor as a feedback control. It would then be possible to use much smaller equipment for insulin delivery. Such a system would operate open loop and the diabetic, with an awareness of dietary and exercise demand (or the diabetic in conjunction with his or her physician), would provide the decision to close the loop.

Experiments with open-loop systems are being carried out at many locations, including West Germany and

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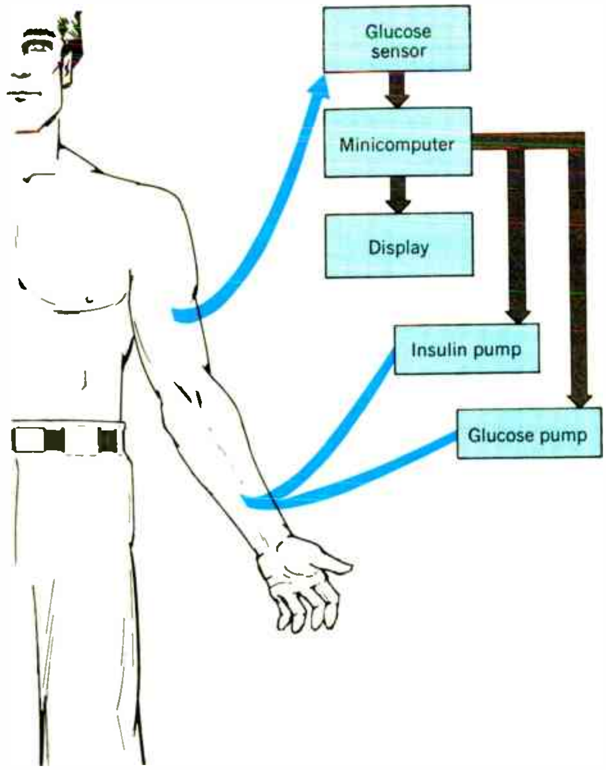
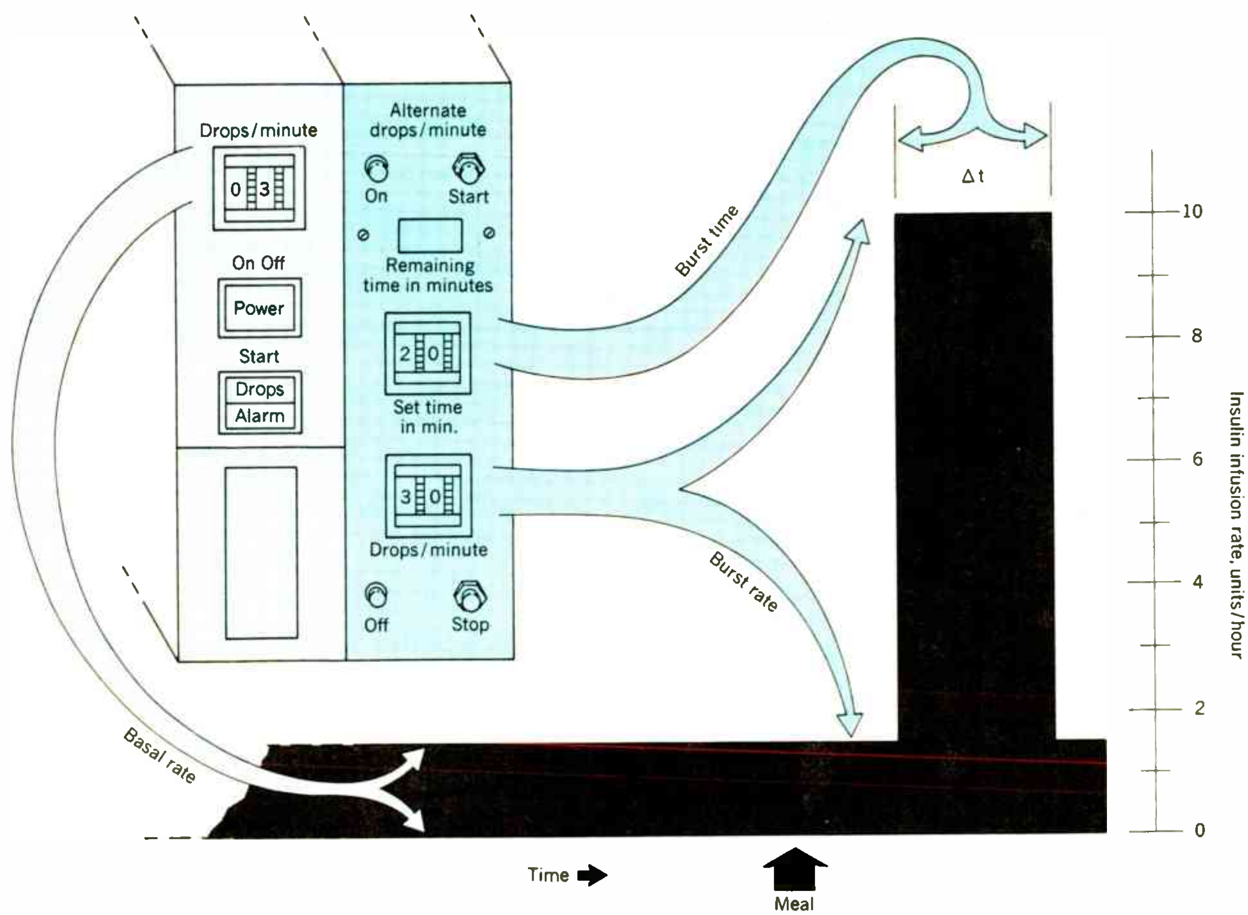
Canada, and Ohio and New Mexico in the United States. The experiments at the University of New Mexico include a standard hospital pump (the IVAC 130) modified by Sandia Labs to provide insulin in the same way that the pancreas does in a nondiabetic individual. The 5-kg pump, which has a drop counter in a feedback loop to insure constant infusion-delivery rates, operates either from internal batteries or from 110-volt, 60-kHz sources.

Normally, the system (see Fig. 2) functions as follows: A low-level basal infusion rate of about one to two units per hour is chosen by a set of dials. After a meal, the pump is actuated to deliver a higher rate (normally eight to ten times the basal rate) for a preset time (20–30 minutes). The high rate is timed automatically and the pump returns to a low rate at the end of the preset time period. While the pump is on a high rate, a set of light-emitting diodes in a display shows the time remaining for the high-mode delivery. An alarm sounds if the pump fails to deliver insulin at the programmed rate.

The level of control of blood-glucose and serum-insulin levels was measured for a diabetic patient being treated at the University of New Mexico Medical School. They were similar to those shown in the illustration in the box on page 40 for a typical diabetic individual who is taking insulin subcutaneously. Results of the first pump study on the New Mexico patient showed a dramatic improvement in blood-sugar levels, but not enough insulin was delivered to bring these levels back to normal. In a second pump study, with insulin delivery increased from seven to ten units per hour, blood-sugar levels were dramatically improved and the glucose levels following the noon and evening meals were similar to those of a nondiabetic—but there was still an insufficient amount of insulin following



[1] Closed-loop system monitors patient's blood-glucose level and delivers needed amounts of insulin or glucose to bring the glucose level as close to normal as possible.



[2] Open-loop insulin-delivery system is programmed to deliver specific amounts of insulin for predetermined periods of time and different times of day. The diabetic patient and the physician close the loop.

The nature of diabetes

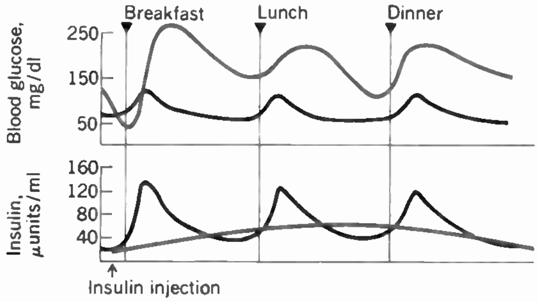
Diabetes is a series of diseases, all of which are characterized by a blood-sugar imbalance. In one form or another, it now affects about 5 percent of the U.S. population, or about ten million individuals.

Diabetes is not a well-understood disease. Its symptoms are not widely known. However, it can be categorized as two general types. The most severe form is manifest generally in young children about the age of puberty and occurs more often in girls than in boys. The main characteristic of "juvenile-onset" diabetes is a complete lack of insulin secretion regardless of onset age. Maturity-onset diabetes, on the other hand, generally is characterized by an inefficiently operating pancreas and also by tissue resistance to the action of insulin to lower blood glucose. Insulin normally secreted by the pancreas is a complex amino acid that is extremely important in the metabolism of carbohydrates. Lack of insulin results in high levels of glucose in the blood. Unmetabolized glucose causes the reactions described in the opening personal drama and, if untreated, ultimately leads to death. With inefficient insulin secretion and/or tissue insulin resistance, the complications are not so severe.

How much control

The control a diabetic can maintain is usually measured by determining the level of glucose in the blood. In actuality, a diabetic not only has abnormal insulin and glucose levels but also has imbalances in other important hormone and amino acids. However, even though there is no assurance that if insulin and glucose levels are made normal all other blood chemicals will resume their normal balance as well, there is some evidence in that direction.

The accompanying illustration shows glucose and blood-insulin levels for normal and diabetic individuals during a typical three-meal day. For a nondiabetic, glucose levels normally run about 100 mg/dl (milligrams per deciliter or 100 milliliters) of blood serum and do not vary appreciably over a 24-hour period. There is, however, some fall in blood glucose following heavy physical activity. In a normal individual, blood-insulin levels (which maintain the glucose levels) increase sharply after a meal when the pancreas is stimulated to secrete large amounts of insulin. Typically, they will increase from about 10 microunits/ml to as much as 100 microunits/ml. The amount of insulin secreted



Glucose and insulin levels throughout the day for a normal individual (black curves) and for a diabetic (colored curves).

depends on the type of food consumed, body weight, activity following a meal, and several other variables.

Blood-sugar levels for a diabetic are shown in color. It is assumed that the diabetic took a single subcutaneous injection of a mixture of long-lasting and regular insulin just before breakfast. After a meal, the glucose level rises to a much higher degree in the diabetic than in the normal individual. The amount of rise depends on a number of factors but may be as much as 300 or 400 mg/dl. The curve shows that, instead of peak insulin pulses following meals, the diabetic has a slow rise in insulin following the injection in the morning. The insulin level peaks about midafternoon or early evening and then tends to taper off.

Diabetics often increase control of insulin levels by using multiple injections during the day. However, this type of control leads to discomfort and possible serious skin and subcutaneous tissue degradation.

Long-term complications

The Juvenile Diabetes Association lists diabetes as the third leading cause of death in the U.S. Diabetes is the major cause of blindness and contributes to other cardiovascular complications. These long-term complications in diabetics are believed to be related to the imbalance in blood glucose.

The major question still to be answered is whether or not better blood-glucose control will alleviate the long-term complications of diabetes.

breakfast for normal glucose levels. These results have been repeated for many juvenile-onset diabetics.

The results using single-step delivery of insulin following meals are extremely encouraging and the modified hospital pump has been entirely satisfactory for postmeal intravenous delivery of insulin in a pulse mode.

The desire to treat mobile diabetic patients led to development of a pump and reservoir small enough to be carried in a vest worn by the patient. The pump delivers insulin intraperitoneally rather than intravenously, which offers several advantages. For example, problems of clotting and infection are considerably fewer in the peritoneum than in the vascular system. Also, there is no variation in pressure in the peritoneal cavity as there is in the vascular system, which means that low-power pumps can be used without fear of pump-rate variations as the pressure into which the pump is working changes.

Moreover, with peritoneal delivery, the total rise in blood-insulin levels is much less and their fall is not as rapid as when delivery is intravenous. The amount of insulin absorbed and appearing in the peripheral blood system is about half that measured when the same amount is delivered intravenously, which indicates that the insulin is probably being absorbed directly into the liver. Blood-glucose levels are under good control as well. All in all, peritoneal insulin delivery is an exciting prospect.

Seeking a better pump

Use of electronically controlled pumps in both closed- and open-loop systems leads to the next step: the possibility of building a completely implantable system for pulse-mode delivery of insulin. The electronic controls are miniaturized in a straightforward way using custom silicon integrated circuits. The main problem lies in finding the best pump system.

As indicated in Table 1, today's pumps fall into three categories: piezoelectric, electromechanical, and bellows. The major advantages of the piezoelectric pump are small size and low power consumption. However, it has disadvantages of low pumping pressure head and difficulty in priming that must be overcome before it can be considered an implant possibility.

At present, almost all experiments with external pumping systems employ peristaltic pumps driven by an electric motor geared down to provide very slow motion. Since pumping rates in an implanted system will probably run between 0.25 and 0.5 cm^3 per day, motor speeds either must be very low or the outputs must be geared down suitably. An attractive alternative to small electric motors is a modified stepping motor. A miniature stepping motor used for certain nuclear-weapon applications and a miniature peristaltic pump are shown in Fig. 3. This pump is capable of putting out about 5 oz-in of torque (3600 g-cm), sufficient to drive the peristaltic pump and to provide the low pumping rates required for insulin delivery in an implanted system.

All of the electromechanical motors require more power than the piezoelectric pump. The stepping motor shown in Fig. 3 could deliver a basal insulin supply with insulin bursts three times a day, following meals, for more than five years, while operating from a 4-ampere/hour lithium iodide battery developed for cardiac pacemakers.

Each of the pumping systems described requires a reservoir in order to operate. A pump combined with a reservoir that was developed at the University of Minnesota and is being produced by the Metal Bellows Company of Sharon, Mass., is the only pumping system that has had implant experience to date. It is filled by using a syringe to inject fluid through the skin and refill septum into a reservoir. As the fluid is injected into the reservoir, it expands, compressing a freon-type gas in the outer chamber into liquid form. At a constant temperature, the freon gas has a constant vapor pressure. Thus, the bellows pump has a constant pumping pressure over 80-90 percent of its fill. By using a suitable restrictor on the output of the pump, pumping rates as low as 0.25 cm^3 a day have been achieved. This type of pumping system has been used to deliver heparin in animals and humans and in chemotherapy treatment of cancer in humans. Pumps have been implanted for periods of up to four years without malfunction.

To provide a pulse delivery of insulin, a bellows pump requires two outputs: a slow output to maintain the basal rate of insulin delivery between meals and a higher delivery rate for pulse delivery of insulin after meals. Such a delivery system is being constructed jointly by Metal Bellows and Sandia Labs.

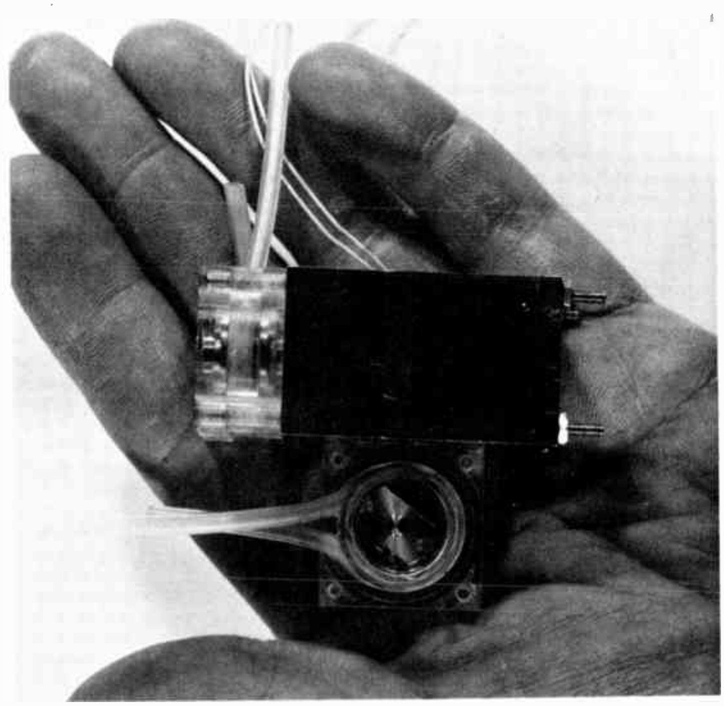
Electronic controls

Electronic controls for any of these pumping systems would have to be built from low-power silicon integrated circuits. The two most promising technologies are complementary metal oxide semiconductor (CMOS) devices and integrated injection logic. Experience at Sandia has been with bulk CMOS. A typical control board for insulin delivery experiments contains about 20 small- and medium-scale integrated circuits. When monitor functions and external programmable controls are added to these circuits, they probably will require about 2000 transistors.

A block diagram of a proposed remotely programmable insulin-delivery system is shown in Fig. 4. The control information is programmed by feeding electromagnetic pulses inductively through the skin and into a ferreed switch. The opening and closing of the switch provide the pulses that set the three parameters needed for insulin delivery: basal rate, burst rate, and burst time period. Each of these control parameters requires about 8 bits of information. Thus, an entire program fed into the control unit will consist of only 24 bits. To ensure that information is fed in properly, a redundant code pulse series will be used—which will increase the number of bits necessary to about 72. As experience is gained with external insulin-delivery systems, additional monitor circuits will be needed and these will require additional programming bits.

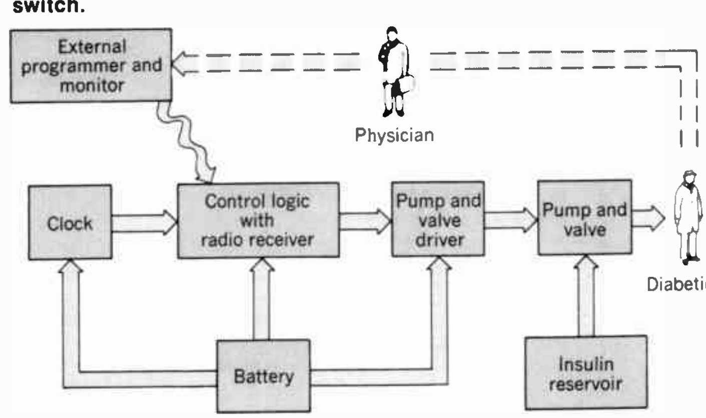
Where do we go from here?

Researchers at the Harvard Medical School say that the bionic pancreas should be available within the next decade



[3] Miniature stepping motor is attractive for insulin-delivery systems using peristaltic pumps.

[4] Components of a remotely programmable insulin-delivery system with insulin reservoir. External programming is accomplished by sending inductive electromagnetic pulses through the skin and into a ferreed switch.



I. Summary of insulin pumps considered for implantation

	Pressure	Volume	Power	Size	Implant Experience	Electronic Controls
Piezoelectric pump	1 mm Hg/volt	μl/stroke	Low	Small	No	Available, high voltage
Electromagnetic pump	Adequate	μl/stroke	Moderate	Small	No	Available,moderate power
Bellows pump	250–750 mm Hg	0.25-cm³/day	Very low	Moderate	Yes	Available

and the biomedical groups at Sandia and the University of New Mexico subscribe to that concept. What then are the major hurdles still to be overcome?

A large number of experiments with open-loop insulin-delivery systems are now in progress. Experiments are only beginning on intraperitoneal insulin delivery, but the technique appears to be very promising.

Improvements in insulin-delivery systems are needed, especially in the areas of monitoring and control. Direct fluid-flow monitoring needs to be incorporated in future systems. Battery status, remote programmability, and a variety of other information must be available to the medical researcher. Smaller, longer-life, lower-power insulin systems—all for external use—must be developed. Present systems are unsightly, lack human engineering, and require skilled technicians to adjust and use them. In general, these improvements can be brought about through the use of standard integrated circuits. Fully customized silicon integrated circuits will not be required for some time.

External insulin-delivery systems for use in experiments with humans offer a rich source of information with a minimum of risk. The reports of such experiments are encouraging and should result in wider acceptance of the concept of pulsed insulin delivery for better glucose control. Computer analyses of blood-glucose and blood-insulin data in terms of insulin-delivery algorithms are also necessary. Mathematical modeling of the entire human body as to insulin storage and use appears feasible and should prove of value when insulin-delivery modes are being chosen for future systems. Various experiments of this type are underway and need to continue with better devices.

Experiments with external systems also are being carried out on animals. Implants will soon follow but remote programmability of units will be required before useful implants can be accomplished successfully. One such unit under construction employs a bellows pump and standard integrated circuits. Plans are to perform first implant experiments this year. Flow monitoring and certain circuit functions will be read out from the implanted unit on a continuous basis. Programming will be done in a manner similar to that used in modern pacemakers. Electromagnetic induction will be used to couple digital pulses into an implanted control circuit.

Assuming that no unforeseen or insurmountable obstacles arise, the combination of external human experiments and animal implant experiments should lead to the development of a miniature, low-power bionic pancreas for experimental human implants within three to five years.

Human-implant unit

The initial human-implant unit might be about 150 cm³ in volume, with a density of approximately one. A 30- to 40-cm³ refillable reservoir should permit 60-day operation between insulin refills. The device will be programmed to deliver insulin at a low adjustable background rate with an automatic reduction during periods of sleep. Higher insulin-delivery rates will be actuated by an external programmer. Insulin levels suitable for snacks, regular meals, and even banquets will be available, and the unit will be capable of complete shutdown if necessary. A variety of diagnostic information will be read out of the implanted unit, including flow rate, control status, reservoir-fill factor, and battery status. Battery life should be in excess of five years.

The unit will be implanted below the diaphragm and will deliver insulin into the peritoneum. Insertion and removal will be accomplished under local anesthesia.◆

The remotely programmable insulin-delivery system work that is described in this article is a team effort by people with diverse backgrounds. Key members of the team are P. Eaton and D. Schade of the University of New Mexico Medical School and W. Corbett and B. D. Shafer of Sandia Labs.

For further reading

- There are two books entitled *Diabetes Mellitus*. That published by the American Diabetes Association, New York, N.Y., contains papers written by a variety of authors discussing various aspects of juvenile- and adult-onset diabetes, and, along with other information, is available from the Association. The other book, now in its sixth edition, is published by Eli Lilly. This discussion is better organized in many respects than the American Diabetes Association book.
- The artificial pancreas was reviewed recently by A. M. Albisser in *Archives of Internal Medicine*, vol. 137, May 1977, pp. 639–649.
- A review of work on blood-glucose control has been prepared by R. Philip Eaton at the University of New Mexico and appeared in the first issue of *Diabetes Care*.
- Two medical journals, *Diabetes* and *The New England Journal of Medicine*, carry many articles on diabetes.
- The American Diabetes Association publishes a monthly magazine, *Forecast*, with informative articles on diabetes for a general audience.

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Power/energy

System security: the computer's role

Several security-related functions can be aided by the digital computer, and linked together by a software scheme

Can computers in power-system control centers prevent blackouts? The answer is yes—and no. Apparently they cannot control a power system so that it will not become unstable. However, they can provide substantial help to the human who is operating the system. In addition to their contributions to various operational functions (see box on p. 50), computers assist the operators in preserving the system's security—its freedom from danger or risk.

Security functions are now incorporated into computer programs to deal with operating conditions as well as with disturbances that could lead to equipment overloads, voltage degradation, frequency decay, system instability, service interruption, or the ultimate catastrophe of a system shutdown. This article discusses how these functions fit into the overall control structure of a power system, and summarizes the extent to which they have been realized in today's power-system control centers. It complements an earlier article by Fink and Carlsen (Mar., pp. 48-53), which discussed in more formal terms and technical detail the problems, approaches, and research needs associated with these functions.

Security-related decisions

In essence, the security functions help to keep the power system in the "normal" state. To clarify the digital computer's role in carrying out these functions, consider the following sequence of operating decisions:

1. Using real-time system measurements, identify whether the power system is normal or not. If the system is in an emergency, go to step 4. If load has been lost, go to step 5.
2. If the system is normal, determine whether it is secure or insecure in the event of a next-contingency.
3. If it is insecure—i.e., there is at least one contingency that can cause an emergency—determine what preventive action should be taken to make the system secure.
4. Execute proper corrective action to make the system normal.
5. Restore service to system loads.

We refer to the function in step 1 as "security monitoring." Steps 2 and 3 make up "security analysis" and steps 4 and 5 are "emergency control" and "restorative control" respectively.

Security functions in system control

Figure 1 portrays a proposed scheme for computer software organization that links the various security-oriented functions together. Also shown are certain other important functions, which are required to support the security-oriented functions. (Less important functions have been omitted for clarity.) At the present state of the art, only those security functions are realizable that relate to steady-state conditions, whereas the dynamic security functions are still a subject of research. However, the following concepts, as shown in the illustration, can be applied to the dynamic security problem (although not to its implementation).

Measurement data on bus-voltage magnitudes and phase angles, as well as on the status of circuit breakers and switches (i.e., open or closed), are continuously fed into the computer. Also inputted, this time manually by the operator, are other data, including information on external power systems connected to the system under discussion. Glaringly bad data, such as transient excursions in the measured values, are rejected by "*filtering*" the incoming data through a simple check of their "reasonability" or of the consistency between breaker status and analog information, or by means of an averaging routine, which smoothes out the excursions.

Although the proposed software scheme could conceivably use the real-time data directly from the power system, there are benefits to be gained by first processing the data by *state estimation* (SE) procedures. These produce, from a limited set of system measurements, a "best" estimate of the vector of bus-voltage magnitudes and phase angles of the entire network. The measurement set is understood to contain an adequate degree and spread of redundancy to allow the statistical correlation and correction of the measurements, to permit the detection, and preferably identification, of bad data, and to yield calculated values for nontelemetered quantities. The resulting information helps to determine, at a given moment, the real and reactive power injections into each node of the power network (the injection vector).

Security monitoring (SM) is the on-line identification of the actual operating conditions of a system by checking real-time data to determine whether it is in a normal, emergency, or restorative state. Auxiliary to the SM function is the determination of the actual network topology from the filtered data, which involves systematic processing of real-time information about the status of circuit breakers and switches. *On-line load flow* (OLF) employs a detailed model of the power network, which is continuously updated from the information about the network's topology. The OLF function requires, as input, an equivalent of the external power systems that are connected to the particular system, and a method for adjusting this equivalent to match the real-time conditions.

If a power system is verified as normal by the SM procedure, the *security analysis* (SA) function is invoked to

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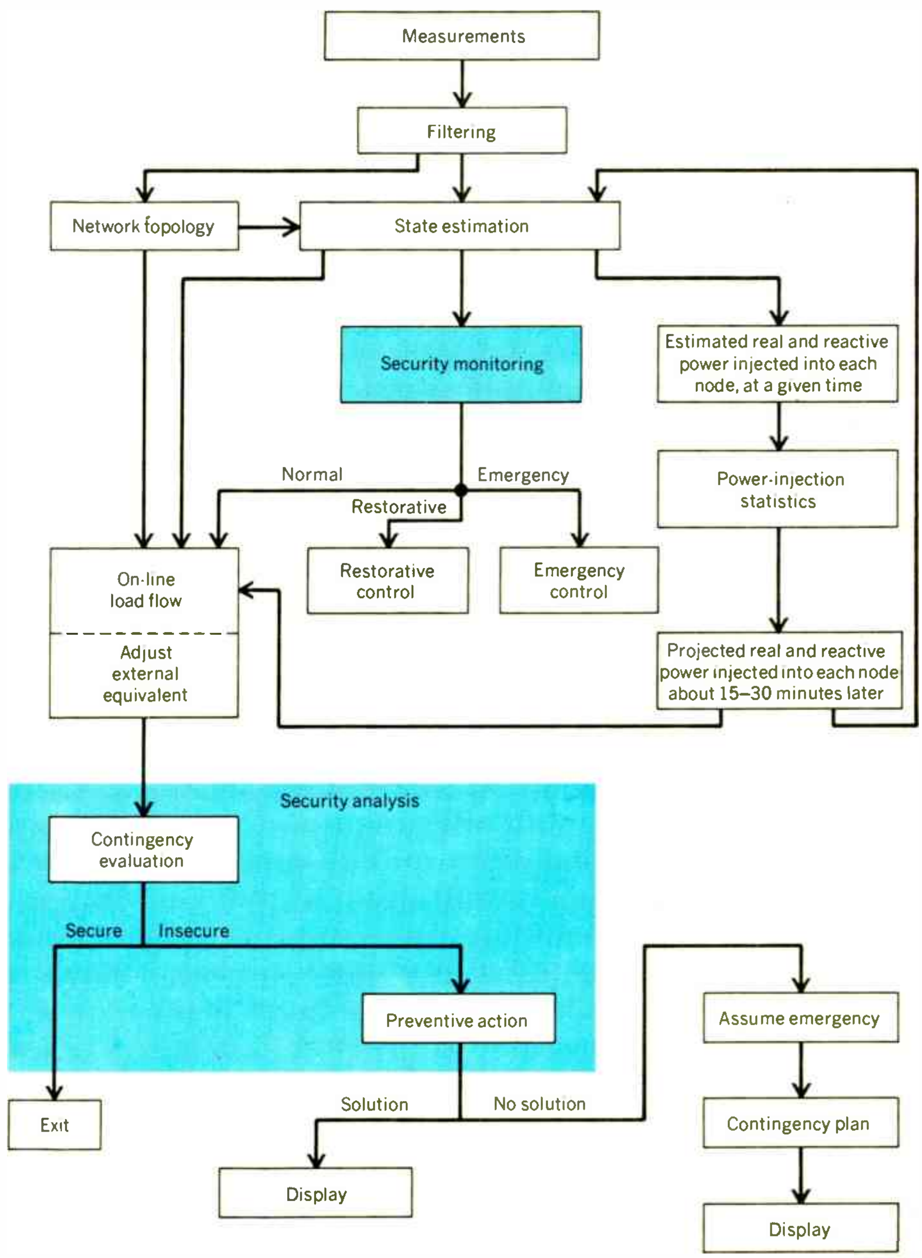
check on its security level. SA consists of a *contingency evaluation*, which utilizes OLF to determine whether the system is secure or insecure, and it also determines what *preventive action* should be taken to make an insecure system secure, or less insecure. Basically, contingency evaluation answers the question, "What if a next-contingency out of a set of probable contingencies takes place?" The possibilities are that either the system will ride through the disturbance and settle down to a normal state, or it will find itself in an emergency. In the latter case, the system is insecure and the contingency-evaluation function must inform the operator as to which contingency is causing the insecurity and of the nature and severity of the anticipated emergency.

The concept of a next-contingency set as a reference for the "what if" question is a sound operating strategy. The system operator should always check whether a next-contingency would cause a problem, especially when the system has already undergone one or more equipment outages due to previous disturbances or operating actions. The contingency-evaluation routine of SA does this for him.

Preventive action requires an optimization routine, or optimum power flow (OPF). Although the literature abounds with optimization techniques, there is still no OPF suitable for use in preventive action. For the sake of this discussion, however, let us assume that a preventive-action solution can be found, optimal or not. Since the power system normally is operated at minimum operating cost, system security will have to be obtained at a price. If the cost of the preventive action is small, the operator can place the control in effect. Where the cost is high but the contingent emergency not too severe, the operator may decide not to take any action to improve system security. He may confirm this decision by running a study to verify that emergency control steps can correct the situation should the contingency take place.

Because of the restrictions on the number of feasible controls, it is not always possible to find a preventive-action solution. In such cases, a *contingency plan* would be developed by assuming that the contingency has occurred and by running the OPF with the objective of minimizing the amount of load to be curtailed. This contingency plan, which, in effect, anticipates emergency



[1] More and more computer programs for energy control centers include at least some of the functions portrayed here, which can help operators maintain system security—namely, the freedom from danger or risk. In this prosposed scheme, measured data from the power system, as well as other data normally supplied by the operator (including information on other systems connected to the power system under discussion), are fed into the computer. After filtering out "bad" data, the network topology is derived. A statistical "state estimation" procedure helps obtain the "best" estimate of system parameters from a limited set of measured data. Procedures such as security monitoring and analysis help alert operators to developing emergencies. Useful for evaluation of contingencies are the data on the system's load flows, which continuously take into account flows into and from external power systems connected into the system under discussion.

control, places the system operator in an alert, ready mode. Without it, the operator would be unprepared for an emergency requiring fast corrective action.

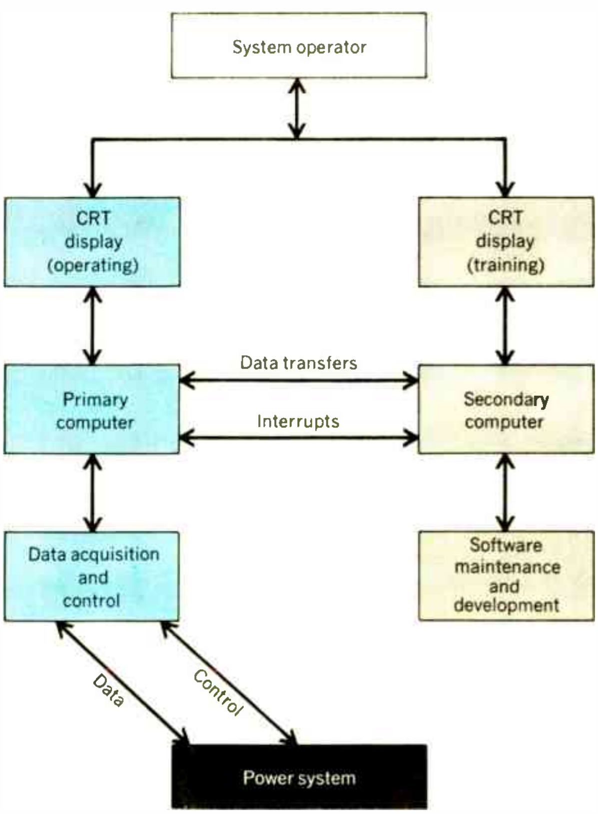
If SM finds the system to be in an emergency or near-emergency state, corrective action via *emergency control* may be executed manually or automatically, depending upon the severity of the emergency. If it is not very critical, corrective action may be achieved by shifting generation from units in trouble to other available units. That is, an OPF routine is part of emergency control. Since the objective of emergency control is to bring the system to a normal condition, although not necessarily a secure one, the OPF problem is not as complex as that for the preventive action. Still, there are no on-line OPF techniques for emergency control.

Severe steady-state emergencies may require immediate load shedding. This can be done manually by supervisory control or automatically by the computer. The OPF would be used to determine the minimum amount of total load to be dropped and at what points of the network the component loads are located.

If the overload is very slight, the operator may decide to ride it out, as the system loading may be decreasing or there may be ample time for field maneuvers to relieve the overload.

Restorative control is achieved almost completely by manual action. Its difficulty depends not only on how much generation and transmission are available but also on the operability of auxiliary facilities necessary to place equipment back in service. For an extensive shutdown,

[2] A dual, redundant computer system like this one is the most common computer configuration used in designing control centers for power systems. In the event of failure of the primary computer, an automatic fail-over scheme can detect the failure and "transfer" all of the critical functions of hardware and software to the secondary computer, which, in effect, becomes the new primary one.



restoration would require an orderly, coordinated procedure of bringing up generation, putting the transmission back together, and picking up load—all in steps and at such a pace that dynamic imbalances in generation versus load and constrictions in transmission capability would not occur to take the system back down again. To carry out this process, the operator would use the security monitoring function to keep track of what the system is doing in terms of status, power flows, voltages, and frequency and supervisory control (see box on p. 50).

Security functions implemented

More and more control centers for real-time monitoring and control of power systems are being installed throughout the world. Some 80 control centers are now in service or under development (Table I) that have, as a minimum, automatic generation control and security monitoring (the other security functions are not yet in wide use). About 50 of these centers are in the U.S.; others are located in West Germany, England, Japan, Norway, Switzerland, France, Canada, Belgium, Sweden, Italy, Spain, Poland, Romania, Hungary, Finland, Israel, Taiwan, Korea, Australia, South Africa, and Argentina. In addition, a number of utilities in the U.S. and elsewhere are in the process of identifying their needs, preparing specifications, or reviewing proposals for new control systems, all of which will include security functions.

At present, 11 control centers have state estimation in service—and this number is increasing, if slowly. Most new control center contracts and specifications call for state estimation, and by the end of 1980, some 35 centers—25 of them in the U.S.—will have SE in operation. Actually, SE should be a part of every control center with any concern for system security.

The on-line load-flow function is in use to about the same extent. Only 11 control centers now have OLF in service but, by the end of 1980, this number should increase to about 38, or almost 50 percent of the control centers.

The utility decision-makers' lack of familiarity with state estimation and its importance to real-time operation has been a prime deterrent to a more widespread application of this technique, but the only explanation that may be given for the low level of usage of the more familiar OLF is its cost. However, the cost-effectiveness of new computers and the pressure for operator training should encourage more utilities to install OLF—which is a must for steady-state simulation of what happens to power systems when certain network changes occur.

Contingency evaluation is in service at 20 control centers, and by the end of 1980 some 45 centers should have this function. This includes control centers that use linear sensitivity factors instead of OLF for CE. The linear factors are derived from passive network models and are used directly with the telemetered line flows. The disadvantages of this method are its inherent inaccuracy and its assumption of the availability and accuracy of measurements, its inability to predict voltage problems, and the cumbersome procedure involved in the on-line update of the factors. Of the 25 control centers that are planning to implement contingency evaluation in the 1978-81 period, only three will use the linear approach.

On-line optimum power flow is in use at only two U.S. control cednters, and these are limited to supporting the economic dispatch calculations. By the end of 1980, three

I. Power-system control centers around the world—practices and trends

In Service	Company	Computer System and On-Line Functions*
June 1969	Michigan Electric Power, Ann Arbor	1 GEPAC 4020 + 1 GEPAC 4060 + 2 GEPAC 4010 + data links to two member companies (AGC, EDC, SM, SA)
June 1970	New England Power Exch., West Springfield, Mass.	1 SIGMA 2 + 1 SIGMA 2 + data links to four satellite computers (AGC, EDC, SM)
July 1970	Pennsylvania-Jersey-Maryland (PJM) Interconnection, Norristown, Pa.	Dual IBM 370/158 + two IBM System 7 + data links to nine pool member locations (AGC, EDC, SM, SA)
Dec. 1970	Central Electricity Generating Board, London, England	Dual ARGUS 500 + data links to seven regional centers (SM, SA, OLF, OSC)
Oct. 1971	Kyushu Electric Power, Fukuoka, Japan	1 TOSBAC 7000/20 + 1 TOSBAC 3000 (AGC†, EDC, AVC, SM, **SA, SBC, SE, OLF**)
Nov. 1971	Houston Lighting & Power,	Duplex SIGMA 5 (AGC, EDC, SBC, SVC, SM, SA, OLF, PLSC)
Mar. 1972	Norwegian Water Resources & Electricity Board, Tokke	1 NORD 1 (AGC, EDC, SE, SA, EC, OLF)
June 1972	New York Power Pool, Albany	Dual IBM 370/155 + dual data links to eight member companies (AGC, EDC, SM, SA)
Oct. 1972	Tohoku Electric Power, Sendai, Japan	1 HITAC 7250 + 2 HIDIC 100 + 1 HIDIC 100 + data link to regional office with 1 HIDIC 500 + 1 HIDIC 100 (AGC†, EDC, SM, **AVC, SA, OLF**)
	Electric Power Utility, Laufenburg, Switzerland	1 IBM 1800 + 1 IBM S/7 (AGC†, SM, SE)
Dec. 1972	Cleveland (Ohio) Electric Illuminating	Dual SIGMA 5 + data links to five P2000 plant computers (AGC, EDC, SBC, SM, OLF, OPF, ASTA, EC, SA, **SE, SVC, ACR**)
Feb. 1973	Kansai Electric Power, Osaka, Japan	1 HITAC 8300 + 1 HIDIC 500 + 1 HIDIC 100 + data link to two IBM 370/158 (AGC†, EDC, SM, SA, OLF)
Mar. 1973	Commonwealth Edison, Chicago, Ill.	Dual SIGMA 5 (AGC, EDC, SM, SA, OLF)
	Tokyo (Japan) Electric Power	Dual TOSBAC 7000/20 + Dual TOSBAC 40C (AGC†, EDC, SM, **SA**)
	General Public Utilities, Reading, Pa.	Dual SIGMA 5 + data links to PJM and three member companies (AGC, EDC, SM)
July 1973	Interbrabant, Schaerbeek, Belgium	1 Westinghouse P2000 + 1 Westinghouse P2500 + 1 Westinghouse P2500 + data link to CPTE (see Apr. 1976) (SBC, SM, SE, SA, OLF, OPF)
	Electricite de France (EDF), National Control Center, Paris	1 CII 9080 + 1 CII 9040 + dta links to five regional control centers (AGC†, SM, SA, SE, OLF)
Sept. 1973	Southern Services, Birmingham, Ala.	Dual IBM 370/158 + 4 ADS 900 + 1 (spare) + video data links to four company dispatch centers and to 13 division control centers (AGC, EDC, SM, **SA, SE, OLF**)
Oct. 1973	American Electric Power, Canton, Ohio	1 IBM 1800 + 3 HP2116B + 1 (spare) + data link to 1 IBM 370/165 (AGC†, EDC, SE, **SA**)
	Philadelphia (Pa.) Electric	Triple Burroughs 6700 + data links to two plant computers and to PJM (AGC, EDC, SM, SA)
Nov. 1973	Hokuriku Electric Power, Toyama, Japan	1 OTSBAC 7000/20 + 1 TOSPAC 3000 + 1 TOSBAC 40 (AGC, EDC, AVC, SE, EC)
May 1974	Pennsylvania Power & Light, Allentown	Dual SIGMA 5 + data links to PJM and to six division offices (AGC, EDC, SBC, SM, SA, **SVC**)
Sept. 1974	Carolina Power & Light, Raleigh, N.C.	Dual SIGMA 5 + 2 GEPAC 3010 (AGC, EDC, SBC, SM, SA)
Dec. 1974	Bonneville Power Administration, Portland, Oreg.	Dual PDP-10 + 2 PDP-11 + 1 PDP-11 + daul GEPAC 4010 + dual GEPAC 3010 + 1 GEPAC 30CS + future dual SEL85 (AGC, SM, SA, SE, **AVC, OLF**)
	Iowa-Illinois Gas & Electric, Davenport, Iowa	Dual SIGMA 5 (AGC, EDC, SBC, SVC, SM, **SA, OLF**)

*On-line functions: (bold face denotes planned functions)

† implemented by analog controller

ACR	= automatic circuit restoration	EDC	= economic dispatch control	SA	= steady-state security analysis
AGC	= automatic generation control	NOX	= minimum NOx emission dispatch	SBC	= supervisory breaker control
ASTA	= automatic system trouble analysis	OLF	= on-line load flow	SE	= state estimation
AVC	= automtic voltage/var control	OPF	= optimum power flow	SM	= security monitoring
DTA	= distribution trouble analysis	OSC	= on-line short circuit	SVC	= supervisory voltage control
EC	= emergency control	PLSC	= pipeline supervising control		

In Service	Company	Computer System and On-Line Functions*
Jan. 1975	Sierra Pacific Power, Reno, Nev.	Dual SLASH/5 (AGC, EDC, SM)
Apr. 1975	City of Gainesville, Fla.	Dual W2500 (AGC, EDC, SBC, SVC, SM)
June 1975	Public Service Electric and Gas, Newark, N.J.	Dual GEPAC 4010 + 1 GE 4050 + data links to PJM (SBC, SVC, SM, SA)
Aug. 1975	Wisconsin Electric Power, Milwaukee	Quad CDC SC-1700 + daul CDC CYBER 72-13 + data link to Wisconsin-Michigan Power (AGC, EDC, SBC, SM, SA, SE, **OLF, OPF**)
	Tennessee Valley Authority, Chattanooga	1 SIGMA 5 + 3 GEPAC + data links to five area dispatch centers (AGC, EDC, SM, **SA, SE, OLF**)
Oct. 1975	Rheinisch-Westfalisches Elektrizitatswerk (REW), Brauweiler, West Germany	Dual SIEMENS 360 (AGC†, SM, SE, SA, OLF, OSC)
	Rhode Island-Eastern Massachusetts-Vermont, Westborough, Mass.	1 GEPAC 4020 + data links to NEPEX (AGC, EDC, SM)
Nov. 1975	Technische Werke der Stadt, Stuttgart, West Germany	1 Siemens 306 + data link to IBM 370 (SBC, SM, SE, SA, OLF)
Dec. 1975	Middle South Services, Pine Bluff, Ark.	Dual SIGMA 5 + data links to three member companies (AGC, EDC, SM, OLF, SA, **OPF**)
	Detroit (Mich.) Edison	Dual SIGMA 5 + data link to Michigan Power (SBC, SVC, SM, **SA, SE, OLF**)
	Ontario Hydro, Toronto Canada	Univac MP 11/42 + 3 NOVA 1200 (AGC, EDC, SM, SE, **SA, OLF**)
In 1976	National Power Administration, Warsaw, Poland	Dual CDC SC-1774 + CDC 3170 (AGC, EDC, SM, **SE, SA, AVC**)
Apr. 1976	Societe pour la Coordination de la Production et du Transport de l'Energie Electrique (CPTE), national dispatching at Linkebeek, Belgium	Dual PDP 11/45 + data links to Charleroi regional dispatching (SM, SBC, SVC)
May 1976	Potomac Electric Power, Washington, D.C.	Dual SIGMA 9 + 4 SPC 16/65 + data link to PJM + data link to IBM 360/65 + video data link to executive office (SBC, SVC, AVC, SM, DTA, **SA, OLF**)
June 1976	Eastern Iowa Light & Power Wilton	Dual PDP 11/35 (AGC, EDC, SBC, SVC, SM)
Dec. 1976	Chubu Electric Power, Nagoya, Japan	TOSBAC 7000/20 + TOSBAC 7000/25 + dual TOSBAC 40-C (AGC, EDC, AVC, SM)
Feb. 1977	Swedish State Power Board, Stockholm	Dual SIGMA 9 + 2 CDC System 17 (SM, **AGC, SA, SE, OLF**)
Apr. 1977	Board of Public Utilities, Kansas City, Kans.	Dual WP 2500 (AGC, EDC, SBC, SM, **SVC**)
May 1977	Utah Power & Light, Salt Lake City	Dual SIGMA 5 (AGC, EDC, SBC, SVC, SM, **SA, SE**)
June 1977	Nova Scotia Power, Halifax, Canada	Dual PDP 11/35 (AGC, SBC, SVC, SM)
	Kansas City (Mo.) Power & Light	Dual CDC System 17 (AGC, EDC, SBC, SM)
Nov. 1977	Corn Belt Power Co-op, Humboult, Iowa	Dual CDC System 17 (AGC, EDC, SBC, SM)
Early 1978	Louisville (Ky.) Gas & Electric	Dual HS 4400 (**AGC, EDC, SBC, SVC, SM**)
	Fuerzas Electricas de Cataluna (FECSA), Barcelona, Spain	Dual GE 4010 + dual interdata 70 (**AGC, EDC, SBC, SVC, SM, OLF**)
	Southern California Edison, Los Angeles	Quad CDC System 17 + dual CYBER 73-16 + data links to eight switching centers + video data link to headquarters office (**AGC, NOX, SM, SA, SE, OLF**)
	Iberduero, Bilbao, Spain	Dual Duplex MODCOMP IV + data links to two regional centers (**AGC, EDC, SM, SE, OLF**)

I. (Continued)

In Service	Company	Computer System and On-Line Functions*
	Jacksonville (Fla.) Electric Authority	Dual PDP 11/40 + data links to distribution center (**AGC, EDC, SBC, SVC, SM**)
Mid-1978	Hidroelectrica Espanola, Madrid, Spain	Dual MODCOMP IV (**AGC, EDC, SBC, SM**)
	Public Service of Oklahoma, Tulsa	Dual MODCOMP IV + data links to two regional offices (**AGC, EDC, SBC, SM**)
	Minnesota Power & Light, Duluth	Dual Xerox 550 (**AGC, EDC, SBC, SVC, SM, SA, OLF**)
	Romergo National Load Dispatching, Bucharest, Romania	Dual SIEMENS 330 + data links to five regional control CENTERS (**EDC, SM, SE, SA**)
	Gas-Elektrizitats-und Wasserwerke (GEW), Cologne, W. Germany	Dual SIEMENS 330 + 1 SIEMENS 330 + data links to one regional control center (**EDC, SM, SE, SA, OLF**)
	Portland (Oreg.) General Electric	Dual MODCOMP IV + video data links to six regional offices (**AGC, SBC, SM**)
	Public Service Company of New Hampshire, Manchester	Dual SEL 32/55 + data links to NEPEX (**AGC, EDC, SBC, SVC, SM, SE, SA, OLF**)
Late 1978	Servicios Electricos del Gran Buenos Aires (SEGBA), Argentina	Dual MODCOMP IV (**SM, SA, SE, OLF, OSC**)
	Virginia Electric & Power, Richmond	Dual Xerox 550 (**AGC, EDC, SM, OLF**)
	Taiwan Power, Taipei	Dual Xerox 550 (**AGC, EDC, SBC, SM, OLF**)
	Northern Indiana Public Service, Hammond	Dual SEL 32/55 (**AGC, EDC, SBC, SVC, SM**)
	Hungarian Electric Power, Budapest	Dual HIDIC-80 (**AGC, EDC, SM, OLF**)
	Florida Power & Light, Miami	Dual CYBER 173-6 + quad CDC System 17 + data links to six remote offices (**AGC, EDC, SBC, SM, SE, SA**)
	Korea Electric, Seoul	Dual LN CP400 (**AGC, EDC, SBC, SM**)
Early 1979	Delmarva Power & Light, Wilmington, Dela.	Dual CYBER 172-4 + quad CDC System 17 (**AGC, EDC, SBC, SM, SE, SA, OPF**)
	Connecticut Valley Electric Exchange System (CONVEX), Berlin, Conn.	Dual PDP11/70 + dual PDP11/34 + data links to NEPEX + data link to IBM 370/165 (**AGC, EDC, SBC, SM, SA, OLF**)
	Electricity Supply Commission of South Africa, Johannesburg	Dual Xerox 550 (**AGC, EDC, SBC, SVC, SM, SA, OLF**)
	Florida Power, St. Petersburg	Dual duplex Xerox 550 + dual LN CP400 + data links to two distribution dispatching offices (**AGC, EDC, SVC, SM, SE, SA, OLF**)
Mid-1979	New England Power Exchange (NEPEX), West Springfield, Mass.	1 IBM 370/148 + 1 IBM S/7 + data links to four satellite computers (**AGC, EDC, SM, SA, OLF**)
	State Electric Commission of Victoria, Melbourne, Australia	Dual SEL 32/55 + dual MAC-16 + data links to two area control centers (**AGC, EDC, SM**)
Late 1979	Agua y Energia Electrica, Buenos Aires, Argentina	Dual SIEMENS 340 + 1 SIEMENS 340 + data links to six regional control centers (**EDC, SM, SE, SA, OLF, OSC**)
	Dayton (Ohio) Power and Light	Dual SEL 32/75 + data links to two companies (**AGC, EDC, SBC, SM, OLF, SE, SA**)
Early 1980	Columbus & Southern Ohio Electric	Quad SLASH/7 (**AGC, EDC, SBC, SVC, SM, SE, SA, OLF**)
	Imatran Voima, Helsinki, Finland	Dual MODCOMP IV + 3 PDP 11/34 + data links to eight district centers (**AGC, EDC, SVC, SM, SE, OLF**)
	Duquesne Light, Pittsburgh,Pa.	Dual SEL 32/75 + data links to distribution control center (**AGC, EDC, NOX, SBC, SVC, SM, SE, OLF**)
Mid-1980	Israel Electric	Dual PDP 11/70 + dual PDP 11/70 + data links to two subsidiary control centers (**AGC, EDC, SBC, SVC, SM, SE, SA, OLF**)
	Italian Electric Power State Board (ENEL), National Control Center, Rome	Dual DEC KL-10 + dual PDP 11/70 + data links to eight area control centers (**AGC, EDC, SM, SE, SA, AVC, EC**)
	Cincinnati (Ohio) Gas & Electric	Dual PDP 11/70 + data links to four remote centers each with PDP 11/34 + data links to two companies (**AGC, EDC, SM, SBC, SM**)
Early 1981	Electricite de France (EDF), National Control Center, Paris	Dual MITRA 125 + third computer + dual Solar 16-40 + data links to seven regional control centers (**AGC, SM, SE, SA**)

more control centers in the U.S. will have this type of application.

Control-center status

Control centers are designed for high availability, fast response times, and easy maintainability—requirements that dictate the use of more than one processor. The computer configuration most commonly used in control-center design is a dual, redundant computer system (Fig. 2), which usually is comprised of two identical computer subsystems—each consisting of one processor—and dedicated main and auxiliary memories, as well as interfaces to the data-acquisition subsystem. The two computer subsystems are loosely coupled via intercomputer communication links. Peripherals, including those needed for the man-machine interface, are connected via switchable device controllers. In variations of the basic configuration, more than one processor may be used for each half of the dual setup, a redundant dual-access auxiliary memory may be employed, or it may be set up as a tightly coupled system sharing a main memory. Another interesting variation, not yet in operation in a control center, is the "dual, duplex" system, in which each half of the dual configuration consists of two tightly coupled processors.

In the dual-computer configuration, one subsystem, designated "primary," is assigned to perform all of the critical operating functions; the other, "secondary" subsystem is responsible for the noncritical operating functions plus off-line processing. If the primary computer fails, an automatic fail-over scheme will detect the failure and transfer all of the critical functions, hardware, and software to the secondary computer, which becomes the new primary. With this system, it is quite common for a critical operating function to be available 99.5–99.9 percent of the time, or better.

Standard operating systems supplied by computer manufacturers for today's control centers are based on single-processor applications and so must be augmented to support automatic fail-over and to maintain the backup posture of the secondary computer. In addition, further revisions may be necessary to enhance the real-time capabilities of the operating system or to improve system response.

As with any other real-time computer application, the response time is a very important performance criterion for control centers. A critical function whose response time is constantly being tested is the man-machine interface—the cathode-ray-tube (CRT) display. In a well-designed control center, the normal response time for a CRT display is less than one second, and at times of operating stress when computer activity is very heavy, it should not exceed 5 seconds. This requirement is important during periods when the security of the power system is in jeopardy or the system is in an actual emergency, times when the operator is most dependent on the CRT display.

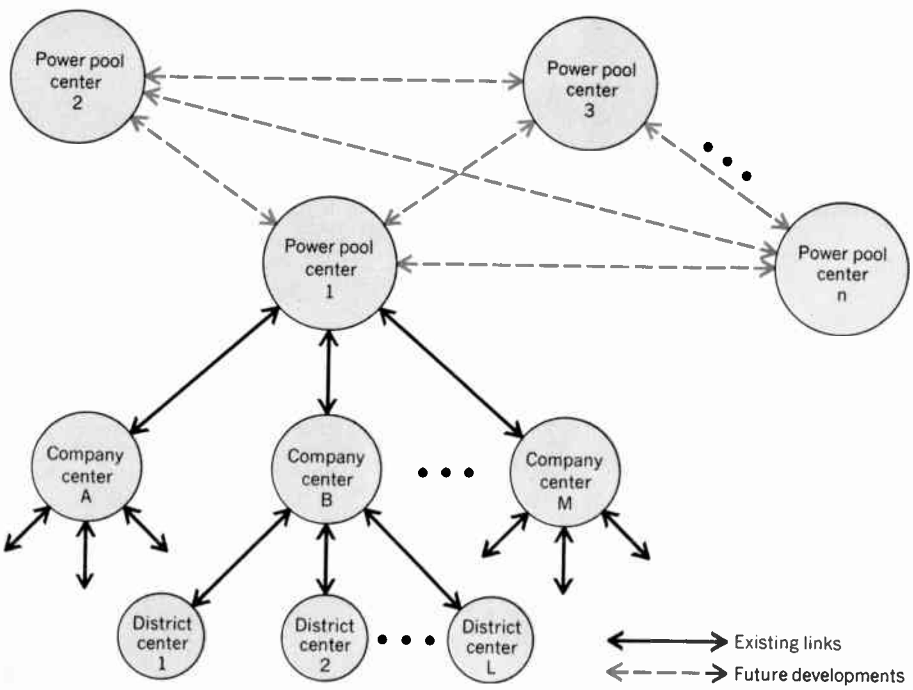
The color CRT display is a universal feature of power-system control centers. It provides practically all of the interaction needed between the operator and the computer system and the power system itself, not only in power-system operation, but also in support functions of software development and in the diagnostics and maintenance of the control system.

All CRTs have graphics capabilities, generally using special symbols; a few control centers use full graphics. This feature is used for displaying one-line diagrams of power plants, transmission stations, and transmission lines.

In keeping with the high-availability criterion, CRT displays are provided in redundant consoles. A console typically has two CRTs. In general, a control room will have six CRTs; however, some control centers may include from 20 to 50 color CRTs.

Prerequisites, future outlook

Applying computers to help prevent blackouts is a difficult task. Computers can perform only what they have been programmed to do—and in the case of real-time control computers for power systems, that is only part of the problem. It is also necessary that accurate operating information be available immediately, that models used



A hierarchy in power-system control, based on organizational responsibilities, may consist of a company, a pool, or a national control at the top level, power plant and substation controls at the bottom level, and several regional or area levels in between.

Computers—an aid to system operation

Aside from the maintenance of security, which is a relatively recent development, there are certain other important operating functions that traditionally have formed the backbone requirements for power-system control centers. In fact, many control centers are built just to carry out some, or all, of these fundamental functions—supervisory control, automatic generation control (AGC), and economic dispatch calculation.

Using supervisory control, a system operator can remotely operate circuit breakers and motorized switches, connect and disconnect capacitor banks or reactors, start up or shut down generating units, and change transformer-tap settings.

The functions of AGC and economic dispatch calculation are part of the multilevel control hierarchy (see illustration on page 49) set up to adjust the amount of real power generated to meet the ever-changing demands of system load. At the control center, the AGC function determines the change in load and allocates the required generation among the on-line generating units. The sampling time for AGC is of the order of a few seconds. The allocation signals are transmitted over communication channels to the power plants, where they are used by the turbine-generator controllers to adjust the outputs of the generating units.

At the power plants, digital computers are rarely used for turbine-generator control, and their use for boiler control is even rarer. A recent Electric Power Research Institute survey of computers in U.S. power plants, including installations scheduled to 1978, shows that, although plant computers have become mandatory for performance calculations, alarm monitoring, and data logging, very few are used for control. For fossil units, less than 20 percent of the computers do any control; for nuclear units, no computer control is performed at all.

Generation is allocated by the AGC in such a way that a higher-level objective dictated by operating economy and security is met. Ideally, there should be optimizing algorithms for generation control for both normal and emergency conditions. However, at the present state of the art, optimization of generation has been developed only for normal operation, using the criterion of minimum operating cost. This algorithm is commonly known as the economic dispatch calculation. Economic dispatch has had a long history of successful implementation in the power industry, from manual sliderule-type devices to analog controllers and, eventually, to digital computers.

Another important operating function is the maintenance of desired voltage levels throughout the system—which is generally accomplished by local devices. The automatic control of system voltage from a control center is not yet a common practice. In centers with this control the determination of voltage settings, or, alternatively, the allocation of reactive power, is the result of an optimization program where the objective function is either system losses or the sum of absolute voltage deviations from a desired voltage profile, or a weighted combination of both. In some centers, the voltage is controlled manually via supervisory control of transformer taps or shunt capacitors.

Finally, computers at control centers are also used for a host of off-line support functions needed for operations planning, engineering studies, and operator training.

by the program faithfully represent the relevant operating conditions, and that the programs produce outputs fast enough and dependably enough to be of timely value to the person making the decisions—the operator.

We still do not have all of the monitoring and control programs that we would like to have. There are still problems in system instrumentation and in telemetry, to a central location, not only of system-dynamics data but even of steady-state data. We have serious difficulties in modeling, and in keeping the models we develop up to date. As we add more computer functions, especially those involving system dynamics, we find it increasingly difficult to guarantee, with existing hardware and software design, the fast response times required. And, finally, even if we succeed in having the programs, system information, models that can be updated, and a high-performance computer system, we will still be confronted with the fundamental problem of producing outputs. The physical limitations of the power-system structure—due to a variety of technical, economic, environmental, and other factors such as interminable delays in construction—have so narrowed down or eliminated our control options that we would be fortunate to find a feasible solution, let alone an optimal one.

In spite of these problems, and considering decision-making or control in real time, the computer does play a vital role in power-system operation and in the prevention of blackouts. And security analysis, in its two functions of contingency evaluation and preventive action, should prove to be the most valuable tool for avoiding emergency situations. True, emergency control is a necessary operating function, but in this writer's view more emphasis should be placed on prevention—on doing something in advance, rather than on frantic, last-ditch efforts, such as load shedding, when an emergency already has occurred. In many sections of the industry, the primary interest is still in voltage reduction and load shedding. It is encouraging to note that more and more control centers are moving in the direction of implementing security functions. It is also encouraging that research efforts are being or will be directed to the outstanding problems of system security, particularly by the U.S. Department of Energy and the Electric Power Research Institute.

As security functions improve and expand in scope, the value of power-system control centers in maintaining and improving the already remarkably high level of electric service reliability will be further enhanced. ◆

Tomas E. Dy Liacco (F) pioneered the adaptive-reliability control system concept in 1966—which brought him the IEEE Power Engineering Society's Prize Paper Award for 1967, as well as world fame. His concept was further implemented at the System Operation Center of the Cleveland Electric Illuminating Company, Cleveland, Ohio, where he is principal systems engineer. He also serves as adjunct professor at Case Western Reserve University in Cleveland. He received the B.S.E.E. and B.S.M.E. degrees from the University of the Philippines in 1940 and 1941, respectively, and the M.S.E.E. degree from the Illinois Institute of Technology in 1955. He was awarded his Ph.D. in 1968 by Case Western Reserve.

Solid state

Large-scale integration: intercontinental aspects

Factors affecting the competitive positions of U.S., Japanese, and European firms include current business and economic climates

Ever since the invention of the integrated circuit (IC) and the silicon planar process, semiconductor producers in the United States have dominated the world markets for ICs, especially at the leading edge of each new generation of technology. This is certainly the case today for products of large-scale integration (LSI) complexity. But there are increasing signs that things might be changing.

Competitive memory products are now being produced in substantial quantites in Japan, and there is a growing interest by European companies in acquiring a stake in U.S. semiconductor companies. A key question is whether the global domination of the industry by U.S. companies will be seriously threatened, particularly as the very-large-scale integration (VLSI) era approaches.

The popular but simplistic view—widely held outside the United States—is that the U.S. domination of this industry has been based primarily on very substantial and continuous financial support from the U.S. Government, primarily through contracts. Whereas this funding has obviously been important, the real foundations of this success are far more complex and need to be understood in detail before the outcome of the impending intercontinental LSI/VLSI battle can be correctly forecast.

Indeed, any prognosis of future structural developments in this industry must begin with an understanding of the principal historical forces that have molded the industry into its present form. The reason, quite obviously, is that the important strategic influences now emerging will continue to be affected by those historical forces for the foreseeable future.

After looking at the historical development of the semiconductor industry in general, and ICs in particular, in the United States and Europe, it will be possible to identify the key factors that have led to the current U.S. domination of world IC markets. Then it will be possible to examine the new strategic forces now gathering momentum, and to project the future for IC producers as we enter the VLSI era.

Origins of the semiconductor industry

As is well known, the germanium transistor first went into high-volume production in the 1950s. Its most immediate application was in cheap, portable radios; the nation that seized this opportunity most effectively was Japan, which possessed at that time the considerable advantage of low labor costs. However, Europe (and Philips in particular) was not left far behind.

In the United States, the gleam in the electronics industry's collective eye was not caused by radios, largely because of the high U.S. labor costs. (The idea of moving labor-intensive assembly operations off-shore had not yet been tried.) Instead, the greatest need (what we might call the "user-pull," as distinct from the "maker-push," effect) for the transistor was mainly in the defense and aerospace sectors—1957 being the year of the Sputnik—and in the infant computer industry. The demands of these military and industrial sectors for devices of higher performance and reliability thus led in time to the emergence of the silicon transistor and later to integrated circuits—both developed by U.S. companies.

The final effects of these original, basic reactions to the advent of the transistor were as follows:

1. The Europeans and Japanese became strong in germanium technology and in the main types of equipment (i.e., consumer electronic products) that were based, at that time, on germanium transistors.

2. The U.S. became preeminent in silicon technology and in the main types of equipment based on it.

3. These distinctive postures, originally taken up 15 to 20 years ago, still pertain today: The Europeans and Japanese lead by a significant margin in most aspects of consumer electronics and the U.S. continues to dominate every other sector of the electronics industry.

Benefits of industrial synergism

What can be learned from this brief historical review is that a significant factor in shaping the development of the electronics industry in different geographic regions has been industrial synergism—the mutual interdependence of different industrial sectors and, in particular, of the equipment and component sectors of the industry.

With the advantage of this historical perspective, the principal factors that have affected—and in most cases will continue to affect—the development of the global IC industry can be identified. Almost from its beginning, the U.S. semiconductor industry as a whole has received substantial and broadly based support from various Government agencies. It has been estimated that between 1958 and 1974 this support totaled about $900 million for research and development alone, representing a subsidy of the cost of U.S. semiconductor innovation to the tune of about $55 million per year (in the terms of, say, 1965 average dollar values).

It is clear that financial support from public funds on such a large scale has grossly distorted normal competitive conditions and commercial criteria in this industry in the United States, and it is difficult to imagine, therefore, how any other nation could succeed without providing comparable support to its own indigenous industry.

The general, theoretical benefits of industrial synergism are familiar. However, it is useful to emphasize the par-

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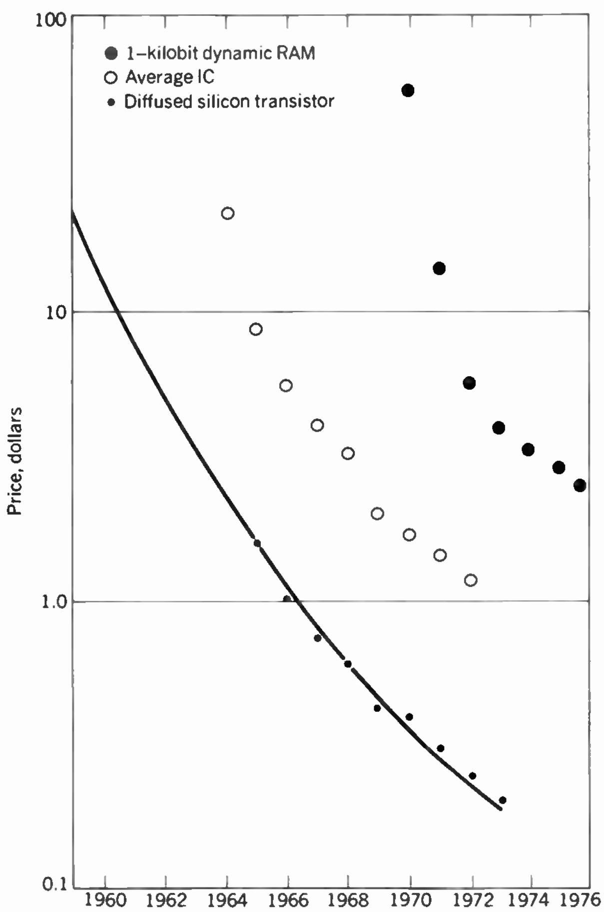
ticular importance of synergism in the development of the global IC industry.

The well-known learning curve for silicon transistors and ICs reveals the systematic relationship between price and cumulative production experience. From that and other sources, it is possible to generate the price-trend curves (Fig. 1) for three silicon devices of progressively increasing complexity—the diffused silicon transistor, the "average" IC as defined by the learning curve, and the most recent 1-kilobit dynamic RAM.

Or consider the changes that have taken place in the performance/cost ratio of computers over the past 15 years or so. Figure 2 is a curve developed for the Rand Corporation. It shows the cost in dollars per million instructions per second (MIPS) for high-performance general-purpose computers for the years 1960–1990. Note that there is, so far, only one working version of the Illiac IV computer, and the 100-MIPS and 10 000-MIPS processors have yet to be developed.



[1] Typical price trends for silicon devices.

[2] Cost trends for high-performance general-application computers.

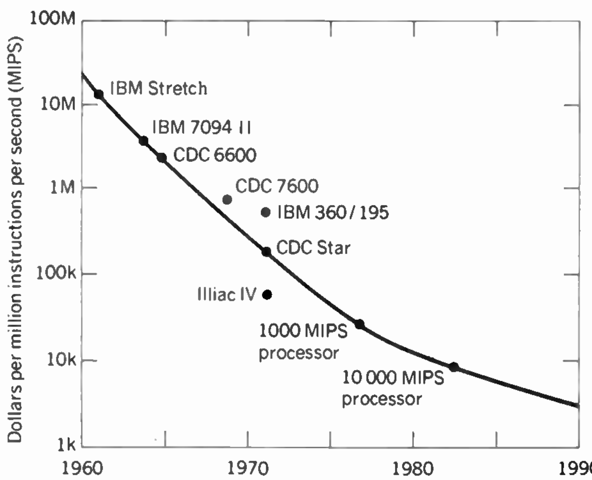


Figure 3 shows the curve redrawn to give the greatest weight to actual, well-documented cost data. It is compared with the data from Fig. 1, normalized in time so that the prices are related to the number of years since production introduction.

The correlation between these two curves is striking, and proves what every IC engineer has always instinctively believed—that the computer industry's spectacular growth has been due mainly to its ability to produce equipment that could compute at ever-increasing speeds and reliability levels, and ever-decreasing cost and size. Essentially, all of these attributes have stemmed from advances in silicon technology.

But there is another side to the coin. Figure 4 shows the growth of the total U.S. consumption of monolithic silicon ICs over the period 1964–1976, with digital ICs indicated separately. Most of these digital ICs were used in computing equipment of all kinds (including military).

The conclusion is inescapable: Just as the U.S. computer industry's growth has been critically dependent on the availability of increasing numbers of ever-improved ICs, so has the spectacular growth of the U.S. IC industry depended to a very high degree on having a large, innovative, and "local" computer market eager to use its rapidly developing semiconductor capabilities.

This growth of the IC industry in the United States must be regarded as a particularly convincing example of the benefits of industrial synergism, and leaves no doubt that the simultaneous U.S. domination of the integrated circuit, computer, and professional electronics sectors are all part of the same basic phenomenon. This is the main, though not the only, reason that the United States dominates the worldwide IC business. The corollary is that the absence, until recently, of such synergetic user industries outside the United States has been the principal reason for the European and Japanese IC producers' early lack of success.

Technological innovation

Although innovation has been a major strategic factor in the growth of the international semiconductor industry, and will continue to be for the foreseeable future, the key elements of innovation are development and marketing, not basic research. In fact, there is no correlation whatever between the commercial success of an IC company and the quality of its basic research program. Historically, an ability to recruit key personnel has been much more important.

Disciplined in-house development of processes and products has been, and will remain, a key factor in any semiconductor company's success. However, for product development work to be relevant, the company must compete actively in the world's most innovative markets for those products—wherever those markets may be.

In Europe and Japan the process of innovation in the field of advanced semiconductor components has been hindered, until recently, by the relative absence of innovative user-pull markets and—especially in Europe—by too much emphasis on basic research and too little on development and marketing.

A recent development of enormous significance, and an excellent example of the innovative strengths of the U.S. IC industry, is the microprocessor. Its strategic importance stems mainly from its great commonality of application (Fig. 5), which allows LSI products to break out of the vicious circle of greater complexity—fewer applications—higher cost. The microprocessor offers as big a step forward for digital systems as did the original integrated circuit. Yet is is symptomatic that in this product area Europe has an almost insignificant capability so far, whereas Japan is already beginning to produce microprocessors on a modest scale.

Market factors

Access to large and innovative (user-pull) markets is a key factor influencing success in the IC business. Today, both Japan and Europe finally have developed large and innovative markets in the consumer electronics sector, but not in other industrial sectors. Hence, these non-U.S. producers have no choice but to aim for the maximum possible penetration of export markets. By and large, this means attacking the U.S. market; the beginnings of this attack are already giving cause for concern to some U.S. IC producers.

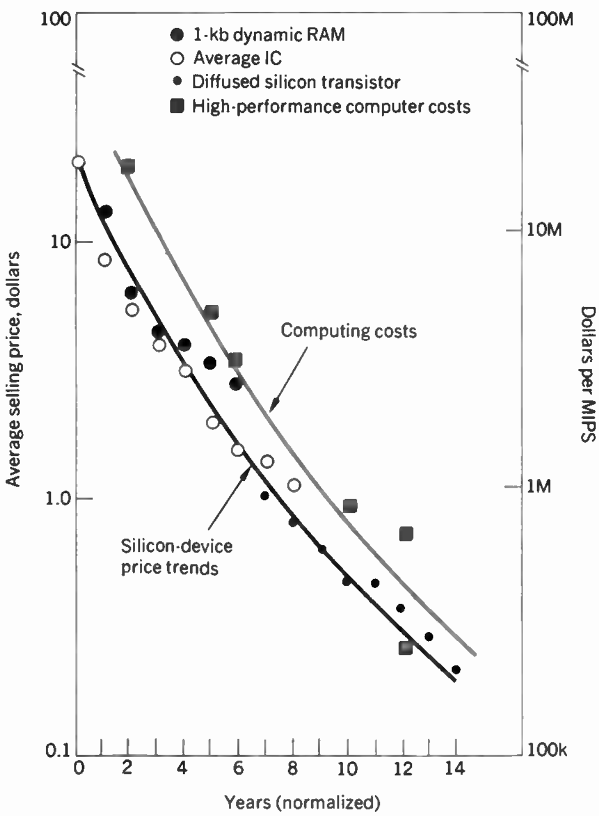
Table I shows Mackintosh estimates of the 1965, 1975, and 1985 markets for ICs in Europe, Japan, and the United States, in both absolute and per-capita terms. The preferential future growth rate of the Japanese and European markets is worth noting. Naturally, the high per-capita usage in Japan is related to high production of electronic goods containing ICs.

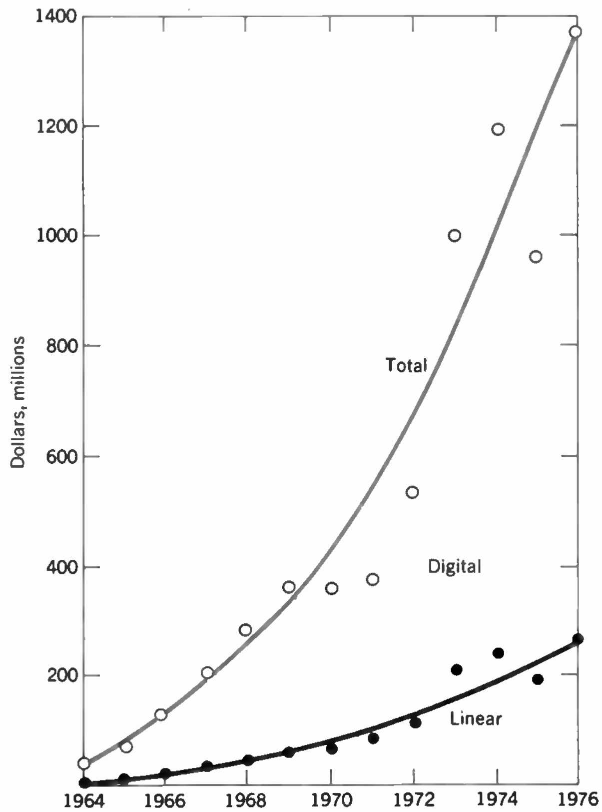
Industrial structure

Major differences exist between the structure of IC companies in the U.S. and those in other countries. In both Europe and Japan, the bulk of the current IC capability resides within vertically integrated and highly structured companies, whereas in the U.S., with the exception of organizations such as IBM and Western Electric, most of the IC capability resides in companies where the semiconductor activity is the major part of its total industrial commitment.

Some blurring of these historically sharp differences has recently occurred through the various vertical integration moves that several U.S. component and equipment

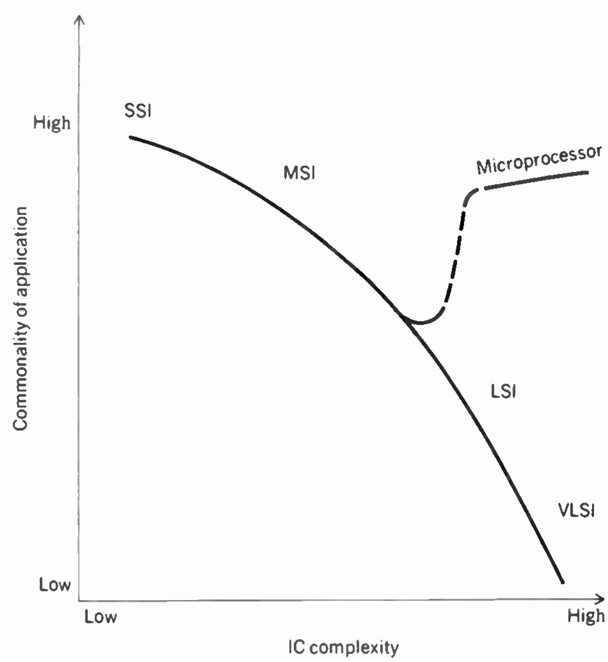
[3] Comparison of computing and silicon-device costs.





[4] U.S. consumption of monolithic integrated circuits.

[5] Complexity versus commonality.



I. Comparison of IC usage trends

	Estimated Total IC Consumption (millions of dollars)			Per Capita IC Consumption (dollars)		
	1965	1975	1985	1965	1975	1985
U.S.A.	60	1200	3500	0.3	5.7	15.9
European Economic Community	4	480	2200	—	1.9	8.5
Japan	7	480	1900	—	4.4	16.2

companies have made. In fact, the whole question of vertical integration is of great importance, and correspondingly great complexity.

In general, it is the writer's view that the vogue for vertical integration is an irrelevant diversion in the long-term development of the electronics industry. We live in an age of specialization, and it has for a long time been difficult to accept that IC companies can, for example, sell watches better than the established specialists. It has been equally difficult to accept that minicomputer companies can succeed in establishing and maintaining a cost-effective semiconductor capability over the long term.

Of course, there are the notable exceptions of IBM, Texas Instruments, and one or two others that seem to disprove the Mackintosh General Theory of Vertical Disintegration—i.e., the general hypothesis that vertical integration, by and large, is a snare and a delusion. However, apart from some special circumstances mainly centered on the microprocessor, this writer believes that of all the vertical integration activities, upward and downward, now going on in many parts of the world, only a few will turn out to be successful in the long term.

Management and people

Anyone who has worked extensively in the electronics industry, inside and outside the United States, will recognize that there often exists in other countries a real sense of inferiority about U.S. management skills. It is not just the general aura of infallibility surrounding, for example, a Harvard M.B.A., but the sheer bewilderment with which the typical non-U.S. electronics executive compares his apparent performance with that of his U.S. counterpart. This supposed infallibility is a misconception.

Table II, by and large, reflects the ability of U.S. management to bridge the gap between radically different technologies (vacuum tubes to germanium; germanium to silicon). Only one of the top ten U.S. vacuum-tube manufacturers in 1955 (RCA) has survived as a significant IC producer today.

The inescapable conclusion is that, popular opinion sometimes to the contrary, U.S. companies in general do not have a good track record in the management of electronics technology. A few, however, have obviously exhibited very impressive skills, and it is these successful managements, of course, on which the U.S. domination (and reputation) is based. What it all adds up to is that the United States' overwhelming success in the IC business has been, not surprisingly, something of a statistical phenomenon. With so many companies starting up, in such favorable conditions, some at least were likely to succeed in a big way. And some certainly did.

There are some other advantages that U.S. management has enjoyed. The distinguishing organizational feature of the successful U.S. semiconductor companies is that they are geared to react swiftly to new developments. They are also, in many cases, led by an impressive new breed of technical entrepreneurs who are skilled at this particular trade. In comparison, European and Japanese semiconductor companies have often been too ponderous in their decision-making and have sometimes been managed by individuals whose understanding of the semiconductor industry was somewhat less than perfect.

In the last analysis, the IC industry, like every other, depends on the right people being motivated in the right way to do the right job. In this sense, the United States has so far had most of the advantages since the evidence is very strong that entrepreneurial drive and freedom are essential conditions for success in the IC industry, and these are qualities that seem to thrive preferentially in the country's relatively laissez-faire economy.

The United States has also had a major advantage in the fortuitous combination of a high rate of personnel mobility with the existence of several large and highly capable research laboratories that have acted as national generators of technology and technologists. Thus, its diffusion of technology has occurred mainly through the diffusion of people, and the commercial exploitation of new techniques has rarely been inhibited for long because the possessor of know-how and the would-be exploiter could not make common cause.

In comparison, both Europe and Japan exhibit a considerably lower degree of personnel mobility, with the result that companies must rely on—and pay for—an in-house program of research and development that is proportionately much larger.

II. Leading U.S. manufacturers

	Tubes	1955 Transistors	1960 Semiconductors	1965 Semiconductors	1975 Integrated Circuits
1.	RCA	Hughes	Texas Instruments	Texas Instruments	Texas Instruments
2.	Sylvania	Transitron	Transitron	Motorola	Fairchild
3.	GE	Philco	Philco	Fairchild	National Semiconductor
4.	Raytheon	Sylvania	General Electric	General Instruments	Intel
5.	Westinghouse	Texas Instruments	RCA	General Electric	Motorola
5.	Amperex	General Electric	Motorola	RCA	Rockwell
7.	National Video	RCA	Clevite	Sprague	General Instruments
8.	Ranland	Westinghouse	Fairchild	Philco/Ford	RCA
9.	Eimac	Motorola	Hughes	Transitron	Signetics (Philips)
10.	Lansdale Tube	Clevite	Sylvania	Raytheon	American Microsystems

Another, indirect, consequence of high personnel mobility in the U.S.—particularly of technical and managerial personnel—has been the emergence of what can be called "skill clusters." So far as electronics is concerned, this can be applied to such centers as Boston's Route 128 and—of particular relevance today—to such areas of semiconductor expertise as "Silicon Valley" in California. (This phenomenon of skill clusters is by no means new. London's Savile Row tailors probably started the fashion about 200 years ago.)

It is abundantly clear that the existence of Silicon Valley confers important advantages on the IC companies that operate there, particularly in regard to the high (but informal) level of localized communication and debate, and to the availability of the strong common-services industry that has developed in that area.

Future prospects

It is not the aim here to provide a detailed forecast of IC technology per se, although in fact future technological developments will profoundly influence any strategic forecast of the IC industry. To that end, the evidence is now strong that a new high-resolution lithographic technology will emerge within the next few years, based probably on electron-beam techniques.

This VLSI technology will find application first in circuits requiring vast numbers of components (principally memory, microcomputers, and imaging), but will later be used also for numerically more mundane applications since by then the production economics will strongly favor VLSI against more classical technologies.

One major change that will occur within a few years is a substantial increase in the investment required to compete at the "leading edge." The industry will thus begin to move into an era in which the sheer size of the initial financial commitment will provide a stabilizing feedback effect, and there will be fewer opportunities for spin-offs to leapfrog into prominence by means of some astute technical, marketing, or economic stratagem. With this general scenario, then, the probable future changes in ten key strategic factors can be considered (Fig. 5).

1. Critically important synergism with major industries.

2. Large and innovative domestic markets.

Much of the future growth in the world's markets for electronic functions is likely to be in domestic and personal-product sectors, not industrial. Despite the maker-push effect that the U.S. IC industry has so far exerted in such products as calculators, electronic watches, and video games, it is in just these areas of consumer, automotive, and personal electronics that Europe and Japan are strong. Thus, their budding IC industries have the prospect of the kind of critically important synergistic relationship with major user industries that the U.S. IC industry has enjoyed with its data-processing customers.

In addition, there is certain to be substantial growth, in both Europe and Japan, in "protected" applications like the telecommunications and "national" computer industries. Overall, then, there will be selective growth of the IC markets in Japan and Europe—much of it in user companies that, by corporate inclination or national preference, will tend to select "local" suppliers, all other things being equal. As a result, Japan and Europe will enjoy much greater parity with the U.S. in these areas.

3. Substantial government support over many years.

Until quite recently, the importance of government support had not been understood properly by the governments of many advanced nations, although things are now changing rapidly. In Europe, for example, the British, French, German, and Italian Governments are all beginning to talk about—and in some cases activate—plans to provide support that is typically in the $50–100 million range, and spread over four to five years. In Japan, there is, of course, the famous VLSI program about which it is very difficult to obtain hard facts. Our own best estimate at Mackintosh Consultants is that the purely Government funding for this project is about $65 million (in 1978 dollars) a year. There is little doubt that it will continue at about this level well into the 1980s.

In any event, several governments are beginning to support their indigenous IC industries with meaningful sums of money, so the United States' long-standing advantage in this respect will diminish, although substantial support of the U.S. industry can be expected to continue.

4. Suitable business climate for entrepreneurs.

5. Availability of substantial venture capital.

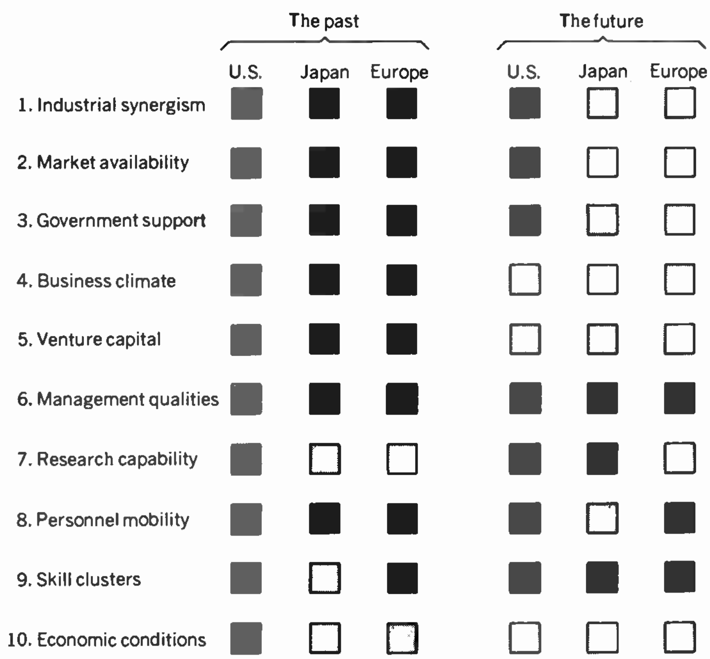
So far as the business climate is concerned, despite the probable stabilizing influence of the advent of VLSI technology, the entrepreneurial touch will remain an important ingredient of success in the IC industry. Long-term success will go only to those who can afford to exploit fully the most complex industrial technology yet devised, and who know how to do so. The multisector conglomerate will tend to lack the total commitment to success that is found in the specialist IC companies.

The U.S. will continue to have the edge over both Japan and Europe, where large corporations are unlikely to allow their semiconductor managers the same freedom of decision that their U.S. counterparts enjoy.

Nevertheless, the opportunities for new enterpreneurs in the United States will diminish as risks exceed acceptable limits. (Indeed, this has already been observable for some time, since there has been a sharp reduction in the number of new semiconductor companies.)

In both Japan and Europe, the financial community historically has been markedly unadventurous about pro-

[6] The shifting balance of advantage.



viding venture capital, and this situation is unlikely to change in the foreseeable future. On the other hand, the fact that the IC capability in these countries is mainly controlled by large companies could be an advantage because most will be capable of funding VLSI technology—especially with the aid of government support. The resource question, therefore, seems likely to become fairly evenly balanced in the future among the U.S., Europe, and Japan.

6. Enough good management in enough good companies.

In this writer's assessment, there is no significant difference between the inherent capabilities of executives in these different countries; managements in each of the countries seem to be about equally skillful (or incompetent) at creating commercial success from this esoteric semiconductor technology.

7. Existence of large, capable research laboratories.

8. Mobility of technical and managerial personnel.

9. Skill clusters (e.g., Silicon Valley).

Taking the United States first, it is unlikely that its strength will diminish significantly in any of these areas. While there may well be some reduction in the amount of basic research carried out, this will be more than offset by increases in applied research in areas such as VLSI techniques, product testing, and software problems. Personnel mobility will certainly remain high, and it is very unlikely that any of the important U.S. skill clusters—whether they are called Silicon Valley, TI, IBM, Bell Labs, or whatever—will disappear.

In Japan, a systematic build-up of the national research capability has been under way for many years and will undoubtedly continue. For reasons that are well known, personnel mobility is low in Japan. This may change as joint ventures, company mergers, and Government policies slowly blur individual corporate identities, and increasingly permeate the Japanese way of life. As for skill clusters, the Japanese electronics industry is already mainly confined to the two metropolitan areas of Tokyo and Osaka. This clustering will be reinforced by an increasing number of cooperative industrial R&D activities, such as can already be seen in the VLSI program.

In Europe, however, things look distinctly worse. The United States and Japan are single nations, each with a single language, national sense of commitment, set of laws, customs, and cultural attitudes, whereas Europe represents a set of highly individualistic nations, each with its own language, national objectives, and way of doing things. Although this is so obvious that it may not even be mentioned, these factors are often overlooked.

Yet, because of the various differences that exist and the additional rivalries that occur as a result, there is not yet such a thing as a true Common Market, in spite of all of the efforts in that direction. Even such neighboring markets as France and West Germany can represent as great a problem in interaction as a far distant market like the United States.

With the exception of Philips, the semiconductor industry basically consists of a number of producers that are predominantly national in nature, each of which is organized principally to serve the needs of its own national markets. One of the liabilities that results from this situation is that Europe has nothing remotely to compare with California's Silicon Valley, nor is it likely that any meaningful geographical skill clusters will ever develop in the European IC industry.

For that same general reason, personnel mobility in Europe is also low, inhibited by both employment traditions and national boundaries, and is unlikely to increase significantly. However, the European research capability in solid-state electronics has always been high, though often commercially ineffective because it is unable to bridge the gap between science and sales. This research capability will improve due to increasing government support, and increasing cooperation both among European laboratories and with laboratories outside Europe.

10. Good fortune—including cheap energy and enormous international economic strength.

This really warrants a complete article in its own right if its relative importance is to be assessed accurately, but a few key points can be summarized briefly.

In the years since the end of World War II, the United States has dominated the economic health of the Organization for Economic Common Development (OECD) nations. This strength has been founded primarily on cheap energy, abundant natural resources, and a large enough population for the producers of manufactured goods to enjoy the benefits of considerable economies of scale.

Meanwhile, other nations—Germany and Japan, in particular—have been recovering from the ravages of war, and one of the pillars of U.S. economic strength has eroded as the dramatic increase of oil prices has coincided with the gradual depletion of U.S. oil resources. For the future, therefore, there is likely to be a much greater balance of economic strength among the United States, Europe, and Japan (Fig. 6).

What the future holds

There are many remaining strengths of the U.S. IC industry—such as its immensely strong technological base, its position on the learning curve, and management-in-depth. Also, European and Japanese management will still suffer from important liabilities such as the relative absence of entrepreneurial freedom. But even allowing for all this, there can be no doubt that the advantage is now beginning to swing away from the United States.

For this reason, in the VLSI era U.S. producers will face problems of daunting magnitude in maintaining global market share and innovatory leads against escalating transatlantic and transpacific competition. The most probable prognosis is that U.S. domination of this critically important industrial sector will eventually disappear, to be replaced by a condition of approximate parity between the United States and Japan, who may possibly be joined somewhat later by Europe. ◆

This article is based on Dr. Mackintosh's keynote address to the International Solid-State Circuits Conference held February 1978 in San Francisco, Calif. The author wishes to thank the West German Bundesministerium fur Forschung und Technologie for permission to draw on some of the data prepared for them under contract by Mackintosh Consultants.

I. M. Mackintosh (SM) formed Mackintosh Consultants, Ltd., in 1968, following stints as general manager at Elliott-Automation Microelectronics and as department manager in the Westinghouse Central Research Laboratories. During the 1950s, he was with Bell Laboratories in Murray Hill, N.J., and in 1957 published a paper describing his development of the first PNPN triode. Dr. Mackintosh served as industrial advisor to the U.K. delegation to OECD in its study of the technology gap.

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Distribution, Power and Regulating Transformers, Supplements to Standard General Requirements for (ANSI/IEEE C57.12.00a and b-1978) [SH06635]	2.70	3.00
Electric Installations on Shipboard, 15th Edition, Recommended Practice for (IEEE Std 45-1977) [SH06825]	12.60	14.00
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Exposed Semiconducting Shields on Premolded High Voltage Cable Joints and Separable Insulated Connectors, Standard for (IEEE Std 592-1977) [SH06916]	3.60	4.00
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Interpretations 1961-1977, National Electrical Safety Code (ANSI/IEEE C2 61-77) [SH07112]	16.20	18.00
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Measurement of Electrical Noise and Harmonic Filter Performance of High-Voltage Direct-Current Systems, Recommended Guide for (IEEE Std 368-1977) [SH07021]	5.40	6.00
Metal-Nitride-Oxide Field-Effect Transistors, Standard Definitions, Symbols, and Characterization of (IEEE Std 581-1978) [SH06718]	6.30	7.00
National Electrical Safety Code (ANSI C2 1977) [SH06767]	5.85	6.50
Periodic Inspection of Cobalt-60 and Cesium-137 Therapy Equipment, Procedures for (ANSI N449.1-1978) [SH07138]	4.50	5.00
* Polyphase Induction Motors, Standard Test Procedures for (IEEE Std 112-1978) [SH07153]	5.85	6.50
Power and Distribution Transformers, Terminology for (ANSI/IEEE C57.12.80-1978) [SH06742]	5.40	6.00
* Radiation Protection Instrumentation Test and Calibration (ANSI N323-1978) [SH07179]	4.50	5.00
* Seismic Testing of Relays, Standard for (IEEE Std 501-1978) [SH07161]	4.50	5.00
Separable Insulated Connectors for Power Distribution Systems Above 600 V, Standard for (ANSI/IEEE Std 386-1977) [SH06593]	3.60	4.00
Standard Cable Penetration Fire Stop Qualification Test (IEEE Std 634-1978) [SH07146]	5.40	6.00
Standard Dictionary of Electrical and Electronics Terms (IEEE Std 100-1977) [SH07088]	22.45†	24.95†
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* Electronic Components—Apr. 24-26, 1978 (Record) No. 78CH1349-0 CHMT	18.75	25.00
* Energy '78—Apr. 16-18, 1978 (Record) No. 78CH1283-1 REG. 5	18.75	25.00
Energy Management Seminar Proceedings—Oct. 4, 1977 (Record) No. 77CH1276-5 IA	7.50	10.00
Information Theory, International Symposium—Oct. 11-14, 1977 (Record) No. 77CH1277-3 IT	6.00	8.00
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* MIMI—Mini and Microcomputers—Nov. 16-18, 1977 (Record) No. 77CH1347-4 C	15.00	20.00
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Book reviews

The Inventions, Researches and Writings of Nikola Tesla. *Martin, T. C.*—Omni Publications, Hawthorne, Calif., 1977, 496 pp., illus., $10.00.

Lightning in His Hand: The Life Story of Nikola Tesla. *Hunt, I., and Draper, W. W.*—Omni Publications, Hawthorne, Calif., 1977, 269 pp., illus., $8.95

The republication of these two books serves to remind us that an adequate biography of Nikola Tesla, a major figure in electrical engineering history, remains to be written. Unfortunately, the same may be said for numerous other electrical pioneers, such as Elihu Thomson, Charles P. Steinmetz, and Arthur E. Kennelly.

In the case of Tesla, what is needed is an informed interpretation of his technical achievements and failures and how they relate to his speculative theories and to the work of such contemporaries as Thomson and Steinmetz. His inventive style and his relationships to financial patrons and the emerging EE profession might be contrasted with those of Edison and others. A sound biography would reveal in Tesla a complex personality engaged in designing novel power systems and experimenting with spectacular physical phenomena that were poorly understood at the time.

Tesla seems an especially interesting example of what can happen to the professional reputation of a gifted investigator who is left behind by a revolution in scientific paradigms. He clung doggedly to perspectives that were appropriate in the early 1890s but that seemed naive to professional scientists after 1900. The ingenious demonstrations and confident forecasts of marvelous applications of his discoveries that attracted large audiences in 1893 were no longer taken seriously in the 20th century. Neither Tesla nor his zealous defenders ever understood why he was generally ignored or subjected to ridicule during his later years. It is understandable that they came to believe that there was a conspiracy, a thesis that has permeated many of the books and articles about Tesla.

The Martin book is a photo-process reprint of a book originally published in 1894. Its value would have been enhanced by a new introductory essay and bibliography listing relevant publications on Tesla since 1894. Essentially, the only difference from the original edition is the dust cover—which not only does not provide information on the price of the reprint or why the book was selected to be reprinted, but even misspells Tesla's name as Nicola. Nevertheless, it is a book that many EEs should enjoy reading and who may not have access to the original.

At the time Martin's book was published, Tesla was near the peak of his professional reputation following several virtuoso lecture demonstrations of physiological and diverse plasma-discharge effects produced by high-frequency and high-voltage sources. One of his lectures, given in St. Louis early in 1893, had attracted an audience of more than 5000, and a popular exhibit of his inventions had been shown at the great Columbian Exposition in Chicago in 1893. The polyphase power system commonly associated with his name had been selected for use in the epic hydroelectric development at Niagara Falls. Tesla was awarded honorary degrees by both Yale and Columbia during 1894.

Slightly more than half the pages of the Martin book are devoted to reprints of four of Tesla's lectures and a few minor papers. The remainder consists of Martin's own Interpretation of Tesla's inventions and discoveries. The engineer who reads this book may be quite surprised that neither Tesla nor Martin employed mathematics or even phasor diagrams in their discussions of alternating-current systems. The contrast with the contemporary papers of Steinmetz is quite striking. The role of Martin in helping to build Tesla's prestige has perhaps not been appreciated sufficiently. It was Martin who evidently persuaded a reluctant Tesla to present two of his key papers before the AIEE in 1888 and 1891. The first was on Tesla's polyphase system and motors and the second on the remarkable high-frequency effects he had produced.

As editor of the *Electrical Engineer*, Martin published frequent accounts of Tesla's work in addition to editing this book. The book sold well, but Martin later complained that he had loaned all he had received for it to Tesla "so that two years of work went for nothing."

The better of two books on a subject is not always the one most recently written. The biography by Hunt and Draper originally was published in 1964. In a forthcoming paper, I deliberately omitted it from a list of books recommended for a self-study program in electrical history for the contemplative EE. After again reading the book for this review, I have found no reason to alter my assessment.

The book well illustrates why the aspirant biographer of a scientist or engineer should have special qualifications for the task other than an enthusiastic interest. In this case, the authors were unable to deal successfully with the technical aspects of Tesla's work and the result was a superficial and sometimes mistaken interpretation. Their account is somewhat better when dealing with Tesla's "dark corridors of compulsion and phobias" (page 107) or the "charlatans, crackpots, and the fanatics" who were attracted by Tesla. (page 148).

I would recommend that the interested engineer, instead of buying this book, read Gordon Friedlander's essay on "Tesla: eccentric genius" in the June 1972 issue of *Spectrum* and wait for a biography that satisfies at least some of the criteria suggested above. I did like the dedication by Hunt and Draper, which reads: "Dedicated to the technical poets who, fortified by calculus, express themselves in dynamos and turbines rather than in drama and verse—the architects of today's culture."

James E. Brittain
Georgia Institute of Technology
Atlanta, Ga.

Recent books

Unified Planning and Budgeting in a Free Society: A Short Treatise on How to Look at Programs and Budgets as a Whole. Shaller, H. I.—Oakview Book Press, P.O. Box 990, Adelphi, Md. 20783, 1976, 95 pp., $15.00.

Digital-Integrated-Circuit, Operational-Amplifier, and Optoelectronic Circuit Design. Ed. by Norris, B.—McGraw-Hill Book Co., New York, 206 pp., illus., $16.50.

Quieting: A Practical Guide to Noise Control, NBS Handbook 119. Berendt, R.D. and Corliss, E.L.R.—U.S. Government Printing Office, Washington, D.C., 1976, 163 pp., illus., $5.10.

ADDbook ONE: Experiments in Digital and Analog Electronics. Malmstadt, H.W., Enke, C.G., and Crouch, S.R.—E&L Instruments, 61 First St., Derby, Conn., 06418, 1977, 400 pp., figs., $17.00.

Publications of the National Bureau of Standards: A Compilation of Abstracts and Key Word and Author Indexes, 1976 Catalog, SP 305, Suppl. 8. Ed. by Burris, B. L.—U.S. Government Printing Office, Washington, D.C., 1977, 729 pp., $8.25.

Solid-State Circuit Design User's Manual. Mandl, M.—Reston Publishing Co., Inc., Reston, Va., 1977, 271 pp., figs., $17.95.

Basic Electric Power Engineering. Elgerd, O. I.—Addison-Wesley Publishing Co., Inc., Reading, Mass., 1977, figs., $18.95.

An Introduction to Thermomechanics. Ziegler, H.—North-Holland Publishing Co., Amsterdam/New York, 1977, 320 pp., $35.95, Dfl. 90.00.

The Study of the Future: An Introduction to the Art and Science of Understanding and Shaping Tomorrow's World. Cornish, E., *et al.*—World Future Society, 4916 St. Elmo Ave., Washington, D.C. 20014, 1977, 317 pp., $9.50.

Structured PL/Zero Plus PL/One. Kennedy, M., and Solomon, M. B.—Prentice-Hall, Inc., Englewood Cliffs, N.J., 1977, 729 pp., $10.95.

Electronic Meters: Techniques and Troubleshooting. Ritter-Saunders, M., Jr.—Reston Publishing Co., Inc., Reston, Va., 1977, 309 pp., illus., $16.95.

Introduction to Structured Programming: Using PL/1 and SP/k. Conway, R., Gries, D., and Wortman, D. B.—Winthrop Publishers, Inc., Cambridge, Mass., 1977, 551 pp., $8.95.

How You Can Learn to Live with Computers. Kleinberg, H.—J. B. Lippincott Co., Philadelphia, 1977, 216 pp., $8.95.

Laser Monitoring of the Atmosphere (Topics in Applied Physics, Vol. 14). Ed. by Hinkley, E. D.—Springer-Verlag, New York, 1976, 393 pp., figs., $39.80.

Quantum Field Theory of Solids: An Introduction. Haken, H.P.J.—North-Holland Publishing Co., Amsterdam/New York, 1976, 342 pp., $50.95. Dfl. 125.00.

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Meetings

The present and future of microwaves are focus of discussion in Ottawa this month

Based on the theme, "Microwaves Today and Tomorrow," the 1978 IEEE International Microwave Symposium (S-MTT) will be held at the Chateau Laurier Hotel in Ottawa, Ont., Canada. The dates are June 27 through 29.

Complementing the technical program will be four workshops, which have been scheduled immediately preceding and following the meeting. "Low-Noise Millimeter-Wave Receivers" and "Microwave/Millimeter-Wave Power Generation, Amplification, and Control" will be the topics on Monday, June 26, and "Superminiaturization of MIC Modules" and "Paramps, FETs, and Mixers" will be discussed on Friday, June 30. Another plus for meeting attendees will be the Microwave Exhibition featuring displays by microwave device, component, and subsystem suppliers.

This year's social highlight, the banquet, will be held on Wednesday evening, following a cocktail party in the exhibition area. The speaker, George Sinclair, will address the question: "Is the engineer losing contact with the real world?" Dr. Sinclair is professor of electrical engineering at the University of Toronto; chairman of Sinclair Radio Laboratories, Ltd., Concord, Ont., and Sinclair Radio Laboratories, Inc., Tonawanda, N.Y.; and president of Laser Fusion Ltd., Concord.

Registration fees for the Microwave Symposium are $65 for IEEE members, $80 for nonmembers, and $12 for Student members (in Canadian dollars). Fees for the workshops are $20 each.

For information, write to the chairman of the Steering Committee: A. L. VanKoughnett, Communications Research Center, P.O. Box 11490, Station H, Ottawa, Ont. K2H 8S2, Canada.

The following is a list of the technical sessions, including their chairpersons and organizers.

TUESDAY, JUNE 27

Morning Sessions

Microwave: Quo Vadis? *H. Sobol, Rockwell Int'l; L. Young, NRL*
Finline and Millimeter-Wave Components. *M. Caulton, RCA*
Filters and Passive Components. *J. Rhodes, Univ. of Leeds; R. Levy, MDL*

Afternoon Sessions

Digital Microwave Systems. *G. Chao, Tectronix; P. Greiling, Hughes*
Computer-Aided Design. *J. Bandler, McMaster Univ.*
Ferrite Devices. *C. Boyd, Hughes*
Fiber and Integrated Optics. *G. Yip, McGill Univ.; D. Anderson, Rockwell Int'l*

WEDNESDAY, JUNE 28

Morning Sessions

Microwave GaAs FETs. *F. Hasagawa, NEC, Japan; L. Eastman, Cornell Univ.*
Special Session on Millimeter-Wave Development in Japan. *T. Makimoto, Osaka Univ.*
Automated Network Analyzer Techniques. *S. Adam, Hewlett-Packard; E. Komarek, NBS*
Microwave Field Theory. *F. Silvester, McGill Univ.*

Afternoon Sessions

Filters and Multiplexers. *C. Kudsia, COMDEV, and R. Levy, MDL; R. Levy*
Microwave Systems. *R. Hicks, Rockwell Int'l, and H. Ogura, Kyoto Inst. of Technology; J. Horton, TRW, and K. Iizuka, Univ. of Toronto*
Microwave Measurements. *E. Komarek, NBS*
MIC Amplifiers and Oscillators. *R. Knerr, Bell Labs*

THURSDAY, JUNE 29

Morning Sessions

MIC Components. *R. Douville, CRC; R. Knerr, Bell Labs*
Microwave Network Theory. *A. Oliner, PINY; P. Silvester, McGill Univ.*
Microwave High Power. *H. Goldie, Westinghouse; K. Tomiyasu, General Electric*
Microwave Solid-State Devices. *G. Haddad, Univ. of Michigan; L. Eastman, Cornell Univ.*

Afternoon Sessions

Low-Noise Techniques. *S. Okwit, LNR; H. Okean, LNR*
Microwave Transmission Lines. *T. Itoh, Univ. of Kentucky; P. Silvester, McGill Univ.*
Submillimeter Waves. *K. Button, M.I.T.*
Microwave Acoustics. *R. Mariani, USAECOM; C. Hartman, TI*

Design automation is topic in Las Vegas

The 15th annual gathering of engineers involved in developing and using computer aids within the design environment will take place June 19-21 when the Design Automation Conference is held at Caesars Palace in Las Vegas, Nev. The meeting provides a forum for those in the electronics industry, as well as in mechanical and building design, to learn about the latest in design verification, packaging algorithms, test-data generation, and design data bases. An art contest is planned, with competing entries of useful outputs from design, automation programs.

Registration fees are $70 for members, $85 for nonmembers, and $30 for students. Further information is available from: Donald J. Humcke, Bell Laboratories, Building 1B-322, Holmdel, N.J. 07733; telephone (201) 949-4039.

The following is a list of the technical sessions, with their chairpersons.

MONDAY, JUNE 19

Morning Sessions

Interactive Graphics. *R. Jantz, Bell Labs*
Computer-Aided Manufacturing at GTE Automatic Electric. *H. Hall, Raytheon*
Computer-Aided Mapping. *C. Rosenthal, Bell Labs*

Afternoon Sessions

Printed-Circuit-Board Layout. *J. Soukup, Bell-Northern Research*
Testing Methodologies and Fault Diagnosis. *H. Anderson, Naval Surface Weapons Center*
Computer-Aided Architectural Design. *R. Frew, Yale School of Architecture*
The Real World of Design Automation (Panel). *D. Peterson, Lear Siegler*

TUESDAY, JUNE 20

Morning Sessions

Data Bases. *D. Nash, Raytheon Missile Systems Div.*
Integrated-Circuit Layout. *L. Abel, Digital Equipment Corp.*
High-Level Design Languages and Systems. *H. Ofek, IBM*
The GTE Sylvania Phoenix System. *J. Roder, GTE Sylvania*
Computer-Aided Documentation. *M. Schleicher, Western Electric*

Afternoon Sessions

Logic Design and Logic Design Systems. *G. Patterson, Bell-Northern Research*
IC Layout and Verification. *D. Schweikert, Bell Labs*
Mechanical Engineering and Manufacturing. *R. Klahn, Bell Labs*
Theoretical Foundations of Topics in Design Automation. *H. Loomis, Jr., University of California*

WEDNESDAY, JUNE 21

Morning Sessions

Test Generation and Testing. *R. Marlett, Westinghouse Electric Corp.*
Software Engineering Tools and Techniques. *G. Case, Sandia Labs*

Afternoon Sessions

Simulation. *C. Rose, Case Western Reserve University*
PCB Layout Systems. *H. Lehrman, Martin Marietta*
PCB Layout Systems (Panel)

EMC group to hold its 20th annual meeting

The 1978 IEEE International Symposium on Electromagnetic Compatibility at the Sheraton-Biltmore Hotel in Atlanta, Ga., June 20-22, marks the 20th anniversary of this annual event sponsored by the IEEE Electromagnetic Compatibility Society. This year's host is the Society's Atlanta Chapter.

Approximately 80 technical papers covering a variety of topics within the EMC discipline will be presented. The program will also include a special session on specifications and a poster session. In addition, manufacturers and distributors will exhibit EMC-related instrumentation, components, and materials. Among the special events will be a dinner outing at Stone Mountain Park and an awards luncheon.

For details, call J. C. Toler at (404) 894-3964. Mr. Toler chairs the Steering Committee.

CIGRE's next meeting brings attendees to Paris

The UNESCO Conference Building in Paris, France, will be the site of the next session of the International Conference on Large High-Voltage Systems (CIGRE) on August 30-September 7. Some 153 papers are scheduled for presentation.

In general, the discussions will be divided among 15 specialized groups, which will consider such topics as: dc links, insulating materials, overhead lines, substations, planning, and the future of electric power transmission. In addition, a roundtable session will be directed in particular to the problems encountered by managers of power systems.

The meeting will include technical visits to systems and laboratories in Paris and its environs. Following the meeting, on September 8-19, two study tours will be offered: one based in Edinburgh, Scotland, and the other in the Val de Loire area of France.

Further information is available from: L. J. Mulligan, Ebasco Services, Inc., 125 Jericho Turnpike, Jericho, N.Y. 11753; (516) 997-9191, ext. 184.

Workshop will discuss control of power systems

The Joint Working Group on Power System Control Centers announces the fifth biennial three-day Workshop on Real-Time Monitoring and Control of Power Systems (S-PE) to be held on the campus of the University of Tennessee in Knoxville, October 25-27. The workshop provides a forum for discussion of problems and proposed solutions in this area. Informal interchange and active participation are encouraged by the selection of approximately 50 individuals who are immediately concerned with some aspect of this work.

Persons who are engaged in any phase of research, development, application, or use in this field and who feel that they can contribute to the workshop should request an application form from: Arthur G. Hoffmann, ECC, Inc., 3545 Chain Bridge Road, Fairfax, Va. 22030; telephone (703) 385-9030.

Papers are invited

- International Computer Symposium 1978 (IEEE Rep. of China Sect.; Chinese Academy of Sciences), Taipei, Taiwan, Republic of China, December 18-20, 1978. Subject: information management, theory, and application. Three copies of complete paper (20-page maximum) and a 200-word abstract to: Professor K. S. Fu, School of Electrical Engineering, Purdue University, West Lafayette, Ind. 47907; or T. I. Ho, Telecommunication Laboratories, Chung-Li, Taiwan, Republic of China. Deadline: July 1, 1978.
- Conference on Television Measurement (IEEE; IERE *et al.*), London, England, May 21-23, 1979. Subject: developments in the specification, measurement, and handling of television waveforms. A 200-word abstract to: Conference Secretariat, Institution of Electronic and Radio Engineers, 99 Gower Street, London WC1E 6AZ, England. Deadline: July 4, 1978.
- 24th Annual Conference on Magnetism and Magnetic Materials (S-Mag *et al.*), Cleveland, Ohio, November 14-17, 1978. An abstract

suitable for reproduction to: Dr. H. C. Wolfe, American Institute of Physics, 335 East 45 Street, New York, N.Y. 10017. Questions regarding preparation of abstracts to: M. B. Stearns, Ford Scientific Laboratory, P.O. Box 2053, Room 3039, Dearborn, Mich. 48121, or H. J. Leamy, Bell Telephone Laboratories, Murray Hill, N.J. 17974. Deadline for abstracts: July 28, 1978.

- 1979 Control of Power Systems Conference (Houston Sect.; Texas A.&M. Univ.), College Station, Tex., March 19-21, 1979. An abstract to: Dr. C. W. Brice, III, Program Chairman, COPS/IEEE, Electric Power Institute, Texas A.&M. University, College Station, Tex. 77843. Deadline: July 14, 1978.
- 12th Annual Asilomar Conference on Circuits, Systems, and Computers (CompSoc *et al.*), Pacific Grove, Calif., November 6-8, 1978. Subject: circuit theory and design, communications and control systems, computer systems, computer-aided design. Three copies of complete paper to: Donald E. Kirk, Electrical Engineering Department, Naval Postgraduate School, Monterey, Calif. 93940. Deadline: July 31, 1978.
- Chicago Fall Conference on Consumer Electronics (S-BCCE), Rosemont, Ill., November 6-7, 1978. A 200-500-word abstract to: Akio Tanaka, Papers Committee Chairman, Zenith Radio Corporation, 1000 Milwaukee Avenue, Engineering Room 360, Glenview, Ill. 60025; telephone (312) 391-7404. Deadline: August 1, 1978.
- IECI '79—Conference and Exhibit on Industrial and Control Applications of Microprocessors (S-IECI), Philadelphia, Pa., March 19-21, 1979. Ten copies of an extended summary (600-word maximum) and an abstract (60-word maximum) to: Paul M. Russo, RCA Laboratories, Princeton, N.J. 08540; telephone (609) 452-2700. Deadline: September 9, 1978. Suggestions for tutorial and special panel sessions are due to the same address by the same date.
- International Conference on Video and Data Recording (IEEE; IERE *et al.*), Birmingham, England, July 17-19, 1979. A 500-700-word summary to: Conference Secretariat, Institution of Electronic and Radio Engineers, 99 Gower Street, London WC1E 6AZ, England. Deadline: October 27, 1978.
- ISH '79—Third International Symposium on High-Voltage Engineering (North Italy Sect.; Italian Association of Electrical and Electronics Engineers), Milan, Italy, August 28-31, 1979. A 200-word abstract is due by November 30, 1978. For information: Gianguido Carrara, CESI, Via Rubatino 54, 201 34 Milan, Italy.
- Sixth IEEE International Semiconductor Laser Conference (S-QEA), San Francisco, Calif., October 9-11, 1978. Ten copies of 200-500-word abstract to: C. J. Nuese, Program Chairman, RCA Laboratories, Princeton, N.J. 08540. Deadline: June 15, 1978. For postdeadline papers describing significant, recent results, ten copies of complete manuscript to Mr. Nuese by October 9, 1978.
- Third IEEE Specialist Conference on the Technology of Electroluminescent Diodes (S-QEA, S-ED), San Francisco, Calif., October 11-12, 1978. Ten copies of 200-500-word abstract to: A. A. Bergh, Program Chairman, Bell Laboratories, Murray Hill, N.J., 07974. Deadline: June 15, 1978. For postdeadline papers describing significant, recent results, ten copies of complete manuscript to Mr. Bergh by October 9, 1978.
- 1979 International Symposium on Circuits and Systems (S-CAS; IECE-Japan), Tokyo, Japan, July 17-19, 1979. For regular papers, four copies of complete manuscript including an abstract, and for short papers, four copies of 1000-word summary to: T. F. Fujisawa, Faculty of Engineering Science, Osaka University, Toyonaka, Osaka 560, Japan. Deadline: October 1, 1978.
- FTCS-9—1979 International Symposium on Fault-Tolerant Computing (CompSoc), Madison, Wis., June 20-22, 1979. Four copies of 200-word abstract to: Gerald M. Masson, Department of Electrical Engineering, The Johns Hopkins University, Baltimore, Md. 21218; telephone (301) 338-7013. Deadline: November 1, 1978.
- 1978 IEEE International Electron Devices Meeting (S-ED), Washington, D.C., December 4-6, 1978. Subjects: solid-state devices; device technology; integrated electronics; electron tubes; energy-conversion devices; quantum electronics devices; detectors, sensors, and displays. Sixteen copies of a 200-word abstract (which should indicate the area covered) to: Professor R. E. Thomas, 1978 IEDM Technical Program Chairman, Department of Electronics, Carleton University, Colonel By Drive, Ottawa, Ont. K1S 5B6, Canada. Deadline: August 4, 1978. Deadline for abstracts of late-news (ten-minute) papers: October 20, 1978.
- International Conference on Communications (ComSoc, Boston Sect.,), Boston, Mass., June 10-13, 1979. Five copies of one-page abstract and manuscript to: Dr. John Logan, Chairman, ICC '79 Technical Program, Bell Telephone Laboratories, 1600 Osgood Street, North Andover, Mass. 01845; telephone (617) 681-6306. Deadline: November 15, 1978. Deadline for notification of intent to submit a paper: September 30, 1978.
- 1979 Winter Meeting of the IEEE Power Engineering Society, New York, N.Y., February 4-9, 1979. Prospective authors should immediately request an author's kit from the PES Special Activities Office at IEEE Headquarters, 345 East 47 Street, New York, N.Y. 10017. Deadline for original manuscripts: September 1, 1978.
- Third World Telecommunication Forum (ITU), Geneva, Switzerland, September 23-26, 1979. A 100-200-word abstract to: Prof. Dr. F. L. Stumpers, N. V. Philips' Gloeilampenfabrieken Research Laboratories, Eindhoven, Netherlands; or (in the U.S. and Canada) to: A. E. Joel, Jr., Bell Laboratories, Room 2C-632, Holmdel, N.J. 07733.

Classified advertising

Positions Open

The following positions of interest to IEEE members have been reported as open. Apply in writing, addressing reply to address given or to Box Number, c/o IEEE Spectrum, Advertising Department, 345 East 47th St., New York, N.Y. 10017. Classified Advertising Rates for this column: $15.00 per line. No advertising agency commission is granted. Copy must be received by the 10th of the month preceding date of issue.

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Positions Available—Electrical & Electronic Eng's. Over 1000 US client companies pay our fees for selected technical referrals. Est. 1959. Send resume & salary history. Atomic Personnel, Inc., Box C, 1518 Walnut, Phila. Pa. 19102.

Graduate Assistantships are available in both teaching and research at West Virginia University. For further information contact Dr. R. E. Swartwout, Department of Electrical Engineering, West Virginia University, Morgantown, West Virginia 26506. An affirmative action/equal opportunity employer.

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Energy Search, EE, field engineer to operate electronic instruments to evaluate wells drilled for oil and gas. Various locations USA. 0-3 years experience, only U.S. citizens and immigrants. Apply Carter Robinson, Schlumberger Well Services, P.O. Box 2175, Houston, Texas 77001. An equal opportunity employer.

Communications Engineers—Exec. search and contingency placements nation-wide: Hardware/software system & component design, implementation & test. All fees paid. Call, submit resume with salary & location requirements to F. Jones, Eastern Executive Assoc., Div. F. X. Jones Assoc., 881 Allwood Rd., Clifton, NJ 07012 (201) 777-6900.

Texas, California, Florida, other SW, SE, W & Foreign location opportunities for sharp EE's having instrumentation, power, minicomputer, microcomputer, semiconductor or electronics exp.—hardware, software or systems. $19-32,000 base starting. Positions with private industry mfg. design and consulting cos having impressive growth. Each contact is made selectively (you are in control) and held in strict confidence. Our client cos assume all placement fees. Resume to J. L. Gresham, BChE, MBA will contact you at home first. Est. 1966, member AIChE. Systemation Consultants, Inc., employment service. 1410 Post Oak Tower, Houston, Texas 77056. (713) 622-1370.

Faculty Position available in Iran. Electrical Engineering Faculty position at the assistant/associate Professor level with specialty in Electromagnetics, Communications, Systems & Control or Electronics. Position requires undergraduate & graduate teaching & graduate research activity. Qualifications include the Ph.D., teaching experience and pertinent post-doctoral or industrial experience. Generous salary based on individual basis. Send resumes & names of two references to M. Irani-Kermani, School of Graduate Studies, NIRT, P.O. Box 41-3144, Tehran, Iran.

Engineers—SE Locations, Process, Powerlight, Software, Hardware, Systems, Instrumentation, Facilities. Fee Paid. No Contracts, 12 yrs. experience. Beall Associates, P.O. Box 5042, Spartanburg, S.C. 29304.

Research Assistantships in Power Engineering—Research Assistantships in Power Engineering are available to qualified graduate students seeking the MSEE, MSME, MSNE degree. For information, contact: Chairman, Purdue Electric Power Center, School of Electrical Engineering, Purdue University, West Lafayette, Indiana 49707. This program is restricted to citizens and permanent residents of the United States. Purdue is an equal access/equal opportunity employer.

Head, Electrical Engineering Department. Applicants are sought for the position of Head of the Electrical Engineering Department, College of Engineering, Rochester Institute of Technology. The Department is ECPD accredited, has 17 faculty members, and offers a cooperative work/study undergraduate program (460 students) leading to the B.S. degree and a part-time graduate program (80 students) leading to the M.S. or M.E. degrees. Candidates should have an earned doctorate in electrical engineering and significant industrial and academic experience. The new department head will be expected to intensify faculty involvement in the local industrial sphere while maintaining a strong commitment to engineering education at the Bachelor's and Master's level. Candidates should contact Professor R. E. Heintz, Chairman, Search Committee, Electrical Engineering Department, Rochester Institute of Technology, Rochester, New York, 14623 by July 15, 1978—an affirmative action employer.

Post Doctoral Fellow starting in September 1978 in digital filters and digital signal processing. Remuneration $12,000. Apply with resume to Dr. V. K. Aatre, Department of Electrical Engineering, Nova Scotia Technical College, P.O. Box 1000, Halifax, Nova Scotia, B3J 2X4, Canada.

Communications and Information Sciences. Faculty positions are available in the Electrical Engineering Department of the Polytechnic Institute of New York at both the Brooklyn and Farmingdale campuses. Applicants should have strong qualifications in the area of communications and/or information sciences. The Polytechnic Institute of New York, founded in 1973 by the merger of the Polytechnic Institute of Brooklyn and the School of Engineering and Science of NYU, carries a tradition of strong emphasis on research. The expansion of the Electrical Engineering Department's Communications and Information Sciences program is supported by a substantial amount of funded research. Interested persons should send their detailed resume and other pertinent information to: Professor Frank Kozin, Chairman of Search Committee, Department of Electrical Engineering, Polytechnic Institute of New York, Route 110, Farmingdale, NY 11735. Polytechnic. An Equal Opportunity/Affirmative Action Employer.

Faculty Positions, George Washington University. The Department of Electrical Engineering and Computer Science, George Washington University, is seeking to fill three faculty positions. Persons with doctorate degrees and/or substantial industrial or research experience in the following areas are being sought: 1) data communications, 2) electrical power systems, and 3) medical engineering and electronics. Rank is commensurate with experience. The University is an equal opportunity, affirmative action employer. Send your resume or inquiries to: Professor Arnold C. Meltzer, Chairman, Department of Electrical Engineering & Computer Science, School of Engineering and Applied Science, The George Washington University, Washington, D.C. 20052.

Faculty Position/Engineers: Small, Liberal Arts, Church-Related College with strong dual-degree program seeks engineer interested in Liberal-Arts education. Ph.D. or near. Send resume to Dr. John Butler, Academic Dean, Georgetown College, Georgetown, Kentucky 40324.

Director, Bioengineering Services, McMaster University Health Sciences Centre. This position is available immediately and applications are invited from Biomedical Engineers who have the qualifications to be registered as a Professional Engineer with the Association of Professional Engineers of Ontario. The facility is responsible for the development and maintenance of a wide variety of biomedical equipment in both hospital and university areas; also, it provides leadership for the injection of science and technology into medical thinking and practice. A joint academic appointment between the University and Hospital is envisaged for the Director who should have wide-ranging experience in biomedical equipment development and service management. Applications including a detailed curriculum vitae, the names of three referees and an indication of the earliest possible starting date should be addressed to: Mr. R. E. Capstick, Manager, Employment & Staff Relations, McMaster University Medical Centre, 1200 Main Street West, Hamilton, Ontario L8S 4J9.

Faculty Positions in South America. Well funded University, pride of the Venezuelan educational system, has excellent opportunities for good teachers and researchers. PH.D. or equivalent required. Openings in the areas of digital systems, communications sytems, propagation, radiation, antennas, biomedical, analog electronics and networks. Successful candidates must be willing to devote considerable effort to learning Spanish as soon as possible after arriving. Send resume to: Prof. German Gonzalez, Jefe Dpto. Electronica y Circuitos, Universidad Simon Bolivar, Apartado 80659, Edo Miranda-Venezuela.

Graduate Assistantships Available in Electric Power Systems Engineering. A graduate program leading to the master of engineering degree with a first field in electric power systems. Contact, Director, Electric Power Institute, California Polytechnic State University, San Luis Obispo, California 93407. An equal opportunity employer.

Dean of Engineering. Texas A&M University is accepting applications for the position of Dean of the College of Engineering. The College of Engineering offers 17 undergraduate degree programs in addition to Master of Science, Master of Engineering, Doctor of Engineering and Doctor of Philosophy degrees. The present enrollment is approximately 6400 undergraduate and 820 graduate students, with a research program in excess of 11 million dollars annually. Texas A&M University seeks candidates having the following qualifications: Proven administrative ability and leadership. Demonstrated academic achievement at the university level and an established reputation in the profession of engineering. Commitment to excellence and quality in teaching, research and the profession of engineering. Applicants should submit a complete resume (with references), including addresses and phone numbers. All materials should be sent to: J. M. Prescott, Vice President for Academic Affairs, Texas A&M University, College Station, Texas 77843. Texas A&M University is an Equal Opportunity/Affirmative Action Employer.

Faculty Position in **Engineering.** Broad-based teaching and research interests with specialization as follows: Electrical engineering (power or systems). Ph.D. required. Rank and salary determined by qualifications. Equal Opportunity Employer. Apply to: Lynn D. Russell, Dean of Engineering, University of Tennessee at Chattanooga, Chattanooga, Tn. 37401.

Research Scientist, Software Engineering. The Corporate Computer Science Center of Honeywell, Inc., located in suburban Minneapolis has an excellent opportunity for computer scientists with a background and interest in software engineering. You will be expected to operate as the lead scientist in a project using technology to solve software problems in a variety of areas including language design, programming methodology, communications, certification, and correctness. Candidates should possess a PhD or equivalent in Computer Science, Electrical Engineering, or Math plus experience in computer technology with an emphasis in software, a demonstration of creative applications of new techniques, and a background in one of the problem areas listed above. Honeywell offers a competitive salary, a solid benefit package, excellent technical resources, and excellent opportunities for both personal and professional growth and recognition. If you wish to further investigate this opportunity, direct your resume to: Ron Heinz, Honeywell Inc., Honeywell Plaza—MN12-2109, Minneapolis, MN 55408. An Equal Opportunity Employer M/F.

Head, Department of Electrical Engineering, North Carolina State University, Raleigh, North Carolina. The Department presents programs leading towards the B.S., M.E.E., M.S., and PhD degrees. It is one of the larger departments in the NCSU Engineering School with diversified research programs and approximately 30 graduate faculty. A candidate with leadership abilities and an interest in developing research is sought to guide the department teaching and research programs. Qualifications include a PhD degree in Electrical Engineering, prior administrative experience, and evidence of professional accomplishment. Position available immediately. Send resume and four potential references to: Dr. Thomas S. Elleman, Head, Electrical Engineering Search Committee, Box 5636, North Carolina State University, Raleigh, NC 27650. An equal opportunity and affirmative action employer.

Control Systems Analyst. Conduct Advanced research and development in aeronautical and energy systems using automatic control theory, statistics, optimization theory, time series analysis, identification and estimation theory and systems analysis. Applicant must have M.S. degree in Control Theory with course work in the above areas, in electrical engineering and computer programming with emphasis in FORTRAN and BASIC on the CDC 6400. 40 hr. week, $7 per hour plus fringe benefits. Send resume to Dr. Raman K. Mehra, Scientific Systems, Inc., 186 Alewife Brook Parkway, Cambridge, MA 02138.

Radar/Sonar Systems Research. Sperry Research Center has a research staff opening for **a** Ph.D.E.E. with two to three years' experience in radar, sonar, or communication systems modeling and analysis. Background in linear systems, statistics, detection and estimation theory, digital signal processing, wave propagation, and computer simulation of systems is desirable. Familiarity with modern digital technology and radar/sonar hardware would be useful. Please submit resume and salary requirements to Janet Porretti, Sperry Research Center, 100 North Road, Sudbury, Massachusetts 01776. An Equal Opportunity Employer.

Senior Electrical Engineer. Experienced Lead Engineer. Requires a B.S.E.E. and minimum 10 years experience in all aspects of Design, Control and Start-up as applied to gas and petrochemical plants. In addition to leading the electrical effort on new projects this position provides a rare opportunity to be actively involved in the reshaping of departmental policies and procedures. Career prospects are excellent. Excellent salaries and benefits. 4½ day work week. Please forward your resumes to: Larry W. Massey, Director of Personnel, DAVY POWERGAS, Inc., 6161 Savoy Drive, Houston, TX 77036, (713) 782-3440. An Equal Opportunity Employer M/F.

Senior Gallium Arsenide Technologist. A position is immediately available for someone to initiate, plan, and direct R&D leading to fabrication of high-speed, low-power GaAs FET digital logic circuits. Job includes carrying out R&D in materials selection, ion implantation and annealing to obtain optimal doping profiles for FETs, design and layout of FET logic circuits, and evaluation of completed devices and circuits. The successful candidate will have a Ph.D. in EE or Physics, extensive "forefront" experience in research in at least several of the following areas: ion implantation and encapsulation of GaAs wafers, design and testing of integrated GaAs FET logic circuits, fabrication metallurgy of GaAs FET devices, epitaxial growth and physics of short channel effects on FETs, and high resolution lithography. Please submit your resume, in confidence, to: Janet Porretti, Sperry Research Center, 100 North Road, Sudbury, Massachusetts 01776. An Equal Opportunity Employer.

Assistant Professor—Fall 1978. Two positions; communications, digital electronics, with basic electronics or circuits background. M.S. required, PhD preferred. Must have commitment to undergraduate education. Send resume, references to: C. Chevalier, Head, Engineering & Technology Department, Norwich University, Northfield, VT 05663. An equal opportunity employer.

The Higher Institute of Electronics, Beni Walid, Libya—Applications are invited for teaching staff members in the following fields: Mathematics; Physics; Engineering, Drawing and Descriptive Geometry; Mechanical Engineering; Mechanical Workshop Supervisors; English Language (Preference will be given to native speakers with technical experience.); Circuit Theory; Electronics; Computer Science; Communications; Instrumentation and control; Microwave and Radar Technology; Technicians required to run the various laboratories of the above fields. The minimum Qualifications for Academic Staff are M.SC. and/or Ph.D. (Teaching experience is preferred.) The minimum qualifications required for technicians is a City and Guilds Technicians Diploma or equivalent, (preference will be given to candidates with previous experience). Please forward your resume to the Embassy of the Socialist People's Libyan Arab Jamahiriya, Higher Institute of Electronics, Cultural Office, P. O. Box 19281, Washington, D. C. 20036.

Electrical Engineering. A position at the assistant/associate professor level is available beginning September 1, 1978. Applications will be accepted until July 15, 1978. Applicants are expected to possess a Ph.D. degree, or equivalent, with specialization in analog and digital automatic control. The appointee will be expected to teach both undergraduate and graduate courses in control system analysis/design and must demonstrate ability to initiate and conduct research. Applicants with industrial experience in control systems design and instrumentation are preferred. Send resume to Dr. R.M. McDonald, Chairman, Engineering Systems Division, University of Tulsa, Tulsa, OK 74104. This Division includes bachelors programs in electrical engineering, mechanical engineering, and systems engineering, and a masters program in engineering systems. The University of Tulsa has an Equal Opportunity/Affirmative Action Program for students and employees.

Head, Electrical Engineering, University of Illinois. Applications are invited for the position of Head of the Department of Electrical Engineering. University of Illinois at Urbana-Champaign. Earned doctorate required. Other qualifications sought include an international reputation in electrical engineering, administrative skill, excellence in teaching and research, and leadership in academic, technical and professional societies. Salary dependent on qualifications. Starting date, May 21 or August 21, 1979. To insure full consideration, resumes should be received by October 15, 1978. Contact: Prof. Clyde E. Kesler, Chairman, Search Committee for E.E. Head, 1108 Civil Engineering Building, Urbana, IL 61801. The University of Illinois is an equal opportunity and affirmative action employer.

Electrical Engineering: Assistant/associate professor position in accredited B.S. program is currently open. Applicants should have an earned doctorate and teaching experience in the digital area. Teaching assignments are flexible. Send resume to Col. Oren L. Herring, Jr., Head, Department of Electrical Engineering, The Citadel, Charleston, S.C. 29409. An equal opportunity/affirmative action employer.

National University of Iran. Immediate faculty positions are available at the Departments of Systems Engineering and Computer Science. Instruction is in Persian. Send resume or inquiry to Dean of School of Information and Management Sciences, National University of Iran, Eveen, Tehran, Iran.

Dean, Sciences and Technologies. University of Houston at Clear Lake City. UH/CLC is a rapidly developing upper level and graduate university located between Houston and Galveston near the NASA Space Center. The bachelor's and master's degree programs are offered in both Sciences and Technologies. Applicants should have an earned doctorate plus university-level administrative experience. Duties include long-range program development, resource procurement, community/industry liaison and limited teaching. Desired appointment: September 1978. Please send nominations and/or resumes, including salary requirements and 3 references by July 1, 1978 to: Dr. Eldon W. Husband, Chair, Search Committee, University of Houston at Clear Lake City, 2700 Bay Area Blvd., Houston, Texas 77058. Equal Opportunity Employer.

Sydney University—Australia. Lectureship in Electrical Engineering. Applicants should be experienced in the theory and practice of Communication Engineering. Appointee will be expected to conduct undergraduate and postgraduate courses in Telecommunications field. Relevant higher degree and/or suitable research or industrial experience is required. Applications by 19 June 1978 to Registrar, University of Sydney, NSW 2006, Australia, from whom further information available.

The Electrical Engineering Department at South Dakota State University is seeking applicants for an Assistant Professor position, to begin August 16, 1978. The preferred areas are power and computer systems. An earned doctorate in electrical engineering preferred, however, an M.S.E.E. with considerable industrial experience will be considered. The successful candidate will be expected to teach undergraduate and graduate level electrical engineering courses, some with laboratories. An active interest in applied research is required. Salary is commensurate with background and ability and is based on the academic year. Closing date is July 1, 1978. Send resumes and two references to Dr. Virgil G. Ellerbruch, Head, Department of Electrical Engineering, South Dakota State University, Brookings, SD 57007. An equal opportunity/affirmative action employer.

Research Engineer to assist in research concerning wind power feasibility and economics. Duties include working with wind power equipment, processing data, and assisting in writing reports and proposals. Experience in the areas of wind power, electric power generation, computer data processing, electronics, and meteorology would be directly applicable to the position. Send application to Dr. Gary C. Thomann, Box 44, Wichita State University, Wichita, KS 67208. Wichita State University is an equal opportunity/affirmative action employer.

(Continued on p.68)

UNIVERSITY OF SALFORD

CHAIR OF CONTROL ENGINEERING

Applications are invited for the Chair of Control Engineering in the Department of Electrical Engineering. The interests of the Department include the following areas: Control of Machines and Power Systems, Computer Simulation, Microprocessor Applications and Control Theory. Although, in general, the emphasis of the work is on electrical engineering applications of control, suitable candidates with other related interests will be considered.

The salary will be within the professorial range, the minimum of which is £8900 per annum.

Applications should be received by the Registrar, The University of Salford, Salford M5 4WT, England (from whom further particulars may be obtained) by 23 June 1978. Please quote reference number E/197/S.

Classified advertising

(Continued from p.67)

Two Faculty Positions. Ph. D. preferably in electrical or systems engineering. One should have in-depth capabilities in at least one of the following areas: instrumentation and electronics, power, controls, and systems. The other position is in digital systems. Beginning August 15, 1978. Assignments will include teaching graduate as well as undergraduate courses, graduate thesis supervision, and independent research. Teaching and industrial experience desirable. Assistant professor preferred. U.S. citizenship or permanent residency visa status required. To ensure full consideration, send resumes by July 5, 1978, to Dr. J. G. Smith, Chairman, Electrical Sciences and Systems Engineering, School of Engineering and Technology, Southern Illinois University at Carbondale, Carbondale, Illinois 62901. An equal opportunity/affirmative action employer.

Energy Research—Washington, D. C. based national association of consumer owned electric utilities seeks dir. of energy research with responsibility for analyzing Federal and industry R&D programs; administering assoc. research grants; preparing statements for Congr. and Exec. agencies; assisting members in power supply, environmental regs.; liaison with DOE, EPRI. BSEE or related technical degree required. Previous utility experience preferred. Salary: $23,500. EOE. Send resumes to: American Public Power Association, 2600 Virginia Avenue, N.W., Washington, D. C. 20037.

Designer. Graduate E & EE, Power Demand Controllers, Programmable Controllers, Voltage Stabilizers, Computerized Control Systems, 5 years exp. Write: Queensboro Transformer & Mach. Co., 115-25 15th Ave., College Point, NY 11356.

Faculty Position in Electrical Engineering. Applications are invited for a faculty position with responsibilities to include teaching at both undergraduate and graduate levels, and participation in research. Applicants should hold the Ph.D. degree in Electrical Engineering and have a background in digital computer applications or computer engineering. The ability and desire to attract and conduct research is essential. Industrial and teaching experience is desirable. Electrical Engineering Department with 20 full time faculty housed in 95,000 square feet of new space offers programs leading to B.S., M.S. and Ph.D. degrees with specialization in computer, control, communication and power systems and in microelectronics. Rank and salary commensurate with qualifications. Preference will be given to equally qualified minority and female applicants. Send resume to Dr. B. J. Ball, Head, Department of Electrical Engineering, Mississippi State University, Drawer EE, Mississippi State, MS, 39762. An equal opportunity-affirmative action employer.

Electrical Engineering and Engineering and Public Policy. The Department of Electrical Engineering and The Department of Engineering and Public Policy at Carnegie-Mellon University are seeking a candidate for a joint appointment at the level of Assistant or Associate Professor. Candidates must have strong credentials in Electrical Engineering and demonstrated research ability in the area of public policy. Areas of particular research interest include telecommunications policy, electric power load management, and social impacts of computer technology. Send resume and list of publications to: Ms. I. Barbara Lydon, Assistant Head, Engineering and Public Policy (IES), Carnegie-Mellon University, Pittsburgh, Pennsylvania 15213.

Senior Electronic Engineer. Creative individual to present new projects to various levels of management and to coordinate a team of specialists engaged in the development of project plans, primarily in power systems. EE degree and experience in utility systems, power generation, transmission and generation and/or power system for industrial applications. Send resume in confidence to: JET PROPULSION LABORATORY, Professional Staffing, Dept. 761, 4800 Oak Grove Drive, Pasadena, CA 91103. An Equal Opportunity Employer.

Experienced Research Engineer for newspaper research. Areas of activity could include facsimile, electronic imaging, equipment control and microprocessor applications. Minimum qualifications are BS in electronics or physics. Salary commensurate with experience. Send resume to ERWIN JAFFE, Director, ANPA Research Institute, P.O. Box 598, Easton, PA 18042.

Positions Wanted

Classified Advertising Rates for "Positions Wanted" column: $15.00 per line. 50% discount for members of IEEE (please supply membership number with copy; 50% discount applies only in "Positions Wanted" column, not in "Positions Open"). Copy must be received by the 10th of the month preceding date of issue. Address replies to Box Number given, c/o IEEE Spectrum Advertising Department, 345 East 47th St., New York, N.Y. 10017.

B.S. Electrical Engineering; Ph.D. Physics (Minor Computer Science); 3 yrs. industrial experience; Pt. time business courses in GSIA Carnegie-Mellon U. Seeks position in industry. Box 8544.

Proposal Mgr.-25 yr. exp. Aerospace new technologies, seeks university position, win gov't grants (funds). Box 8545.

Solid-state programmable limit switch can replace cam-operated counterpart

This programmable electronic limit switch is designed for OEM and plant production equipment used in such industries as steel, packaging, bottle and can manufacturing, metal working, plastics, printing, pulp and paper, and materials handling.

On an installed-cost basis, the switch is competitive with cam-operated limit switches, according to its manufacturer. It can be incorporated directly into OEM equipment or installed in the field to retrofit existing plant equipment.

Advantages of the switch over electromechanical limit switches include: stable repeatability; faster programming setup, and adjustment; maintenance-free, long-life operation; and provision for increased machine operating speeds of up to 100 r/min or more.

The programmable switch consists of seven modules, which, in combination, can provide any number of limit controls. Plug-in limit-setting modules and relays allow other limits to be added in the field. Limits may be adjusted to any value, at the turn of a dial, with no machine downtime.

The only part of the switch system mounted on the machine is the electromagnetic transducer. Other modules are connected to the transducer by a single four-conductor cable with a length of up to 500 feet (152 meters).

The switch, known as "Dial-a-Limit," provides stability within ±0.25 degree—a level far better than what is available using cam-type controllers. The switch's new design completely eliminates parts that wear out or need periodic adjustment.

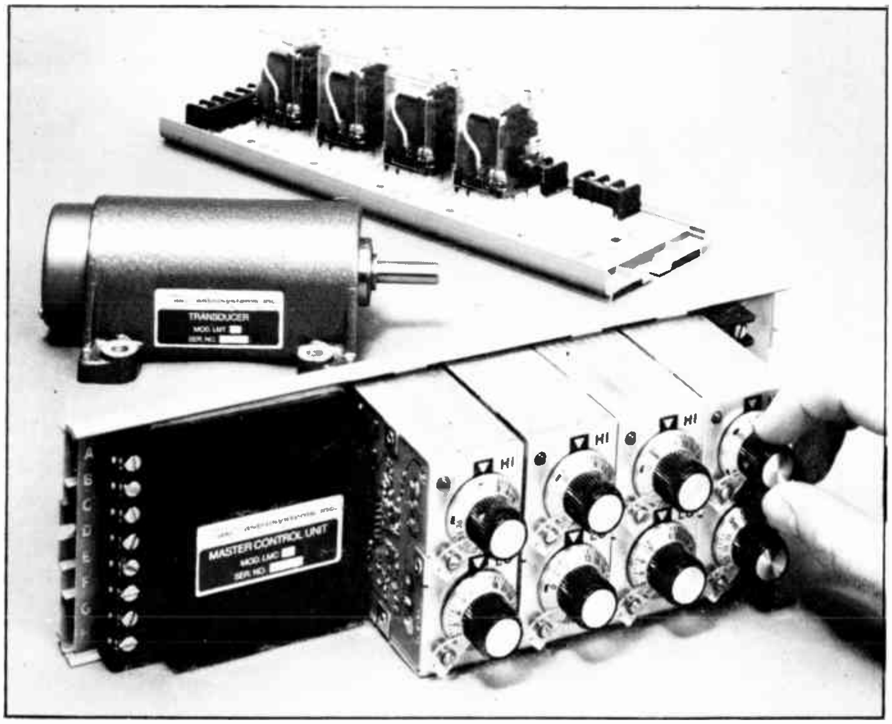
Two types of limit-control output are offered by the Dial-a-Limit switch system: DTL/TTL-compatible transistor switch output for direct connection to logic-control systems, or single-pole double-throw relay output for direct machine control. Because position measurement is absolute, the accuracy of the output is not affected by power fluctuations.

Other features of the switch system include simple, terminal-block wiring, snap-track mounting of control and relay units, and plug-in mounting of limit modules and relays. A full 0- to 360-degree range in limit setting is available.

The switch system is available off-the-shelf for immediate delivery.

For technical and price information, contact the manufacturer, Astrosystems, Inc., 6 Nevada Dr., Lake Success, N.Y. 11040 **Circle No. 40**

This solid-state limit switch system is expected to find application in equipment now using electromechanical cam-type switches or solid-state proximity units.



5-MHz microprocessor exceeds 8080A and 8085A performance levels

The 8085A-2 microprocessor is completely compatible with other MCS-85 family members. This 5-MHz, 8-bit microprocessor accepts 8080A software programs without the need for any modification, and is bus compatible with 8080A components.

The 8085A-2's throughput rate can be increased by more than 2.5 times that of the 8080A microprocessor. Its instruction time is 800 ns. The new system requires only a single +5-volt power supply for all components, including erasable PROMs. This contrasts with three supplies for an 8080A microprocessor.

A typical three-chip 8085A-2 system can replace up to ten or more 8080A system components, and each 8085A-2 component can replace a group of three to five 8080A components. Buffers are required only in larger systems.

The 8085A-2-based system includes the MCS-85 microcomputer system components family, compatible MCS-80 devices, and a line of support products. Like the central processing unit, MCS-85 components will be available in selected high-speed versions as well. MCS-85 components allow a complete system to be built using only three devices: the 8085A or 8085A-2 central processing unit; the 8156 or 8256-2 2-kb random-access memory, input/output port, and timer; and the 8355-2 16-kb read-only memory and input/output port (interchangeable with the 8755A or 8755A-2 EPROM and input/output port).

The three devices provide a 5-volt system with a central processing unit, 256 bytes of read/write memory, 2 kilobytes of program storage, 38 programmable parallel input/output lines, serial input/output ports, a system clock, a system controller, multilevel maskable vectored interrupt, and a programmable timer and event counter.

Typical instruction cycle time using an 8085A-2 based system is 0.8 μs, with a 5-MHz clock rate that can be set with a crystal oscillator or a TTL clock input.

Each 8155 or 8156 2-kb random-access memory, input/output port, and timer module is comparable to two 256- by 4-bit static random-access memories, and also contains 22 programmable input/output lines and a 14-bit programmable timer/counter.

The 8755A 16-kb EPROM and input/output port contains a 2048- by 8-bit PROM that can be erased with ultraviolet light and is electrically reprogrammable.

Samples of the 8085A-2 are available.

Full details may be obtained from the manufacturer, Intel Corp., 3065 Bowers Ave., Santa Clara, Calif. 95051.

Circle No. 41

New product applications

IC counters offer three-state outputs

The Am25LS2568 and Am25LS2569 are programmable up/down BCD and binary counters respectively. They feature three-state outputs and a choice of synchronous and asynchronous clear. Maximum clock-to-output delay is 27 ns.

Fabricated with low-power Schottky technology, the devices replace up to five SSI and MSI packages that were previously required to implement the equivalent function. They are available in 20-pin molded and ceramic dual-in-line and flat packages for use over military and commercial operating temperature ranges.

Prices start at $2.90 for the molded package in 100-unit lots.

Advanced Micro Devices, Inc., 901 Thompson P1., Sunnyvale, Calif. 94086.
Circle No. 42

DIP-type NiCd battery is designed for PC-board use

The "DataSentry" DIP-type NiCd battery is rated for 70 mAh at 15 mA. It will typically power a small memory, drawing 10 μA for nearly three months, or a larger memory, drawing one-half ampere for more than five minutes. It is offered in voltage modules of 2.4 or 3.6 volts dc. The modular approach allows building up of battery system voltage.

The battery can also be used as an electronic component. It can be constant-current overcharged continuously, to keep it in a "ready serve" mode, with only a few milliamperes.

Storage-temperature range is -40 to +50°C. The battery is rated for a 65-mA capacity at a one-hour discharge rate, and is designed for a continuous over-charge rate of 7 mA.

In 1000–4999 quantities, unit price is $2.32 for the 2.4-volt battery and $3.48 for the 3.6-volt version.

General Electric Co., Battery Dept., P.O. Box 861, Gainesville, Fla. 32602.
Circle No. 43

Photodetectors match eye's spectral response

This series of photodetectors closely matches the spectral response of the human eye in light-intensity measurement and control applications. No correction factors are required to obtain an output indication in lumens, regardless of the light source measured.

Six different active areas from 1 to 300 mm² range in responsivity from 0.03 to 90 nA/lux to cover most requirements. A hybrid circuit is also available, which provides a near linear response over a wide range of input light levels up to 15 lumens. It operates at voltages from ±2 to a single-rail 40 volts. Typical responsivity of the hybrid photodiode/amplifier at 20°C and ±15 volts is 20 mV/lux.

Prices range from $10 to $90 depending on quantity and surface active area.

Centronic, 1101 Bristol Rd., Mountainside, N.J. 07092. **Circle No. 44**

Portable 225-MHz counter is priced at $295

The model 5725C is a 225-MHz, direct-count, three-function counter that operates from any external 9- to 15-volt dc source such as a car battery or air-craft power supply. It can also be

operated from the ac power line with an optional converter.

Unit priced at $295, the instrument uses a single switch for selection of readings in Hz, kHz, and MHz over a range of 10 Hz to more than 225 MHz with a nominal sensitivity of 50 mV.

Readouts to full resolution are made in 1 second, and selective-signaling audio tones may be measured to 0.1 Hz resolution in 10 seconds. Totalizing is achieved with the front-panel control, including start and stop positions, and a reset push button.

Marketing Dept., Ballantine Laboratories, Inc., P.O. Box 97, Boonton, N.J. 07005. **Circle No. 47**

Video display has 1100-line resolution

Worst-case resolution of this video display monitor is 1100 lines at 100 cd/m² (30 fL). This is equivalent to 660 lines worst case at a 90-percent modulation index. This high brightness and resolution mean a greater black- to-white range for better gray-scale images. Gray-scale images will not wash out, even in high ambient light.

In medical imaging, the monitor finds application in multiple-image displays, B-scan ultrasound displays, image-processing displays, and CT displays. In the analytic field, the unit may be used for scanning electron-microscope applications. Other uses include displays for electronic countermeasure systems and industrial or government security systems.

Price of the 634 video display in single quantities is $1125. OEM discounts are available for quantities of ten or more.

Tektronix, Inc., P.O. Box 500, Beaverton, Oreg. 97077. **Circle No. 46**

Differential fluid pressure transducers have wide ranges

Designated the LX17XXDD and LX17XX-DDF series, these transducers are available with differential pressure ranges of -5 to +5 lb/in²d, 0 to 15 lb/in²d, 0 to 30 lb/in²d 0 to 60 lb/in²d, 0 to 100 lb/in²d, 0 to 300 lb/in²d, and −15 to +15 lb/in²d, with common-mode pressure from 30 to 300 lb/in².

Both series of differential pressure devices are housed in a brass package that provides total mechanical isolation of the transducer element. This eliminates any sensitivity to stress, such as may be created by mounting the transducer.

The devices deliver output voltages within better than 1 percent accuracy. Price of the LX17XXDD series is $105 each (quantities of one to 24) in any operating pressure range; price of the LX17XXDDF line is $125 each in these quantities.

National Semiconductor, 2900 Semiconductor Dr., Santa Clara, Calif. 95051. **Circle No. 45**

32k and 64k ROMs offer 300-ns access times

The 2332 ROM stores 32 kbits, and the 2364 ROM stores 64 kbits. Both operate at 300-ns maximum access time; use a single +5-volt, ±10-percent power supply; and are directly TTL compatible on all inputs and outputs.

The family features a separate output enable function to eliminate bus contention and to assure compatibility with the multiplexed bus structures of new microprocessors. The devices are interchangeable with the new generation of 5-volt EPROMs and will be compatible with future devices storing more than 64 kbits.

The 2332 ROM costs $27 in a plastic package and $32.25 in a cerdip package; the 2364 ROM costs $53.50 in a plastic package and $67.25 in a cerdip package.

Intel Corp., 3065 Bowers Ave., Santa Clara, Calif. 95051. **Circle No. 48**

TO-5/TO-39 heat sinks are OEM priced at 3.2¢

The 6200 series of heat sinks clip on a device without the need for special tools. A press-fit between the device and the heat sink provides an excellent path for heat conduction and insures positive device retention.

Typical case-to-ambient thermal resistances at 75°C case-temperature rise are as follows: 6201PB—54°C/watt, 6202PB—43°C/watt, and 6203PB—38°C/watt.

Designed for TO-5 and TO-39 packages, the series is offered in a preblack anodized finish per MIL-A-8625 Type II. Typical pricing for the 6201 PB is 3.2 cents in quantities of 10 000.

Thermalloy, Inc., Dept. M, 2021 W. Valley View Ln., Dallas, Tex. 75234. **Circle No. 49**

4k RAMs offer access times from 120 to 250 ns

The 2141 family of HMOS 4096- X 1- bit RAMs consists of seven types that provide four speed versions and three low-power selections. Maximum access times range from 120 to 250 ns.

New product applications

Minimum cycle times equal maximum access times. All seven devices use a single +5-volt, ±10-percent power supply and are TTL compatible on all inputs and outputs.

The family offers low power requirements combined with fully static operation. The "L" series device, for example, operates with only 40-mA maximum supply current. Current drops automatically to 5 mA maximum when the devices are deselected.

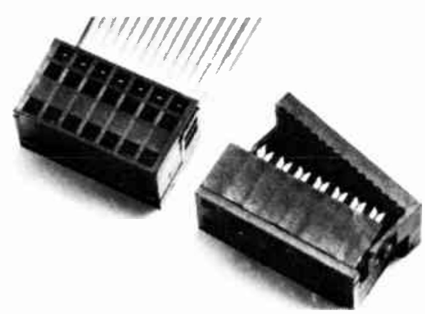
Prices for the family start at $18.75 in quantities of 100 to 999. The seven types are available from stock in standard 18-pin cerdip or plastic dual in-line packages.

Intel Corp., 3065 Bowers Ave., Santa Clara, Calif. 95051. **Circle No. 50**

Connectors speed ribbon-cable termination

These series of planar (ribbon) cable connectors have been designed for use in microcomputer systems, minicomputers, stand-alone logic assemblies, and backpanels—as well as a wide variety of test and measurement hardware.

The 804-series of DIP/socket connectors accepts 28 stranded and 28 and 30 solid AWG conductors. The connector



features a fixed 0.033-cm IDC contact with a dual-beam configuration. The connectors are available with 14-, 16-, 21-, and 24-position versions.

The second of the planar cable connectors is the 805 series, which inserts into IC sockets and provides planar cable interconnection to PC boards.

The 804-series connectors are priced at 0.09 cent per contact in quantities of 1000 pieces. The 805-series connectors are priced at 0.06 cent per contact in these quantities.

Spectra-Strip, 7100 Lampson Ave., Garden Grove, Calif. 92642.
Circle No. 51

TV demodulator has direct channel selection

This transparent demodulator unit features direct channel selection for easy shifting to other RF sources. The PM5560 offers synchronous and envelope detection, which provides accurate demodulation, especially at high modulation levels. Automatic gain con-

HONEYWELL'S Avionics Division in Minneapolis, creators of systems and components for highly advanced technological applications such as the Space Shuttle, currently has exciting career opportunities for entry level and experienced engineers. We're seeking innovative BSEE Engineers who thrive on professional challenge and welcome increased responsibility. Product applications will include radar altimeter development, commercial avionics, microwave component design and system concept definition.

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(These positions offer a lucrative per-diem package and a choice of attractive locations across the country.)

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Honeywell

New product applications

trol eliminates possible measuring errors caused by drift of the transmitter output level.

VHF range of the TV demodulator is 40 to 300 MHz; the UHF range is 470 to 960 MHz. Modulation can be adjusted and checked without special equipment with the built-in test carrier and sound-deviation meters.

Philips Test and Measuring Instruments, Inc., Mahwah, N.J.
Circle No. 52

13-MHz signal source is programmable

The model 172A programmable signal source offers full 13-MHz synthesizer performance, an interactive front panel with 40-character display, and storage for up to 100 all-parameter generator settings. A microprocessor can relieve the system controller of formatting responsibility.

This signal source provides full function generator versatility in addition to 5½-digit synthesizer resolution. Modular construction with low calibration interaction minimizes down time.

Price is $4300, with a delivery time of 30 days.

Wavetek, P.O. Box 651, San Diego, Calif. 92112. **Circle No. 53**

System "compresses" video signals

The model 260B video compressor accepts signals from a conventional CCTV camera and reduces the bandwidth by a factor of several thousand for coupling to the telephone system. Still pictures only are transmitted, with a typical frame time being 78 seconds per image for medium resolution of 256 X 512 picture elements. A companion device, the model 275 video expander, must be used at the receiving location to reconstruct the television image.

The 260B may be used with the normal dial-up telephone network, leased lines, radio links, microwave links, or satellite channels to provide low-cost visual communications.

A small remote panel permits the user to select from three separate video input signals, to initiate or terminate a transmission at any time, and to pause in the middle of a transmission for split screen effects.

Colorado Video, Inc., Box 928, Boulder, Colo. 80306. **Circle No. 56**

New product applications

DVMs "process" own measurements

This line of 5½- and 6½-digit voltmeters feature a choice of processing programs and interface options. Eight programs compute various results using the measurements as base data. A ninth program employs an internal clock as a time reference and offers full time control over measurements. Start, stop, and interval between measurements can all be set on a time base of 96 hours.

Processing capability includes: offset, multiplication, ratio, limits, percentage deviation, maximum, minimum, peak-to-peak, temperature, and statistics. For systems use, there are four interface options available: BCD, binary, RS 232, and IEEE Standard 488.

The 5½-digit model is priced at $2995; the 6½-digit model costs $3995. The processing option is an additional $990.

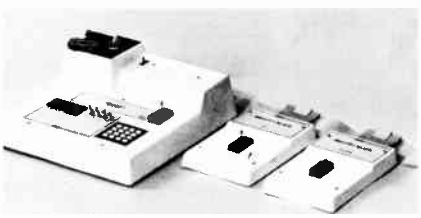
Guildline Instruments, Inc., 2 Westchester Pl., Elmsford, N.Y. 10523.

Circle No. 54

PROM system programs FPLAs

The "Smarty" is a universal PROM programming and emulating system that comes complete with built-in programmer, a 1k X 8 PROM simulator editor, and a punched-paper-tape reader controller.

The permanently connected "personality slaves" are available for all PROM families, all individual PROMs, and FPLAs. Up to 15 slaves can be daisy-chained to the system for single- or



multiple-unit programming. All slaves have their corresponding PROM/FPLA/RAM part numbers printed on them to simplify use.

The system has RS-232 and 20-mA current loop TTY interfaces, keypad and terminal control, and a production-line option that will burn in 240 PROMs simultaneously.

Price is $1595. The optional microcassette drive is priced at $696. Family and unit slaves are $195 to $450.

Sunrise Electronics, 307-H S. Vermont Ave., Glendora, Calif. 91740.

Circle No. 55

Analog board mates with popular minicomputers

This single-board analog-output system plugs directly into the backplane of

Search Reopened

DEAN OF ENGINEERING

The Newark College of Engineering of New Jersey Institute of Technology invites applications and nominations for the position of Dean of Engineering. Newark College of Engineering ranks among the leading schools in the nation in the number of B.S. degrees granted in Engineering, and offers graduate degrees through the doctorate. The Dean administers the development of all engineering programs and is responsible to the Vice President for Academic Affairs.

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New product applications

Computer Automation's LSI-2, -3, and -4 minicomputers. The system, designated the DT1735, is designed to fit in one standard half slot of the computer's card cage.

The minicomputer and the board form a complete eight-channel analog-output system for computerized control and readout applications. All eight channels are powered directly off the minicomputer +5-volt power through a dc-dc converter.

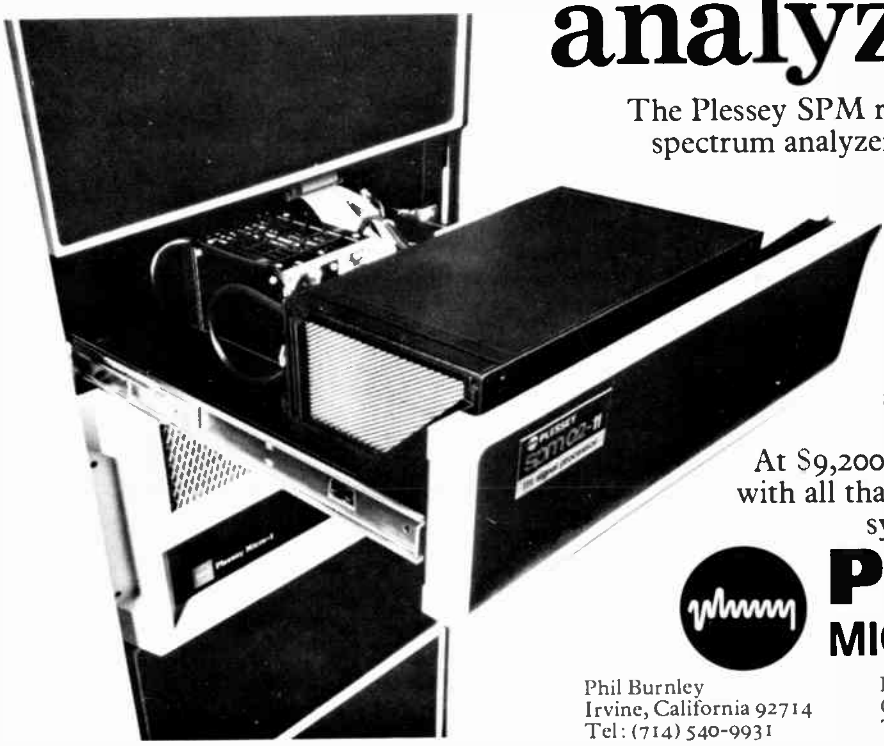
The DT1735 offers full 12-bit resolution and an accuracy within ±0.012 percent FSR. Differential linearity is ± ½ LSB. Gain and offset are adjustable to zero for each channel. Price is $1895 for eight channels and $1095 for four channels.

Data Translation, Inc., 4 Strathmore Rd., Natick, Mass. 01760. **Circle No. 57**

Encoder display has digital compensation

This series of digital displays for use with linear and rotary incremental encoders is available in four- or six-digit models with optional rate indication and digital compensation for temperature, tension, relative humidity, or other process variables. All units are equipped

Good news for PDP and LSI-11 users: Plessey has added on FFT analyzers.



The Plessey SPM range of Fast Fourier Transform spectrum analyzers offers both the system builder and the end-user excellent performance at a fraction of the cost previously possible. And now the range has been extended to include the SPM 02-11 which makes efficient, low-cost FFT processing power available to PDP-11 and LSI-11 minicomputers.

At $9,200 the SPM 02-11 comes complete with all that's needed to interface with your system. OEM discounts available.

PLESSEY MICROSYSTEMS

Phil Burnley
Irvine, California 92714
Tel: (714) 540-9931

David Garrison
Gaithersburg, Maryland 20760
Tel: (301) 840-9455

654 2 059

Circle No. 21

with quadrature detection circuits that permit multiplication of input pulses by a factor of up to 16. A four-digit scale factor multiplier provides indication in English or metric linear units, as well as angles in degrees, radians, or grads.

Available for panel-mounting or bench-top use, the 1900A series may be used with all commercial two-phase incremental encoders designed to operate from a 12-volt dc source. With Trump-Ross "Tru-Tac" encoders, resolutions of 0.15 degree can be achieved.

Fluidyne Instrumentation, 2930 Lakeshore Ave., Oakland, Calif. 94612.

Circle No. 59

"Silent" fan designed for office equipment

The TA500S tube-axial fan has been designed for use with office and peripheral computer equipment that operates in populated areas. Overall sound power level is 6 dB lower than this manufacturer's TA500 fan, with 15 percent lower input power. Air performance is 100 ft^3/min at zero static pressure.

The five-blade impeller is injection molded as one piece in black polyester thermoplastic. The housing is a one-piece black-painted zinc die casting, and the drive is a 50/60-Hz shaded-pole motor that is available with either sleeve or ball bearings.

Torin Corp., Torrington, Conn. 06790.

Circle No. 61

30-MHz dual-trace 5-mV scope costs under $1000

This 30-MHz dual-trace oscilloscope features 5-mV sensitivity, single-shot trigger, built-in delay of 120 ns, and a 20-ns/cm sweep capability with a rise time of 11.7 ns.

Other features include: a dc to 30-MHz

bandwidth, 5-mV/cm to 5-volt/cm sensitivity, and sweep speeds ranging from 0.2 μs/cm to 0.5 s/cm. Synchronization is automatic to repeated waveforms over 20 Hz, with free run below 20 Hz. The instrument offers trace rotation, plus and minus polarity, a warning lamp for an uncalibrated condition, push-button operation, and lever-type input switches.

New product applications

Priced to sell for less than $1000, the unit is offered with a two-year manufacturer's limited warranty.

Leader Instruments Corp., 151 Dupont St., Plainview, N.Y. 11802. **Circle No. 60**

Software designed for on-line interactive processing

"Incoterm Transaction Entry Management System" (ITEMS) software includes a high-level English-type language known as "transaction definition." User programmers can use this language to develop data-entry and editing applications that are specific to each installation.

The software operates in 3270 protocol on this firm's series 30 and 40 intelligent terminal systems and allows eight display stations and eight printers to be operated under the control of independent concurrent programs.

There is a one-time-per-customer fee of $7500 for the software with a continuing fee of $2400 per year. These fees allow the customer to use the software at all sites with no additional charges.

Incoterm Corp., Honeywell Information Systems, 200 Smith St., Waltham, Mass. 02154. **Circle No. 65**

SMALLER AND FASTER MAGNETIC BUBBLES PRODUCED EXPERIMENTALLY

Independent developments in the U.S. and The Netherlands show promise for future application in computers with magnetic-bubble memories. In the U.S., International Business Machines Corporation staffers have discovered that certain combinations of garnet materials and processing procedures are capable of forming stable magnetic bubbles as small as 0.4 micrometer in diameter or eight times smaller than those in garnets now available commercially for data storage. Decreased size of a magnetic bubble provides the potential for a dramatic increase in the amount of information that can be packed into a bubble device in a given area since each bubble, regardless of its size, can hold only one bit of information. At Philips Research Laboratories in Eindhoven, The Netherlands, new materials have been developed in which bubble speed is 30 to 100 times faster than in previously known materials. Investigations have shown that magnetic layers of manganese, europium, and lutecium containing iron garnet deposited on the (110) face of a single-crystal substrate of the nonmagnetic gadolinium-gallium-garnet permit bubble speeds up to 500 m/s. Increased speed is significant because bubble speed determines the maximum frequency of the rotary magnetic field used to move the bubble and, therefore, the maximum clock frequency at which bubble memories can be operated.

BELL WILL INSTALL FIBER-OPTIC INTRACITY EXCHANGE TRUNK

Flushed with success of the small-scale light-wave communications system under test in Chicago, the Bell System plans to have a fiber-optic intracity exchange trunk in commercial operation in regular service by the end of 1980. Location of the trunk has not yet been determined but candidate cities are Chicago, Boston, New York, Los Angeles, Atlanta, Philadelphia, Pittsburgh, and Rochelle Park and Union City, N.J.

In Canada, between telephone switching sites in Calgary and Cheadle in southwestern Alberta, Harris Corporation will build a 51-km fiber-optic high-capacity communications link. Under a contract with Canada's Alberta Government Telephone System, Harris will start on the project this year with completion scheduled for the fall of 1979.

NEW MICROSCOPE TECHNIQUE LOCATES ATOMS

Electron energy-loss spectroscopy is the name of a new electron microscope technique capable of sorting out electrons, generated by the microscope, that have been slowed down by interactions with electrons in the material being studied. For interactions with inner-shell electrons, the amount of energy lost is characteristic of a specific element. Therefore, particular atoms can be identified and their locations determined. Developed at Bell Labs, the technique has been used to identify and locate low-atomic-weight elements that can adversely affect miniature solid-state devices. Medical researchers are also expected to use the technique widely. The National Institute of Mental Health, for example, has already used electron energy-loss spectroscopy to confirm, for the first time, exactly where serotonin is stored in blood platelets. Researchers also have found lithium stored in the same parts of the platelets. Finding the two chemicals in the same place is an important clue to medical researchers trying to discover how lithium functions to control mental depression.

News from Region 1

ATLAS/ATE SEMINARS

A one-day seminar on IEEE Standard Atlas Test Language and Atlas Syntax has been scheduled for June 12 at the Boston Park Plaza Hotel in Boston, Mass. Designed to provide a fundamental working knowledge of Atlas, the course will address the structure of the language as presented in two IEEE Standards: Standard Atlas Test Language (IEEE Std 416-1976) and Standard Atlas Syntax (IEEE Std 416A-1976). The course is aimed at managers, engineers, and programmers in commercial and military operations who are responsible for automatic test equipment, hardware, and software for testing and test applications. Fees are $67.50 for IEEE members, $75 for nonmembers. For details: Thomas Van Hook, IEEE Standards Office, 345 East 47 Street, New York, N.Y. 10017; (212) 644-7960.

The Atlas seminar will be followed, on June 13-15, by the ATE Seminar/Exhibit on Automated Testing for Electronics Manufacturing, which is sponsored by Circuits Manufacturing magazine. For further information: Sheila Goggin, Circuits Manufacturing Magazine, 1050 Commonwealth Avenue, Boston, Mass. 02215; (617) 232-2668.

SIGNAL PROCESSING COURSE AT R.P.I.

An advanced short course in two-dimensional digital signal processing will be held August 14-18 at the Communications Center of Rensselaer Polytechnic Institute in Troy, N.Y. The course will cover theory, practice, and application, and will provide the opportunity to use the interactive design facilities of R.P.I.'s Computer Graphics Center. Complete information may be obtained from the course director, Professor John Woods, Rensselaer Polytechnic Institute, Troy, N.Y.12181; (518) 270-6330. Registration will be open through July.

TRENTON STATE FEATURES MICROCOMPUTERS

Three short courses designed to meet the needs of engineers, computer scientists, and others interested in the areas of microcomputers and digital electronics will be offered by Trenton State College during the week of August 21. The courses are: "Assembly Language Programming and Interfacing for the 8080/8085/Z80 Microprocessor" (fee, $350); "Programming in Basic for the Microcomputer Owner" (fee, $300); "Microcomputer Digital Logic Circuits" (fee, $300). Courses will consist of lectures coupled with laboratory sessions. Classes will be limited to 20 participants. For further details and registration forms: Division of Continuing and Adult Education, Trenton State College, Trenton, N.J. 08625; (609) 771-2255.

M.I.T. SUMMER PROGRAM

Ultrasound, Sound, Microwaves, Laser and Ultraviolet: Biophysical and Biological Basis, Hazards and Applications in Medicine and Industry, July 24-28 at the Massachusetts Institute of Technology, Cambridge. Tuition for the one-week program is $580 ($350 for two days). Write to: Director of Summer Sessions, Room E19-356, M.I.T., Cambridge, Mass. 02139.

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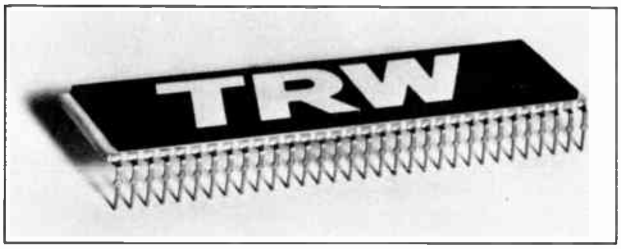

Now you can afford to go digital

We've done today what everyone thought was years away. We've developed a Monolithic Video A/D Converter to sell for less than $500—it works just great—and best of all, it's ready for delivery now.

TRW's new 8 bit TDC 1007J costs only $485 (in 100's), features up to a 10 to 1 power reduction over existing converters, is less than ⅓ the size, and converts with unmatched accuracy up to 30MHz (33 ns conversion time).

The TDC 1007J exceeds the standards that networks require for studio equipment, yet is economical enough for field and/or industrial use. If you have a product that is now using one of those expensive Video A/D Converters you can mount the TDC 1007J (and about $30 worth of other components) on a card and start saving a bundle immediately. (Incidentally—we are making available, in small quantities, an evaluation board. It's a fully tested drop-in unit containing everything you need to go digital—just ask for TDC 1007 PCB.)

Let us show you how you can go digital...economically. Available from stock from Hamilton/Avnet or contact your local TRW Electronic Components field sales office or call Willard Bucklen at (213) 535-1831, or send coupon.

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TRW *LSI PRODUCTS*

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Circle No. 30

New product applications

20-MHz pulse generator priced at $595

The model 101C pulse generator has a fixed rise time of less than 10 ns and provides a variable output to ±18 volts from 50 ohms. Simultaneous auxiliary front-panel outputs are designed for TTL logic levels (a 4-ns rise time) and CMOS

(open-collector output capable of 40-volt amplitude or 100 mA).

Two accessories—one a code generator—can generate an arbitrary code up to 4096 bits long. The other, a burst generator, generates a presettable burst of pulses from one to 999.

The unit is priced at $595.

Concord Instrument Div., Systron-Donner Corp., 10 Systron Dr., Concord, Calif. 94518 **Circle No. 58**

Sequence controller IC has 4096-word range

The Am2910 address sequencer controls up to 4096 words of microprogram-stored microinstructions. In addition to an ability to address sequentially, the controller provides conditional branching to any instruction within its 4096-microword range.

An on-chip loop counter keeps count of how many times a single microinstruction or loop has been executed. The loop counter automatically controls this repetition.

The sequence controller is available in a 40-pin ceramic DIP or a 42-pin flat package for use over the military and commercial operating temperature ranges. Prices start at $25.95 in 100-piece lots.

Advanced Micro Devices, Inc., 901 Thompson Pl., Sunnyvale, Calif. 94086. **Circle No. 66**

Miniature power relays rated at 5 and 10 amperes

These miniature power relays are rated at 5 and 10 amperes and can handle loads up to 280 volts ac. They employ 0.5-inch-long 0.062-pin terminals that match standard slip-on female connectors offered by Molex and Winchester.

The relays feature 3750-volt ac rms input/output photo isolation and operate at logic levels of 4 to 8 volts dc or 9 to 16 volts dc with a control current of 15 mA.

Pricing in 1000-lot quantities ranges from $3.60 to $5 depending on current, voltage, and terminal configuration.

Delivery is four to five weeks in moderate production quantities.

Theta-J Relays, Inc., 1 DeAngelo Dr., Bedford, Mass. 01730. **Circle No. 62**

Test clips protect MOS ICs from static

These IC test clips fit on DIP packages to protect MOS ICs from static. Cable versions include a connecting cable preattached to the top of the clip. Attaching all leads at the far end of the cable to a working ground effectively short-circuits each IC pin to ground and eliminates the problem of static discharge during handling.

The test clips are available in 14-pin, 16-pin, 24-pin, and 40-pin configurations. Cables are available in 40-, 45-, and 60-cm lengths in each clip size. Prices for each clip and cable assembly range from $7.75 to $21.75 (unit quantities).

Continental Specialties Corp., 70 Fulton Terrace, New Haven, Conn. 06509. **Circle No. 63**

520-MHz automatic counter is temperature compensated

This 520-MHz automatic frequency counter features a temperature-compensated crystal oscillator to maintain stability under extreme conditions of ambient temperatures. The counter has an LED display of eight digits, with

resolution of 1 Hz up to 80 MHz and 10 Hz above 80 MHz.

Designated the PM6664, the unit can handle various power requirements automatically. It offers a wide range of automatic input sensitivity: 20 mV rms (100 Hz-520 MHz) to 1 volt rms. Input attenuation is automatic and continuously variable, ensuring accurate measurements.

The counter weights 1.4 kg and measures 145 by 44.5 by 220 mm. Price is $645 ($545 without crystal oscillator).

Philips Test and Measuring Instruments, Inc., Mahwah, N.J. **Circle No. 64**

CCD memory driver IC comes in a DIP

Designated the SN75363NE, this CCD memory driver DIP has six internally connected heat-sink pins for improved heat dissipation. Package leads fit standard 14-pin sockets.

Designed for use between TTL and high-current, high-voltage systems, the circuit can drive high capacitive loads (typically 1000 pF) at frequencies ranging from 1 to 5 MHz.

Operation is from standard bipolar and MOS supply voltages. It has been optimized for operation with V_{cc2} supply voltage from 11 to 15 volts and with nominal V_{cc3} supply voltage from 0 to 4 volts higher than V_{cc2}.

The device is characterized for operation from 0 to 70°C. Price in 100-piece quantities is $3.60.

Texas Instruments, Inc., Inquiry Answering Service, P.O. Box 5012, M/S 308 (Attn: SN75363NE), Dallas, Tex. 75222. **Circle No. 67**

30- and 55-volt Darlington couplers come in 6-pin DIPs

This series of Darlington optically coupled isolators offers collector/emitter breakdowns of 30 to 55 volts. Collector leakage is typically under 10 nA at 80 volts. Current transfer ratios to 500 percent minimum are specified at 1- mA input currtrent. At 10 mA, CTR is over 1000 percent.

Offered in 6-pin DIPs, the couplers are priced from $1.65 to $1.59 in 100-piece quantities.

The manufacturer assures 5000-volt dc surge protection for application in controllers, telecommunications, vending machines, instruments, and motor-control circuits.

Spectronics, Inc., 830 E. Arapaho Rd., Richardson, Tex. 75080. **Circle No. 68**

Bilateral FET is optically isolated

The model H11F optically couples the GaAs IRED to a silicon bilateral analog FET. The series is designed to perform two major functions: as a fast (less than 15 seconds) bilateral analog switch with 60-volt p-p signal capability and as a linear variable resistor with less than 2000 ohms "on" resistance and more than 300 MΩ "off" resistance.

Typical applications as a variable resistor include: distortion-free attenuation of low-level signals, automatic gain control using an isolated AGC signal, and electronically adjusting active-filter fine tuning or band switching.

As an analog switch, it can be applied in isolated sample-and-hold circuits, even where signal polarity is undefined. It can also be used for multiplexing both ac and dc signals.

Prices start at 98 cents in 1000-lot quantities.

General Electric Co., Electronics Park 7-42, Syracuse, N.Y. 13221. **Circle No. 69**

Waveform generator covers 10 nHz-999 Hz

Designated the model 350 low-frequency generator, this unit uses a crystal-controlled clock and digital synthesis techniques to generate sine, square, triangle, ramp, haver-sine, haver-square, haver-triangle, and inverted waveforms.

The unit has nine frequency ranges, with three-digit resolution providing an overall frequency range of 10 nHz (3.17 years) to 999 Hz. When operating in the

New product applications

ramp or triangle modes, the minimum step amplitude is 50 μV at a maximum signal amplitude of 20 volts p-p. When operating in the sine-wave mode, the minimum step phase-angle resolution is 0.00045 degree (1.62 seconds of arc).

Modular plug-in units include a variable-phase generator, a trigger unit, and an amplitude-control unit. The basic model is priced at $1400.

Exact Electronics, Inc., 455 S.E. 2nd Ave., Hillsboro, Oreg. 97123. **Circle No. 71**

Design kit available for fiber optics

This fiber optics designer's kit contains an assortment of emitter and detector bushings, splice bushings, polishing bushings, several sizes of connector ferrules, a polishing plate, a hand tool for terminating fiber optic cable, and sample lengths of cable.

An instruction book provides cross-

referenced data concerning semiconductor emitters and detectors, as well as fiber optic cables.

The kit contains enough components to house 25 emitters or detectors, to make five free-hanging and five bulkhead-mounted splices, and to terminate 20 cables.

Price is $165.

Amp Inc., Harrisburg, Pa. 17105.
Circle No. 70

Graphics package permits three-axis plotting

"3-D Plot" is a software/firmware package that can provide three-dimensional plotting analysis when used with the Tektronix-4051 graphics computing system. Consisting of two ROM packs, the package can overcome the constraints of speed and space when dealing with three-dimensional plots. A "conics" ROM is a function and image generator that reduces plotting time. The "graphics" ROM is an image manipulator that packs data into less memory space.

A "dark vector" feature permits moves and draws in one matrix. Moves are

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New product applications

distinguished from draws by making the sign of the x coordinates negative. As a result, hidden line determination is speeded.

The package is priced at $950.

Second Source Industries, 735 Addison St., Berkeley, Calif. 94710.

Circle No. 72

Video A/D converter is priced at $485

This 8-bit monolithic video A/D converter can perform conversions in 33 ns and is priced at $485 in quantities of 100. The single chip contains 20 000 bipolar components and provides 255 comparators with combining logic.

Designated the TDC1007J, the device requires only 2.5 watts of power, plus 1 watt for peripheral circuitry (as opposed to up to 25 watts for older converters). Operating temperature range initially is specified at 0 to 70°C.

The device meets video requirements for conversion rates of more than four times the color subfrequency.

TRW LSI Products, P.O. Box 1125, Redondo Beach, Calif. 90268.

Circle No. 75

Wire-wrappable board designed for CMOS uses

These two CMOS boards are equipped with two power and two ground planes. The 2-065 CMOS board is capable of mounting up to 36 16-pin DIPS or an equivalent mix of other popular DIP sizes.

The boards are designed to meet the requirements of CMOS product designs where it is common to implement simple delay and differentiation functions with resistor-capacitor networks. The center mounting of the component pins permits easy access from the discrete components to the IC packages.

The model 2-045 is priced at $35.75, and the model 2-065 is available at a price of $44.95 (unit price in quantities of one to nine).

Hybricon Corp., 410 Great Road, Littleton, Mass. 01460. **Circle No. 78**

Modem filters handle 60- to 600-baud data rates

This family of fixed-frequency active modem filters offers an inverting midband gain of 0 ± 0.5 dB. Relative to the midband gain, these active filters attenuate the in-channel space and mark frequencies by no more than 1.5 dB, while attenuating adjacent channels' space and mark frequencies by 28 dB minimum.

Fixed frequencies are 60, 75, 110, 150, 300, and 600 baud. All filters operate from a single-ended power supply that may range from +10 to +30 volts dc.

Prices start at $42 in quantities of one to nine, and are as low as $19 each at the 1000-piece level.

Frequency Devices, Inc., 25 Locust St., Haverhill, Mass. 01830. **Circle No. 76**

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The IEEE 1977 Membership Survey in the United States prompted a 9,227, or 36.8% usable response, to an extensive questionnaire mailed on June 24, 1977 to 25,056 Members, Senior Members and Fellows. Tabulation was performed in the fall of 1977.

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The 1977 Survey is published in two paperbound volumes: Part I and Part II. Part I (79 pages) is the basic report, containing respondents' profile, data on fringe benefits and professional activities. Part II (96 pages) contains numerous cross-tabulations of salary vs. varying sets of two demographic characteristics.

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Circle No. 214

New product applications

Voltage regulator IC uses PWM switching

This pulse-width-modulation (PWM) switching voltage regulator is designed primarily for power supply control. Designated the TI494, it has on a single chip all the functions required for PWM control circuits: a 5-volt regulator, a current-limit amplifier, an adjustable oscillator, a dead-time control comparator, a pulse-steering flip-flop, and output control circuitry.

Both the error amplifier and the current-limit amplifier have a common-mode input voltage range from -0.2 volt to a V_{CC3} of -1.5 volts. Fixed internal offsets provide a current-limit amplifier and a 45-percent maximum duty cycle for the dead-time control comparator.

Prices in 100-piece quantities for the plastic DIP are $2.88. The ceramic DIP is priced at $3.31.

Texas Instruments, Inquiry Answering Service, P.O. Box 5012, M/S 308 (Attn: TL494), Dallas, Tex. 75222. **Circle No. 69**

Asynchronous/synchronous controllers combined

This universal line multiplexor combines a four-line asynchronous controller with a single-line synchronous controller on a single board. The communications "subsystem-on-a-board" interfaces asynchronous terminals as well as a synchronous line to a host computer.

The multiplexor occupies a single slot in this manufacturer's Nova or Eclipse chassis, and it is software compatible with the manufacturer's ALM series asynchronous and SLM series synchronous line multiplexors.

The unit features full modem control, including auto answer, and provides cyclic redundancy check to assist system software in implementing various synchronous line protocols, such as IBM's "bisync."

Data General, Rt. 9, Westboro, Mass. 01581. **Circle No. 79**

IC counters offer three-state outputs

The Am25LS2568 and Am25LS2569 are programmable up/down BCD and binary counters respectively. They feature three-state outputs and a choice of synchronous and asynchronous clear. Maximum clock-to-output delay is 27 ns.

Fabricated with low-power Schottky technology, the devices replace up to five SSI and MSI packages that were previously required to implement the equivalent function. They are available in 20-pin molded and ceramic dual-in-line and flat packages for use over military and commercial operating temperature ranges.

Prices start at $2.90 for the molded package in 100-unit lots.

Advanced Micro Devices, Inc., 901 Thompson P1., Sunnyvale, Calif. 94086. **Circle No. 81**

Spectrum's hardware review

For more information on the following products, circle numbers on the Reader Service Card corresponding to bracketed numbers.

Optical connector, designed to accommodate duplex (two-fiber) fiber-optic cables with 0.013- to 0.017-inch- (0.33- to 0.043-cm-) diameter fibers has a self-centering feature that aligns mating fibers along their center axis, AMP Inc. [90]; **12-bit analog-input module is pin compatible with popular microprocessors,** Burr-Brown Research Corp. [91]; **Price reductions averaging 25 percent have been made in this manufacturer's line of Corguide optical waveguides,** Corning Glass Works [92]; **Semiconductor add-in memory system for DEC PDP-11/04 and 11/34 minicomputers provides 32k by 18 bits of dynamic MOS memory on a single card,** Fabri-Tek, Inc. [93]; **Miniaturized and metalized Synthar type TSZ long-time-constant capacitors retain 99 percent of their charge for 150 hours,** Industrial Condenser Corp. [94]; **Model 2000 data logger is expanded in capability to include types B, E, N, R, and S thermocouples scaled to read in °C, °F, and °K, in addition to standard ranges for types J, K, and T thermocouples,** Instrulab, Inc. [95]; **Room-temperature-curing instant adhesives for industrial applications come in several formulations, each intended to solve specific types of bonding challenges,** Loctite Corp. [96]; **Ultrathin silver-oxide watch power cell has a diameter of 0.455 inch (1.16 cm) and it is only 0.085 (0.216 cm) thick,** Panasonic (97); **Ultraminiature polystyrene capacitors with values ranging from 0.1 to 5 μF at 100-volt ratings are less than one fourth the size of comparable units,** PFC, Inc. [98]; **Portable, plug-in micro/minicomputer power-supply regulators exceed performance ratings of conventional ultraisolation transformers and include voltage-regulation, over-voltage-protection, and short-circuit current-limiting features,** Sola Electric Co. [99]; **Dual-density, 75-in/s 800/1600-b/in, magnetic-tape system is available for use with Sperry Univac V77 minicomputers,** Sperry Univac, Div. of Sperry Rand Corp. [100]; **Free Weston model 6000 autoranging digital multimeter carrying case is offered to purchasers of the meter during the period May 1–August 31, 1978,** Weston Instruments, Div. of Sangamo Weston, Inc. [101].

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Manufacturers who are advertising their important new products here are making available product literature for your use. Simply circle the corresponding numbers on the SPECTRUM Reader Service Card inside the back cover of this issue.

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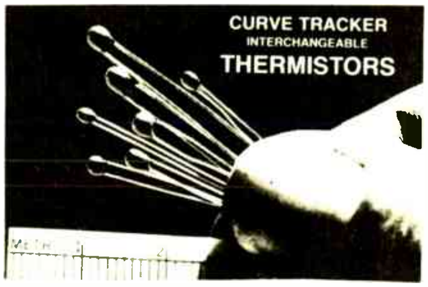

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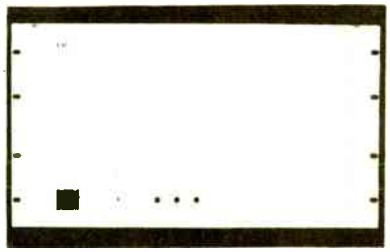

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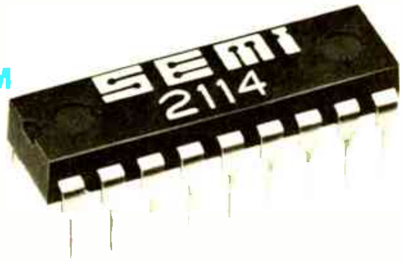

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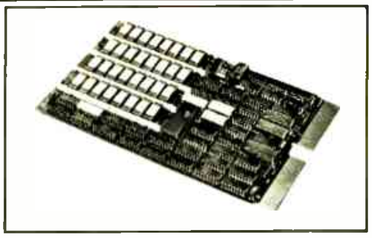

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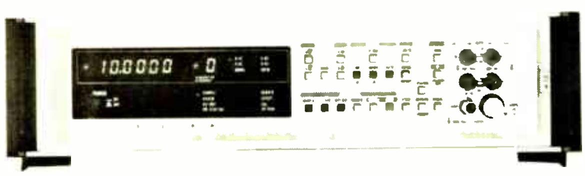

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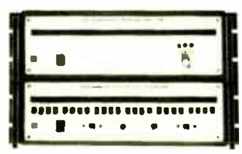

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The applications guide is published by Analog Devices, P.O. Box 280, Norwood, Mass. 02062. **Circle No. 120**

Fundamentals of phase-control SCRs

This 12-page applications note presents information on the basic operation of phase-control silicon-controlled rectifiers (SCRs). Nineteen graphs, figures, and circuit diagrams illustrate the discussions of junction temperature, voltage blocking, thermal resistance, power dissipation, etc. Applications information and an appendix of mathematical derivations are also included.

The applications note is published by FMC Corp., Semiconductor Products Div., 800 Hoyt Street, Broomfield, Colo. 80020. **Circle No. 121**

Applying reed switches to temperature sensing

This nine-page manual describes how reed relay switches, originally designed for telephone systems applications, have been adapted to tempertature-sensor applications. Thirteen illustrations highlight the discussion. Specific uses suggested include engine temperature sensing, oven overheat alarm, food-freezer thaw warning, and cooling-fan stop indicator.

The manual is published by Midwest Components Inc., P.O. Box 787, Muskegon, Mich. 49443. **Circle No. 122**

Understanding software for corporate financial accounting

This 68-page manual provides a step-by-step guide for executives and data-processing professionals involved with the selection of a computer-based financial application system. Besides a wide range of case histories, the manual features many charts, graphs, and sample reports. Highlights include the flow of cost accounting, transaction analysis, and on-line information needs. Generating reports, financial statements, and related information necessary for accurate decision making is also demonstrated.

The manual is published by Software International, Elm Square, Andover, Mass. 01810. **Circle No. 123**

Getting NBS time via satellite

This 12-page brochure describes the National Bureau of Standards time code now being broadcast from the Geostationary Operational Environmental Satellites. These satellites are in orbit over the equator and provide 24-hour, continuous service to the entire Western Hemisphere. Reception is easily implemented with a small antenna and a commercially available automatic receiver.

The brochure (Publication TFS-602) is published by the National Bureau of Standards, Boulder, Colo. 80303. **Circle No. 124**

New thoughts on microelectrode measurements

This 24-page laboratory handbook and reference list is intended for electrochemical researchers in biological science. Detailed are the various methods and equipments used to perform potential or current and impedance measurements in electrolytes. Chapter listings include: electrode fundamentals, micropipette electrodes, ion-specific microelectrodes, and electrotitration. References are also provided.

The handbook is published by W-P Instruments, Inc., P.O. Box 3110, New Haven, Conn. 06515. **Circle No. 125**

Understanding temperature and power controls

This 44-page catalog of temperature controllers, thermostats, and magnetic contactors contains five pages of "how to" information on selecting temperature controllers, a glossary of technical terms common to temperature-controller descriptions and specifications, and several applications examples illustrated with typical wiring diagrams.

The catalog is published by Chromalox Division, Emerson Electric Co., 7500 Thomas Blvd., Pittsburgh, Pa. 15208. **Circle No. 126**

Spectrum's literature review

To receive these items, circle the indicated Reader Service Card numbers.

Hybrid and monolithic data converters (tutorial and catalog), Datel Systems, Inc. [135]; **Catalog of microcomputers, accessories, software packages, parts, and literature**, Tandy Computers [136]; **Measuring molecular parameters with light-scattering instrumentation**, Chromatix [137]; **Making multiple power system measurements with a polymeter**, Dranetz Engineering Laboratories Inc. [138]; **Temperature-resistance characteristics of a positive-temperature-coefficient silicon thermistor**, Texas Instruments Inc. [139]; **Relay selection and application manual**, Relay Specialties, Inc. [140]; **YAG laser primer/catalog**, General Photonics Corp. [141]; **Check list evaluates power structure of typical computer installations**, Computer Power Systems Corp. [142]; **Liquid-crystal displays—principles of operation, construction, and application**, Beckman Instruments, Inc. [143]; **EMI defined, discussed in filter handbook**, AMP Capitron Division [144]; **Mounting power semiconductors for adequate cooling**, Westinghouse Electric Corp. [145].

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Limited funds may be available to encourage the participation of a few researchers. Applications for travel support are currently available and must be returned to the Symposium Chairman by 1 August 1978.

Researchers are also encouraged to submit papers and poster session displays. A short outline of proposed papers or displays should be submitted to the Symposium Chairman by July 17, 1978. Anyone interested in attending, presenting papers or displays, or otherwise participating in this symposium should contact: A. Atley Peterson, Symposium Chairman, Bureau of Alcohol, Tobacco and Firearms, 1200 Pennsylvania Ave., N.W., Washington, D.C. 20226 (202) 566-7436.

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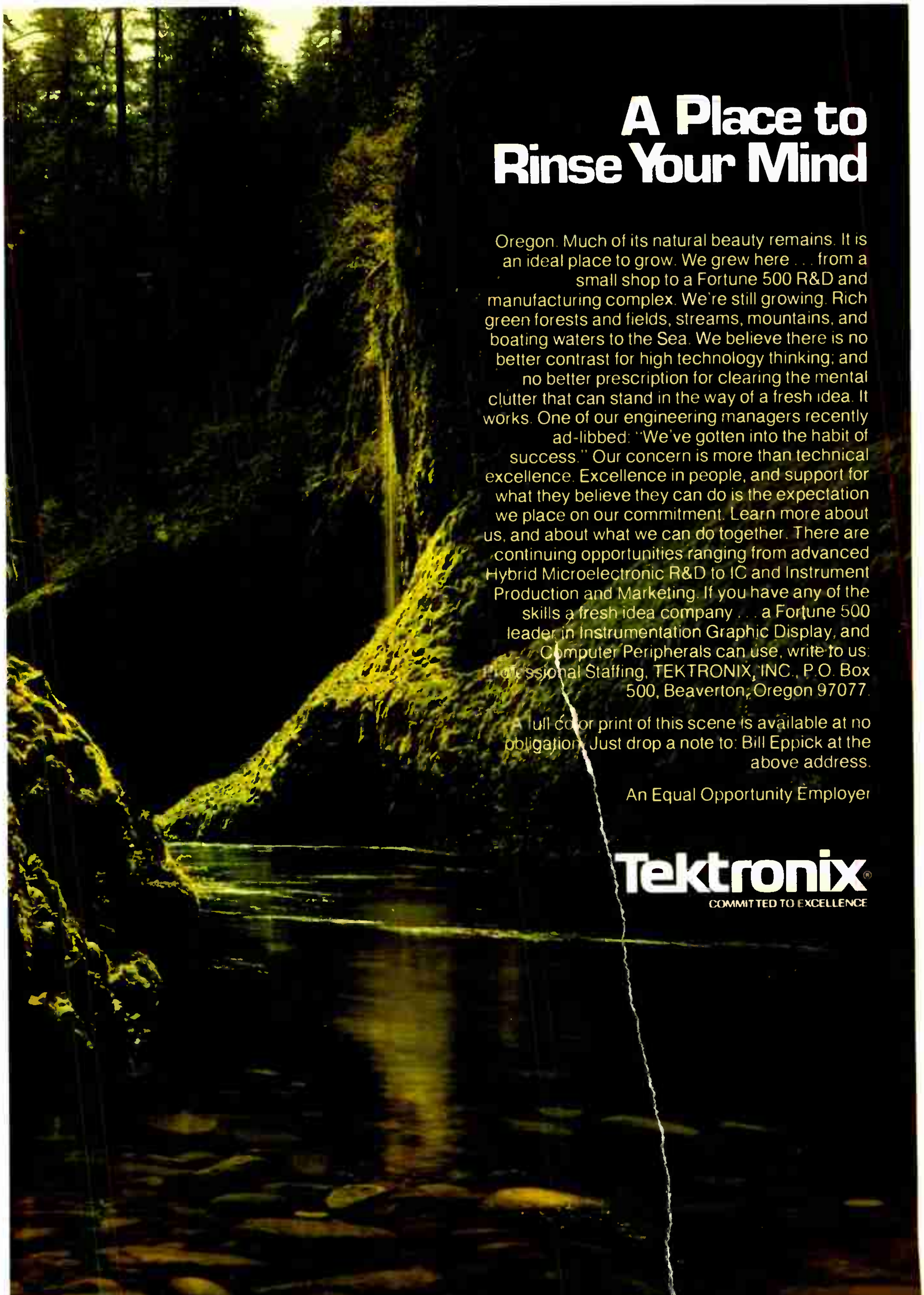
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