October 11, 1973

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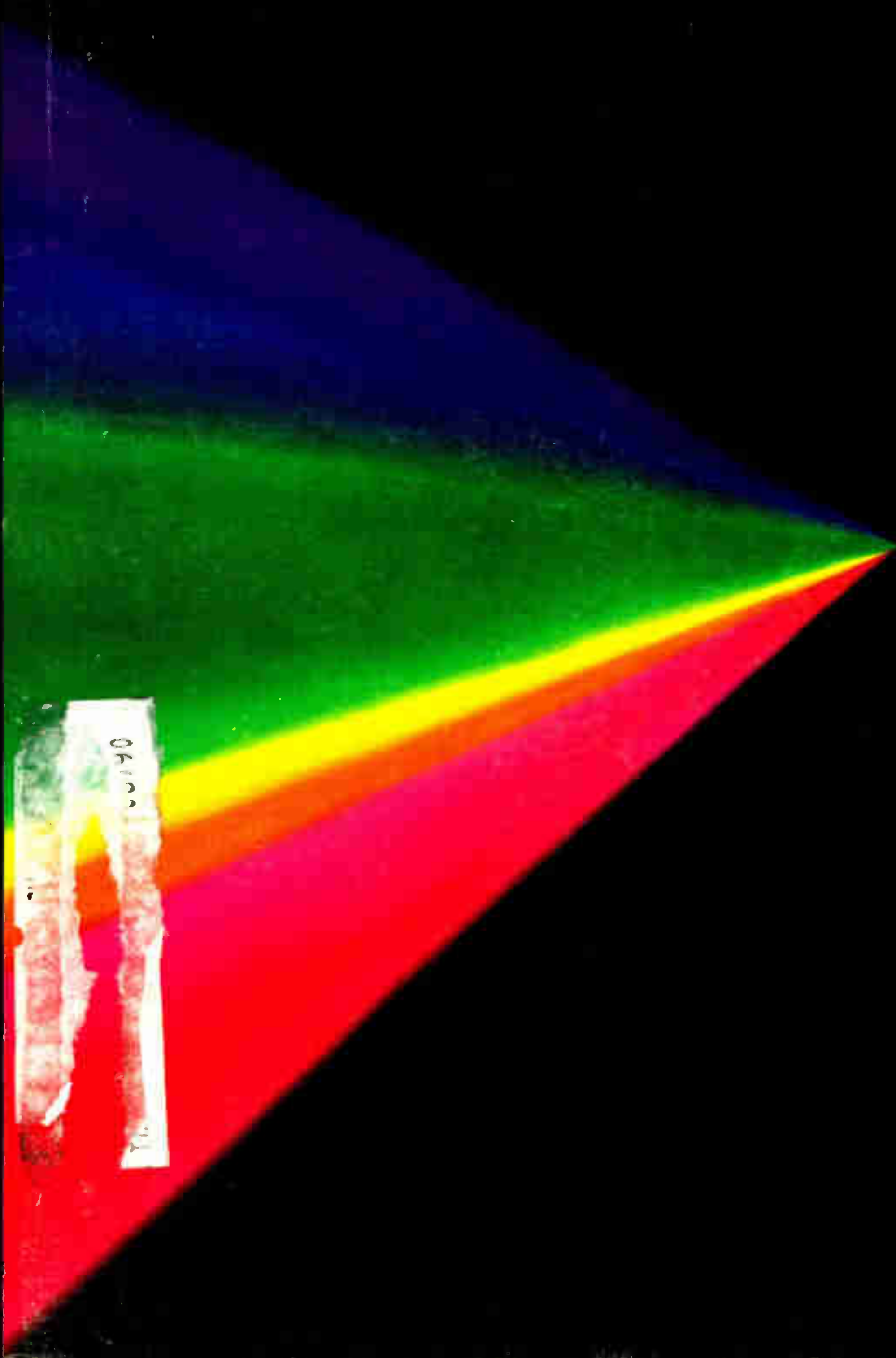
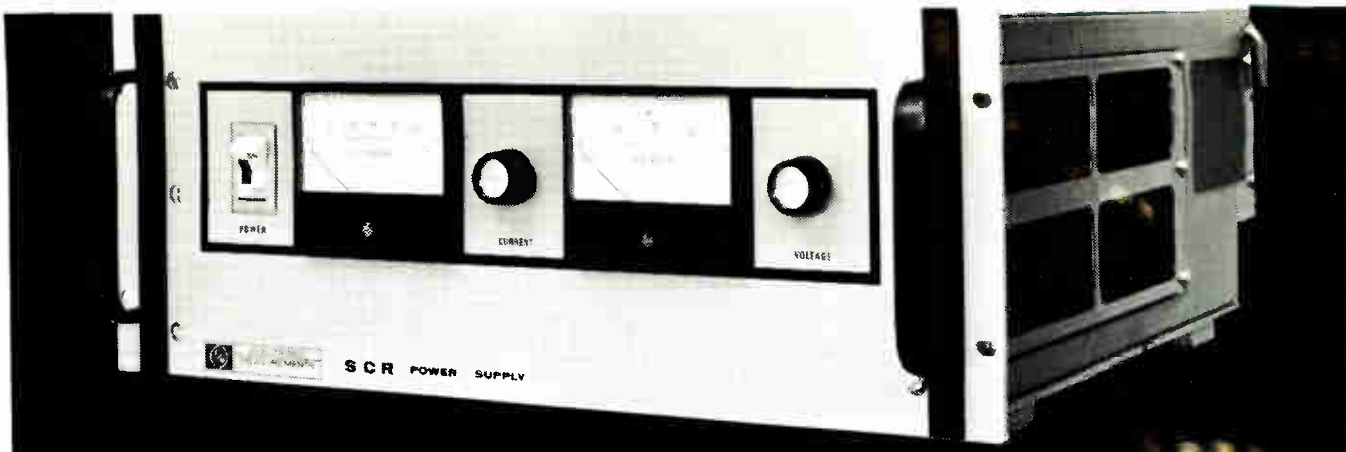


The Optical Spectrum



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10V-500A	1,600	2,000
20V-125A	1,050	1,200
20V-250A	1,275	1,500
20V-500A	2,050	2,650
30V-100A	1,050	1,200
30V-200A	1,450	1,800
40V-60A	950	1,100

	Price	
Rating	EM	SCR
40V-125A	$1,300	$1,600
40V-250A	1,975	2,500
50V-200A	1,975	2,500
80V-30A	950	1,110
80V-60A	1,200	1,500
100V-100A	1,975	2,500
120V-20A	975	1,300
120V-40A	1,200	1,500

	Price	
Rating	EM	SCR
160V-15A	$ 950	$1,100
160V-30A	1,300	1,600
160V-60A	1,975	2,500
250V-10A	950	1,100
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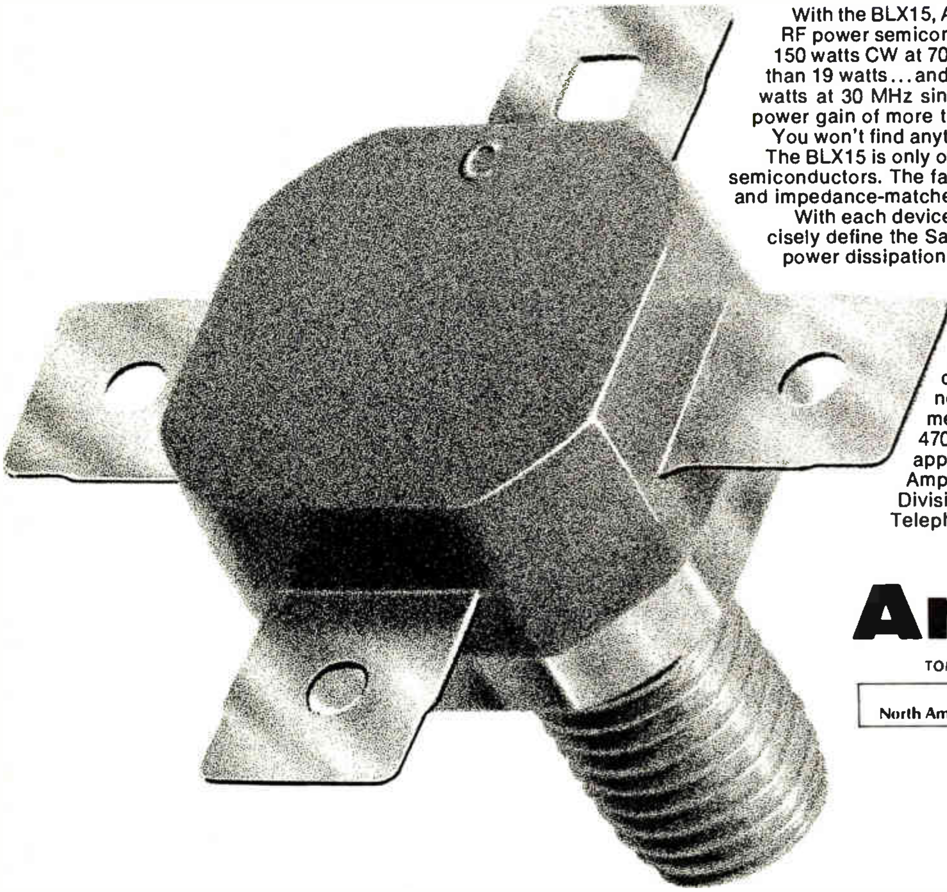

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7.0		2N3926		BLX68	BGY23	BLX93
8.0	BLX13	BLY87A	BLY91A			
12.0		2N3927				
13.0			2N3632			
15.0		BLY88A	BLY92A		BGY24	
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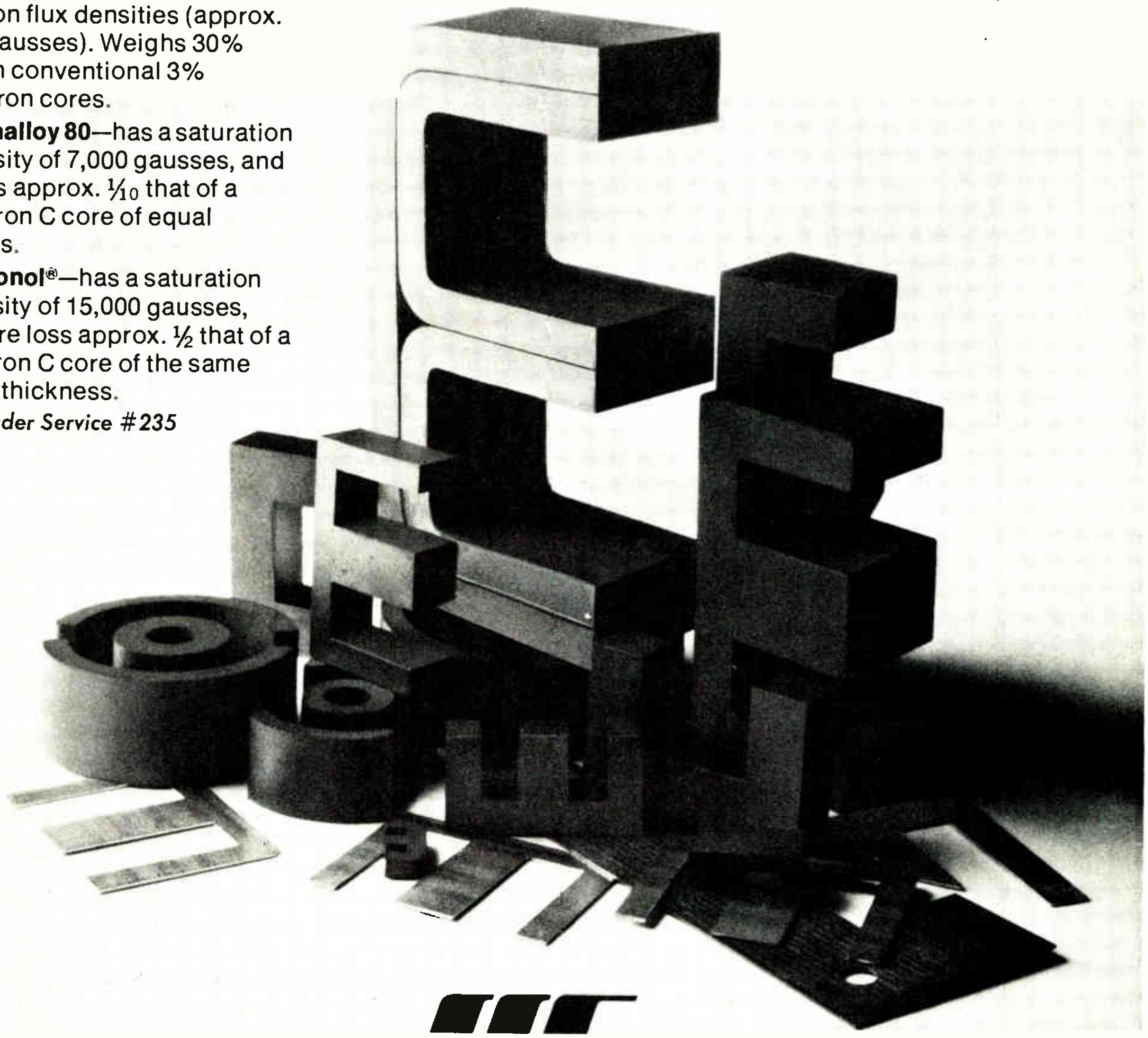

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Electronics

The International Magazine of Electronics Technology

Vol. 46, No. 21 • October 11, 1973

Highlights

The cover: Focus on optoelectronics, 109
Technologies and devices that exploit electronic reactions to the optical spectrum are on the upsurge. This survey of the optoelectronic hardware available today is correlated with the ultraviolet, visible, and infrared wavelengths each device handles.

For rapid reference, the multicolor foldout chart on page 115 lines up light sources, detectors, and transmission materials under the relevant portions of the optical spectrum.

Communication catches on in Alaska, 75
Long-distance direct dialing between towns, telephone links to small, scattered villages, and a domestic satellite program are updating Alaska's primitive communications system. By year's end, $91 million will have been invested in these and other projects.

How to switch from gates to microprocessors, 91
The once-and-for-all-time logic design is giving way to the quickly alterable microprocessor chip set. But this means the system designer must learn the techniques of programing the device.

One-layer package slashes ceramic DIP cost, 119
Replace three layers with one, make the package reusable by sealing the lid with epoxy, raise the yield—and you have a ceramic DIP that's cost-competitive with plastic.

And in the next issue . . .
The great takeover: the why and how behind electronics' revolutionary impact on industry, government, and the lifestyle of the private citizen.

Coming next issue
A special issue devoted to the growing pervasiveness of electronics.

Electronics

Publisher's letter

Alaska, a state which is over twice the size of fabled Texas, is sparsely populated, containing only some 350,000 people. It's stitched together by two things: a transportation network and communications. And electronics is an essential element in both.

Recently, our Communications and Microwave Editor, Lyman Hardeman, a Texan, went to Alaska and brought back the story (see Probing the News, p. 75) on how a group of isolated communities are getting their first telephone service, thanks to electronics. Hardeman discussed communications problems with the governor of Alaska, William Egan, who stresses that the economic future of Alaska depends on progress in communications and transportation.

Says Hardeman: "One out of every 7 or 8 Alaskans is a pilot, and given the wildness and vastness of Alaska, two-way radios are a necessity rather than a luxury. Often a bush pilot is the only link with the outside world. Some of the towns that are just being hooked into the radio-based dial-telephone network simply had no contact with the rest of Alaska except when a plane touched down."

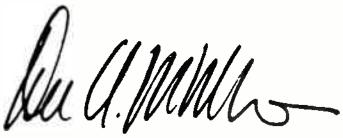
The optical spectrum is the scene of a lot of activity these days, what with lasers, light-emitting diodes, fiber optics, and a host of other developments of interest to electronics engineers.

To give more clarity to the details of what fits where in the optical spectrum, we've put together a fold-out, four-color chart of that area of the electromagnetic spectrum. You'll find it, and an accompanying article starting on page 109. Suitable for mounting on a wall, the chart relates wavelength, energy, and frequency and shows the range of operation of a number of emission sources, transmission materials, and detectors. The presentation on the optical spectrum, by the way, carries the byline of Lyman Hardeman, our Communications and Microwave Editor, his second of the issue.

And speaking of bylines, the newest member of our staff has his first *Electronics* byline in this issue. Chronicling the latest, and biggest, step in the journey to the marketplace of silicon-on-sapphire devices (see p. 85) is Joel DuBow, Components Editor.

DuBow brings to our pages a broad background of electronics training and experience. A holder of a BSEE from Brooklyn Polytech, he went on to earn a master's degree at Princetown and a PhD at the electrical engineering and applied physics department at Case-Western Reserve. He has worked for RCA, where he was engaged in research on MOS devices and processing, among other things, and Radiation Inc., where he was involved in work on materials for optical memories.

His move to New York brings him to a new territory for one of his big interests—backpacking. Having done most of his backpacking in the West, he is looking forward to what the trails of the eastern ranges have to offer.



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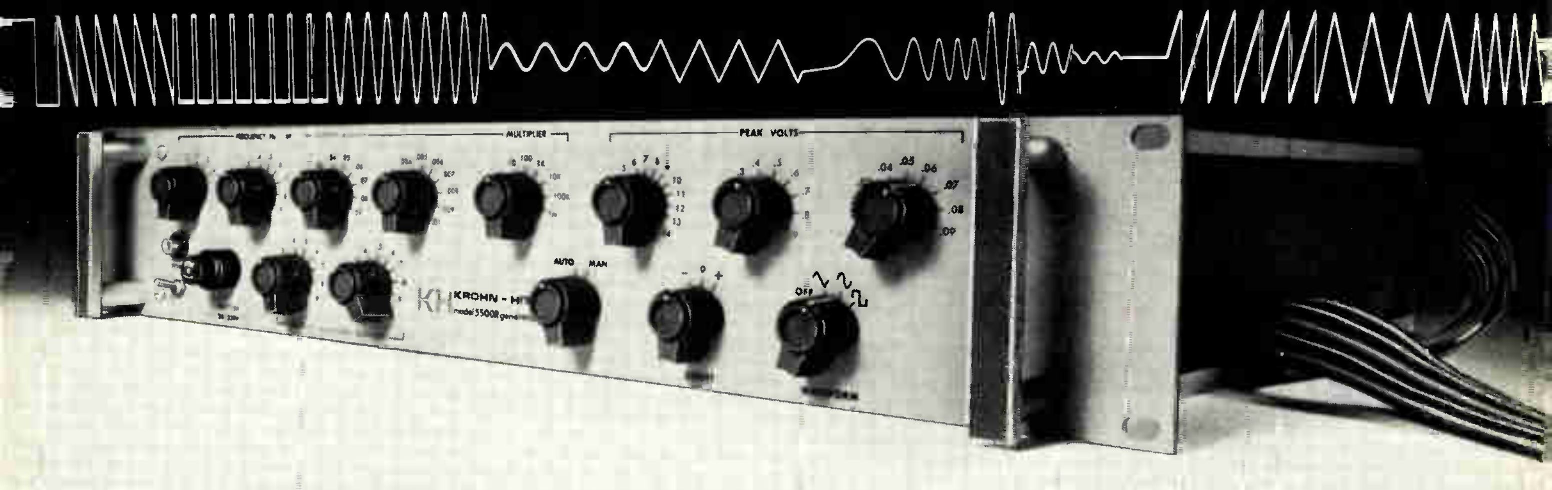

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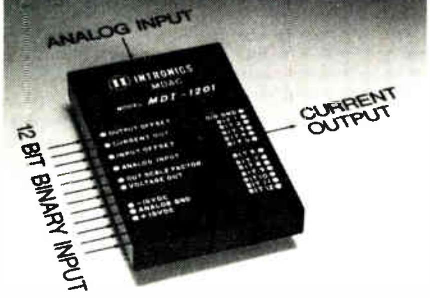

Readers comment

Process boosts thin-film yield

To the Editor: The article by O.J. Digiondomenico and Ted M. Foster concerning thick-film hybrids [*Electronics*, Aug. 16, p.104] was an excellent comparison of thin- and thick-film technologies. However, I would differ slightly with the authors about thin-film batch sizes. There has been a recent rapid development of cold high-rate sputtering techniques.

This new generation of equipment is being coupled with load-lock or cartridge vacuum chambers that greatly increase capacity per batch. These two changes can reduce the cost per run. The use of "cold" sputtering also reduces the problem of film damage by secondary electrons while reducing substrate heating at the same time.

The "sputter-gun" type of source is available from Sloan Technology Corp., and a new planar-cathode source is available in complete systems from Airco Temescal Corp. and Vacuum Technology Associates Inc.

Ted Van Vorous
President
Vacuum Technology Associates
Boulder, Colo.

Back to the Bactometer

To the Editor: We are pleased that you devoted space to our Bactometer 100 in "Instrument hastens identification of disease-carrying micro-organisms," [*Electronics*, July 19, p.35]; however, part of the article is misleading.

The Bactometer 100 was developed by Bactomatic Inc., not by Applied Magnetics. Applied Magnetics is not now marketing the instrument, but it may do so in the future for food applications only.

Finally, the opening statement, although eye-catching, is misleading, as our method has potential only for the detection of growing micro-organisms, not their toxins. Furthermore, to date, no work has been done to detect *Clostridium botulinum* in any type of sample.

Paxton Cady
President
Bactomatic Inc.
Palo Alto, Calif.

40 years ago

From the pages of Electronics, October 1933

No condition facing the radio in[illegible] try is more important to the pres[illegible] and future prosperity of the a[illegible] than the unemployment situation in which the average radio engineer finds himself.

If he has a job at all, the technical radio man is likely to have imposed on him low wages, long hours, Saturday and Sunday overtime, and insecurity of employment. In certain plants, good men are temporarily taken on at bare subsistence wages, drained of their ideas, and then in a few weeks turned out on the street again—the process to be repeated with a new batch of "laboratory fodder."

It is clear that such a policy cannot build for stability or real progress of the art. New products and services which the public buys, come from engineering minds. It is poor economy to kill off the producers.

The Institute of Radio Engineers has recognized this unsound employment condition by the appointment of a special committee to study the problem, with no less a chairman than the president of the Institute, Dr. L.M. Hull himself. This committee can set out the facts and propose solutions. It early developed that the NRA Codes had no place to take up the radio engineers' problems, but there is still hope that out of the improved business conditions resulting from NRA, the radio engineer may benefit.

Meanwhile there is much talk about organizing the engineers for self-protection.

The visit of Senator Marconi to this country, and his optimistic reports of his successes in transmitting intelligence beyond the theoretical horizon, on very short waves, have focused attention again on this vast region below 10 meters, perhaps even below one meter, which is being rapidly explored and exploited. From all appearances history is to be repeated; wavelengths once thought useless are suddenly found to be of great importance; soon the scramble to stake claims in this new goldfield will be on.

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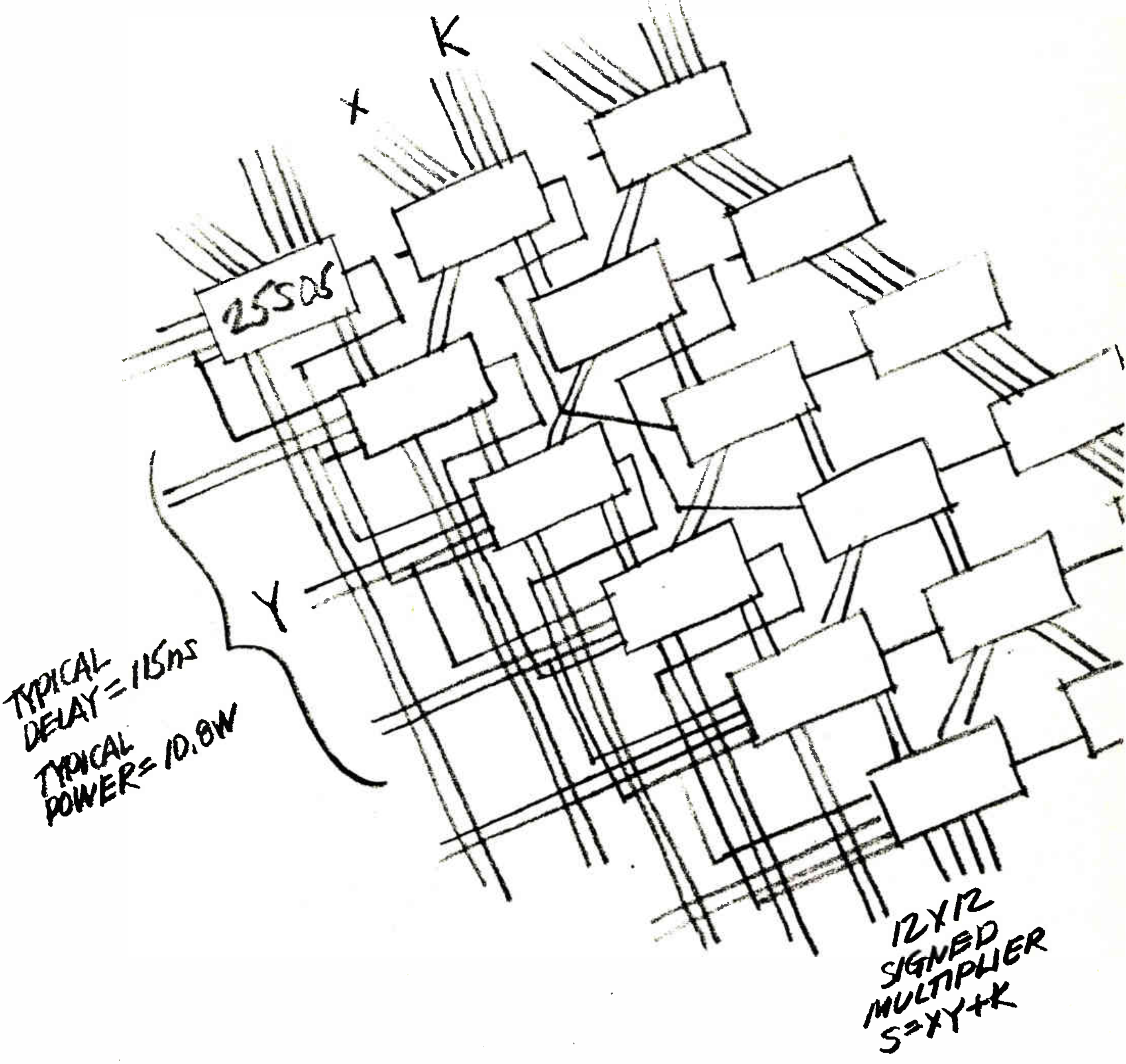

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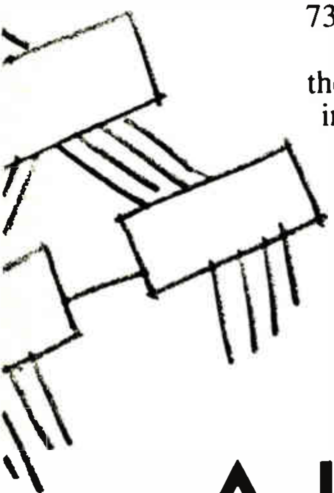

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- Input multiplexer selects from 2 input sources
- 8-pin ceramic mini-DIP

Available now: 3355 data sheets and parts for new high speed designs.

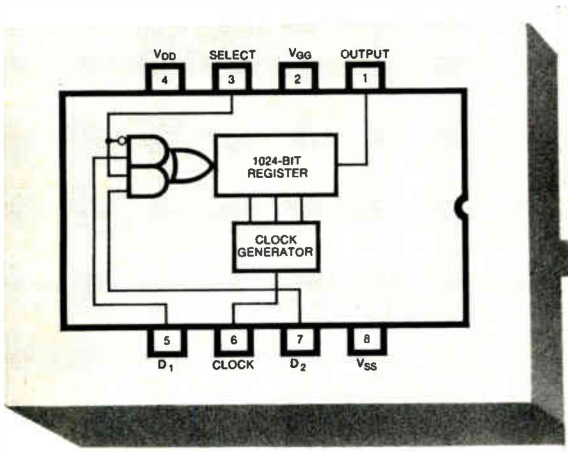

Fig. 1. Logic and Pin Diagram
The 3355 is a single-phase static shift register. Data is loaded into the register on the negative transition of the external clock. The SELECT input allows data to enter the register either from D_1 or D_2. D_1 is selected with a LOW on SELECT input; D_2 is selected with a HIGH on the SELECT input. The output will drive directly one unit TTL load (1.6ma @ .4V).

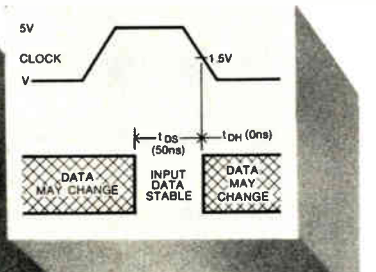

Fig. 2. Timing Diagram for Data Hold (t_{DH})
Note that because $t_{DH} = 0$, data can be changed *immediately* after clock goes LOW. This permits any combination of TTL devices and 3355's to be clocked on the *same* negative-going edge. Multiplexing 3355's to achieve higher data rates requires no elaborate timing considerations. Cascadability is guaranteed without the need to specify a minimum output delay. Built-in hysteresis in the clock circuit permits the use of clock edges with long rise and fall times.

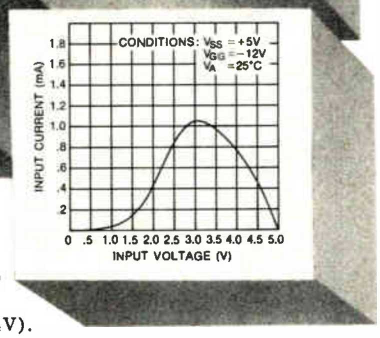

Fig 3. Typical Input Characteristics
The above V/I curve is characteristic of the pull-up device on all 3355 inputs, including the clock. Demonstrably, this device presents no load to a TTL LOW state (.4V), but turns on when a TTL output goes HIGH (2.4V) to pull the TTL output above the minimum required input HIGH voltage for 3355 (V_{SS} minus 1.0V).

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People

Lindmayer seeks solar-cell power

Cell maker. Lindmayer of Solarex is committed to cheaper, better solar cells.

"Let's face it, the time for solar energy has arrived," asserts Joseph Lindmayer, who believes that traditionally high costs and low efficiency are not scientific gospel when it comes to solar cells. To back up his conviction, the solid-state expert and his colleague, Peter Varadi, recently quit their jobs at Comsat Laboratories—where they headed the physics laboratory and the materials science department, respectively—and started their own company, Solarex Corp., Rockville, Md.

In a few months, Solarex will set up a small production line to manufacture $50 panels 4 square inches in area to charge batteries of unattended yachts and cars, Lindmayer says. Later, Solarex will build arrays for buoys, lighthouses, and microwave repeaters.

"We've already talked with builders of communications systems," he says. "In Brazil, for example, solar panels could power small receive-only television terminals" and be designed with battery backup "so they will always have the needed power." With those projects, some $250,000 raised from backers, and possibly help from the National Science Foundation and some potential customers, Lindmayer and Varadi are mapping a careful strategy for their entry into the market.

To succeed, they need more than lofty goals. "I feel the time has come to get over 20% efficiency," Lindmayer declares. Today, most cells hover around 11% efficiency, and Lindmayer acknowledges that the theoretical limit is 25%. But while at Comsat, he designed the classic "violet" cell [*Electronics*, May 22, 1972, p. 30], which the company now claims to be 18% efficient. By new techniques, Lindmayer is convinced that he can attack the interrelated problems of cheaper production, higher efficiency, and the use of less silicon to achieve more powerful cells at one-tenth the cost.

How? Up to now, solar-cell technology has been "underdeveloped simply because the sole users were the satellite makers," Lindmayer states. Such a limited market could not support a serious R&D effort and, consequently, terrestrial solar arrays have been hand-crafted from satellite rejects or cells made to space requirements, he says. Semiautomating the production line and reducing the steps needed in the vacuum-evaporation process, he believes, would be a start toward reducing costs.

Designing the cells for earth use will help, too, Lindmayer asserts. "We believe that silicon in almost any size and form can be used," he says, "so we will lower our requirements for defect density, orientation, resistivity control, and surface quality." Paying special attention to interconnect techniques and extremely simple solar panel construction are among the other tricks Lindmayer plans to use. An R&D program will explore the use of very thin layers of silicon. The job won't be easy, but "our basic commitment is to make the cells cheaper," he says. □

Success begins today, says Regis

Lawrence J. Regis, Signetics' new general manager for MOS products doesn't believe in "waiting until mañana" for success in the industry to happen. After a month on the job, he has been implementing some structured, goal-oriented, plans for his new department.

"Success in the semiconductor business," he declares, "is very seldom the dramatic breakthrough. The difference between a successful company and a less successful company is the day-to-day attention to

People

the nitty-gritty details."

Discipline is Regis' main tool. He has already been "forcing people to get together and cross parochial boundaries" to enable marketing people, for example, to understand the problems of manufacturing personnel. Regis is also handing out responsibility. He is making the person closest to a particular problem responsible for indicating what should be done about it, and for estimating the probability of success or failure of the recommended course of action. "There's a heck of a lot of human resources that haven't been tapped."

First obligation. With the responsibility for worldwide sales, marketing, and product areas for MOS, Regis says, "the MOS department won't significantly depart from the classic areas Signetics is in." He wants to stick with the company's current line for now, since, he says, "We haven't scratched the surface with the existing customer base. Our first obligation is to support these customers." Accordingly, he says that such things as seat-belt interlocks and watch circuits will have to wait.

His expertise in such matters stems from his work at Advanced Memory Systems, Sunnyvale, Calif., as vice president and general manager of OEM activities, and his 12 years at Texas Instruments.

Despite Regis' strict plans for his department, he admits that "organized recreation doesn't make any sense to me." At his Los Gatos, Calif., home, he, his wife Jackie, and their four children, swim in their pool, go to plays or movies, and sometimes rent a camper to trek to Carmel Valley.

Goal-oriented. Lawrence Regis pays attention to details and corporate interfaces.

hp MEASUREMENT COMPUTATION NEWS
innovations from Hewlett-Packard

OCTOBER, 1973

in this issue

Now, view 12 data channels in binary

HP's new logic analyzer displays 15 consecutive 12-bit words before or after the trigger event.

HP's new high-speed logic state analyzer displays data directly on a CRT in system format—ones and zeros in octal, BCD or hexadecimal—giving you truth tables at a glance. With this new analyzer, you can design, test and service digital equipment faster and more efficiently.

The 1601L analyzer captures data, at rates up to 10 megabits/second, from as many as 12 channels. Data is displayed as 16 consecutive 12-bit words, in 1's and 0's format. The information is stored in shift registers and can be displayed indefinitely. Four trigger modes let you move the display window anywhere in the data stream, from 15 states before the trigger to 99,999 states after the trigger.

(Continued on page 3)

Six HP counters fit most bench or system needs

If you're looking for a single electronic counter that satisfies almost any need up to 550 MHz, try HP's 5326/5327 universal counters/timers. All are excellent bench instruments that interface simply and inexpensively with automatic systems.

There are six models from which to choose. The simplest counter is the seven-digit 5326C that measures frequency to 50 MHz. Top of the line, model 5327B measures frequency up to 550 MHz, has a built-in digital voltmeter, includes time interval, and uses HP's unique time interval averaging to measure down to 150 ps. The 5327B also measures frequency ratio, period and period average.

With a minimum gate time of 0.1 μs, an HP universal counter can make nearly 10,000 measurements per second.

After selecting the basic counter, you can add options like 8-digit readout, a high-stability crystal time base with aging rate of only 5×10^{10} per day, complete programmability, and digital output. Every front panel control, even the analog control trigger level settings, can be programmed remotely.

For details, check I on the HP Reply Card.

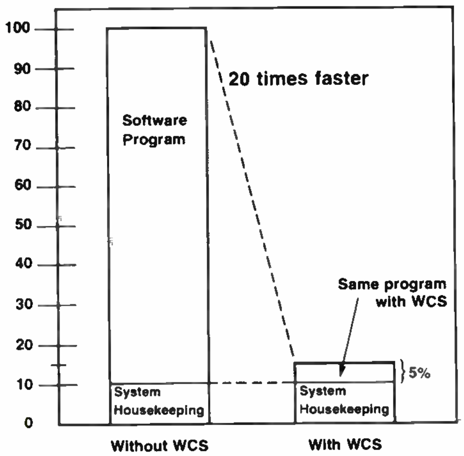
HP computers cut time and cost with microprogramming

A single IC board lets you execute programs 2 to 20 times faster, quickly debug your programs, dynamically enhance your instruction set, and save valuable memory space. Called "Writeable Control Store," WCS allows you to implement microprograms in HP 2100A and 2100S computers.

Microinstructions stored on WCS work with FORTRAN II and IV, ALGOL, and Assembly language. These microprograms execute at 196-ns cycle time, so you can run programs up to 20 times faster than using conventional software.

Each WCS board stores 256, 24-bit microinstructions—enough to effectively double your machine's instruction set. Up to three WCS boards plug into the I/O slots of your CPU. When you order WCS, you receive a complete software package including core and disc based assemblers, editors, and utility routines.

Now, for half price, you can benefit from microprogramming. WCS is field or factory installed.



For details, check Q on the HP Reply Card.

Solid-state plug-ins aid VHF/UHF swept testing

Besides microwave frequency coverage to 18 GHz, the HP 8620 solid-state sweeper line includes two versions for VHF and UHF applications. Each offers the performance needed for stringent swept tests yet these sweepers are economically priced. For the 3-350 MHz range, insert the 86210A module into the 8620B mainframe. The 86220A plug-in covers 10-1300 MHz. Both versions have 1% sweep linearity, low spurious signals, high stability, and fully-calibrated Start/Stop and ΔF sweeps plus CW operation. A 70 dB output attenuator is optional.

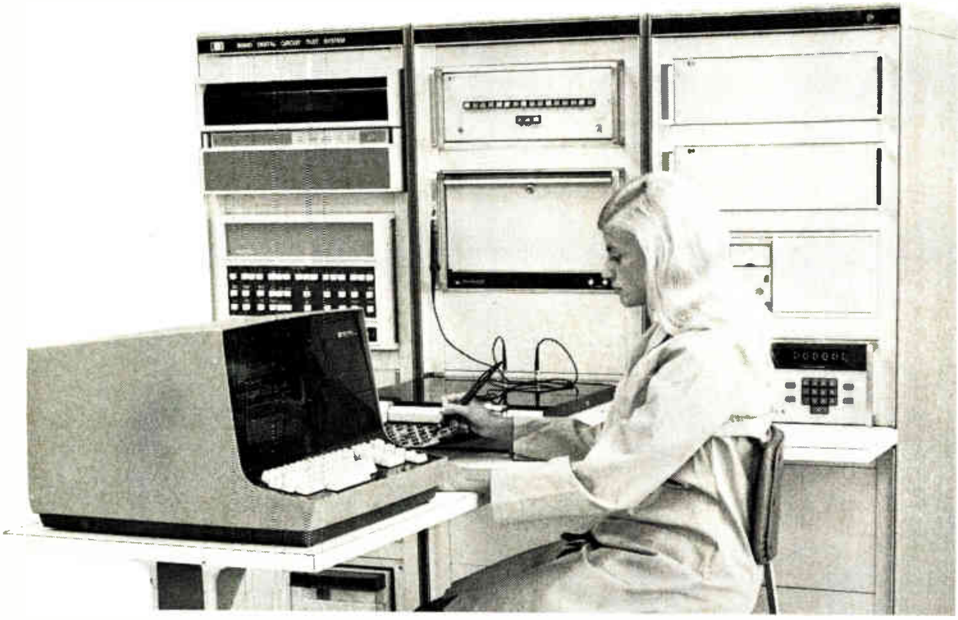
The 86210A has +13 dBm maximum calibrated output power levelled to ±0.25 dB. Accuracy is ±7 MHz in CW mode and ±10 MHz in all sweep modes. A special frequency adjustment control lets you maintain frequency calibrations with changing ambient temperatures.

The 86220A has +10 dB maximum calibrated output power levelled to ±0.5 dB. Accuracy is ±10 MHz in CW mode and ±15 MHz in all sweep modes.

For more information, check N on the HP Reply Card.

Easy to operate, HP's solid-state sweepers stress high performance from 3 MHz to 18 GHz.

New automatic system for fast digital assembly testing



You don't need reference units because the 9560 system uses stored test patterns (truth tables). You can test at rates up to 22,000 patterns/second.

Manufacturing and maintenance costs of digital equipment can be sharply reduced with HP's new digital test system. The 9560 is fast because it tests all pins of a unit under test simultaneously. It's flexible, too: different units can be tested without interface rewiring because pins are set up as inputs by the test program. And you buy only the capability you need, expanding from 60-pin capability up to 360 pins simply by adding 12-pin digital test modules.

Logic reference levels are programmable, absolute, and independent for inputs and outputs, so your assemblies can be checked reliably at marginal conditions. Test programs and fault diagnostics are written in easy-to-use ATS BASIC. Computer-aided generation of test programs is available as a service or as a software package.

Choose either the 9560B paper tape system or the 9560D dual replaceable disc system. The disc memory offers virtually unlimited storage of test programs, diagnostics and test data.

To learn more about automatic digital assembly testing, check O on the HP Reply Card.

(Continued from page 1)

Included with the 1601L is a new probe system for single- and multiple-point probing of TTL, ECL and MOS logic families. It distinguishes high, low and floating levels with respect to a TTL or variable (± 10V) threshold. And the new probe system simplifies connections to ICs: you can connect it directly to back-plane test points without any test clips or extender boards.

Also available is the HP 5000A that displays two channels of data 32 bits long. Instead of a CRT, 32 LEDs display 32 successive clock cycles. The LEDs turn on for a logic "high" and turn off for a logic "low."

For more information on HP logic analyzers, check A or F on the HP Reply Card.

Tiny quartz oscillators: lab quality components

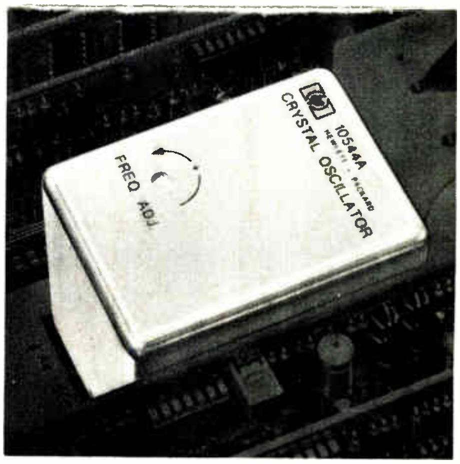
HP's miniature quartz oscillators offer laboratory quality with component convenience. Aging rate is $< 5 \times 10^{-10}$/day; yet these accurate frequency sources are small enough to mount readily on PC boards for use in instruments, communications, and navigation equipment.

The 10544A oscillator is an economical 10-MHz unit with phase noise 125 dB below carrier frequency. Output is 1 V into 1000Ω.

The 5-MHz 10543A oscillator is better suited for mobile, portable and airborne uses. It has its own built-in voltage regulator, so it needs only a single 15 V to 30 V source. Phase noise is down 145 dB, and the model 10543A is better insulated so it's less affected by ambient temperature changes. (Shift is <5 parts in 10^9 over a range of -28° to ±65°C.) The 10543A also delivers more output, 1 V into 50Ω.

HP quartz oscillators can be obtained in the range 5 to 15 MHz. Quantity discounts are available.

For more information on crystal oscillators, check B on the HP Reply Card.



Good things come in small packages, like these quality crystal oscillators in small board-mounting units.

Now, get 4-in-1 meter calibrator

The new 6920B ac/dc meter calibrator combines in one package all the outputs needed to test panel meters, multimeters, and other meters having an accuracy in the order of 1% or higher. You can use the 6920B to calibrate:

- dc voltmeters from 10mV to 1000 V
- dc ammeters from 1 μA to 5A
- ac voltmeters (average reading) from 1 mV to 1000V
- ac ammeters (average reading) from 1 μA to 5 A.

Output is constant voltage for voltmeters, constant current for ammeters. DC accuracy is 0.2% plus one digit; ac accuracy is 0.4% plus one digit. AC output is rms-calibrated and has the same frequency as the input line power (except when an external ac input is used).

Ten-turn digital potentiometer readout control (to three significant digits) determines output value within the limit of the range switch setting. You can set the output to normal "On-Hold" or spring-loaded "On-Test" positions.

For details, check J on the HP Reply Card.

One instrument—HP's new 6920B meter calibrator—can calibrate all your general-purpose meters.

New pulse generator for MOS testing

The new 8015A has an option called "counted burst" that produces a precise number of pulses regardless of rep rate.

When you need to test MOS logic, try HP's new 8015A pulse generator with dual output. Each output can produce pulses as much as 16 V, or you can combine outputs for a 30 V range, from +15 to -15 V. Each output has a separate normal/complementary switch and separate selectable source impedance, 50Ω or 1 kΩ, for reflections and varying loads. Graduated level controls adjust the top and baseline of the pulse. And if you don't need dual output, a lower-priced single-output pulse generator is available.

With such versatility, you can test CMOS, low-threshold MOS and most high-threshold MOS logic, as well as TTL, HTL and discrete circuits. Repetition rates range from 1 Hz to 50 MHz. To step through logic states one at a time, you can generate single pulses or set it to a very low rep rate.

Transition time varies from 6 ns to 0.5 sec. Use the faster time for the different IC families and the slower time for trigger level detection and process control.

For details, check L on the HP Reply Card.

New data generator for digital circuit tests

Need to evaluate digital circuits or systems at high bit rates? The new 3760A high-speed data generator supplies psuedo random binary sequences (PRBS) in nine different lengths (2^3-1 to 2^{15}-1 bits) at rates from 1.5 to 150 megabits/sec. Or you can have the output in word form, with word lengths from 3 to 10 bits selected at the front panel. Data is available in normal or complemented form with either RZ or NRZ coding. For clock extraction tests in PCM digital communication work, you can periodically insert a block of 1 to 99 zeros.

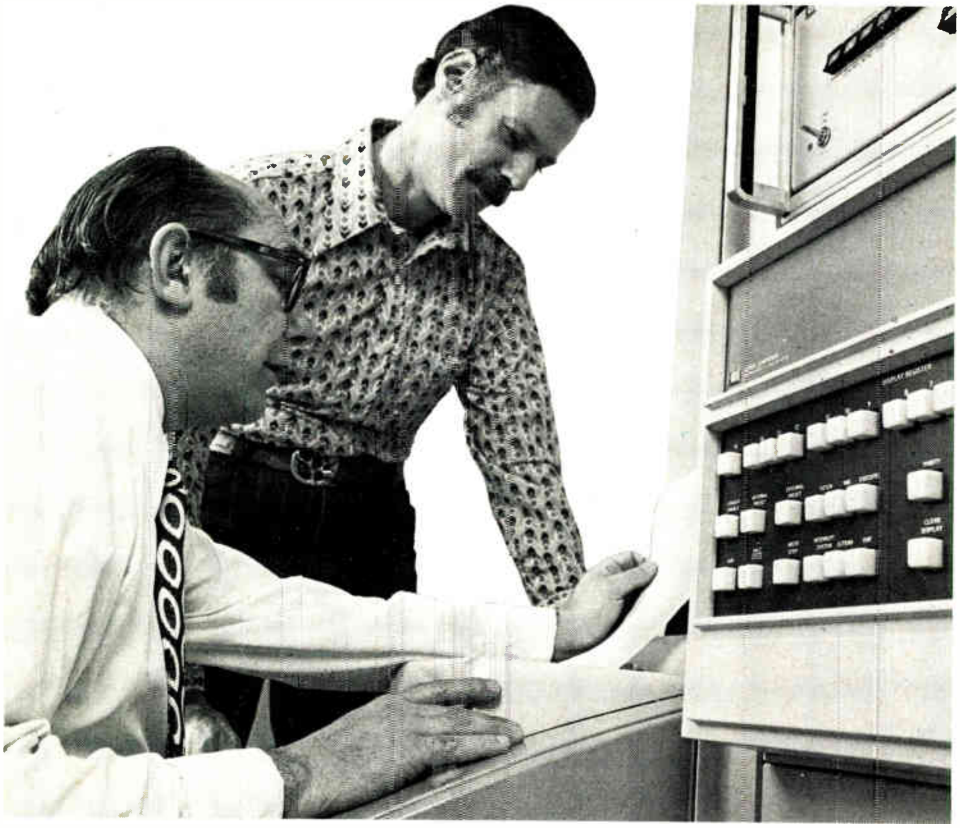
The generator can be triggered either manually or automatically from an external clock, or an optional internal clock can be used. Clock output can be normal or complemented.

Both the clock and data are continuously adjustable in amplitude from 0.1 to 3.2 V p-p and in offset from 0 to ±3 Vdc. Data (and sync) can be delayed up to 100 ns with respect to the clock for easy equalization of cable lengths. For digital communications systems testing, the 3760A data generator combined with the HP 3761A error detector becomes a versatile bit error rate test set.

Check E on the HP Reply Card for details.

Test such digital circuitry as high-speed logic, computer memories, disc stores and digital tape recorders with this versatile data generator.

HP data acquisition systems sport new software packages



HP's new 9601B real-time BASIC data acquisition system includes 12K memory, system teleprinter, punched tape reader, A/D interface subsystem, and operating software.

Now you can have real-time data acquisition with all the convenience of ATS BASIC programming. The new 9601B core-based Real-Time Executive (RTE) system with built-in data acquisition capability measures up to 64 single-ended or 32 differential analog inputs at sample rates to 45 kHz. This is expandable to 1056 single-ended or 528 differential inputs; and you can add digital input/output and analog output capabilities.

The 9601B relates system operations to external processes and external events occurring in real time. A single teleprinter handles system control and data logging; this is augmented by additional data logging devices to which output can be directed. Since output is buffered, system operations aren't delayed waiting for the completion of printouts.

The 9601B is upward-compatible to the core-based 9601C RTE-C system which is programmable in FORTRAN or assembly language, offers faster response, and has a wider choice of system control functions. Or, upgrade the 9601B further to an HP 9601E disc-based RTE system that combines mass storage and on-line program development with real-time operations.

HP also offers a modular library of **FORTRAN subroutines** for sensor-based data acquisition and control applications. These ready-to-use subroutines handle several tedious conversion and statistical processing tasks, so you are free to concentrate on the unique aspects of your application. Programs include thermocouple linearization, statistical analysis, curve fitting, determining humidity, interpolation, integration, and code conversion. Except for curve fitting and code conversion, these subroutines can be used in BASIC in the HP 9601B system.

For more information, check O on the HP Reply Card.

New low-cost low-frequency automatic network analyzer

Ideal for low-frequency analysis, HP's new calculator-based network analyzer system measures amplitude and phase in the frequency range of 1 Hz to 13 MHz. A designer can use calculator programs to create and analyze a circuit; then use the system to compare a physical circuit to the theoretical one.

The HP 3043A low-frequency network analyzer consists of a 3320C frequency synthesizer, a 3575A gain-phase meter, and a 9820A desktop calculator. The calculator controls the instruments and processes data. Results can be displayed, printed or plotted. HP also provides an electrical engineering software package, at minimal cost, with programs on attenuator design, transfer functions, component design, and logic circuits.

The input signal range is 0.2 mV to 20 V rms. For amplitude measurements, display resolution is 0.1 dB. Display resolution for phase measurements is 0.1°.

Calculate how to save time and money testing circuits and components. Check C on the HP Reply Card for more information.

HP's low-cost, low-frequency network analyzer system runs under calculator control.

Two-channel recorder ran 2K miles without a trace of failure

A choice of input plug-ins means versatility for HP's two-channel 7402A oscillographic recorder.

Start with 50 mm chart width and durable stainless steel pens with carbide tips. Then select a preamplifier plug-in for the sensitivity you need: 1 μV/division with differential, floated and guarded input; 1 mV/div. with a differential, balanced to ground input; and 20 mV/div. with a single-ended input. Chart speeds are 1 to 25mm/second. Frequency response is ±2% of full-scale from dc to 40 Hz, and overshoot is <2%. Rise time is 7.0 to 7.5 ms.

And you don't have to worry about pen fatigue or failure. We ran a stainless steel pen continuously for two months (about 2000 miles or 3200 kilometers), and there was no apparent change in the trace.

For more information, check K on the HP Reply Card.

Because the 50 mm chart width is 25% wider than other comparably priced recorders, the writing resolution is 25% better.

New card reader enhances HP calculators

Now, you can input data on punched or marked cards to your HP 9810, 9820, or 9830 programmable calculator. The new 9869A companion card reader reads 128-character Hollerith code and converts it to 7-bit ASCII for the calculator. And the new card reader won't slow you down—it reads a fast 300 cards/minute.

Use either 40- or 80-column format. You can even design your own card, thanks to a special command that transmits all the marks on the card without regard to coding. Data is stored in intermediate buffers for optimum transmission, which means you operate on blocks of data rather than stacks of cards.

With the new card reader, users can program a 9800 series calculator at their desks or at home. Applications include payroll, quality control, inventory control, education, medical records, and consumer surveys.

For more information, check P on the HP Reply Card.

Increase your calculator mileage—the 9869A card reader lets several people program simultaneously on cards.

Let us give you our new dc power supply catalog

Choosing the right power supply for your application is easy with HP's new *DC Power Supply Catalog*. This 120-page catalog contains product descriptions, photographs, outline drawings (with U.S. and metric dimensions), terminal strip details, specifications, and prices for HP's complete line of power supplies.

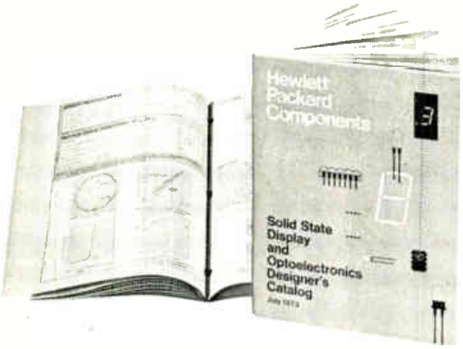
Products covered are:

- General-purpose lab and system power supplies
- OEM modular supplies
- Precision voltage and current sources
- Digitally programmable power sources
- Multiprogrammer systems

For your free copy, check S on the HP Reply Card.

HEWLETT-PACKARD COMPONENT NEWS

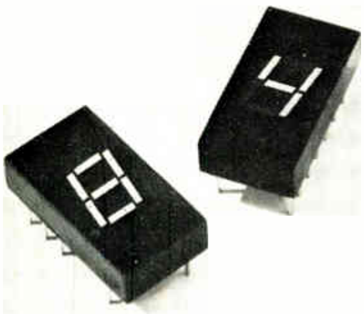
New optoelectronics devices catalog now available



HP's new 100-page *Optoelectronic Designer's Catalog* is filled with detailed specifications and application notes on our broad line of optoelectronic products, including LED displays, LED lamps, high-speed optically-coupled isolators, and PIN photodetectors.

For your free copy, check R on the HP Reply Card.

Send for your free LED display



The 7700 series LED displays are available in common cathode and common anode configurations.

That's right—check the reply card and we'll send you a free 5082-7730 LED display. These single-digit seven segment indicators feature a large (0.3 in. or 0.8 cm) red numeric plus right or left-hand decimal point. High contrast, continuous uniform segments, and wide viewing angle ensure readability. These low-cost LEDs are IC-compatible, too.

Also available is the new 5082-7740, the common cathode version. This choice of common anode or common cathode lets the designer minimize his display system cost by using the LED that complements his drive electronics.

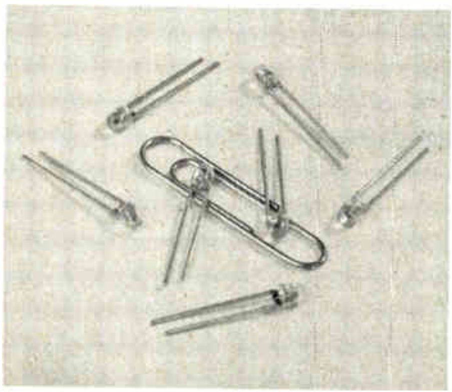
For your free sample, check G on the HP Reply Card

New low-cost commercial LED lamp

HP's latest lamp is our lowest-priced gallium arsenide phosphide LED for high-volume applications. Use it in calculators, cameras, appliances, or automobile instrument panels. Power requirement is low, only 20 mA at 1.6 V. Model 5082-4487 has a typical light output of 0.8 mcd while model 5082-4488 has a guaranteed minimum output of 0.3 mcd.

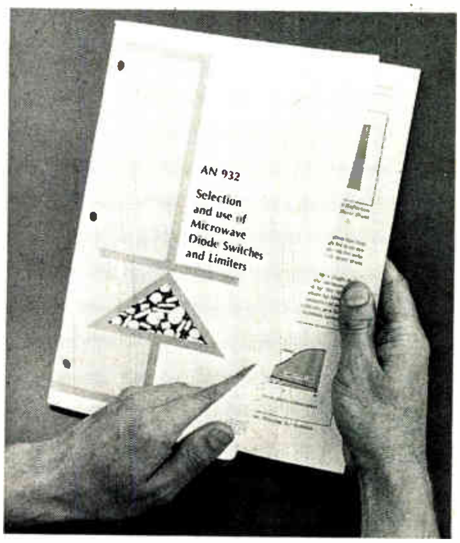
For specifications, check H on the HP Reply Card.

100 Clear lens and low profile make these new LEDs ideal for high-density applications.



New application note on microwave diode switches

If you are using or considering diode switches and limiters for your system, this application note is a must.



A new application note explains how to select and use microwave diode switches and limiters. In a practical tutorial style, this book covers:

- The effects of system mismatches and how to minimize these effects.
- How to select the proper switch for switching, attenuating, or modulating.
- How to change the threshold and slope of a limiter.
- The trade-offs in selecting coaxial modules, stripline modules, or complete switches.
- How to design bias networks.
- Multi-throw circuits and driver circuits.
- How to test switches and limiters.
- How to construct module test fixtures.

For your free copy of AN 932, check T on the HP Reply Card.

1

MEASUREMENT COMPUTATION NEWS

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✔ I'd like Literature ☑ Please contact me about:

- ○ ☐ A. 1601L digital analyzer with CRT
- ○ ☐ B. 10543/10544 quartz oscillators
- ○ ☐ C. 3043A network analyzer
- ○ ☐ D. 3580A low-frequency spectrum analyzer
- ○ ☐ E. 3760A data generator
- ○ ☐ F. 5000A logic analyzer
- ○ ☐ G. 5082-7730 LED display (free sample) and -7740 version
- ○ ☐ H. 5082-4487 LED lamp
- ○ ☐ I. 5326/5327 universal counters
- ○ ☐ J. 6920B ac/dc meter calibrator
- ○ ☐ K. 7402 oscillographic recorder
- ○ ☐ L. 8015 pulse generator
- ○ ☐ M. RF modules for 8620 series sweepers
- ○ ☐ N. 9560 digital test system
- ○ ☐ O. 9601B RTE-BASIC data acquisition system
- ○ ☐ P. 9869 card reader
- ○ ☐ Q. Writable control store
- ○ R. *Optoelectronics Designer's Catalog*
- ○ S. *DC Power Supply Catalog*
- ○ T. AN-932 *Selection and Use of Microwave Diode Switches and Limiters*

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PRICES

The following are U.S.A. domestic prices only:

1601L	$1900
10534	$850
10544	$450
3043A	$16,250
3580A	$3800
3760A	$4295
5082-7730/7740 (1K)	$2.70 each
5082-4487 (1M)	$.10 each
5326	$995—$2195
5327	$995—$2195
6920B	$750
7402	$1450
8015	$1750
86210	$1375
86220	$1775
9560	$53,900
9601B	<$25,000
9869	$2775
WCS	$1500

DIRECT RESPONSE SYSTEM

For fast response, use the above reply cards. Please note that you can choose two types of HP response:

- ✔ Literature (You will receive more information on a product.)
- ☑ Please contact me. (You will receive product information *and* a follow-up call by an HP field engineer.)

If both reply cards on th s page have been used, contact your nearest HP field office or one of the regional offices listed on the preceding page. Or write directly to the Hewlett-Packard Company, 195 Page Mill Road, Palo Alto, California 94306.

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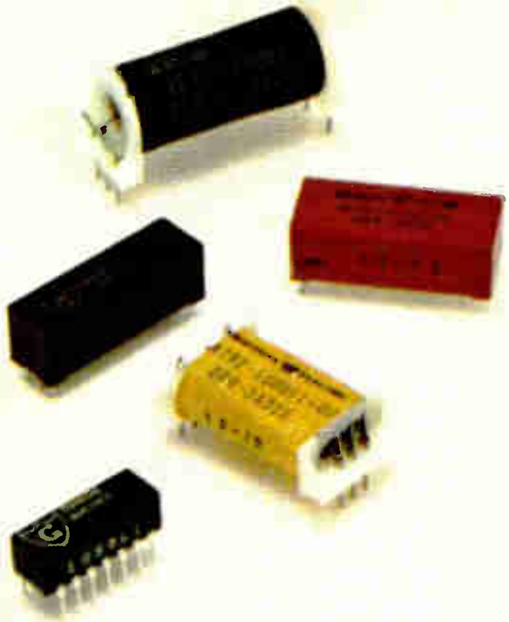
SOLID STATE RELAYS—Relays and time delays that perform the function of electro-mechanical relays with total isolation between control circuit and switching output. Right off-the-shelf or in custom designs.



REED RELAYS—Six miraculous series of newly-improved reed relays for low level to 15 watt applications. Form A or multiple switching combinations. Encapsulated or economy open-frame types.

like these

It's a promise... from your Guardian Angel

Meetings

Instrumentation-Automation Conference: ISA, Astrohall, Houston, Oct. 15–18.

Canadian Computer Show and Conference: CIPS, Exhibition Park, Toronto, Oct. 16–18.

American Society for Information Science Annual Meeting: ASIS, Hilton, Los Angeles, Oct. 21–25.

Connector Symposium: Connector Study Group, Cherry Hill Inn, Cherry Hill, N.J., Oct. 24–25.

Northeast Electronics Research & Engineering Meeting (NEREM): IEEE, Boston, Nov. 6–8.

Conference on Magnetism and Magnetic Materials: AIP, IEEE, Statler-Hilton, Boston, Nov. 13–16.

Nuclear Science Symposium: IEEE, Sheraton Palace, San Francisco, Nov. 14–16.

National Telecommunications Conference: IEEE, Hyatt Regency Hotel, Atlanta, Nov. 26–28.

International Symposium on Computers: MMG, Fair Grounds, Munich, West Germany, Nov. 27–30.

International Electron Devices Meeting: IEEE, Washington Hilton, Washington, D.C., Dec. 2–5.

Fall Conference on Broadcast and TV Receivers: IEEE, O'Hare Inn, Chicago, Dec. 3–4.

Vehicular Technology Conference: IEEE, Sheraton Cleveland, Cleveland, Dec. 4–5.

Joint Conference on Sensing of Environmental Pollutants: ISA, IEEE, *et al.*, Sheraton Park, Washington, D.C., Dec. 10–12.

Reliability and Maintainability Symposium: IEEE, Biltmore, Los Angeles, Jan. 29–31.

Aerospace and Electronic Systems Winter Convention (Wincon): IEEE, Biltmore, Los Angeles, Feb. 12–14.

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High Voltage Silicon Rectifiers

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Circle 31 on reader service card

Centralab perspectives

FOR USERS OF ELECTRONIC COMPONENTS

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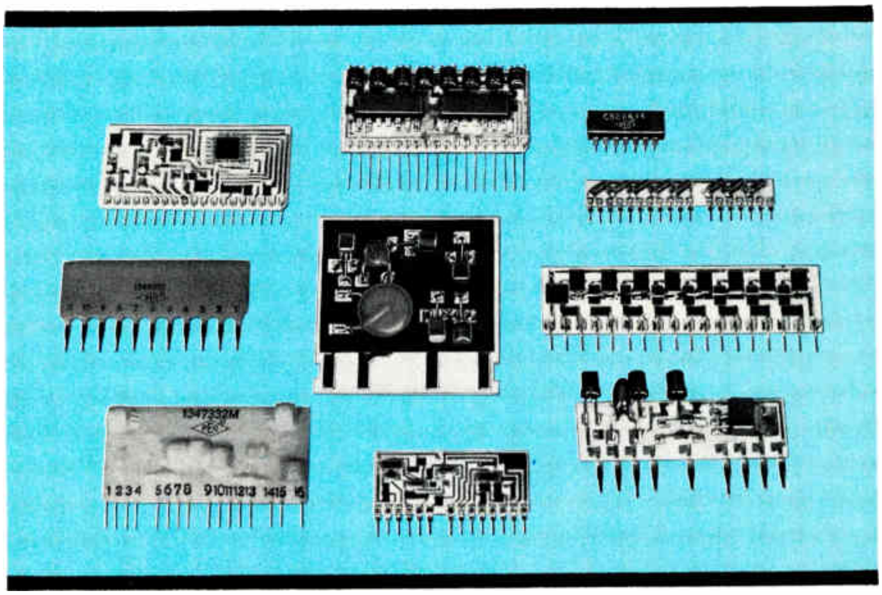
Electronics Division
GLOBE-UNION INC.
5757 NORTH GREEN BAY AVENUE
MILWAUKEE, WISCONSIN 53201

Even if 1975 circuit designs are frozen it's not too late for thick film hybrids.

Centralab can help designers meet the challenge of today's technology changes with two thick film systems. Supplying custom requirements, from quick design to volume production, is a matter of weeks.



Backed by the experience of designing more than 50,000 custom hybrids, Centralab can supply a wide variety of circuit combinations and package configurations.

Quick turn-around time is only one reason thick film circuits have gained such a strong foothold in many product designs. IC's require longer design lead time. Discretes can't match hybrids for size or reliability.

A case in point. Late in the design cycle for the 1974 passenger cars, governmental safety regulations called for changes in seat belt warning systems. A new seat-belt-ignition interlock would be required on all 1974 models. One major automotive firm brought their problem to Centralab. Hybrids could be the answer. Within two weeks, 8 packages had been designed by Centralab and samples shipped. Both active hybrid and passive circuits were included in the Centralab modules that were a major part of the interlock system. Two weeks later, prototype quantities were furnished and volume production quantities were shipped five weeks after that. From inquiry to mass production took a total of just 9 weeks! Tight scheduling. Exacting specs. Volume orders for millions of pieces. That's the kind of challenge Centralab meets best and the kind of service customers have come to rely upon.

Centralab, a pioneer in thick film circuits, is supplying the needs of automotive, computer, data processing, business machine, point-of-sale, consumer and industrial product manufacturers. And they've proven, time and time again, that they can meet the needs for reliable circuits faster.

The two thick film systems Centralab offers means broad flexibility to accommodate custom requirements. Their silver/carbon PEC system offers an economical approach for consumer and industrial applications where tight resistance tolerances are not critical. Used to produce resistor, capacitor or RC networks in a variety of values and package configurations, it also makes possible complete discrete hybrid circuits by adding encapsulated semiconductors to the basic thick film network.

The noble metal/cermet MEC system is ideally suited to commercial and industrial applications — for high stability under extreme environmental conditions, for high voltage and high power applications as well. It is the system used for stable resistor banks and complex hybrid circuits. It meets the need for high-density packaging and is supplied in conformally coated single in-line or plastic molded dual in-line packages.

Customized circuitry is a Centralab specialty. Whether it's staircase networks, passive filters, frequency dividers, pull-up networks, clock drivers, video amplifiers, solid state switches, motor speed control or other special applications for hybrids. Why not consider them for your product?

You can get complete information and our latest thick film catalog by writing A. R. Wartchow, Manager Electroceramic Marketing or calling 414/228-1200.

Now our most popular thick-film resistor networks are ready and waiting, in quantity, at your A-B electronics distributor. Pull-up networks and terminator networks with tolerances of ±2% in popular values from 68 ohms to 22K ohms. All in compatible 14 lead .300 series DIP's. Or if you need something special we'll quickly custom design any circuit that'll fit into a 14 or 16 lead DIP. And we mean quickly. Overall specs include: absolute tolerances to ±.5%. Tracking ±50 ppm/°C (and lower). TCR to ±100 ppm/°C. Write for free technical publications 5850 and 5851. Allen-Bradley Electronics Division, 1201 S. Second St., Milwaukee, WI 53204. Export: Bloomfield, NJ 07003. Canada: Cambridge, Ontario. United Kingdom: Jarrow, Co. Durham NE32 3EN.

Actual Size

Allen-Bradley
Milwaukee, Wisconsin 53204

Circle 34 on reader service card

Electronics newsletter

Protection added on the power chip

National Semiconductor will soon be offering a power-transistor integrated circuit that contains on a single-chip the power device, as well as all the overload protection and current- and thermal-limiting features of most discrete power assemblies. **The monolithic IC, which can deliver 35 watts over a bandwidth of 1 MHz, works like an ordinary npn high-gain transistor (β of 10^6), but eliminates the need for external-protection circuits.** The chip contains the equivalent of a power transistor, two drivers, a biasing circuit, a current-limiting circuit, a power-limiting circuit, and a thermal-limiting device—tough to get in discrete form. The chip could be used in many applications, such as in audio equipment and for power-supply regulators.

Disk for minis has big storage

A high-performance disk-storage unit for minicomputers is to be introduced in December by Diva Inc., Eatontown, N.J. **The unit, reported to have the same specifications as IBM's big 3330 disk system,** is intended for use with such machines as DEC's PDP-11, the Interdata machines, and Data General's Nova line. Like the 3330, **it will store 100 million characters per spindle on a maximum of eight spindles and transfer the data to the computer at over 800,000 characters per second.**

California law defines taxes on software

A nationwide controversy over whether or not computer software is tangible property, and thus subject to taxation, may be resolved by a new California law. The law incorporates a compromise, sponsored by Wema on behalf of the western computer industry, that Wema hopes will be followed in other states.

It restricts computer taxation to hardware costs, including the value of software normally bundled with the computer and not separately priced. This effectively limits taxable software to monitors, compilers, assemblers, and similar basic software considered a permanent part of the computer system, regardless of how the system is used. The bill exempts processing programs, such as language translators and data-management software and applications programs like accounting, computer-aided design, and process-control, which are normally bought or written separately. The State Board of Equalization (tax board) had tried in 1971 to define programs as taxable property.

EIA challenges FTC's position on audio advertising

In a matter of weeks, the Federal Trade Commission will act to protect the nation's audiophiles **by ruling out deceptive advertising about the power output of audio amplifiers.** But the Electronic Industries Association argues that the FTC Bureau of Consumer Protection is going about its ruling all wrong, employing fuzzy technological standards, and proposing a multiplicity of statements that will confuse consumers and generate unacceptable "advertising clutter."

Manufacturers are disturbed by the FTC requirements that wattage be expressed **in minimums per channel at a load impedance of 8 ohms across a rated power band of not less than 60 hertz to 10 kHz, as well as to disclose total harmonic distortion at any power level from 250 milliwatts to the rated power output.** The EIA opposes this approach, arguing that there is a substantial risk that different companies would use different measurement techniques to determine the power output of their amplifiers.

Zenith tests acousto-optic surface profilometer

A new instrument that will complement scanning-electron microscopes by showing the profiles of plane surfaces is being tested by the Zenith Radio Optical Systems group. **The device uses an acousto-optic deflector, driven by two swept frequencies with a fixed difference between them.** The deflector splits a light beam into two parts, which are reflected off the target and recombined on a photodetector. This recombination produces an ac signal whose phase is proportional to the difference in the length of the beam's optical paths. This difference is proportional to the slope of the surface.

By varying the drive frequency of the detector, the deflection angle is varied, and it is possible to raster-scan surfaces for display on an oscilloscope. Resolutions of 100 angstroms in 1-micrometer steps are possible. Since slope is sensed, the system is insensitive to vibrations along the instrument axis. Reflectivity variations on the surface are ignored because only the phase of the beat signal is sensed. Without a laser or oscilloscope, the system will sell for about $42,000.

GI pushes high-voltage technology

Fueled by a recently granted patent on its zinc-modified borosilicate glass encapsulation for diodes, **General Instrument Corp. is developing an 18-kilovolt, 1-microampere rectifier stack** as part of its Glass Amp II rectifier line. Conventional silicon dioxide does not have the dielectric strength needed to withstand the fields across the junction. The glass, which is applied as a slurry and fired, chemically bonds with the silicon surface, passivates the exposed junctions, and forms a hermetic seal around the device. Semiconductor division vice president M.I. Barbis says **the company is pushing the theoretical limits of device-breakdown characteristics.** GI is also readying a leadless version of its rectifiers, which will have two molybdenum contacts protruding from the glass and will be useful for power-hybrid applications.

GI's Kiloglass technology, used for its high-voltage products, is a proprietary process based on an alkali-free borosilicate glass, which contains 5.8% zinc oxide and lesser quantities of aluminum and lead oxides to block ionic diffusion and lower the softening point of the glass.

Fast bonds for ICs come off film strip

High-speed bonding of integrated circuit chips received a big boost last week when Kulicke and Soffa Industries Inc., Horsham, Pa., showed off **its new Innerlead Bonder, which can bond up to 1,000 chips per hour automatically; a manual operator can handle only 80 to 100.** The machine, the model 1320, uses a sprocketed polyimide film strip to which are laminated metal lead frames. This approach is the same as General Electric Co. used in its Minimod system [*Electronics,* Feb. 1, 1971, p. 44]. **Although the GE design was taken over by Texas Instruments, the K&S model is the first to be available commercially.** Prices start at $9,200 for a manual model and rise to $23,000 for an automatic unit featuring an indexing X-Y table, TV camera and monitor, preforming station, and eutectic bonder. Minnesota Mining and Manufacturing, DuPont, and Amp Inc., are supplying the film strips to K&S.

Seat belt interlocks flow smoothly to auto manufacturers

But a small random sample shows that new car buyers are leery of the device

That Federally mandated piece of electronic cunning, the seat-belt interlock [*Electronics*, March 1, p. 70], is reaching consumers in 1974 autos with a minimum of problems. There are isolated complaints of improper interlock function, but a sampling of 10 greater New York auto dealers indicates no dissatisfaction.

In one instance, the seat-belt system on a new Ford sold in Revere, Mass., failed after only 12 miles and the car had to be towed to a garage. The driver couldn't complain too loudly, however—he was a salesman at the local Ford dealership.

In California, a Ford dealer in Los Angeles reports that some cars have their interlock systems wired up wrongly at the factory, and his mechanics have had to straighten things out. A similar situation is reported by a Chrysler-Plymouth dealer in the New England area. On one car the engine started without the belt's being buckled. Another dealer had the opposite happen—the car wouldn't start, no matter how the belt was connected.

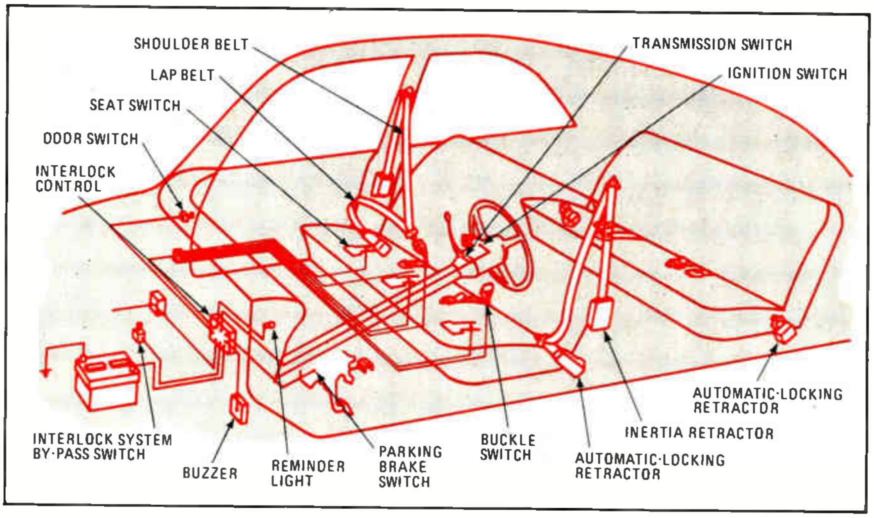
Rebellion. In most cases, however, the interlock systems are working well, although some customers are rebelling at the idea of being required to wear seat belts. A New Hampshire congressman has even introduced a bill to ban the interlock systems on grounds that they're an invasion of privacy. But automakers report that despite some early problems, alleviated in part by shifting orders to backup suppliers, seatbelt components and modules are being delivered on schedule. But the auto industry, coming off a record 11.8 million unit production year in 1972, is being faced with short supplies in many types of parts. "The 73s had run us out of everything," points out a Ford man.

Delco Electronics division of General Motors Corp., Milwaukee, for one, says it has made more than a million interlock units, and production "has been going great," according to a divisional purchasing agent. A spokesman at Chrysler Corp. reports things are "going good," and another at Philco-Ford division, which is supplying roughly 70% of the interlocks for Ford Motor Co., says he has "an ample supply of parts." Also, C-MOS circuits are already being designed for 1975 model vehicles.

At the semiconductor suppliers, whose remarks tend to defer to their auto industry customers, business is generally running smoothly. Comments H.B. Shannon, manager of market planning for MOS IC products at RCA Solid State division, Somerville, N.J., a supplier of C/MOS circuits to Ford and Chrysler, "It's a simple circuit and really doesn't require special accomplishment in order to make it and hit anticipated yields."

Perhaps the biggest problem reported thus far was with the C-MOS parts from Solid State Scientific destined for Chrysler Corp. Solid State Scientific could not get into adequate production with the Chrysler design, although the company is successfully turning out hundreds of thousands of a similar circuit for Ford. Even Chrysler is nonplussed. "They've been supplying us with a C-MOS chip for a digital auto clock

Complicated. At least 15 interconnections in the 1974 cars are involved with the seat-belt interlock system. Some new-car buyers are complaining about the system, which was mandated by the Federal Government to ensure driver safety.



for two years now and everything's just fine," says a Chrysler spokesman. Industry sources say that design changes required at the last minute by Chrysler could have lowered yield as Solid State Scientific rushed to meet production deadlines.

Who. Apparently, however, Chrysler ordered most of its C-MOS chips from RCA's Solid State division, Somerville, N.J. A supplier both of C-MOS chips for Chrysler and Ford and of completed interlock modules for General Motors, RCA is probably one of the biggest and most successful semiconductor suppliers of interlocks.

Another supplier of C-MOS circuits for Chrysler is National Semiconductor Corp., which began shipping parts last month. National also supplies bipolar ICs for General Motors, and transistors for Ford. Other IC suppliers include Texas Instruments, Fairchild Semiconductor, Motorola, Signetics, Delco Semiconductor, Sprague Electric and Stewart Warner.

The final word on the success of the seatbelt interlocks will come from the customers. Says one semiconductor supplier who declines to be quoted: "It's possible real problems may crop up later. Apparently, none of the "big three" finalized their designs until early this year which means they have not been able to complete the customary year-long field testing under summer and winter conditions." Success is of critical concern to semiconductor houses. Says Joseph Obot, marketing manager for consumer products at National Semiconductor: "Seatbelt interlocks could prove to be the test of how pervasive semiconductors become in automobiles. If a lot of problems arise, it could decelerate the swing to ICs." □

Commercial electronics

Word processing system uses CRT to display edited text

The most recent firm to challenge IBM's majority share of the word-processing market is Lexitron Corp., Chatsworth, Calif. The firm's Videotype I system is claimed to be the only CRT-display-editing typewriter on the market now, except time-shared and dedicated computer systems used for typesetting publications.

The CRT permits a full page of type to be displayed, with a considerable saving in paper, as well as time. And the system can display about 7,000 upper and lower case proportionally spaced characters just like those in the IBM Executive. Although the Videotype I includes extensive editing and justifying capability, the unit is so similar to a typewriter and so automated that a typist can use it immediately without extensive training.

Lexitron says an independent study found that its Videotype I system takes 36 minutes to type and edit material that takes an hour on the IBM systems. The IBM MT/ST word processing system can typically increase a typist's output from 250 to 400 lines per day to 700 lines per day. That system rents for about $300 a month.

But while the Lexitron system raises the rental to $400 a month, it also raises the average number of lines typed to 1,000 to 1,200 per day.

The machine was "adapted to the person—we don't make the person adapt to the machine," says Jon Pugh, marketing vice president at Lexitron. Except for a few special keys, the keyboard is arranged like the popular IBM Selectric, with platen knobs used for advancing the copy which rises from the bottom of the screen like a typed page. All typing and corrections are made on the screen. Data is stored in a cassette. The output is printed on a modified Executive typewriter. One page is stored in a semiconductor memory, not the cassette, so that page can be printed while another is being typed or edited.

The Lexitron machine has the ability to insert or delete any material, including paragraphs from pages other than the one displayed. Justification to even up the right-hand margins and automatic decimal-point tabulation for columns of figures are inexpensive options. Pugh claims that the editing capability reduces the average number of pages that must be typed for each finished copy from 3.5 to 1.75.

Shift register now. Pugh says that the system became practical only because the cost of its extensive electronics has dropped dramatically in the last few years. It contains several dedicated single-board processors tied in through a common data bus, so that functions can be added or changed, and newer, less expensive circuitry can be adapted, simply by changing boards.

For example, J. Niles Puckett, director of engineering, says that the system uses three long shift register memories instead of random-access memories: "RAM wasn't cost-effective when we began the design three years ago, and it still isn't. Until the 4,096-bit RAMs become available in quantity in 1975, the shift registers make more sense."

Most of the logic is hard-wired TTL, with some ROMs, but the company is continually looking at new LSI circuits that could be designed into future systems. Puckett adds, "We could do the job with a small computer and a large memory, but we couldn't sell it for under $40,000," The Videotype 8 lists at $17,950. □

Solid state

GI's MOSFETs get technology push

Although MOS IC technology has been capturing most of the headlines, discrete-MOS technology is also growing, and the fastest growth is in television, radio, and communications applications. General Instrument Corp., Hicksville, N.Y., is aiming at these markets with its new line of MOS discretes that are processed by ion implantation, have fine-line geometries, and utilize other high-technology techniques.

GI has developed a series of MOSFET devices that it believes could well beat monolithic chips into new automotive a-m/fm radios. Called the MEM G40-G45 series, these enhancement/depletion devices are n-channel tetrodes with the second channel doped to produce zero volts cutoff and sharp, linear, 15 dB/volt (V_{gs2} vs G_m) automatic gain-control

TI's Fred Bucy warns against selling technology know-how and turnkey semiconductor plants to Communist nations

Even as West and East Bloc countries discuss relaxing the trade embargo on high technology, a sharp disagreement has developed between two major semiconductor manufacturers on how far this relaxation should extend. One viewpoint is exemplified in last month's Wescon speech by C. Lester Hogan, president of Fairchild Camera & Instrument Corp., who wants few restrictions made in East-West semiconductor trade.

Hogan stands ready to sell semiconductor products as well as the production equipment, technology, and management know-how to the Communist countries. This would mean the Communists would manufacture high-level semiconductor products themselves. The French company, Sescosem, a division of Thomson-CSF, has already broken the ice with the first turnkey semiconductor plant—sold to Poland—and Fairchild, waiting for the trade detente, does not deny having one quote outstanding on an MOS plant for Poland, and another two behind that for Russia.

On the opposite side is Texas Instruments, whose executives take a dim view indeed of trade agreements with the Communist bloc, on the grounds that such agreements are not protected by patent rights and do not offer either open markets or the opportunity to build a decent market share. J. Fred Bucy, vice president of Texas Instruments, points out that "it's one thing to sell high-technology products in the foreign market, but quite another to sell the know-how to make these products." He is adamant against turnkey contracts, and sees an equal risk in selling the Communists such pieces of production equipment as line-and-expose towers, diffusion furnaces, epitaxial reactors, and the like. "It's axiomatic in high-technology industries," says Bucy, "that the only adequate payment for know-how is market share. No lump-sum payment or turnkey-service fee can be great enough to fund the research and development necessary to enable the seller to maintain his advantage. You can be sure," he emphasizes, "that if we give away the know-how without obtaining a market share, they won't buy a dime from us—devices or equipment. We will be giving away the crown jewels."

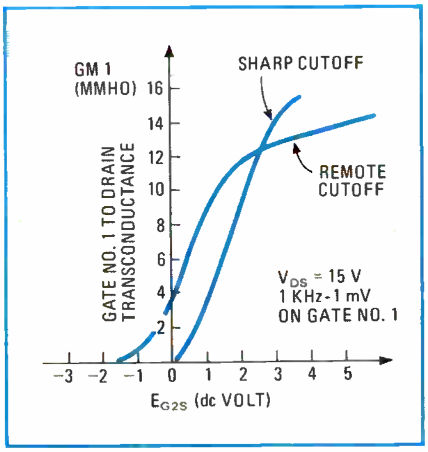
In Bucy's eyes, a big question with East-West trade is patent recognition. Because of the long-standing embargo on high-technology trade, few Western semiconductor patents are recognized by the Russians or other Eastern Europeans. "Since we can sell into the Communist community only through their governments," says Bucy, "the only way we can participate in their markets is for them to agree to recognize our patents retroactively, pay us full royalities, and/or give us access to sell directly in their markets on an equal footing against their state-owned factories."

Bucy also feels that if the free world is footloose with its technology, it may be building a monster that soon will gobble up domestic markets. The Communist countries will build their semiconductor capability with Western-supplied production equipment and know-how, and/or with Western-built turnkey plants protected by high tariff barriers," he says, and when they get their costs down and their own markets saturated, they will be "right out there exporting into ours."

Con game. As for the potential size of the Comecon market, Bucy thinks the anticipated market size has been exaggerated by almost a third, and puts the East Bloc market potential at $1.5 billion to $2 billion for the period from 1973 to 1980, in contrast with the Fairchild estimate of $5 billion [*Electronics*, Sept. 27, p. 42]. This means that any semiconductor plant set up in Eastern European countries capable of anywhere near the capacity of typical Western manufacturing facilities will quickly saturate the domestic Communist market and be ready to export their overcapacity to the West.

The semiconductor capability of the Comecon has been greatly ex-

aggerated as well, according to Bucy. "The shell game they're playing," says Bucy, "is taking small quantities of laboratory-developed devices, giving them to people who are visiting Russia, and saying 'look at our capability—now why not sell us the equipment to manufacture this, because we can do it ourselves anyway.' If they can, let them do it. The truth is, they don't have the capability of producing in large quantities at high yields. And that's what they want us for."



Sharp cutoff. GI's enhancement-gate tetrode allows single-polarity agc. Previous tetrodes needed negative voltage for complete cutoff and had flattened gain control.

characteristics. The series forms the basis for GI's Autodyne a-m/fm tuner, which is currently under evaluation by major auto companies and which will be announced at this winter's Consumer Electronics Show in Chicago.

These devices enable construction of a positive-polarity agc and a one-polarity radio with agc down to zero volts. Previously, either first-stage agc wasn't used, which can lead to interference problems in big cities, or a voltage pedestal was used to raise the source potential, utilizing three power resistors that are currently hard to obtain. Although aimed at automotive markets, Ed Kramer, product manager for MOS devices, believes they will also have land-mobile-communications applications. Quantities of 1,000 will sell for 66 cents each in TO-72 packs or 38 cents each in plastic packages.

Another development is the use of ion implantation to obtain a 1-GHz discrete n-channel MOS for uhf circuits. Narrow channel width is essential for the device, planned for announcement this winter.

Frank Garbis, Components division vice president, says GI will enter the C-MOS market by selectively second-sourcing the RCA-4000 series and introduce some discrete MOS products of its own in the multiplex and high-speed analog-switching areas. Products soon to be announced include four-channel, eight-channel, and dual eight-channel bilateral switches with decoding.

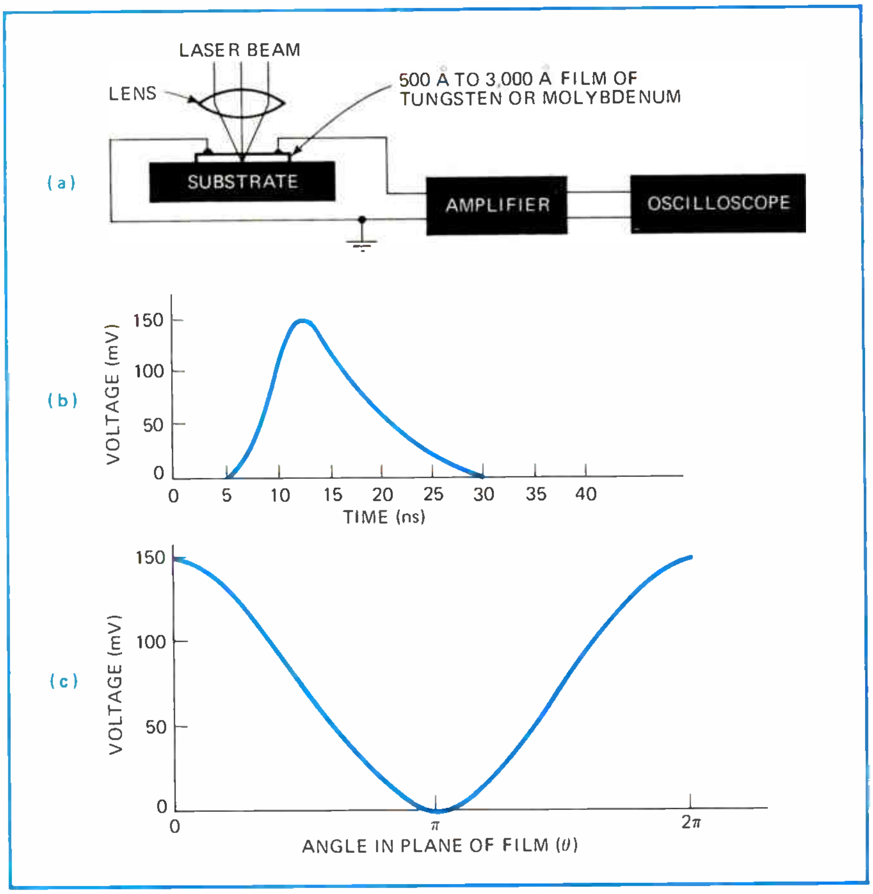
The company also plans a C-MOS quad multiplex driver, the MEM-4900 series, which can also serve as a TTL-to-MOS logic level converter. GI is also working on C-MOS in multilayer hybrid circuits to increase the packing density by reducing power-dissipation function. The company already makes a 50-chip 5-kHz low- and high-pass audio filter with 500 dB/octave roll-off. □

Thermo-optic effect is new device hope

If the experimental work on a new optical-detector mechanism is successful, a new generation of ultrafast, inexpensive, and sensitive pulse photodetectors that are compatible with most IC technologies may be the result. The new work stems from an incident of scientific serendipity at IBM's Thomas J. Watson Research Center, Yorktown Heights, N.Y.

As Robert Van Gutfeld, research-staff member and Philip Seiden, director of the physical sciences laboratory, were studying thermal effects in tungsten and molybdenum for possible bolometer applications, they noticed that a laser beam produced on the film a voltage that was perpendicular to the direction of light propagation. Recently, they observed signals as large as 150 millivolts for a 1-kilowatt, 5-nanosecond optical pulse at 4,600 angstroms.

The output voltage is proportional to the light intensity, independent of contact material, and it is not affected by magnetic fields, by moving of the light beam across the film, or by polarization angle. The voltage is rotationally periodic in the plane of the film. By analyzing the thermal profiles, Van Gutfeld found that the time constants, signal



Thermo-optic effect. Using the setup in (a), the new effect can be observed. The response to a 1-kW pulse in (b) and (c) shows the voltage dependence in the plane of the film.

INTRODUCING THE TEKTRONIX TRANSIENT DIGITIZER

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shapes, and reversal of voltage polarity with illumination from the back of the film are determined by the temperature gradient normal to the direction of the film.

Considerable evidence supports the hypothesis that film stress causes an anisotropy in these otherwise isotropic films. Sputtered films, films evaporated onto substrates heated to 450°C, and films annealed at 800°C show small or no transverse voltage effects. Annealing at lower temperatures (less than one fourth the melting temperature) increases stress and enhances the effect. Heating the films to 250°C increases the voltage, which is consistent with the increase of Seeback coefficient (the open circuit voltage caused by a temperature difference) with rising temperature.

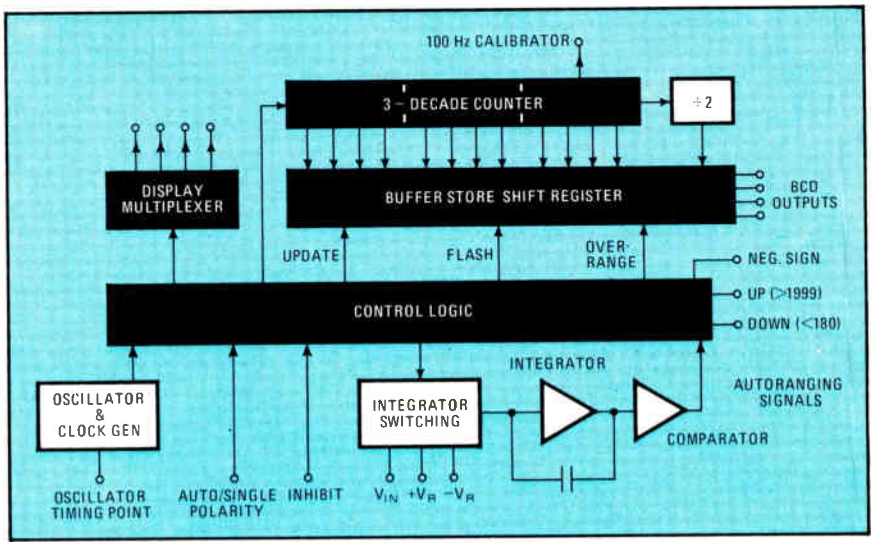
Lack of a thermal gradient sets the minimum thickness at 500 Å, and leakage paths limit maximum thickness to a few micrometers. The longest wavelength occurs at 10 μm, when the film totally reflects the incident light, although work is going on to enhance the absorption at that wavelength. Short pulses are needed to establish the temperature gradient, and this limits maximum optical pulse width to a few hundred nanoseconds.

Since detectors made from these films require no bias, and detectors can be made readily by single evaporation, masking, and bonding steps, applications for low-cost arrays and detectors at 1.06 μm are feasible. Since the effect is only a function of temperature gradient, the position of the beam on the detector is not critical. □

Instrumentation

New chip could halve DPM prices

The digital panel meters that have been rapidly replacing analog devices have mostly had separate analog and digital portions, and they have needed peripheral display decoder/drivers and reference supplies—but all these components and interconnections lower reliability and raise costs.



Block of chip. Diagram of IPL's MC 804 DPM/DVM chip. An off-chip capacitor cancels the accumulated offset voltage and allows the combination of analog and digital features on a single chip.

This month that situation should brighten, when Integrated Photomatrix Ltd., Dorchester, U.K., and its newly established subsidiary, Integrated Photomatrix Inc. of Mountainside, N.J., introduce a completely monolithic 3½-digit DPM chip, the MC 904. It will have a 300-microampere, 24-volt BCD output for digital system applications. Another version will soon be available with straight binary output. According to Gerry Parsons, manager at IPL, the addition of an integrating capacitor, a reference voltage and four discrete decoder/driver transistors is all that is needed to make up a complete DVM. According to IPI marketing vice president James McCormick, the chip will sell for $7.50 in large quantities, thus allowing DPMs to be built for about half the current price of $100. The chip's small-lot price should be about $15.

The main innovation in the device is in system design, not LSI technology. An on-chip capacitor is used to cancel out the offset voltage that remains after each frame in the dual-slope integration technique used in DPMs. Other than that, standard p-channel MOS techniques with 10-micrometer design rules are used to produce the 130-by-130-mil chip. The DPM has dual-polarity 100-mV and 1-V scales, 0.01%/°C of reading, temperature coefficient accurate to 0.1% of reading ±1 digit, and requires ±15-V supplies. □

Commercial electronics

LSI chip helps meter fuel-oil deliveries

This winter, a truck-mounted computing unit that is based on an MOS LSI chip will begin metering fuel oil and giving customers their invoices on the spot. The first electronic fueling system—the result of a collaborative effort by three parts of the Emerson Electric Co.—eliminates fuel-oil dealers' clerical and billing expenses, the company says.

In fact, "the tank-truck market is just a part of it," says Rodney P. Buffington, product manager for Brooks Instrument division, Statesboro, Ga., since the Brooks Tank Trunk Transaction Computer is designed so that it can handle any petroleum or cryogenic liquid. The computer works on an electrical signal, and it can monitor any type of meter that generates pulses, he explains. Buffington predicts a $10 million domestic market for electronic tank-truck meters within five years. The complete system, including valves and pumps, will be competitive with present mechanical

■ A projected price of $650 (the present range is $600 to $1,500.
■ A 19-ounce weight, versus 43 ounces for some models now.
■ Half the usual size.
■ A 4.5-mile range (compared with 1.5 for most models).
■ Vhf and uhf channel reception capability.
■ Four channels.
■ Compatibility with existing police equipment.
■ Better performance in saturated city environments.
■ Operating performance to -40°C. Solid-state design also gives the radio longer duty cycles.

In drawing up the specifications for the radio development, LEAA surveyed 500 law enforcement agencies to find out what their needs were. As the specifications are readily available, LEAA hopes all manufacturers will meet them in their sets. Even so, "some goodies could be added," Shollenberger suggests, "such as a lower profile antenna" and a design "to make the radio even more hands-free." □

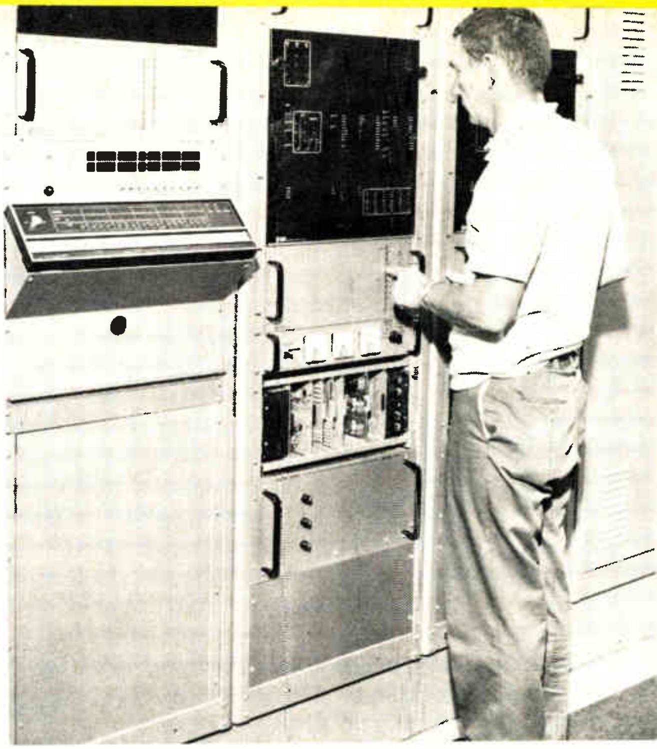
Industrial electronics

Minicomputers boost elevators' efficiency

Now elevators have joined the many kinds of equipment controlled by general-purpose minicomputers. U.S. Elevator, San Diego, Calif., a subsidiary of Cubic Corp., recently installed a complex computer-controlled system at the Security Pacific Bank in San Diego—one of the most advanced systems available.

Called the CMC-1200, the system can control up to 12 cars with 48 levels of service. In practice, few buildings have this many elevators, and the floor limitation is not a problem, since in multistory buildings certain floors are served by only one bank of elevators.

The computer used so far is the Data General Nova 1200, with 4,096 words of memory. But U.S. Elevator has developed an interface board that permits the use of other computers. Early last year, the largest company in the field, Otis Elevator of New York City, installed a combined elevator-conveyor system at the Colgate-Palmolive Co. in Jersey City, N.J. That system, according to Arnold Mendelsohn, assistant manager of research and development at Otis, uses a Digital Equipment Corp. PDP-8 minicomputer. Most of the other elevator manufacturers equip their installations with computer logic controls, which are actually hard-wired controllers rather than general-purpose computers.



On the rise. U. S. Elevator Co. uses a minicomputer to control its CMC-1200 elevator system.

In developing its system, U.S. Elevators drew heavily on Cubic talent. A major aim was better response, and average waiting time has in fact been reduced to 10 to 15 seconds.

Spoof-proof. The system monitors status and requests 10 times a second, while maintaining and consulting an "activity history" to insure fast service. It will mass cars at the lobby in the morning, for example, and at areas of heavy demand such as where a large conference has ended. The system also checks to make sure that the cars it dispatches arrive; if they are held up, another car is sent.

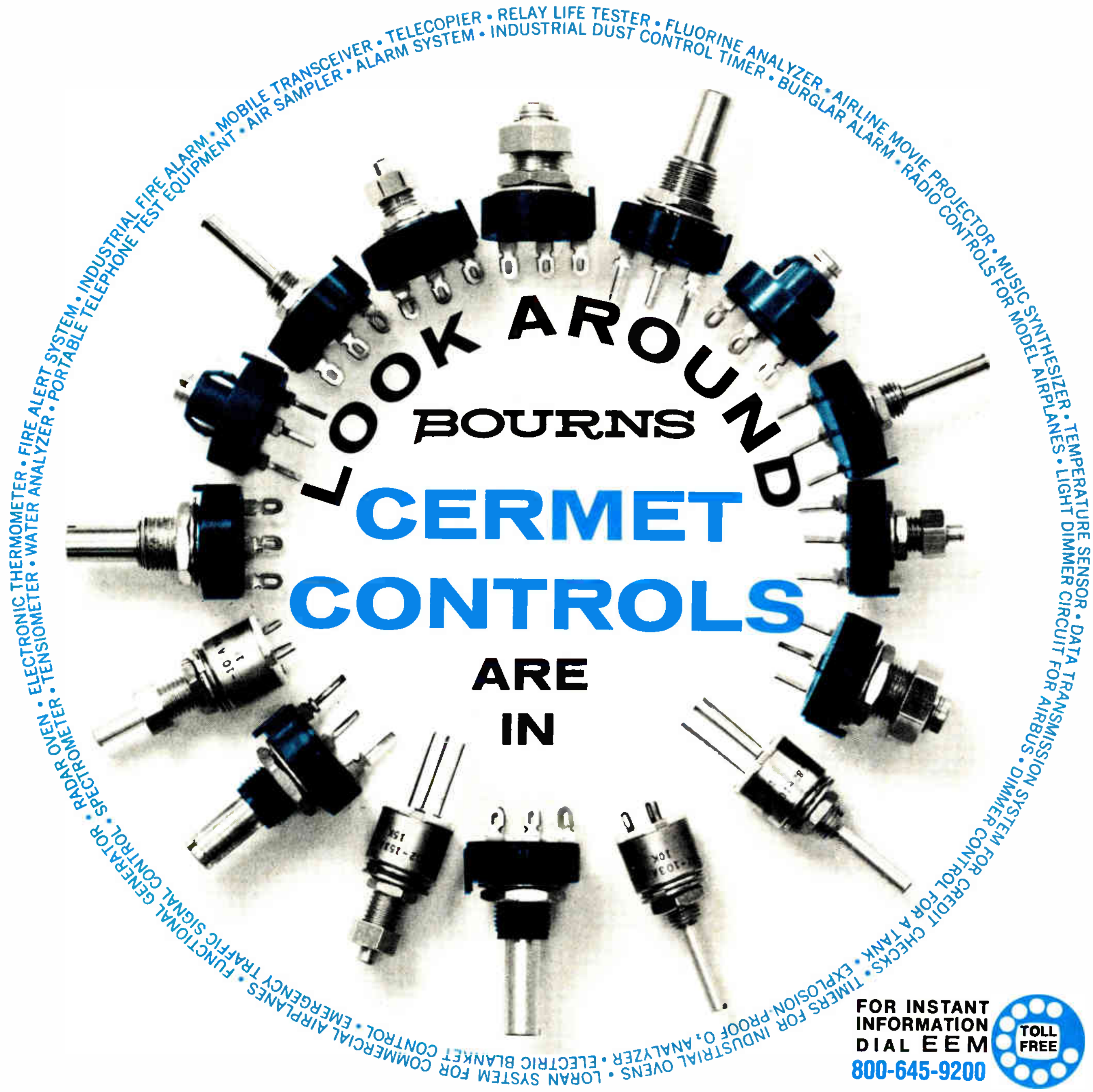
The computer gives priority service to selected floors, such as VIP suites, and a spoof-proof feature prevents people from interfering with car assignment, as by reversing an up car when people are waiting for it: a weight-sensing mechanism (monitoring the current in the motor that holds up the elevator) notifies the computer, which cancels the false call. This device also foils the practical joker who pushes all the buttons in an empty car, then jumps out of it.

The CMC-1200 meets all state and Federal safety standards, with redundant mechanical, electromechanical and electronic safety features. If power fails, a slower "street car" system operating on auxiliary power sends the cars from the lobby to the top floor and back, stopping along the way as needed. The computer back-up system uses logic of medium complexity and provides fair to good service, during periods when the computer might be down for service, says U.S. Elevator.

A major advantage of a minicomputer is that the control is easily modified by changes in the software program. This simplifies elevator system production because standard controllers can be used, and the software can be changed for different building requirements. It also means that programs can be changed quickly if building needs change.

However, at Otis, Mendelsohn says that "in most cases, the basic minicomputer is designed to perform arithmetic calculations and not to operate in an elevator environment where there is a lot of input/output information." To adapt such a system requires input/output ports and also main buffers, which increase the cost. Otis is now designing a parallel processor to its own requirements, which Mendelsohn says will fit the elevator environment at an economical cost.

U.S. Elevators contends that the cost for the system depends on its



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size. In a 12-story building it investigated, the company says the cost for the computer system would be significantly less because it permits better use of elevators and therefore reduces the number required. □

Computers

A microcomputer to bypass the compiler

For many years computer engineers have tried to design a practical machine that would directly execute programs written in a high-level language, such as Fortran, without the use of a computer. Research laboratories have produced some experimental models, but they usually worked with a subset of one of the better-known languages and were not commercially feasible.

Now a small Canadian firm, Micro Computer Machines Inc., Willowdale, Ont., has developed a machine, the MCM/70, which is programed in APL (A Programing Language, developed some years ago by IBM). The MCM/70 interprets APL statements with the help of an extensive microprogram, but bypasses the time- and memory-

News briefs

IBM contests Telex damages

Balking at paying damages of $352.5 million in an award by Federal Court Judge A. Sherman Christensen in Tulsa, Okla., to the Telex Corp., IBM Corp. has filed for a new trial before the original court in an attempt to reduce the amount of the judgment. IBM says it does not want to reargue the "fundamental core" of the decision, but asks to correct the award "with respect to the issues of damages and equitable relief." IBM cites errors of fact or legal procedure in the original trial as its reason for the retrial petition. If successful, the request would eliminate the award to Telex, and lift the injunctions that prevent IBM from collecting penalties on prematurely terminated long-term leases.

Sprague sells thin-film operation

Sprague Electric Co. has sold its thin-film hybrid-circuit operation in Worcester, Mass., because, according to president Bruce Carlson, the division did not fit in with Sprague's product line. The buyer is Hybrid Systems Inc., Burlington, Mass., which will lease the space in Sprague's semiconductor plant where the division is based. Sprague will retain a "minority position" however, which is said to gross about $3.5 million annually.

DIP logic array is leadless

Billed as perhaps the first integrated-circuit device to be offered in a leadless dual in-line version, a programable logic array from Rockwell International [*Electronics*, Sept. 13, p. 39] will be configured to mate with the Burndy zero-insertion-force, leadless, gas-tight, high-pressure receptacle. Moreover, the device is said to be the first of its kind available off the shelf. Leadless DIP sockets have been available on a custom basis, manufactured by both Amp Inc. and Amphenol.

Sierra awards total $700,000

Sierra Research Corp., Buffalo, N.Y., has received awards totaling more than $700,000 for various models of its SAMS Air Navigation System and associated test equipment. Contracts totalling $442,000 were received from the Royal Norwegian Air Force, and other awards totalling $236,000 have been received from The U.S. Navy, Canadian Defense Ministry, Royal Danish Air Force, and the Federal Aviation Agency. According to the company, sales of the SAMS equipment have passed the $3 million mark as of this May.

What's DAFL stability? 1 ppm/24 hrs.

The Model 6201 Signal Generator offers you a new experience in precision testing over the 61-kHz to 1024-MHz range. Simply set your desired frequency on the six-digit counter, flip the lock switch, and enjoy the confidence of a locked, crystal-stable output signal. That's what DAFL — Digital Automatic Frequency Lock — is all about. It means 1 ppm stability, all day, all night.

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INSTRUMENTATION

Electronics review

consuming step of compilation, or translating the program from APL into machine language.

Shoebox-size chassis. The machine has a standard 50-key keyboard, plus a 10-key numeric keyboard for input, and it displays results on a one-line gas-plasma panel. It has a 2,000-byte metal-oxide-semiconductor memory as working storage, expandable to 8,000 bytes, as well as another 150,000 bytes on an optional magnetic-tape cassette. The microprogram is kept in an extensive read-only memory; logic circuits are a mixture of MOS and transistor-transistor logic. The entire machine is completely self-contained in a chassis measuring 13 by 15¾ by 5¼ inches, including the cassette drive; provision is made for externally connecting a strip printer, a cathode-ray-tube display, or a communications interface.

Mers Kutt, president of Micro Computer Machines, says he isn't quite ready to accept orders yet. He plans to market the machine through regional representatives in the U.S. and Europe, as well as in Canada. He hopes to have both his patents and his distribution network completed by the first of the year, by which time he expects also to have his production line geared up to the point that deliveries can be made quickly. At $3,500 each, he expects sales to be brisk. □

Fabrication

IBM study aims at super-dense devices

The ability to fabricate devices smaller than the wavelength of light for high-density memory applications may be a result of a new technique being studied at IBM's Thomas J. Watson Research Center, Yorktown Heights, N. Y. This work in scanning electron microscopy increases the resolution of such instruments by a factor of three over what had been achieved previously. By using SEM as a process-control tool, sub-micron-size devices can be more

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clearly examined, a crucial factor in making super-dense storage cells.

The new technique permits a solid specimen to be placed inside the high-field region of the condenser-objective lens in a high resolution SEM and collect the elastically scattered high-energy electrons instead of the low-energy secondary emitted electrons usually collected. In the conventional scheme, the sample must be located away from the lens because the magnetic fields which focus the incident electron-beam would otherwise greatly deflect the low-energy secondary electrons. In the new technique, the secondary and back-scattered electrons are deflected away from the detector. Resolution is improved by adding external energy filters. But more important, by changing the voltages on the filters, the secondary or the low-loss electrons can be observed with the same instrument.

Alec Broers and Conrad Broemer, who developed the technique, believe that the major impact of the development is to put surface scanning and transmission SEM together in a single instrument. It could significantly influence semiconductor-device process control by allowing one instrument to view first the top 100 angstroms with the new technique and the next micrometer or so using standard SEM techniques.

Broers described how this technique was used to solve the electromigration problem. By collecting the low-energy electrons, holes caused by electromigration could be observed. By looking at the top 100 angstroms of the surface, researchers could also examine the oxide on the top of the wafer and conclude that migration wasn't along grain boundaries as was commonly supposed. This led to using copper in metalization to prevent aluminum migration.

Thirty-angstrom resolution has been attained, and ultimate resolution should be about 8 angstroms. The developers believe that the technique will also see extensive biological applications since thin membranes may be nondestructively observed without special sample preparation. □

Raytheon Semiconductor Update

Announcing Monometallic Silicon Nitride Passivated Glassivated Wireless Bonded Semiconductors in conventional packages.

Technically speaking that describes the new Raytheon Semiconductor line of *super-ultra-reliable* transistors and diodes available for the first time ever in standard packages. But we simply refer to them as our SURE products. They're specifically designed for critical applications calling for extremely reliable performance, or for operation under the most severe environmental conditions.

The SURE packaging innovation combines the latest advancements in beam lead technology with assembly techniques that are truly state-of-the-art (and that's not just the usual cliché). In this unique process there are no "flying" wire interconnections between the terminal post and the silicon chip. Instead, external leads for the base and emitter are formed to permit bonding *directly* to the beam leads of the device. Both collector beams are common to and bonded directly to the header.

This means there are two less interconnections than a standard transistor to worry about. Another plus factor: The bonds are the gold-to-gold compression type, well known for their excellent reliability. So you end up with a device that's capable of much higher operating temperatures, higher shock, g's and vibration than comparable die-mounted semiconductors. (And we've yet to reach the ultimate limits in these areas. Not an idle brag, but a fact.)

Actual scanning electron microscope picture of a SURE transistor mounted on the newly developed TO-18 header.

The beam lead chip is, of course, silicon nitride surface passivated. It does not require additional sealing to protect the surface of active silicon from contamination. And if you are a real purist, you can specify beam leads that are glassivated over the metalization.

As you can see in the actual scanning electron microscope picture, the unique, perfectly shaped edges of the chip form a precise 54-degree angle with the vertical. This is a result of Raytheon Semiconductor's exclusive V-ATE process which ensures more accurate, repeatable separation of chips without the inherent stress producing scribe-and-break or irregular etch methods commonly practiced. In this way we can also maintain a thicker, more rugged device with superior thermal characteristics.

At present Raytheon Semiconductor SURE products include bipolar PNP and NPN transistors and switching diodes. They are available in a TO-18 3-lead metal can and a TO-86 14-lead quad-transistor flat pak.

SURE products are without a doubt the highest quality semiconductors of their kind ever built. In fact they're so good that maybe *Monometallic-Silicon-Nitride-Passivated-Glassivated-Wireless-Bonded-Semiconductors* is a more deserving name. But for our salesmen's sake if you want more information on Raytheon Semiconductor's new *super-ultra-reliable* transistors and diodes, just ask us for SURE.

Reader Service No. 231

The cover for the new Raytheon Semiconductor linear catalog really says it all: TOTAL LINEARS. That simply means we can fill 9 out of 10 of your needs for linear integrated circuits.

For example, Raytheon Semiconductor offers more than 50 op amps, a half-dozen wideband amps, 16 voltage regulators, two-dozen comparators and sense amps, 19 line drivers and receivers, as well as assorted memory drivers and low power audio amps.

Many of these linear devices are proprietary with Raytheon Semiconductor. Like the 1556A Beyond Super Beta Op Amp. Or the new 4194 adjustable and 4195 fixed voltage regulators you've probably read about. And the only true Quad 741 High-gain Op Amp; we call it the 4136.

Also we have a score of linear chips and beam lead circuits you won't easily find elsewhere.

So that you can easily choose the right linear IC for a particular application, we've included special Selection Guides that give you a quick way of comparing key parameters of similar devices within each product group.

To get your personal copy of this new comprehensive 192-page catalog, send us your request on your company's letterhead. And for one-stop-shopping for your total linear IC needs, contact your nearest Raytheon Semiconductor salesman, representative, or franchised distributor.

New Low-level Audio Amp Doubles Battery Life

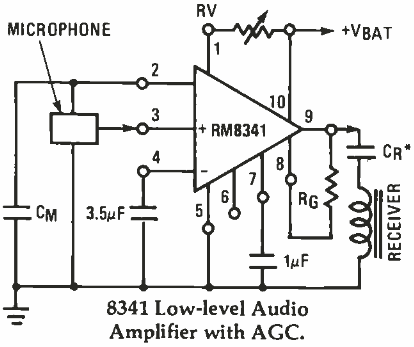
Raytheon Semiconductor is now producing a new low-level audio amplifier that outperforms anything in its class. Designated the 8341, it's ideal in battery powered circuits such as hearing aids, remote microphones, tape preamps, and other milliwatt amplifier applications.

The quiescent current of the 8341 is only 0.5mA. So you'll get twice as many hours from your battery supply than you would with a similar device. The voltage gain is a healthy 70dB — even over a supply voltage range of 1.1V to 1.7V. And the total harmonic distortion is only 1%. What's more, it has AGC with a dynamic range of 30dB.

From a design standpoint, the first and second differential gain stages are biased with current sources that are independent of supply voltage changes. So you can expect less than a 2dB change in gain over the entire battery life cycle. The output stage is a single-ended class AB type to minimize battery current drain. It's also biased to provide a maximum AC output swing of plus or minus one-half of the supply voltage.

With an external resistor you can set the maximum gain below the nominal 70dB level. Or if desired, you can vary the gain by means of an external volume control.

The AGC threshold is adjustable by means of an external resistor, and its transient response is determined by a small external capacitor.



8341 Low-level Audio Amplifier with AGC.

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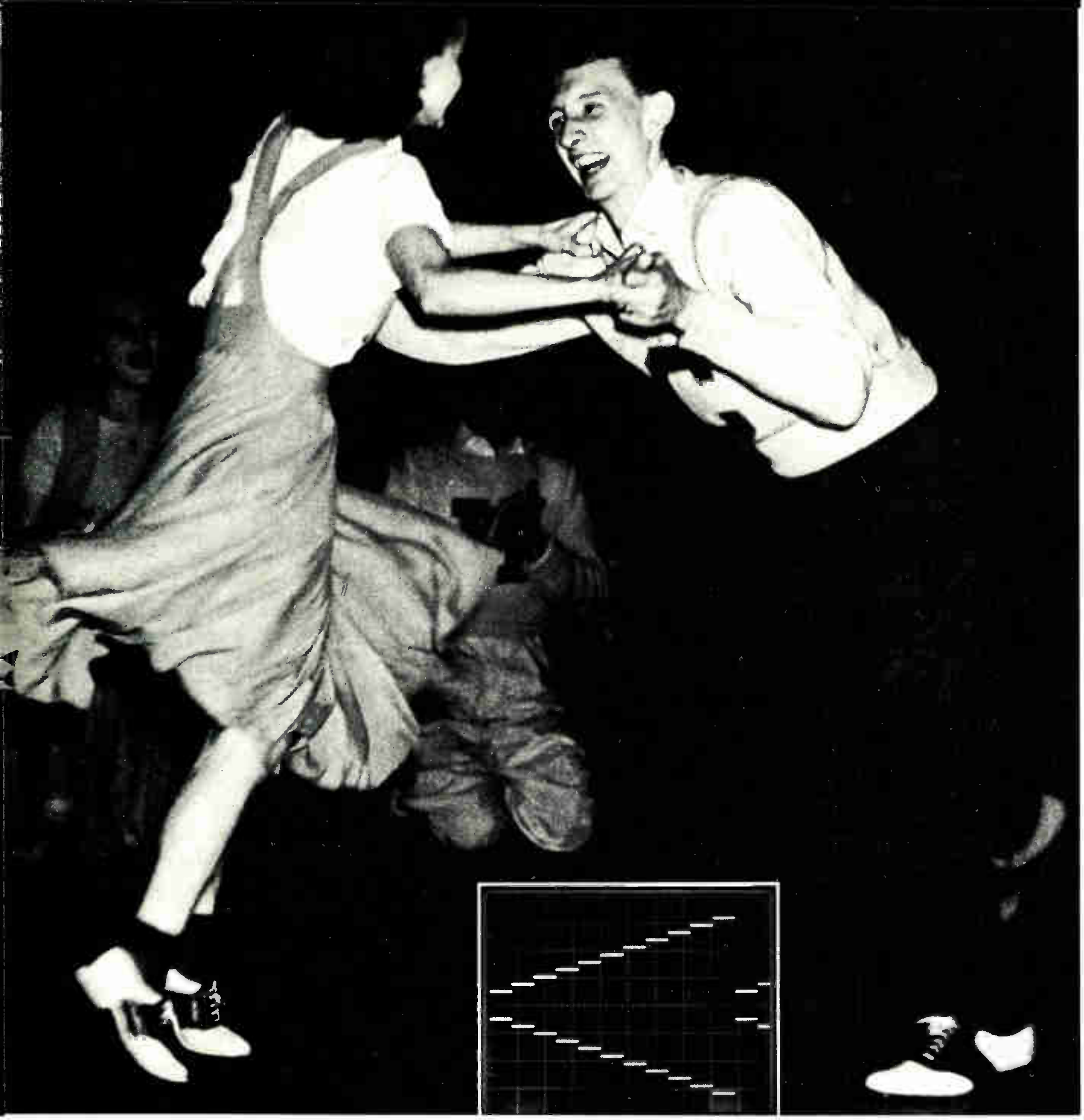

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Washington newsletter

Chinese experts on EDP start tour of 12 U.S. firms

Fourteen top computer specialists from the Peoples' Republic of China, interested in "big machines, their architecture, technology, and applications," will also be exposed to integrated circuits, minicomputers, and system networks during a month-long tour of the U.S. computer industry just beginning in Boston. A dozen U.S. companies and several universities will be visited by the members of the Chinese Society of Electronics, whose **tour is sponsored by the National Academy of Sciences as part of a series of scientific exchanges** arranged by Henry Kissinger, now Secretary of State, during his February trip to Peking. NAS officials say **it's the only exchange relating to electronics.**

The Chinese group arrived Oct. 5 in Washington. The visitors are led by Yen Pei-Lin, CSE council member and director of the Institute of Computing Technology of the Chinese Academy of Sciences, and Wang Tsung-Chin, deputy manager of the China Radio Appliances Corporation. After Boston, they are scheduled to visit New York, Minneapolis, Texas, and California.

RFPs expected for improved Personal Rapid Transit setup

Requests for proposals for development of a second-generation Personal Rapid Transit operating testbed will be issued soon by the Urban Mass Transportation Administration. **Expected to cost between $15 million and $20 million, the project encompasses two new design vehicles and three stations along several miles of track** northwest of downtown Denver and is to be the forerunner of a regional system being planned locally. In contrast with UMTA's first automated system, in Morgantown, W. Va., the new line is to move twice as many passengers, using smaller vehicles but doubling the frequency of service.

Delays in postal automation worry several companies

Some research and development contractors complain that **the U.S. Postal Service's continuing delays in launching its long-heralded billion-dollar-plus automation of preferential mail centers** [*Electronics*, May 10, p. 49] are giving them fits as development programs draw to a close and funds dry up. Although the postal service has told industry it expects to finish re-examining its plans in December, **its five-year phased procurement of the massive amounts of electronics-directed hardware most likely won't begin before sometime next year,** say postal and industry sources. Two major reasons for the delay are that the service wants to evaluate the prototype equipment more thoroughly before committing the money, and that right now it's more worried about better service than automation because of public complaints about slow mail. Leading competitors for postal funds include Burroughs Corp., E-Systems, IBM, Philco-Ford, and RCA.

Addenda

The Office of Federal Aviation administrator, Alexander P. Butterfield, has categorically denied that he has any plans to resign [*Electronics,* Sept. 27, p. 53]. . . . A potential for electronics was spelled out in two strong recommendations from a Law Enforcement Assistance Administration advisory commission. **It advised every police agency to develop a communications subsystem** that would answer emergency calls within 30 seconds and dispatch a patrol car to arrive within three minutes, and to "immediately implement a full-time telephone service."

Washington commentary

Opposing a consumer protection agency: EIA's view

The Consumer Electronics Group of the Electronic Industries Association (EIA/CEG) is opposing passage of legislation to create a Consumer Protection Agency within the Federal Government that would advocate consumer interests. In recent congressional testimony, GEC special counsel J. Edward Day advanced some strong arguments of interest to readers of Electronics. *Excerpts from his testimony follow.— Ray Connolly.*

The Consumer Electronics Group is principally concerned with two aspects of the bill. Section 204(A) would authorize CPA participation and intervention in rule-makings and adjudications to represent "the interests of consumers" which the CPA finds may not otherwise be "adequately protected." This section is of concern on two grounds. First, how will the proposed CPA choose the particular "interests of consumers" it will represent from among the numerous competing interests? Second, . . . the CPA authority to participate in informal agency proceedings . . . could be seriously disruptive of the day-to-day operations of administrative agencies.

Choosing sides

It is unclear whether the CPA is to present several different interests to the host agency or, as under the Senate version, S. 707, present only one "important interest of consumers." If the former is the case, we do not see how the CPA would add to the decision-making process . . . because such proceedings traditionally draw numerous parties representing many differing positions. In such a case, therefore, the CPA would only add repetitive exhibits and testimony and further lengthen and delay the already lengthy time between the inception and conclusion of administrative proceedings.

On the other hand, if the CPA is to present only one interest of consumers to an agency, CEG has grave doubts as to how, in an age of competing consumer interests, the CPA is expected in many situations to select a single consumer interest to represent. For example, in a proceeding looking towards the establishment of more efficient automobile-emission-control devices and standards, which side would the CPA represent? On the one hand, there is the position which, in the name of public health and environmental protection, calls for ever stricter standards and ever more exacting devices. On the other side, there is also another legitimate consumer position: the economic cost to the car owner.

In a time of continuing inflationary and international pressures on the cost and availability of gasoline, and having in mind proper concern for the energy crisis, where should the CPA stand: with the environmentalist-priority consumers or with the economic-priority consumers?

Neither liberals nor conservatives are able to agree within their own groups as to which is the pro-consumer side in tariff cases or cases under the antidumping law or the countervailing-duty law. Does the consumer side support low consumer prices for imported products, or does it support protection of American workers against unfair foreign competition?

Acquiring expertise

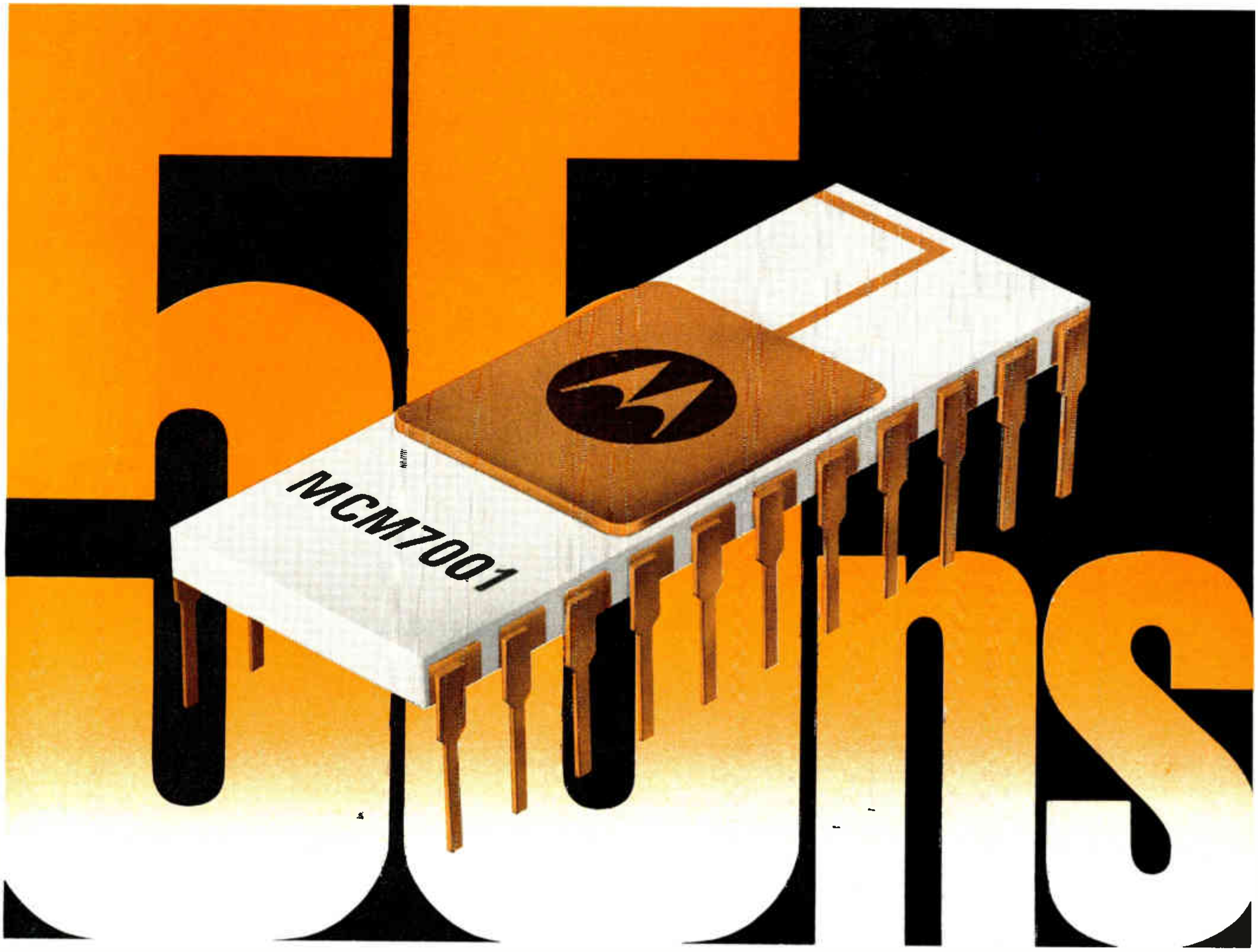
I have heard various attempted rebuttals to this concern about how the CPA would determine which of competing consumer interests was the one to be espoused with all the power, prestige, and publicity advantage of a Federal Government agency.

Some of the rebuttals say it is only a matter of judgment and that the CPA can be expected to make proper judgments and strike the proper balance.

Another attempted rebuttal is the claim that the CPA would be more independent and free of industry pressure. I don't go along with the idea that when a Government agency agrees with industry it has caved in to pressure, but when it agrees with professional consumerists, it has acted in the public interest. I don't think the CPA would be independent at all. It would come to each proceeding with a built-in bias and through its special potential for attracting publicity would impose the pressure of that bias on every step of that proceeding.

Agency rules against *ex parte* communications, Government-wide rules against conflict of interest, high ethical standards in selecting appointees, congressional and media oversight, are the ways to keep agencies independent and objective.

CEG submits that the better approach to protecting the interests of consumers lies in amendments, where needed, of the various enabling acts for the Federal agencies in order to specify more precisely what those agencies must do in order to regulate even-handedly and satisfactorily. Thus, the better answer lies in seeking to improve the host agencies and in continued, but even more effective, congressional oversight; not in delegation of the basic oversight function to a new untried agency that would be subject to its own "growing pains" and temptations to empire-building.



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The MCM7001 is a dynamic memory with charge pump, so the effect is that of a static RAM with ultra-low standby power. To be specific, 68 μW/bit, max. Cycle time is 180 ns. Not bad. It's TTL compatible. As a direct second cource of an AMS product, an alternate supply is built in.

Naturally, the MCM7001 is first thought of as the fastest MOS RAM for add-on memory systems. At 55 ns, it's fast enough for most main frame applications, too. The MCM7001 is clearly the 1K MOS RAM leader. And Motorola is readying a new leadership 4K NMOS RAM as well, to provide designers with the industry's lowest standby power, fastest speed of any major 4K RAM, and even a ready-made second source.

These RAMs, and the 8K NMOS ROMs introduced recently, make Motorola the leader in NMOS memory.

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MC6565L	Quad 80-bit static SR
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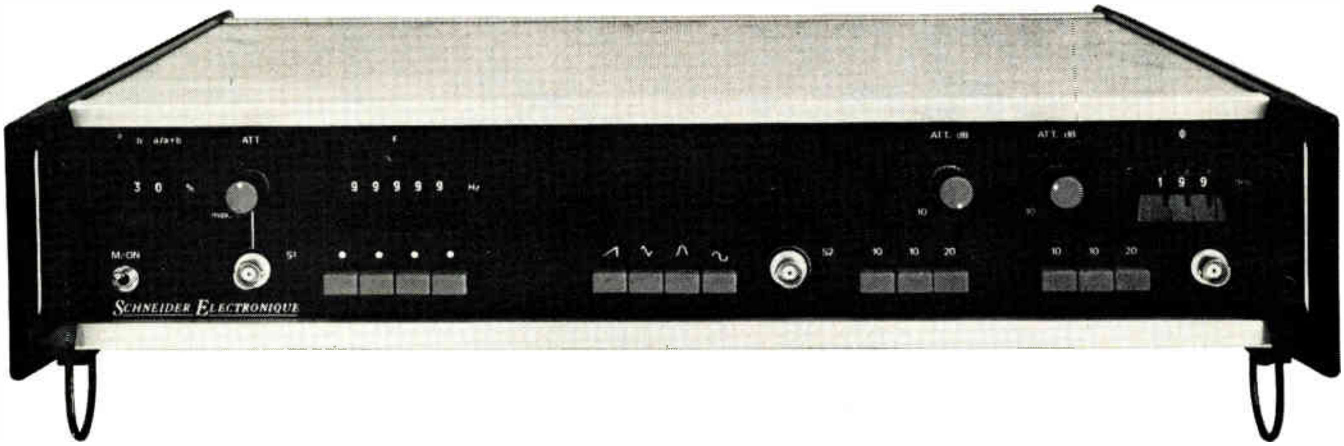

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Bosch readies IC-based fuel-injection system

When Robert Bosch GmbH introduced its electronically controlled fuel-injection system back in 1967, there was little doubt that the company would some day come out with a redesigned version. Using some 300 discrete components, the system's control unit begged to be integrated.

It took six years and nearly two million units, but West Germany's leading automotive-accessory producer has finally readied an injection system using integrated circuits. Incorporating three ICs, the system's control unit has but 80 components. It measures only 6½ by 6½ by 2 inches and easily fits into tight spaces around the car.

Bosch calls its new version L-Jetronic. The L points to a different approach in system design and stands for Luft, the German word for air, which is the main parameter in controlling the fuel-to-air ratio. The amount of air needed for an optimum ratio is metered in an air-flow meter.

Fundamental. The use of air is a radical departure from the principle employed in the original injection system, the D-Jetronic. There, manifold pressure—the D stands for Druck or pressure—was the main controlling parameter.

An air-metering system, as opposed to manifold pressure sensing, offers several advantages, Bosch men say. For one thing, it compensates for any degradation in engine performance that occurs with increasing engine life and thereby insures a clean exhaust over virtually unlimited periods. Furthermore, the L-Jetronic's control unit allows the system to be easily adapted to accommodate future control devices, such as sensors that can spot oxygen content in the exhaust.

Still another advantage is that the system can handle its job with less electronic hardware and at less overall cost than the D-version. The electronic circuit requirements, a Bosch sales engineer says, are down by roughly 35%. "Depending on car type and other factors, the system is from 30% to 40% less expensive than its forerunner," he adds.

The Jetronic's redesign was prompted in large part by the tougher exhaust-gas emission standards in the U.S. that are to become effective in 1976. "With air metering being more accurate than manifold-pressure sensing, a much cleaner exhaust can be obtained," says one Bosch man. The redesign and development job, which took about three years, also explains the delay in going from discrete components to an IC version.

Customers. With the L-version entering volume production, Bosch is discontinuing its D line, which is currently being used in some 18 car models. The company's first L-Jetronic customer is Adam Opel AG, the German subsidiary of General Motors. Opel will use the system on its Manta GT/E models, a passenger car to hit the market within the next few months. □

Around the world

Liquid-crystal display runs off C-MOS chip

Liquid-crystal displays with low voltage threshold and high contrast, now under development at Hitachi Ltd.'s Hitachi Research Laboratory, should be capable of being driven efficiently and directly by the C-MOS chips in battery-operated calculators. The devices have a threshold of about 5 volts and reach a contrast peak in the order of 60:1 at about 8 v.

Hitachi achieves the lower threshold voltages by adding up to about 0.6% by weight of cholesteric liquid crystal to a nematic liquid-crystal mixture. The decrease in threshold voltage becomes significant with the addition of 0.3% of cholesteric material, and is optimum in the range of 0.4% to 0.5%. The experimental liquid-crystal material used is a conventional nematic mixture of methoxy benzyldene butyl aniline and ethoxy benzyldene butyl aniline with about 0.1% ionic dopant to which small amounts of cholesteryl nanonate has been added. The display configuration is conventional, with a transparent conductive front electrode and mirrored rear electrodes sandwiching a thin layer of liquid-crystal material, which has a resistivity in the order of several megohms per square millimeter of area.

Triangular LED fits in small case

Sharp Corp. has succeeded in fabricating an inexpensive gallium-arsenide infrared-emitting diode in an all-glass package with maximum diameter of only 2 millimeters and length of 6 mm. This size makes the LED ideal for such applications as tape and card readers, where diodes must be located on 0.1-inch centers. Sharp earlier developed a diode in a microwave-type pill package for these applications, but it cost more than three times the price, which is about $2.50, of the new GL-200 diode.

The improved design of the semiconductor device gives the diode more than three times the output of the earlier device at the same 30-milliampere forward current. It is rated for infrared output, centered at 9,400 angstroms, of 0.4 milliwatts typical, 0.2 mW minimum. This higher output is obtained by using a triangular diode chip arranged with the junction perpendicular to the lens, and one corner of the triangle closest to the lens. Thus, infrared radiation along two sides of the triangle is emitted without attenuation and either goes directly to the lens or is reflected from the glass wall.

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Sagging prospects for planes hit French avionics

Avionics suppliers in France are revising their plans downward to take into account the disastrous drop-off in civil aircraft sales. The production pace for the Franco-British Concorde program is expected to be cut back later this month, the Franco-German Airbus program is inching along with only 13 firm orders, and Dassault-Brequet has started on the job of phasing out its short-range Mercure transport program altogether.

Although Concorde and Airbus officials maintain outward confidence that their orders will pick up later, the Mercure program seems doomed. Dassault management has ordered a halt in procurement of all materials beyond the 10 aircraft ordered by France's subsidized domestic airline, Air Inter. In the aircraft business this is the first step toward canceling a program. **Dassault people are passing the word in Paris that they have lost hope of competing with Boeing's 737, the Mercure's nearest rival,** due to the dollar devaluation and the French plane's high production costs.

New tube brings consumer video color camera closer

Watch for the upcoming parade of one-tube color television cameras to add color to the Japanese electronics industry next year. Several are expected to use a new 1-inch vidicon with integral color-stripe filter just announced by Matsushita Electronics Corp., and scheduled to go on sale this month. Initially, single engineering samples will be sold for about $380 each, but part of this price is development cost and the company hopes to greatly reduce the price for large production lots.

The tube has an integral color-stripe filter with repeating groups of red, green, blue, and index stripes to enable phase separation of the three primary colors. This method, with an external stripe filter, was pioneered by NHK for the chroma channel of its two-tube color cameras developed about 10 years ago. But since the single Matsushita tube must pick up both chroma and luminance signals, the width of each group has been reduced to 75 micrometers to give a total of about 170 groups across the 12.7-millimeter effective width of the tube for better resolution. Stripes are composed of organic dyes, which give the lowest cost.

In the not too distant future, **customers in Japan should have a choice of products, with Toshiba, Hitachi, Sony, and Matsushita tubes, from a larger number of camera manufacturers.** The variety of products at assorted prices and perhaps with assorted quality should encourage the consumer market.

French government to control private phone exchanges

The French postal and communications ministry has warned makers of private telephone-exchange equipment that the French market will soon be placed under its surveillance. The ministry is setting up a consulting company that will advise future buyers of electronic exchange equipment which systems are most appropriate for the user's needs. The consultation will be obligatory. **This is the first sign of restriction on the private exchange market in Europe, which has mushroomed in the past three years.** One wary U.S. executive calls the plan "an affront to the free-enterprise system." The move seems aimed against IBM and

La Compagnie Générale des Constructions Téléphoniques, an ITT subsidiary, which dominate the French market. Industry observers **expect the ministry to act as a protectionist influence, helping along CIT-Alcatel and SAT,** the only French companies trying to get into the lucrative electronic exchange market. Thus far, IBM has about 60 electronic PABX systems installed or on order in France, handling about 30,000 lines, CLT-Alcatel has only two systems ordered, and SAT has one.

Bowmar's LEDs light up Britain's calculators

Bowmar Instrument Corp.'s British subsidiary, Bowmar Instrument Ltd., has contracted to supply LED calculator displays worth $2.5 million over the next year or so to the British calculator maker Sumlock Anita Electronics Ltd., a subsidiary of Rockwell International. **This move makes Bowmar virtually the sole supplier of LED displays to the two major British canculator makers, Sumlock Anita and Sinclair Radionics Ltd.**

Japanese group acquires license for German video disk

Telefunken-Decca's TED video disk is about to establish itself on Far Eastern markets now that Japan's Asahi Shimbun—the country's biggest newspaper publisher—Nippon educational television, and Asahi Sonorama have acquired the rights to produce the disk under license. The licensor to the Asahi-NET group—which, according to Telefunken, is one of Japan's biggest audio-visual software suppliers—is Switzerland-based TED-Bildplatten AG, a joint venture of Telefunken, Decca, and Teledec. TED AG was recently set up to handle worldwide licensing of the Telefunken-Decca system.

Matsushita buys into Spanish TV maker

Japan has acquired its first significant share in Spanish electronics. Matsushita Electrical Industrial Co. has purchased an 80% interest in Anglo Española de Electricidad, which was previously held by Lear Siegler Inc. Anglo Española, based in Barcelona, had $10 million sales in 1972, mainly in TV receivers.

Matsushita's entry into Spain's TV industry is well-timed, say sources, because the Spanish government is expected to decide in 1974 the color system to be adopted by the state TV-broadcasting company, Televisionespañola. The company has the exclusive franchise for TV broadcasting in Spain, and it is operated as an arm of the information ministry. When the decision comes, **color-TV sales are expected to boost total receiver sales, which have flattened out in recent years as consumers waited for color TV.**

Grundig expands its line of four-channel gear

Grundig AG has widened its lead over other German entertainment-electronics producers by introducing yet another piece of four-channel sound equipment. With its Studio 2040 Hi Fi unit—the first quadromatrix system produced in Germany—already on the market, the company has unveiled its RTV 1040 HiFi Quadro tuner-amplifier. **To be available in the spring of next year and expected to sell for about $600, the equipment is designed to handle four-track quadro tape, CD-4 records and SQ-matrixed programs on records, tape, cassettes, or fm broadcasts.** The equipment features touch controls for tuning stations.

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These connectors are available from stock in 10 15, 18, 22, 25 and 30 position double readout, through all TRW/Cinch edge connector distributors. Contact them, or your local TRW/Cinch sales office, or write to TRW/Cinch Connectors, an Electronic Components Division of TRW Inc., 1501 Morse Ave., Elk Grove Village, Illinois 60007; phone (312) 439-8800. Ask for Product Bulletin PBC-183. CM7308

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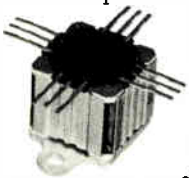

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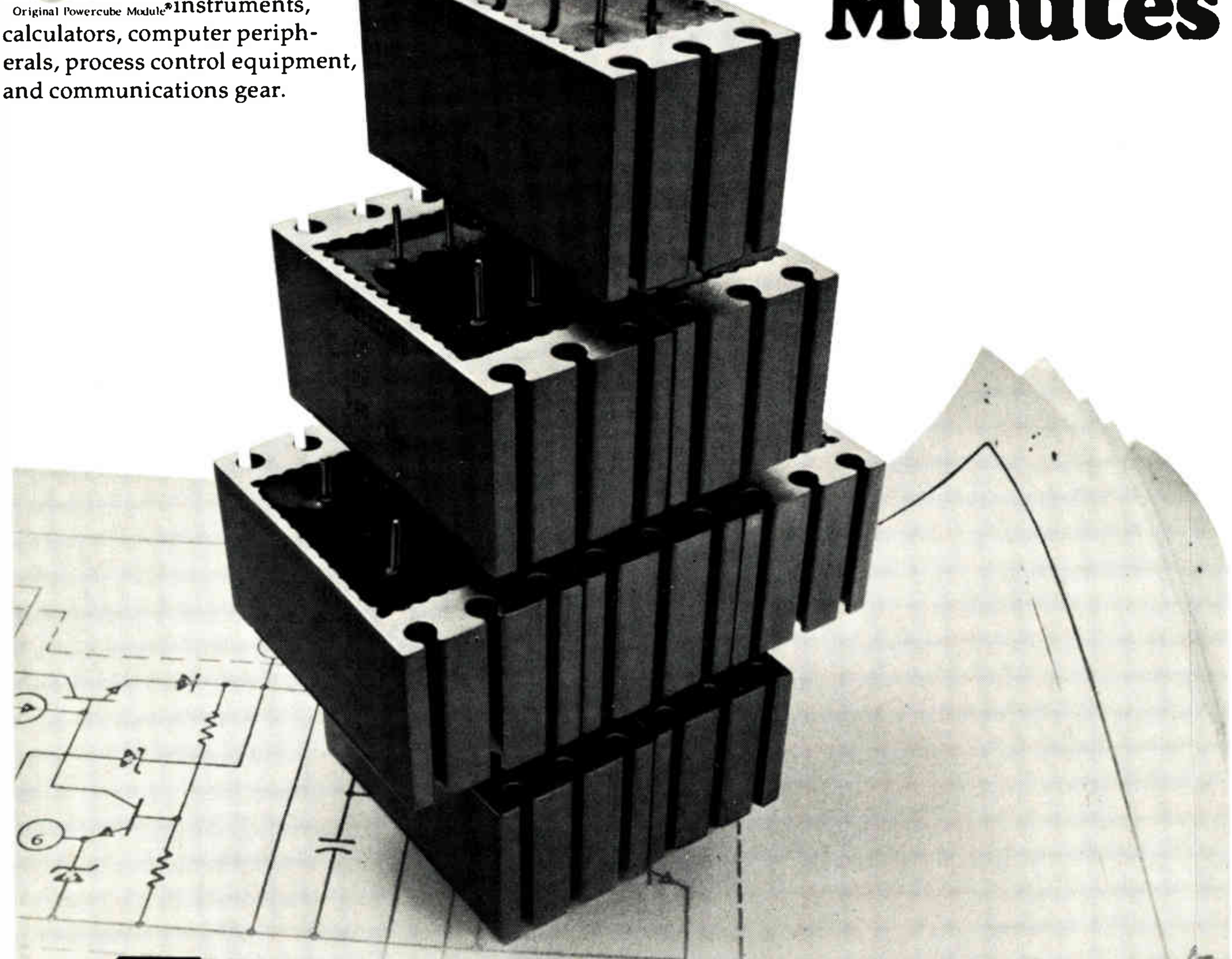

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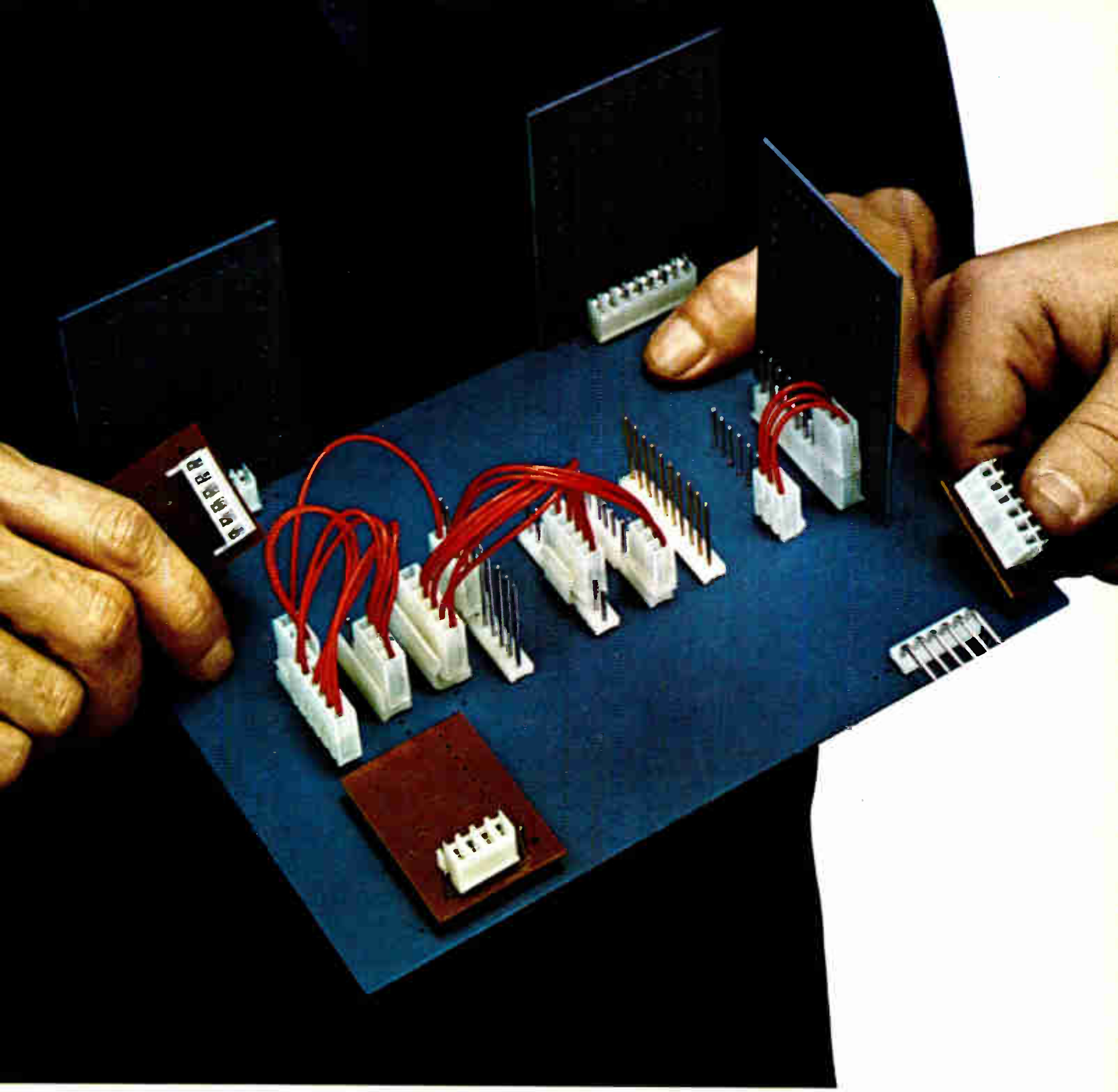

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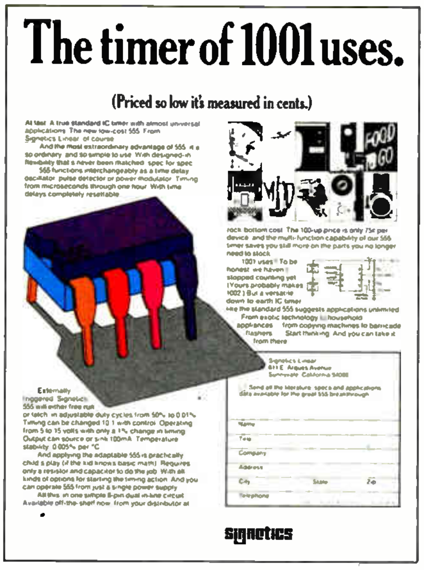

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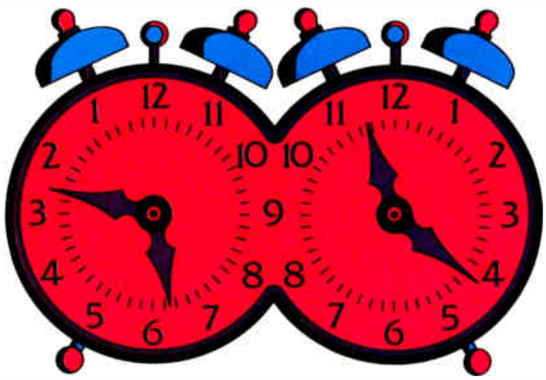

oscillator, pulse detector, power modulator, or what have you. Any kind of output you can dream up from one side, and the control from the other side. Go wild-it can become anything from a toy to a household appliance to a communications breakthrough.

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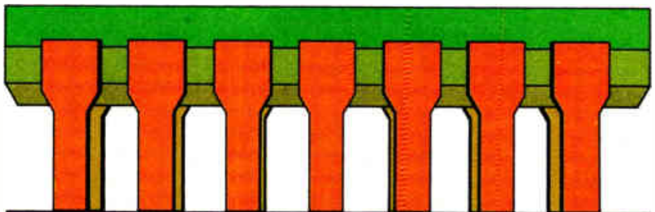

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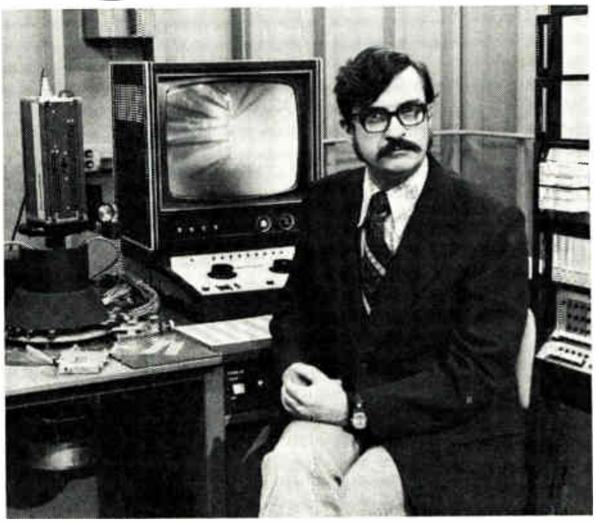

John Thome
Manager, Microelectronic Engineering
Allen-Bradley Co.
Milwaukee, Wisconsin

Fast payback on high throughput. That's what Allen-Bradley demanded when the company went shopping for a laser trimmer a year ago.

"And that's why we settled on Teradyne's W311," says John Thome. "We were confident the system would live up to its billing. Teradyne people never have been the promises, promises type."

Now, 6,000 grueling hours later, John Thome can report that "our payback is right on schedule." Up to 15,000 resistors an hour go through the W311—24 hours a day, six days a week. Downtime is minimal. Remarkably, what few service problems have cropped up have usually been solved by a single phone call to Teradyne's service bureau.

What Allen-Bradley is trimming is thick-film resistor networks to be DIP-packaged. Typical trim accuracy required is 1 to 2%, with some 0.5%. If you know Allen-Bradley, you know each trim has to be every bit as clean as it is accurate and fast.

Would Allen-Bradley buy the W311 again?

"We not only would, we did," says Mr. Thome. "Our second system was delivered in April to increase capacity."

Fast payback is one good reason why more than 50 Teradyne laser trimming systems are now working overtime all over the world. To get the full story, write: Teradyne, 183 Essex Street, Boston, Massachusetts 02111. In Europe: Teradyne Europe S. A., 11 bis, rue Roquépine, 75 Paris 8ᵉ, France.

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The wiring of Alaska

With its severe weather and widely scattered population, 49th state is scene of multiple programs to meet unique communications challenges

by Lyman J. Hardeman, Communications and Microwave Editor

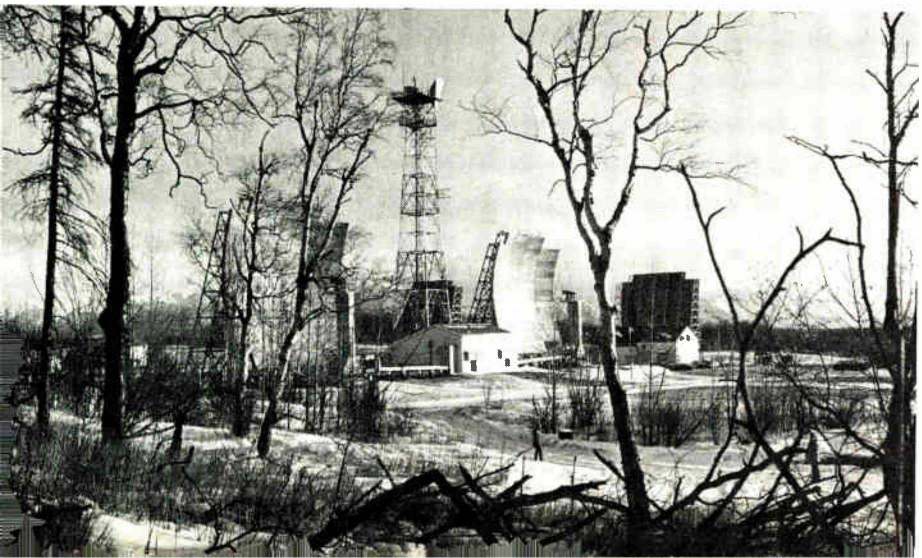
The Baltimore Colts of the National Football League were tired but happy late in the afternoon of Jan. 17, 1971—they had just become the champions of the solar system by defeating the Dallas Cowboys in the Super Bowl. But far to the north, in the State of Alaska, the event brought joy of another kind: transmitted via satellite, the football game was the first live commercial television broadcast ever seen there.

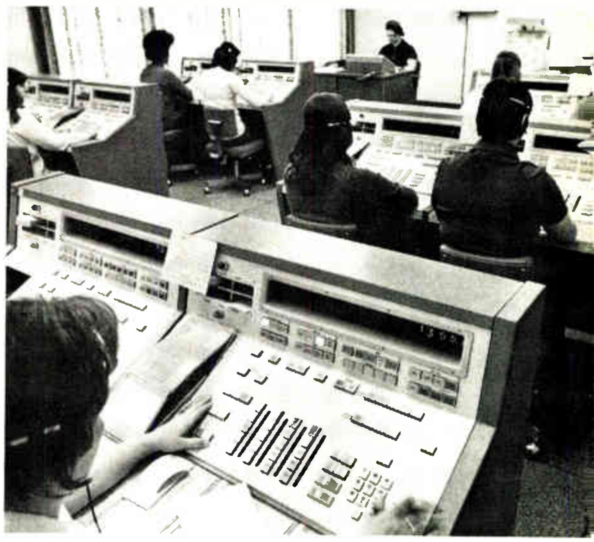
While routine live-TV coverage has not become economically feasible since then—videotapes of network newscasts are flown in daily from Seattle—that telecast can be considered a signal to begin the vast communications expansion going on in the 49th state. And plans call for still further expansion to meet the growing needs of a state whose population is expected to increase at the rate of 5% per year from the present level of 350,000, while communications needs increase at about four times that rate.

Alaska's rugged terrain, harsh winters, and vast wilderness work together to present the communications-system designer with a challenge different from that of the lower 48 contiguous states. But since the challenge is like that offered by numerous other relatively unpopulated areas of the world, the solutions to communications problems in Alaska may well serve as models for other developing areas.

The backbone structure of the Alaska communications network was developed and operated by the military almost from the turn of the century to serve both commercial and military communications requirements. The system that evolved consisted mostly of tropospheric-scatter links, but there are also terrestrial-microwave, submarine-cable, and open-wire installa-

Hello, world. Alaskans in the remote village of Ksigluk, above, gather around their newly installed village telephone. In other developments: below, a microwave link interfaces with tropospheric-scatter terminals of Air Force's White Alice network; right, electronic switching has replaced traditional plug-in boards in Anchorage, Fairbanks, Juneau, and Ketchikan.





tions, as well as a limited amount of manually operated switching equipment.

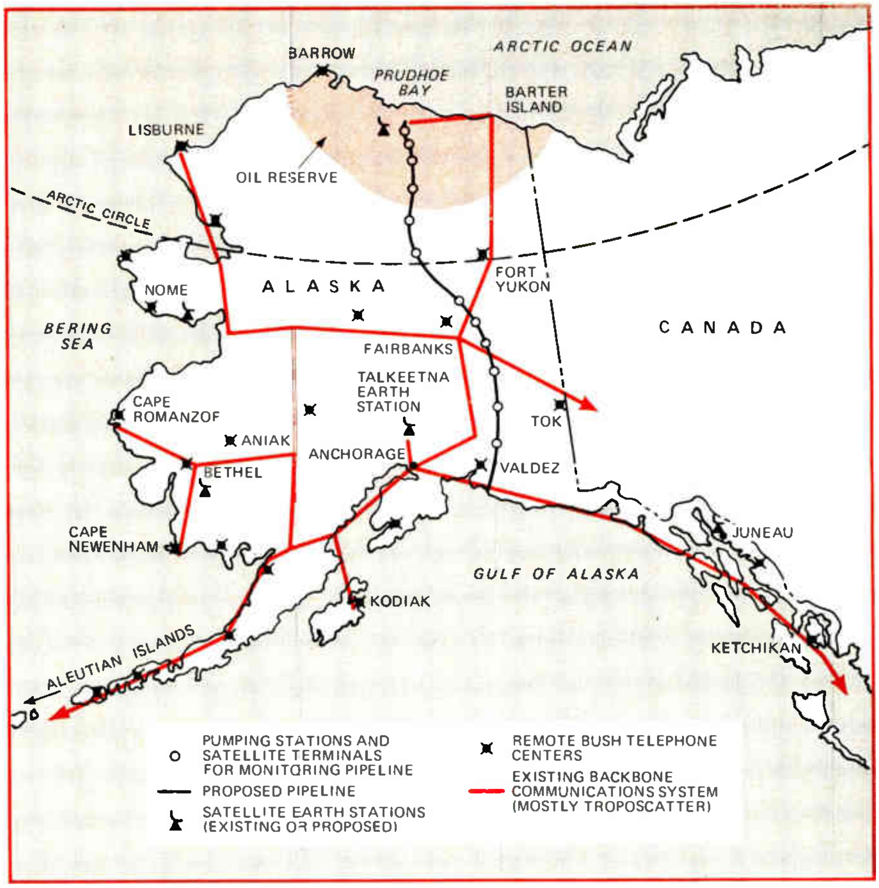
In January 1971, about half the long-haul facilities were purchased for $28 million by RCA Alascom Inc., a subsidiary of RCA Corp., for operation as a commercial common-carrier system. The remaining facilities—known as the White Alice System, which includes about 680,000 transmission-channel miles—is still operated by the U.S. Air Force to meet military needs.

Spending. In the two and a half years since the purchase, RCA has invested about $36 million in programs for the state's commercial communications network and has commitments to spend another $55 million before year-end. Other plans will further raise the total investment beyond $110 million by 1974, says RCA chairman Robert W. Sarnoff. These programs include:

- Automatic toll switching systems to bring direct long-distance dialing to subscribers in key population centers.
- A village telephone plan, called the bush program, to take telephone service to more than 140 isolated villages through the state.
- The construction of terrestrial microwave routes between isolated points through the state to supplement the original backbone system.
- Plans for a domestic satellite system to augment, and eventually replace, troposcatter systems for intrastate voice and video traffic, and to allow communications with the other 49 states.

In addition, a gridwork of vhf marine-radio base stations has been installed to promote more efficient use of Alaska's waterways. And earlier this summer, RCA Alascom and Western Union completed negotiations to extend Mailgram and a store-and-forward data-transmission capability compatible with that of Telex and TWX subscribers in the contiguous 48 states.

In still another program, RCA is planning to construct a redundant satellite/terrestrial microwave system to follow the route of the 800-mile trans-Alaska oil pipeline [*Electronics*, April 24, 1972, p. 40], which is expected to gain congressional approval in time to allow construction to begin next spring. The redundant communications design assures a higher level of reliability than more conventional pipeline systems. The design has been a key factor in satisfying environmentalists who fear an undetected pipeline break would seriously upset the critical balance of conditions that support life in the northern wilderness.

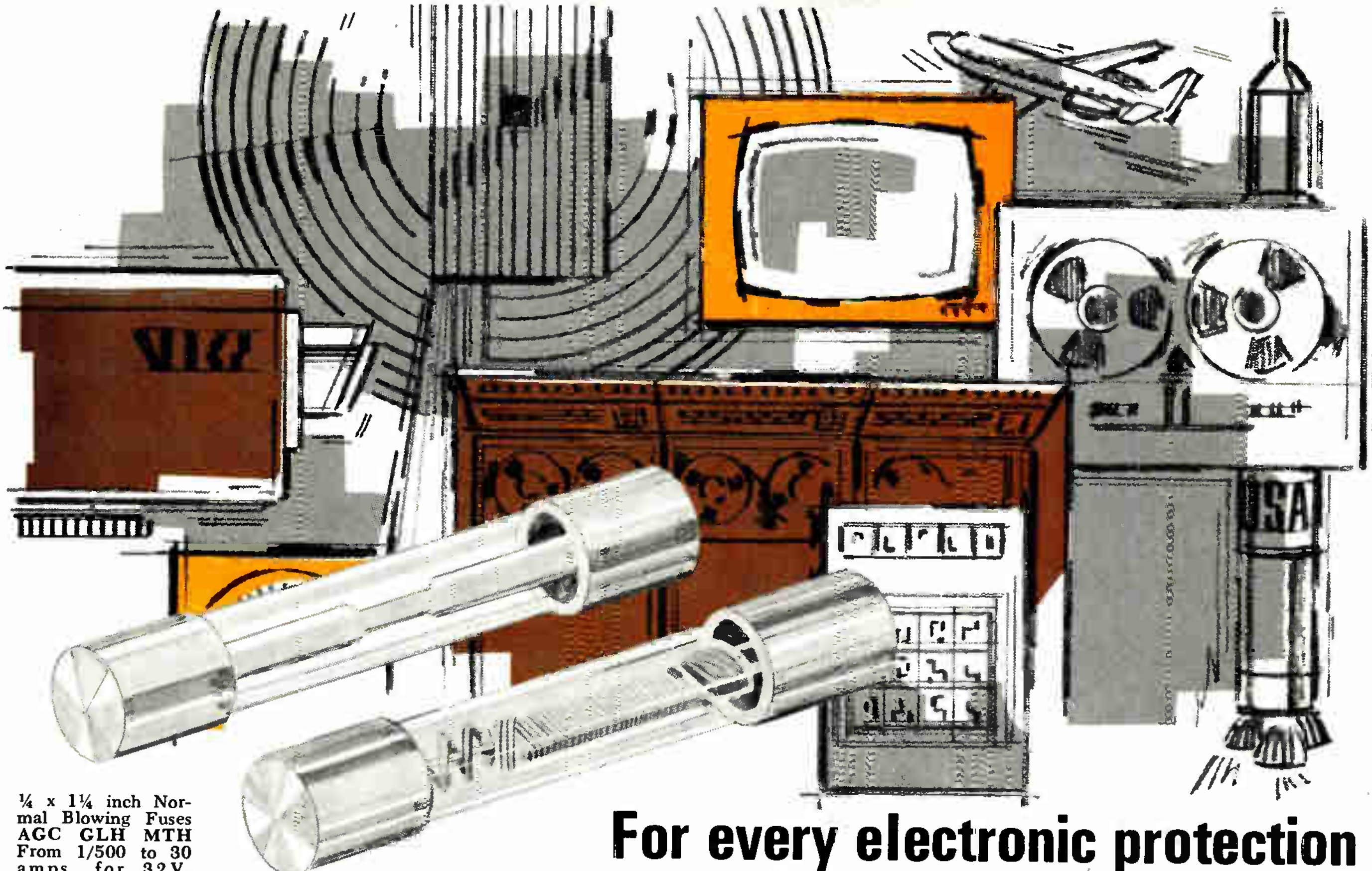


Toll switching. As the state's long-lines common carrier, RCA Alascom interfaces with operating companies in each local area to build an integrated direct-dial network. These local companies may be municipally owned, such as the City of Anchorage Telephone Utility, or operated by private interests, such as the General Telephone Co. of Alaska, a subsidiary of General Telephone & Electronics Corp. In all, there are some two dozen local entities with which to coordinate long-lines trunks.

Since RCA has gained control of the long-distance network, four toll centers—at Ketchikan, Juneau, Anchorage, and Fairbanks—have been equipped with NXID switches, which are electromechanical toll machines built by North Electric Corp., Galion, Ohio, for automatic direct long-distance dialing. All long-distance calls made in Alaska, whether intrastate or interstate, are now routed through these switching centers.

To augment these switching systems and provide for future growth, estimated at greater than 20% per year for the next five years, two new switches—one in Anchorage and one in Fairbanks—are being installed, The new switch, type SP-1, built by Northern Electric Co., Ottawa, Ont., is similar to the Bell System's TSPS electronic switching system.

The Anchorage switching office completes 19,000 toll calls on an average day in August, Alaska's busiest month. This is 62% of the state's total. To keep up with the maintenance requirements of the expanding facility, the office recently installed automatic test equipment built by Northeast Electronics Corp., Concord, N.H. The equipment, called Trace (transmission routine automatic checking equipment), makes daily checks of each voice circuit terminated at the



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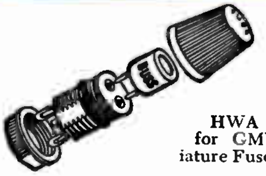

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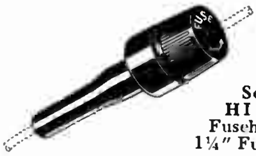

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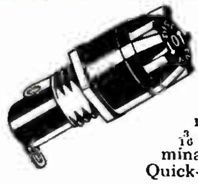

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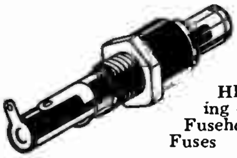

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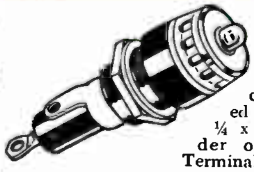

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When completed, the bush telephone system will provide at least one centrally located subscriber telephone in each Alaskan community of 25 or more persons. About 31 villages, housing a total of fewer than 10,000 persons, have so far been incorporated into the total system, which, when completed, will include some 150 villages and a total of 23,000 persons.

The bush telephone system is based around conventional IMTS (improved mobile telephone service) equipment supplied by General Electric's Communications Systems division, Lynchburg, Va. The system includes signaling gear, located at remote centers, and telephone terminals in each village. Other parts of the network include 2-gigahertz short-haul microwave links. These links, supplied by Wescom Inc., Downers Grove, Ill, combine the circuits of serveral villages for interconnection with the state's backbone transmission system.

Special permits are required from the FCC to operate the vhf radiotelephone at fixed locations. In addition, land-use permits for relay sites must be obtained from the U.S. Department of the Interior. But regulatory problems aren't the only ones facing the bush program. For example, heat and electricity must be supplied to the isolated control centers, which are unmanned and must endure subzero winters.

In most cases, these problems have been solved by using well-insulated enclosures and propane-fueled thermoelectric generators to provide power throughout the long winter months. The waste energy of the generators provides necessary heat within the enclosure. Access to electrical power is also often a problem, even in the villages.

Operation of the community phone is necessarily rudimentary. An attendant, who may also serve as village storekeeper, postmaster, and school-teacher, logs all calls and assists with making calls when necessary. He must also collect toll charges and somehow have enough left over to pay a monthly base rate of $35.

Charges or no charges, villagers often log 50 calls a week and more, reports John O'Lary, who heads the Nome facility, a repair and control center for 22 bush phone installations in western Alaska. He adds that villagers, especially in coastal areas, now phone each other with information about where fish are biting and what kind of prices they're fetching. Residents also use the phones to help follow the caribou and reindeer herds.

Space communications. Because of increased use of the communications facilities throughout Alaska, many segments of the state's long-haul transmission facilities have been filled to capacity. As a result, Howard R. Hawkins, an RCA executive vice president, responsible for the Alascom operation, says that the greatest need now is for long-lines trunking, especially in the barren western part of the state.

A convenient way to solve these transmission problems would be to use communications satellites. The multipoint thin-route nature of Alaska's telephone-communications needs match well with the demand-access multichannel-type systems being developed for many of today's satellite systems. And a communications satellite, unlike conventional terrestrial microwave systems, makes possible network-television distribution that is about as economical for transmission from New York to a small village in Alaska as for transmissions to major cities within the contiguous 48 states.

Recognizing these benefits of satellite communications, RCA in September received FCC approval to set up a domestic satellite system with earth stations near Juneau and Anchorage, as well as stations near New York City, Los Angeles, and San Francisco. Additional applications are being prepared for earth terminals in Nome, Bethel, and the Prudhoe Bay area on Alaska's North Slope.

For an interim period of about two years, these terminals will operate with transponders in Telesat Canada's ANIK-2 satellite, launched earlier this year. The system will later use RCA-owned satellites, to be operational by mid-1975. □

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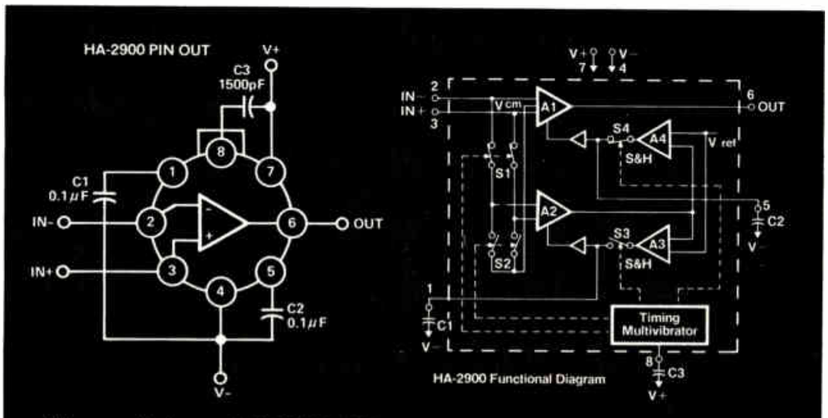

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Circle 79 on reader service card

Solid state

SOS surges into picture

Watch and clock circuits due from Inselek and RCA mark entry of technology into volume production for wide market

by Joel DuBow, Components Editor

When silicon-on-sapphire watch and clock circuits are announced this winter by the Inselek Corp. and RCA, it will mark another giant step for that high-performance MOS technology: the move into volume production for widespread applications. With that, the market is expected to grow to $20 million by 1975 from its 1973 total of $5 million—the major pacing factors being sapphire price and supply.

Robert Burlingame, Inselek's applications manager, believes that some time between 1976 and 1978, the price of sapphire, which is still about $10 per wafer, will be low enough for the technology to begin replacing silicon in high-volume, low-cost applications. At that point, he says, many manufacturers will switch from silicon to sapphire, and business volume should increase dramatically from today's beachhead: mainly high-performance MOS devices, such as high-speed digital and timer circuits.

As for customer resistance to the new technology, Burlingame says it's based largely on fears of engineers who use C-MOS to provide noise immunity that the speed of SOS will increase noise and dissipate more power. Burlingame says this just isn't so, but that it will take some time for engineers to accept it.

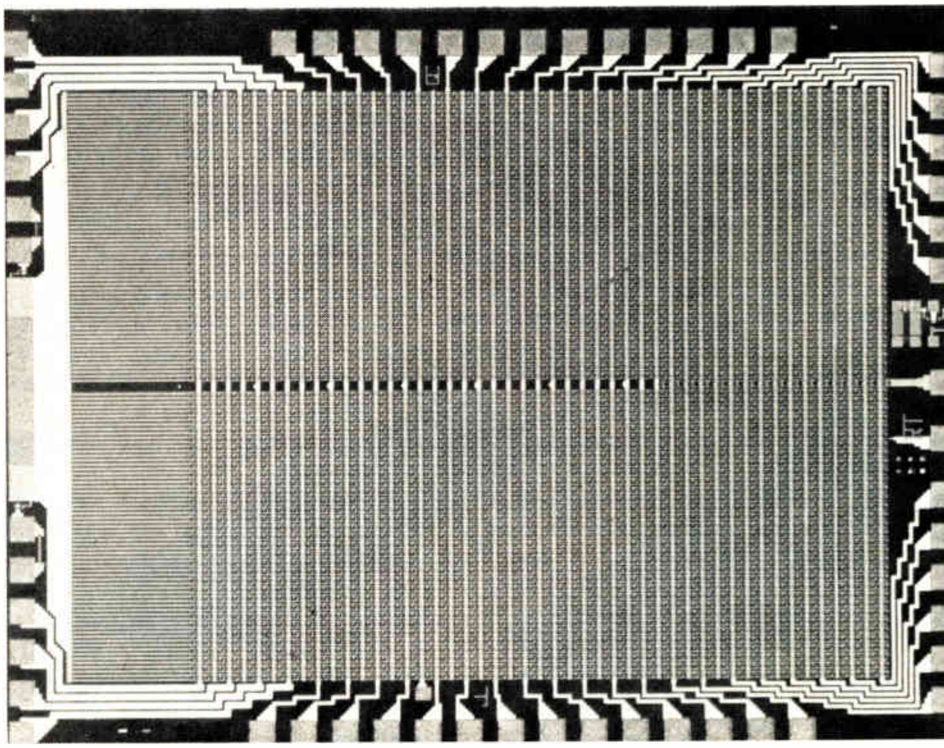
The next few years also should see more companies joining Inselek, RCA, and Rockwell International, plus improved performance as manufacturers gain enough experience in production techniques to push the state of the art in packing, power, and processing technologies.

Inselek's head of materials, David Dumin, says that his company has agreements with Optel Co. to manufacture watch circuits, with the Chrysler Corp. for clock circuits, and with Rockwell to second-source other developments. RCA has a sizable effort in the timer area and plans to announce liquid crystal displays to go along with its clock and watch circuits. And by early 1974, both companies plan to have the watch circuit and liquid-crystal driver on one chip mounted on the display. Separate timer and display circuits also will be marketed.

Rockwell also is working on watch circuits, but doesn't plan an announcement for about a year. Emile Eschay, a Rockwell vice-president for product marketing, feels that MOS devices using SOS will lend themselves readily to the watch market but that watch makers will not be able to assimilate IC technology and mass produce watches with SOS for another year. Rockwell is a pioneer in SOS technology and has two key 1968 patents on field-effect-transistor fabrication and epitaxial deposition on insulating substrates.

On the other hand, Inselek's Dumin declares that SOS timers are enjoying a seller's market. Chips that could sell for $3 are going for $8, he says, with customers paying the going price or not getting circuits. The major difficulty in producing the

From Anaheim. Rockwell's new SOS programable logic array, shown in a 30-times blowup, effectively contains 128 AND gates. It's designed to go into digital control systems.



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chip is not just its complexity, but the combination of 1.5-volt operation with a complex function.

In the works are central-processor chips, SOS versions of the 4000 series, and larger memory products. Major efforts in high-frequency circuits for telecommunications are currently going on at Rockwell and Inselek. Rockwell, which specializes in LSI and high-performance circuits, plans to announce a 1,024-bit random-access memory with 60-nanosecond access time and 300-milliwatt dissipation. The company is also developing a 4,096-bit RAM for announcement at the end of next year.

Dumin feels that the emphasis has changed from optimizing performance to low cost and better cost-performance mix. For example, SOS might potentially be as fast as emitter-coupled-logic, and it may be worth the effort to find out. But in any event, says Dumin, speeds should match those of TTL. As for cost performance, SOS should be competitive with bulk C-MOS but not with dynamic MOS memory circuits such as the 1103 simply because the latter have a four-year wafer experience lead. Inselek is readying a 256-bit C-MOS RAM and an equivalent sapphire 74/200 TTL device to work in conjunction with a standard 4000 series C-MOS device for announcement around the first of the year.

Further down the road is introduction of three-inch wafers. Ion implantation is already in production at Inselek and is in pilot runs at RCA. Also expected is that current design rules of about 0.3 mil will be refined as better masks become available and production experience accumulates. And looking into the far future, Inselek is working on depositing silicon on ceramics related to beryllia and sapphire to increase the substrate thermal conductivity. What's more, optoelectronic arrays are a natural for the transparent sapphire substrates and are beginning to receive attention. Sapphire costs are going down.

Essential to the growing maturity of sapphire technology was the prolonged trench warfare involved in defeating material and processing problems in order to get the process out of the lab. There were no dramatic breakthroughs; rather, steady progress led to the present commercial promise of SOS. There were improvements in epitaxial deposition, and better polishing, cleaning, and diffusion. These led to solution of the auto-doping problem—contamination of the silicon film by aluminum and oxygen fusing up from the sapphire substrate—and to increased field-effect mobility.

Of course, when materials and processes are perfected, then device performance is brought closer to its theoretical value. The upshot has been an accumulation of production experience permitting silicon-on-sapphire devices to compete with bulk silicon counterparts on a price-performance basis.

In fact, says Dumin, "Aside from the first epitaxial deposition step, processing of silicon on sapphire is virtually identical to processing silicon on bulk. Conventional metalization and thermal oxidation are used throughout the process."

What are the advantages inherent in the technology that have kept companies working on the sapphire technique? For one thing, SOS has speed, packing density, and isolation advantages over conventional MOS technology. For IC circuits using the same design and processing, the SOS circuit will be five to ten times faster and 20% denser than its conventional silicon counterpart.

Elimination of parasitic capacitances is the key to the speed advantage. For a typical 1-micrometer silicon film, the source and drain diffusions go right through the silicon to the sapphire. There are thus no source and drain to substrate capacitances.

Furthermore, all metalization sits directly on the sapphire, eliminating the wiring capacitance and diffused cross-under capacitance found in conventional MOS technology. Thick oxides are not required for isolation since the devices are sapphire-isolated.

Also eliminated is the field-inversion problem. This is accomplished by having a thin channel so that wider channel concentrations are possible. And since designers usually float— that is, do not make electrical contact—to the channel region, parasitic transistor action is eliminated. The channel always floats 0.7 V above the source volume, doing away with source bias effects on threshhold voltages.

What's more, sapphire has inherent advantages that mean higher yields, especially with the larger 3-in. wafers. For one thing, its melting point is much higher than that of silicon; this means it doesn't warp during high-temperature processing and introduce the misalignment and breakage common in 3-in. silicon.

For another, a sapphire wafer that has been misprocessed and has low yield can be reworked easily by stripping off the silicon, repolishing, and starting all over. Yields also are increased because SOS processing uses two photomasks less and has seven or eight fewer processing steps.

But production barriers had to be hurdled before SOS achieved a competitive position. These included development of a process unique to silicon on sapphire, and improvement of device reliability. Previously, high leakage currents were reduced by improving sapphire quality and polishing the substrate. However, with the process now under control, leakage current is no longer a function of process cleanliness. In fact, SOS devices are approaching their theoretical leakage current limit of a factor of two greater than bulk.

Also, taboos against thermal oxidation no longer exist. Inselek reports achieving bulk field-effect mobilities in films as thin as 0.2 micrometer thick. The key to good epitaxial layers, according to Inselek's Dumin, is microscopic substrate smoothness so that the deposited silicon atoms only see oxygen as they descend.

The major present limitation of SOS is its low heat capacity, about four times worse than silicon's. This will limit its application for large RAMs, since the speed advantage of SOS will be outweighed by its inability to get the heat out. In addition, the thin silicon films and rapid diffusion to either of the film interfaces leads to very low (1 to 5 nanoseconds) minority carrier lifetimes, making SOS technology unsuitable for manufacture of bipolar transistors. □

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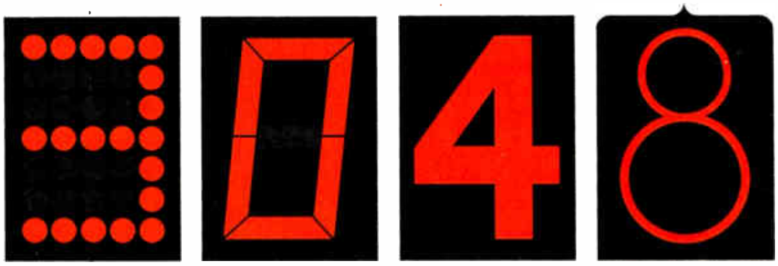

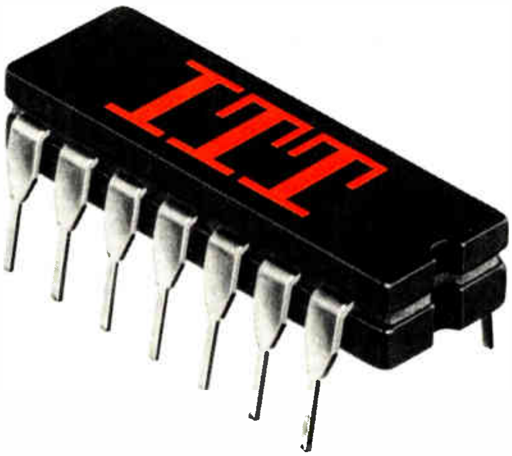

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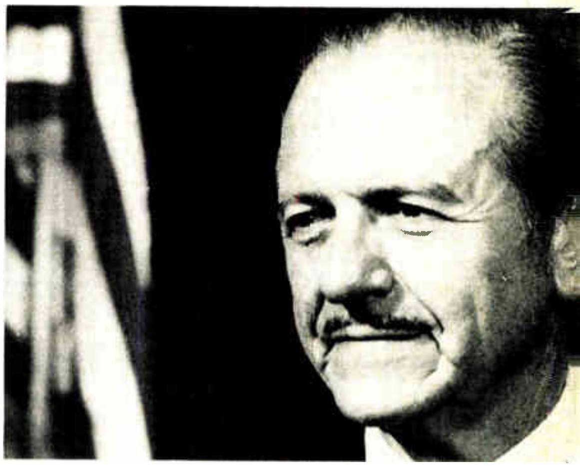
Government

Aerospace goes up Hill

Industry leaders come away from Senate hearing on condition of industry with promise of technology resource study

by *William F. Arnold, Aerospace Editor*



Lending an ear. Utah Democrat Frank E. Moss opened Senate hearings.

Although it's still strong, the U.S. aerospace industry is worried about its future. This growing concern surfaced quickly during Senate hearings in late September on what the future role of NASA should be when leaders of most of the nation's aerospace companies focused on a larger question: Will Congress come to the aid of the commercial aerospace industry?

Although Congress isn't likely to answer the question soon—the reply is vital to the aerospace and electronics industries—the body seems willing to consider new ways to bolster the slowing pace of the country's aerospace market. Thus, the final outcome of the industry-legislative dialogue may mean a new set of roles for Government, industry, and NASA on its 15th anniversary.

Faced with declining Federal funding for research and development, increasing competition from foreign companies that are actively backed and subsidized by their governments, and the rising costs of new-aircraft programs, the industry leaders discussed several proposals with the Senators:

- Create a Federal agency in the Treasury Department with funding up to $3 billion to guarantee private loans for the research, development, and production costs of starting new commercial transports, suggests Karl G. Harr Jr., president of the Aerospace Industries Association.
- Guarantee loans to airlines so that they can afford to buy new transports to compete with foreign carriers, proposes Oliver C. Boileau, president of Boeing Aerospace Co.
- Stabilize and possibly increase NASA's budget levels so that companies can adequately plan for programs and manpower levels, says Sanford N. McDonnell, president of McDonnell Douglas Corp.
- Get NASA back into communications-satellite research because no private company will spend $100 million on R&D for new technology, urges Daniel J. Fink, vice president and general manager of General Electric's Space division.
- Broaden NASA's role to become the over-all civilian-technology problem-solver for Government and to ease the transfer of technology from Government R&D into civilian use, suggest several others, including William B. Bergen, president of Rockwell International's North American Aerospace group.
- Unless the Federal Government increases its R&D support to industry, the country will lose its competitive edge internationally, warns David S. Lewis, chairman of General Dynamics Corp.

Uneasiness prevails. While none of the leaders expressed panic, the scope of their suggestions indicates a growing uneasiness about future competitive prospects with foreign companies. In opening the hearings, Sen. Frank E. Moss (D., Utah) ticked off some signs of the industry's condition: Employment has declined a third since 1968, foreign aerospace imports have increased 70% since 1958, domestic mergers may wrest control from some aerospace companies, and international alliances between U.S. and foreign companies are becoming common.

To Moss's list, the company leaders added such considerations as the declining number of prime contractors that can undertake larger Government programs; the low level of NASA's aeronautical programs, which is likely to continue with the agency's commitment to the space shuttle; the parallel contraction in defense spending; the difficulty of getting engineers and scientists back when a company wins a major program, and the general threat of a potential technology gap.

Bleak year. At stake ultimately in the industry-Congress dialogue is the survival of a strongly competitive U.S. aerospace industry that contributed $3 billion to the country's shaky balance of payments in 1972. Yet, warns the AIA, total U.S. aerospace sales are expected to decline this year. And European companies are coming on with competitive products.

To underscore their plight, the leaders gave the senators some comparisons. Lewis of General Dynamics pointed out that the United Kingdom announced in August that it would put up $100 million of the $200 million necessary to develop a new wide-bodied commercial jet transport for 70 to 100 passengers, a practice of government subsidies to industry R&D widely followed in Europe. Yet, Boeing's Boileau confirmed that his company began its $750 million development program for the giant 747 when its net worth was only $400 million. He added that he didn't know how the company could develop a new plane without Government help.

However, while everyone at the hearings understood the problems, the proposed solutions to create a Federal agency to grubstake companies in new-aircraft development has several problems, in light of the controversial loan guarantee to Lockheed for the L-1011. Since the Government probably wouldn't pour dollars into both a DC-10 and L-1011, how would it have decided whether to give McDonnell Douglas or Lockheed the needed $400 million? The problem was discussed by Lewis and Sen. Howard W. Cannon (D., Nev.). And Harr acknowledged in answering a question by Sen. Cannon that the proposal raises the "serious and disastrous threat" of nationalizing the aerospace industry, as Europe has done.

Also, the promise of funding the controversial supersonic transport (SST) came up when Sen. Warren G. Magnuson (D., Wash.) asked Harr: "If the bill passes, you could start an SST, couldn't you?" Harr reluctantly admitted, "Yes." Congress may be powerless to increase any funding anyway, Sen. Cannon said, explaining that the Office of Management and Budget probably wouldn't let NASA have any funds beyond those approved.

But, although the company executives didn't get a $3 billion funding agency or more money for NASA, they didn't come away empty-handed. Sen. Magnuson introduced a bill, as a "working paper," he said, to set up a technology-transfer office within NASA and a National Technology Resources Council within the Executive Office of the President to make a national technology resources survey. He proposed to give the council $10 million for the next two years and NASA $200 million this fiscal year.

Moreover, Sen. Barry Goldwater (R., Ariz.) suggested that the Senate Armed Services Committee ought to hold the same type of hearings and that Moss's committee should hold other hearings solely on the issue of R&D priorities. Perhaps Wernher von Braun, vice president for engineering and development, Fairchild Industries, summarized the industry's concern when he told the senators that "world leadership and technological leadership are inseparable. A third-rate technological nation is a third-rate power—politically, economically and socially." □

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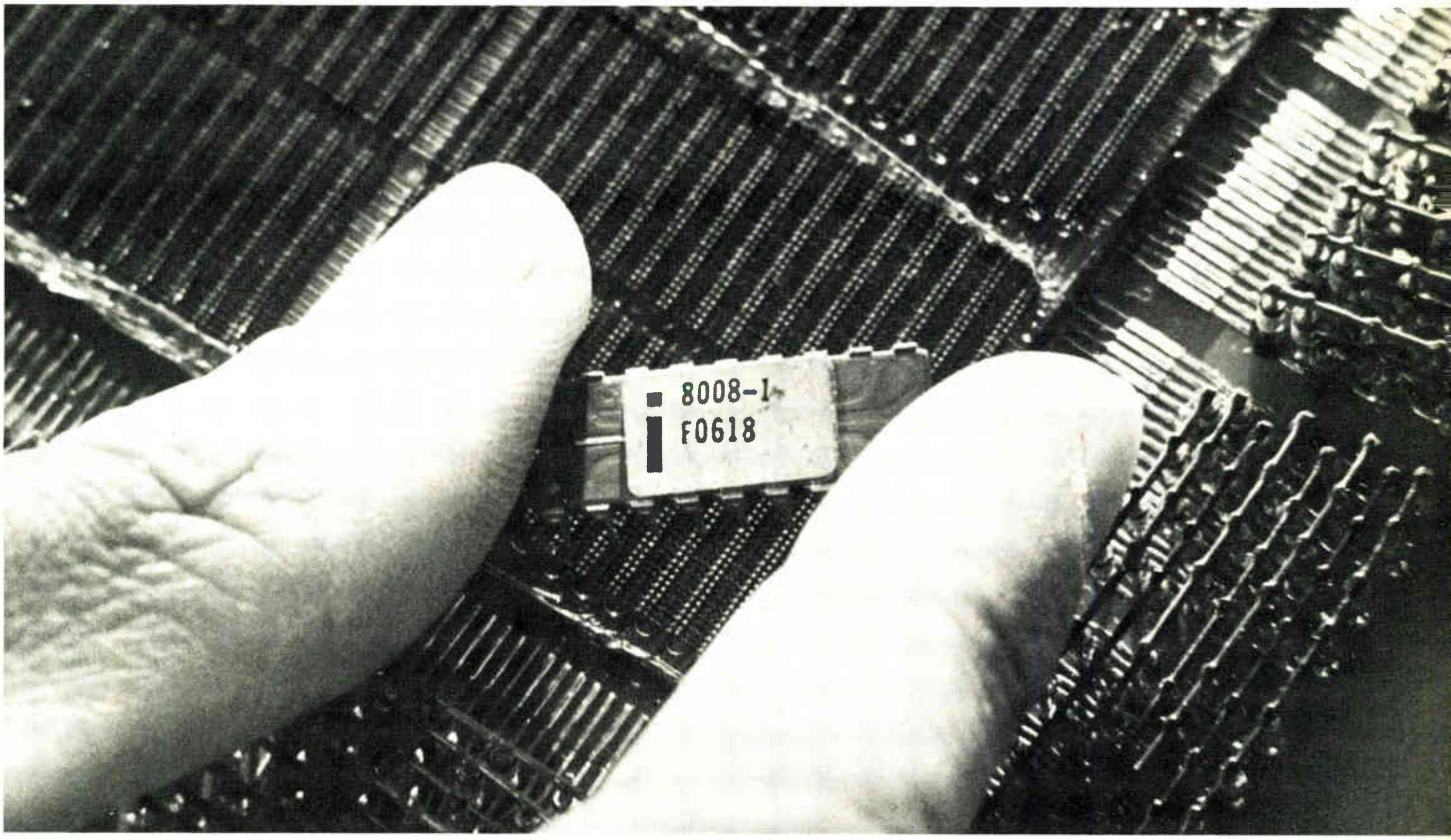


Designing with microprocessors instead of wired logic asks more of designers

When engineers accustomed to hardware logic gates tackle a job with the new microprocessors—as they're almost sure to do sooner or later—they'll need to know some of these programing techniques

by Bruce Gladstone, *Varitel Inc., Sherman Oaks, Calif.*

☐ The microprocessors recently introduced by various semiconductor companies foreshadow wide changes in the design of many electronic products and systems. These miniature computers substitute programing for logic design—an alternative that seems to surface for all but tiny specialized systems and ultrahigh-speed systems. The primary advantage of microprocessors is the short design turnaround time they make possible.

But to realize this advantage, as well as the corollary advantages of easy field alterations and inexpensive customizing, the logic or system designer will need to use new tools—some of which may be unfamiliar to him. Thus, instead of gate networks, he will use masks, comparisons, and jumps; and instead of time delays, he will use circulating loops.

Basically a microprocessor is no more—and no less—than a full-fledged processing unit essentially like the processor at the center of any computer system of any size. It has three major differences from a conventional processor: it is fabricated entirely as one integrated circuit or as a small number of such circuits; it is relatively slow, compared to most minicomputers, partly to enable its fabrication as an IC; and it sells for $300 or less. Required with the microprocessor in any working system are a read-write memory for data, another memory—possibly read/write but usually read-only—for a program, and circuits for obtaining access to limited-performance input/output gear. Generally, these peripheral circuits, each on its own IC, are used in larger quantities than the microprocessors, so that the working system fills up one or more good-sized printed-circuit boards.

When a designer uses a microprocessor instead of hard-wired logic, he determines the system functions by a program—a sequence of instructions—stored in a memory. If he uses a read-only memory, the program is immune to inadvertent alteration. Replacing the program can completely alter the function of the machine that contains the microprocessor.

Using a genuine read-only memory, of course, would run counter to the flexibility advantages of using a microprocessor, except in large-volume applications. But using a programable read-only memory, or better yet, a reprogramable read-only memory, allows an existing system to be altered quickly—in a matter of hours. As a result, a manufacturer can become much more responsive to his market.

Microprocessor characteristics

The most significant characteristics of today's microprocessors (not counting calculator sets and serial processors) are their speed, addressing modes, interrupt capabilities, and the number of internal registers. These and other characteristics are summarized in the table on this page.

The value of speed, in those applications that require it, is obvious. (Some techniques for speeding up the slower microprocessors are described later.) The more addressing modes and the more internal registers that are present in the microprocessors, the less external

TABLE 1. MICROPROCESSOR CHARACTERISTICS

		Intel MCS-4	Rockwell PPS	Intel MCS-8	Intel 8080	Signetics PIP	National GPC/P	AMI 7300
Word size (bits)		4	4	8	8	8	4-16	8
Instruction time (microseconds)		10.8 – 21.6	5 – 10	7.5–22.5 12–44 (Note 1)	2–6	<5 – <10	3.3 – 9.6	4 – 32 (Note 2)
Memory size	Pgm	4,096 bytes	16,384 bytes	16,384 bytes	65,536 bytes	8,192 bytes	65,536 bytes	4,096 words (Note 4)
	Data	1280 nibbles (Note 3)	8,192 nibbles (Note 3)					65,536 bytes
No. of instructions		45	54	48	48+	64	Micro-program	Micro-program
Interrupt capability		Reset to 0 only	None	1-level vector to 8 locations	Multi-level vector to 8 locations	1-level stack to store machine state	1-level stack to store machine state (Note 5)	3-level
Address modes		Pointer Indirect Immediate Register	Pointer Immediate	Pointer Immediate Register	Pointer Immediate Register	Direct Indirect Relative Immediate Register Indexed	Direct Indirect Relative Immediate Register Indexed	Direct Indirect Relative Immediate Register Indexed
Registers		16 x 4 bits pc + 3 stack	2 x 4 bits pc + 2 stack 1 pointer	5 x 8 bits pc + 7 stack 1 pointer	5 x 8 bits pc + unlimited stack 1 pointer (Note 6)	4 x 8 bits pc + 7 stack	4 x 16 bits pc + 16 stack (Note 7)	16 x 8 bits pc + 32 x 8 stack (Note 7)
RAM & ROM		Special or standard (Note 8)	Special	Standard	Standard	Standard	Standard	Standard and special microprogram
TTL chips		Clock only	None	20–40	Clock & buffers	4–6	15–20	Clock & buffers

Notes:
(1) 8008-1 instruction times are 0.6 x (8008 instruction times)
(2) Executes microinstructions from 512 x 22 microprogramed ROM at 4 μs/microinstruction.
(3) One nibble = 4 bits = ½ byte
(4) Microprogram
(5) Conditional jump MUX external to chips allows 2-level interrupt very simply.
(6) Pc stack is stored in main memory and is accessible to programer
(7) Stack is general-purpose to store pc, registers, and flags.
(8) 4008 & 4009 chips allow easy interface to standard RAM & ROM

memory capacity is likely to be required. The requirement for external memory is important because, in most systems, the memory cost dominates all other considerations. If the microprocessor can handle interrupts, it can perform more than one task at a time, and it can also do single tasks more quickly because it can overlap processing and input/output.

Many microprocessors, as indicated in the table, have a pointer-address mode. This permits a machine with a short word length to address a large memory array. And because such large arrays may require more bits in an address representation than can be contained in an instruction word, the address is kept in a special register or pair of registers preloaded by an instruction in the program. Subsequent instructions then refer to locations in the memory, which are addressed by the contents of the pointer register. However, the preloading instruction adds to the overhead in machine operation, reducing the over-all performance.

Some microprocessors also have immediate and indirect-address modes. These modes are to be distinguished from direct addressing—the simplest and most common. In any processor, an instruction word consists of an operation code (op code) and an operand code (that which is to be operated upon). When the operand code is a direct address, the processor executes the instruction on data in the location specified by that address (Fig. 1). When the operand code is an immediate address, the processor executes the instruction on the operand code itself. And when the operand code is an indirect address, the processor executes the instruction on data found at the address specified by the operand.

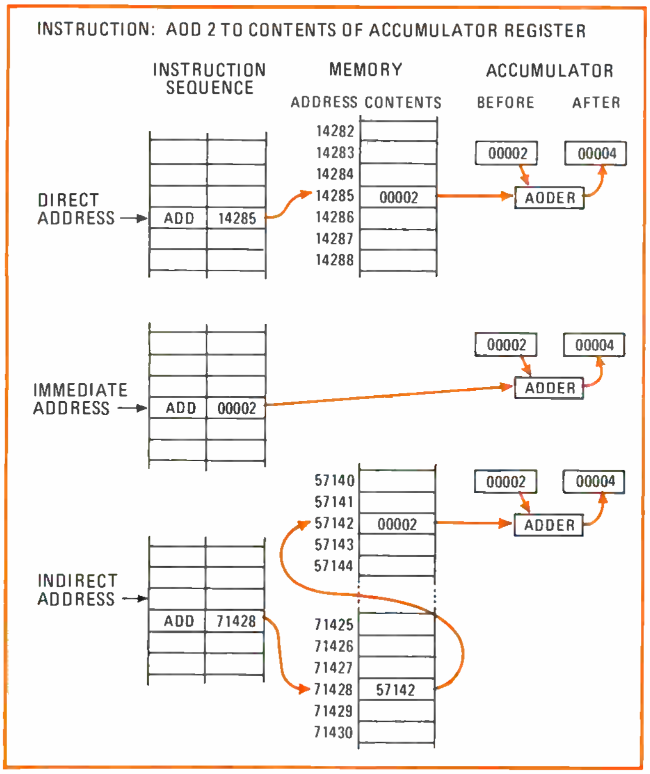
Indirect addressing and pointer addressing are similar, except that the address pointer is in an internal register instead of in a main-memory location. The particular mode of address is identified by the op code itself or by a flag bit associated with the op code.

Indirect addressing is a powerful tool in all software systems. It's particularly powerful in minicomputers, where the limited word length prevents direct access to more than a small part of the memory, and for the same reason, it can be equally powerful in microprocessors.

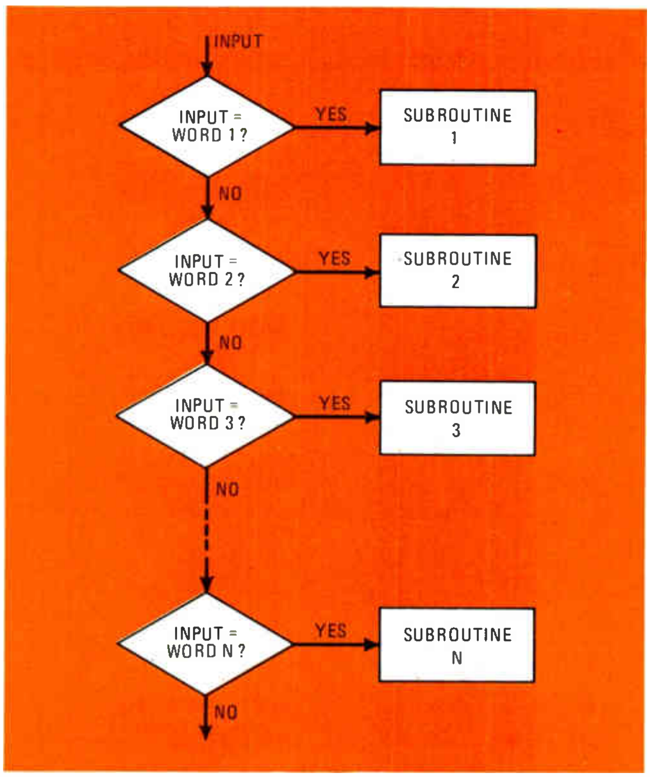
Some microprocessors are microprogramed—that is, their control sequences are stored in read-only memories in the same way as object programs, which determine each machine's function. These microprograms are functionally similar to those used in large machines and minicomputers, in which, during the last few years, they have largely replaced hard-wired control.

Available software is an important aspects of the use of microprocessors. Writing a program in machine language (directly in binary notation) is—like walking from Portland, Maine, to Portland, Ore.—not impossible, but exceedingly difficult. At the very least, an assembler or cross-assembler is necessary to convert a program written in a symbolic language into machine language. Even new assemblers are written in symbolic notation.

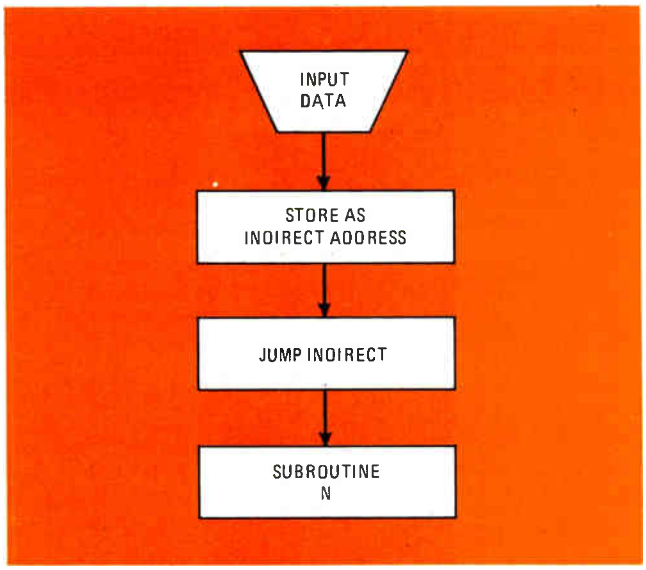
An assembler is executed on the same machine that is to run the object program; a cross-assembler would be executed on a different machine—most likely a minicomputer—but would produce a machine-language program that is executable on the microprocessor. Simulators, debuggers, and canned subroutines are other desirable software packages. Here, a microprogramed



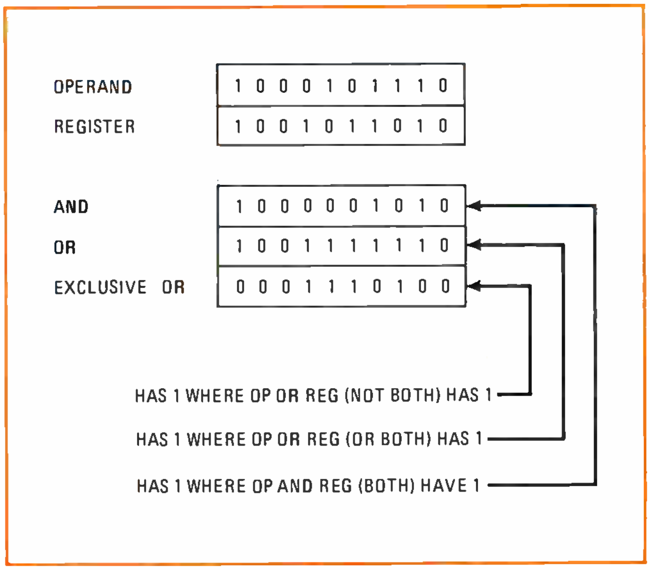
1. Address modes. Three ways of addressing memory are in common use, and some microprocessors use all three. Direct mode is the simplest, immediate is handy when working with constants, and indirect often simplifies the handling of subroutines.



2. Sequential test. An external signal can be identified and used to trigger an internal routine by comparing it successively with several test words. A match causes a program jump out of comparing sequence to a subroutine that processes the external signal.



3. Indirect jump. To simplify the task of locating a subroutine, sometimes an incoming signal can itself identify the location, and the program jumps indirectly to the subroutine via the input buffer.



4. Logic operations. These instructions can be used to mask certain unwanted bits in a register or to generate signals that are to be sent outside the microprocessor.

microprocessor has a distinct advantage—because the microprogram can be recast to make one machine emulate another, the microprocessor may be able to utilize existing software at minimal cost.

Design tools

Logic designers are accustomed to using a number of standard tools, including gate networks, time delays, counters, and discrete input/output controls. Each of these has its counterpart in a microprocessor program, but applying the programed counterparts by rote may yield an uneconomical solution to a design problem. However, careful analysis of requirements and knowledge of microprocessor programing techniques will simplify design of an optimum system.

For example, programed logic is time-shared—it works only when the program reaches a particular point in its execution. But gate networks are always available; when the correct combination of inputs appears, they generate outputs, whether the rest of the system is ready for them or not.

Gate networks consist of ANDs, ORs, and NOTs; their inputs combine in the way determined by the combination of logic blocks to produce either an output from the

Features of microprocessors

Two widely used microprocessors are the Intel 4-bit MCS-4 and 8-bit MCS-8 chip sets, which can be put together in various combinations to produce systems of different capabilities.[2,3] The processor chips in these two sets are, respectively, the 4004 and the 8008, for which several program routines are listed in this article. To make these routines more intelligible, brief functional descriptions of these two chips follow.

The Intel 4004 contains five functional sections: an address register and stack with an address-incrementing circuit, a set of 16 4-bit registers for indexing and general-purpose temporary storage, a 4-bit arithmetic and logic unit, an 8-bit instruction register and decoder, and peripheral circuitry.

The 16-bit registers and the instruction register are the most important sections in the present context. The index registers can be used either singly for temporary storage during computations, or in pairs to address memory and to store data fetched from the read-only memory.

The 8-bit instruction register can hold at any one time a 4-bit operation code and a 4-bit operand. Some instructions in the 4004 are of double length (16 bits instead of 8), have multiple operands, and are stored in successive read-only memory locations; they take two system cycles for execution instead of one.

The 4004 has a total of 45 instructions in its repertoire, plus a no-operation dummy instruction that uses up one instruction cycle but doesn't do anything. The 4-bit operand code in an instruction can specify, among other things, one of the 16 individual registers, or, with 3 bits, one of the eight register pairs. The upper end (most significant bits) of the register pair is the same as one of the even-numbered individual registers.

The Intel 8008 contains four functional sections: an instruction register, a local memory, an arithmetic-logic unit, and input/output buffers. The arithmetic-logic unit includes four control flip-flops—carry, zero, sign, and parity—which indicate conditions that arise during each instruction execution and are the basis for executing subsequent conditional jumps.

Part of the local memory consists of seven 8-bit registers. Of these, one, designated A, is the accumulator, which contains one of the operands and the result of every arithmetic operation. Four others, registers B, C, D, and E, may be used for any temporary storage, while the remaining two, registers H and L, contain respectively the high- and low-order bits of an indirect address in external memory. (Because external memory is limited to 16,384 words, addressed by 14 bits, register H in this application contains only 6 bits.)

processor itself or an alteration in the execution of the program. These functions are executed in a microprocessor by three basic operators—MASK, COMPARE, and JUMP. (A specific microprocessor may not have these particular instructions, but it should be able to execute their equivalent in some form.) The MASK excludes from subsequent operations any bits in an operand that are unwanted or are optional or "don't-care" bits, the COMPARE matches the operand against another bit pattern, and the JUMP transfers the sequence of instructions being executed in the program to one that will perform the desired action as a result of the COMPARE operation.

Instructions are ordinarily executed directly in sequence, as they occur in the program; this sequential operation continues undisturbed if, for example, the match attempted in a COMPARE is unsuccessful. But if the match succeeds, the operation executed after the JUMP (second operation after the COMPARE) is not the one immediately following the JUMP (Fig. 2). Here the microprocessor receives a signal from the outside world. This signal may be a pulse or level on a single wire, a series of pulses placed in order in a shift register to create a processor word, or a word received simultaneously in parallel on a group of wires.

This input, in whatever form, is compared successively with each of several previously stored words in the memory. Whenever any comparison shows that the input and a stored word are equal, the program, instead of executing the next comparison, jumps directly to a sub-routine stored elsewhere in the memory. The address of the beginning of this subroutine is the JUMP instruction's operand. Although the diagram doesn't show it, in many applications the subroutine would return to the next comparison at its completion.

In an alternative procedure (Fig. 3), the input signal, whatever its nature, causes an indirect jump to the proper subroutine. The input signal loads an address in a particular location in the memory, which is not the location of the JUMP instruction. Then, following a successful comparison, the program jumps indirectly to the subroutine via this intermediate location.

Logic operators

In some microprocessors, pure logic operators, corresponding to the gate functions of hardware logic, are available. These operators, usually the AND, OR, and exclusive-OR functions, are convenient to generate signals to be sent out from the microprocessor in response to incoming signals. (These functions are not to be confused with the AND, OR, and NOT of hardware logic.) In a program, the AND operator is the most straightforward way to perform the MASK function.

Logic operators retain 1 bits in a specified register where called for by logic 1 bits in the operand (Fig. 4)—in both the register and the operand for an AND, in either that register or the operand, or both, for an OR, and in either that register or the operand, but not both, for an exclusive-OR.

Not all microprocessors have all three of these logic operators in their instruction sets, but the designer will

TABLE 2. JUMP INDIRECT ROUTINE
(INTEL 4004 CODING)

Mnemonic	Operand	Action
FIM	1P 2	FETCH IMMEDIATE, A TWO-WORD INSTRUCTION; TRANSFERS CONTENTS OF 2ND WORD TO REGISTER PAIR SPECIFIED BY OPERAND IN FIRST WORD. (P IN AN OPERAND DESIGNATES A REGISTER PAIR.) HERE REGISTER PAIR 1 IS LOADED WITH THE NUMBER 2 -- AN ARBITRARY NUMBER THAT DEPENDS ON PREVIOUS ACTIONS IN A PROGRAM OF WHICH THIS ROUTINE IS A PART.
SRC	1P	SEND REGISTER CONTROL; ADDRESSES THE READ-ONLY OR READ-WRITE MEMORY WITH THE CONTENTS OF THE REGISTER PAIR SPECIFIED. HERE PAIR 1 IS SPECIFIED; SINCE PAIR 1 WAS PREVIOUSLY LOADED WITH THE NUMBER 2, MEMORY LOCATION 2 IS CALLED FOR.
RDR		READ DATA FROM THE SELECTED MEMORY LOCATION INTO THE ACCUMULATOR.
XCH	4	EXCHANGE THE CONTENTS OF THE ACCUMULATOR AND THE INDEX REGISTER SPECIFIED. HERE REGISTER 4 IS SPECIFIED; IT IS THE UPPER HALF OF PAIR 2. THUS WHATEVER WAS READ FROM MEMORY IS NOW IN REGISTER 4.
JIN	2P	JUMP INDIRECT TO THE ADDRESS CONTAINED IN REGISTER PAIR SPECIFIED -- HERE PAIR 2. PAIR 2 COMPRISES REGISTERS 4 AND 5; SINCE REGISTER 4 CONTAINS A NUMBER BROUGHT FROM MEMORY, AND REGISTER 5 IS EMPTY, PAIR 2 CONTAINS A MULTIPLE OF 16. THE JUMP IS TO THE BEGINNING OF A 16-WORD SUBROUTINE.

TABLE 3. LOOPING ROUTINE – MULTIPLE WORD TEST
(INTEL 8008 CODING)

Mnemonic	Operand	Action
LCI		LOAD REGISTER IMMEDIATE (2 WORDS). HERE DATA FROM THE 2ND WORD OF INSTRUCTION IS PLACED IN REGISTER C.
LLI		THE SAME; REGISTER L.
LHI		THE SAME; REGISTER H.
INP	1	READ DATA SUPPLIED BY INPUT DEVICE 1 INTO ACCUMULATOR (REGISTER A).
NDM		FORM LOGIC "AND" OF MEMORY LOCATION SPECIFIED BY CONTENTS OF REGISTERS H&L WITH ACCUMULATOR.
INL		INCREMENT REGISTER L, TO SPECIFY LOCATION OF TEST WORD.
CPM		COMPARE CONTENTS OF MEMORY LOCATION SPECIFIED BY H&L WITH THE ACCUMULATOR; IF THEY ARE EQUAL, SET THE ZERO CONDITION FLIP-FLOP.
JTZ	MATCH	CONDITIONAL JUMP, A 3-WORD INSTRUCTION; JUMP TO INSTRUCTION (SYMBOLIC ADDRESS "MATCH") SPECIFIED BY 2ND AND 3RD WORDS OF THIS INSTRUCTION IF THE ZERO FLIP-FLOP IS ON.
DCC		DECREMENT REGISTER C; IF RESULT IS ZERO, SET THE ZERO FLIP-FLOP.
JTZ	NMATCH	CONOITIONAL JUMP TO THE FIRST INSTRUCTION (SYMBOLIC ADDRESS "NMATCH") OF NEXT ROUTINE.
INL		INCREMENT REGISTER L AGAIN.
JMP	*-12	UNCONDITIONAL JUMP, A 3-WORD INSTRUCTION, TO THE ADDRESS SPECIFIED BY THE 2ND AND 3RD WORDS; * MEANS THIS INSTRUCTION AND *-12 MEANS THE INSTRUCTION 12 WORDS BACK -- THE "INP" INSTRUCTION.

TABLE 4. LOOPING ROUTINE – TIME RELAY
(INTEL 4004 CODING)

Mnemonic	Operand	Action
FIM	OP 12	FETCH IMMEDIATE (2 WORDS). LOADS 2ND WORD OF INSTRUCTION -- 12 -- INTO REGISTER PAIR SPECIFIED -- PAIR 0.
ISZ	0 *	INCREMENT AND SKIP IF ZERO (2 WORDS). INCREMENT CONTENTS OF REGISTER SPECIFIED IN OPERAND OF FIRST WORD, AND IF THE RESULT IS 0, EXECUTE THE NEXT INSTRUCTION IN SEQUENCE (SKIPPING 2ND WORD OF THIS INSTRUCTION). IF THE RESULT IS NOT 0, JUMP TO THE ADDRESS SPECIFIED IN THE 2ND WORD. HERE THAT ADDRESS IS THIS INSTRUCTION'S OWN, INDICATED BY *, SO IT KEEPS JUMPING BACK TO ITSELF UNTIL REGISTER 0 AGAIN CONTAINS 0 -- 16 REPETITIONS.
ISZ	1 *-2	INCREMENT AND SKIP IF 0 (2 WORDS). THIS HAPPENS JUST ONCE BEFORE RETURNING TO THE PREVIOUS ISZ FOR 16 MORE REPEATS, AND FOUR TIMES BEFORE EXITING PERMANENTLY -- A TOTAL OF 64 STEPS IN THE DOUBLE LOOP.
BBL	0	BRANCH BACK AND LOAD; THE OPERAND IS PLACED IN THE ACCUMULATOR. THIS RETURNS TO THE ROUTINE DELAYED BY THIS DOUBLE LOOP; THE 0 OPERAND CLEARS THE ACCUMULATOR.

soon find that at some cost in memory space and running time, almost any operator not explicitly included can be made up from available instructions. Because of this cost, implementing the gate functions is likely to be more economical in hardware outside the microprocessor than in the program, if their outputs are required externally. These functions pay off, however, if there is some regularity in the task they perform—for example, if one group of bits is to be compared to many test words.

In some microprocessors, this multiple comparison can be programed very compactly. For example, in the Intel 4004, the contents of any memory location can be loaded into a general-purpose register, which is specified in a JUMP INDIRECT instruction. Thus, data can modify the flow of instructions, and a multiple branch is no more than a simple procedure of looking up numbers in a table.

The routine (Table 2) requires only five instructions occupying six words. Four instructions identify the memory location—in this case an input/output device—and they bring data from that location into the accumulator and then put it into an even-numbered register—one of 16 4-bit registers in the 4004 that can also be addressed as eight 8-bit register pairs. Each even-numbered register is the upper half of a register pair, so that loading anything into an even-numbered register and leaving 0s in the lower half is equivalent to loading a multiple of 16 into the register pair. The last instruction in the routine is the JUMP INDIRECT, which refers to the register pair for the address of its destination—the beginning of a 16-byte subroutine. A maximum of 16 such subroutines can be selected.

Programed AND-OR

Another very useful technique in microprocessor programing is the use of a routine that branches back to itself in a continuous loop, together with a provision to count or otherwise limit the number of times the program executes the loop. (Without such a provision, the processor will continue executing the looped program indefinitely—chasing its tail, so to speak.)

TABLE 5. DISCRETE EXTERNAL CONTROLS – LAMP BANK
(INTEL 8008 CODING)

Mnemonic	Operand	Action
LAC		LOAD ACCUMULATOR WITH CONTENTS OF REGISTER C.
LLI		LOAD REGISTER IMMEDIATE; 2ND WORD OF THIS INSTRUCTION TO REGISTER L.
LHI		SAME; REGISTER H. L&H NOW CONTAIN THE ADDRESS OF THE LAMP-BANK IMAGE IN THE MEMORY.
ORM		FORM LOGIC "OR" OF MEMORY LOCATION SPECIFIED BY REGISTERS H&L WITH THE ACCUMULATOR. LOCATION CONTAINS LAMP-BANK IMAGE.
NDD		FORM LOGIC "AND" OF REGISTER D WITH THE ACCUMULATOR.
LMA		MOVE CONTENTS OF ACCUMULATOR INTO MEMORY LOCATION M (SPECIFIED BY H&L). THIS IS THE NEW IMAGE OF THE LAMP-BANK.
LAI	4	LOAD ACCUMULATOR WITH CONTENTS OF 2ND WORD OF THIS INSTRUCTION -- THE NUMBER 4.
OUT	ADD	MOVE CONTENTS OF ACCUMULATOR TO OUTPUT CHANNEL, IDENTIFYING THE DEVICE FOR A SUBSEQUENT OUTPUT OPERATION. THE DEVICE IS THE LAMP-BANK.
LAM		MOVE MEMORY LOCATION M INTO THE ACCUMULATOR. THIS BRINGS OUT THE NEW IMAGE OF THE LAMP-BANK AGAIN.
OUT	WR	MOVE CONTENTS OF ACCUMULATOR ONTO PREVIOUSLY SELECTED OUTPUT CHANNEL, THUS ALTERING THE CONDITION OF THE LAMP-BANK TO MATCH THE NEW IMAGE IN MEMORY LOCATION M.

The equivalent of an extensive hardware AND-OR network can be implemented with a looped program. Using the Intel 8008, the program (Table 3) can be written in 12 instructions occupying 21 words, only 15 of which are actually part of the loop.

First, the number of times the loop is to be executed is entered in one of the general-purpose registers; this corresponds to the number of AND gates in the hardware equivalent. Each pass through the loop brings an 8-bit word into the accumulator register, masks out any unwanted bits in that word, and compares it with a test word previously stored in the memory.

For each input word, the mask and the test word are stored in adjacent locations in the memory. Masks and tests for successive inputs are stored in successive pairs of locations. Thus, after specifying the number of passes through the loop, a pair of general-purpose registers is loaded with the address of the mask to be applied to the first input (one register can't hold a complete address). Then the program enters the loop for the first pass.

During each pass, the program fetches an input word, forms the logic AND of that word with the mask in memory, and compares the result with the test word next to the mask. If the two match, the program branches to a routine to process the input word. If the match is unsuccessful, the loop counter is decremented by 1 and tested to find out if it now contains 0. If it does, the loop has been executed the prescribed number of times, and the program branches to another task; if not, the two pointer registers that track the masks and test words are incremented, and the program goes back to fetch another input word.

Looping is also the obvious way to generate time delays. For example, to program a delay with the Intel 4004, a four-instruction seven-word routine (Table 4) can be used. Initially, the number 12 is loaded into register pair 0, which then contains 0000 1100. (In fact, the number is in the single register 1, while register 0—the upper half of pair 0—contains four 0s.) A one-instruction loop then increments register 0 over and over again, testing the contents each time until the register again contains 0000—a total of 16 steps. Another single instruction then increments register 1 once and returns to the one-instruction loop, unless the increment has placed four 0s in register 1.

Because register 1 initially contains 12, it is incremented four times—each time preceded by 16 repetitions of the incrementing of register 0; therefore, a total of 64 incrementing steps are taken by these two instructions alone. Finally, when register 1 turns up with contents 0000, the program returns to the routine that has been waiting for the completion of this time-delay loop—perhaps to permit some mechanical operation to take place. As described here, the delay is slightly more than 1.5 milliseconds, but it can be set to any amount by changing the numbers loaded into the registers and fine-tuned to a certain extent by inserting dummy instructions (no-ops) in the routine. A no-op uses up one instruction cycle—10.8 microseconds in the 4004—but doesn't do anything.

Input-output images

In designing such logic systems as digital controllers, sensing discrete conditions and generating discrete outputs are important. The conditions include switch closures, status bits, and the like. Typical outputs perform such functions as lighting lamps and energizing relays, tasks that data-processing systems rarely perform.

A microprocessor controls and monitors these signals in a unique way—it maintains an image of them in its memory. For example, one 8-bit word can sense eight status lines, treating each input signal as new data to be read and stored in one bit position of the word. And by programed bit manipulation, another word can control the lighting of eight lamps.

For instance, a program to light lamp No. 3 and extinguish lamp No. 4 in a bank of eight lamps can be written for the Intel 8008 with 10 instructions that occupy 13 words. The program (Table 5) assumes that one general-purpose register—say, register C—has previously been loaded with 0000 0100, which identifies lamp 3 (counting from the right) as the one to be turned on, while another register, D, contains 1111 0111 to point out lamp 4 as the one to be turned off; a location in memory contains an image of the bank of eight lamps, with their prior on-off status.

The contents of register C are first loaded into the accumulator, where the logic OR is formed with the image of the bank of lamps, and then the logic AND is formed with the contents of register D. The OR operation leaves a 1 in the accumulator for each lamp that should be on at the end of the routine; the AND leaves a 0 for all lamps that should be off. Because the accumulator contained only a single 1 bit before these two logic steps, only one lamp changes from 0 to 1; and since register D contains only one 0, only one lamp changes from 1 to 0.

Now the accumulator contains the updated image of the bank of lamps, which is stored back in the main memory temporarily, while the address of the actual bank is sent out through the output port. The image is then brought back into the accumulator and sent out after the address to switch the lamps.

Functions like these can be implemented with a small input/output card or subassembly containing two 8-bit registers. One of these, an input register, stores changes in external conditions that are to be sensed, and input commands transfer its contents, as required, into memory. Similarly, output commands transfer data into the other register, from which output signals can be generated as needed.

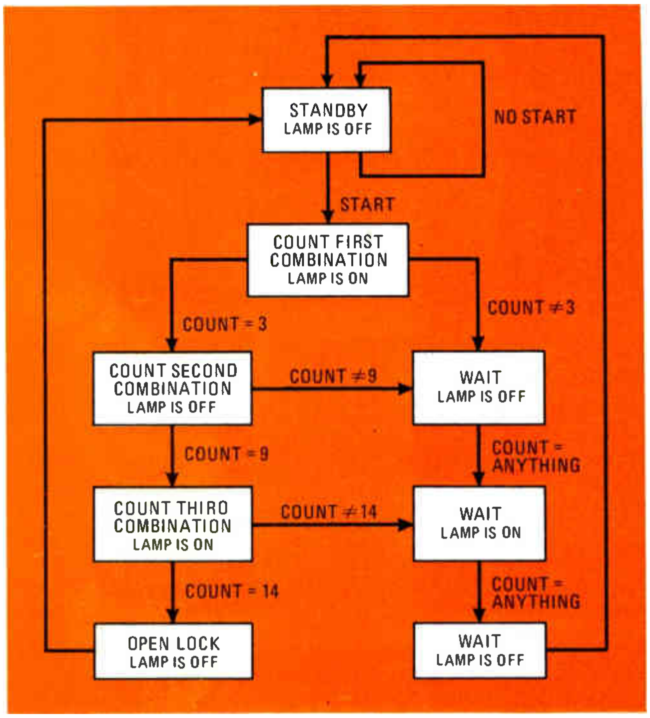
Designing systems around microprocessors

Electronic lock illustrates power of chip set to handle complex operations; adding such capabilities as I/O controllers and interrupts can expand a system

Translating logic-gate networks into program sequences, as described in the previous section of this article, is the first step toward a microprocessor-based system—but only the first step. Program sequences must then be gathered into a completed design that will perform the desired function.

An example shows how to accomplish this conversion. The logic design[1] is an electronic lock—the buzzer type often used in apartment houses, banks, and other secure areas—with a sequential combination instead of a simple button. In its standby state, the lock is closed. To open it, a button is pressed, starting the sequence. After a short time delay—a few seconds—a light begins to flash on and off at a low frequency, several seconds for each half-cycle. During each half-cycle, the button must again be pressed a prescribed number of times. If the sequence is executed correctly, a signal energizes the lock and opens it one half-cycle later, and then the circuitry returns to its standby state, reclosing the lock. A mistake in the sequence returns the circuit to standby without opening the lock.

For a half-cycle time of 4 seconds and a combination of 3-6-5—the number of times the button is pressed during each half-cycle—the state diagram appears in Fig. 5. This diagram defines the successive states the sequential circuit must occupy, and it is the starting point for either



5. Electronic lock. Lock opens only when button has been pressed the correct number of times during three successive time periods. Its operation is described in this state diagram, which is the starting point for either a hardware or a programed design.

a hardware-logic design or a microprocessor program.

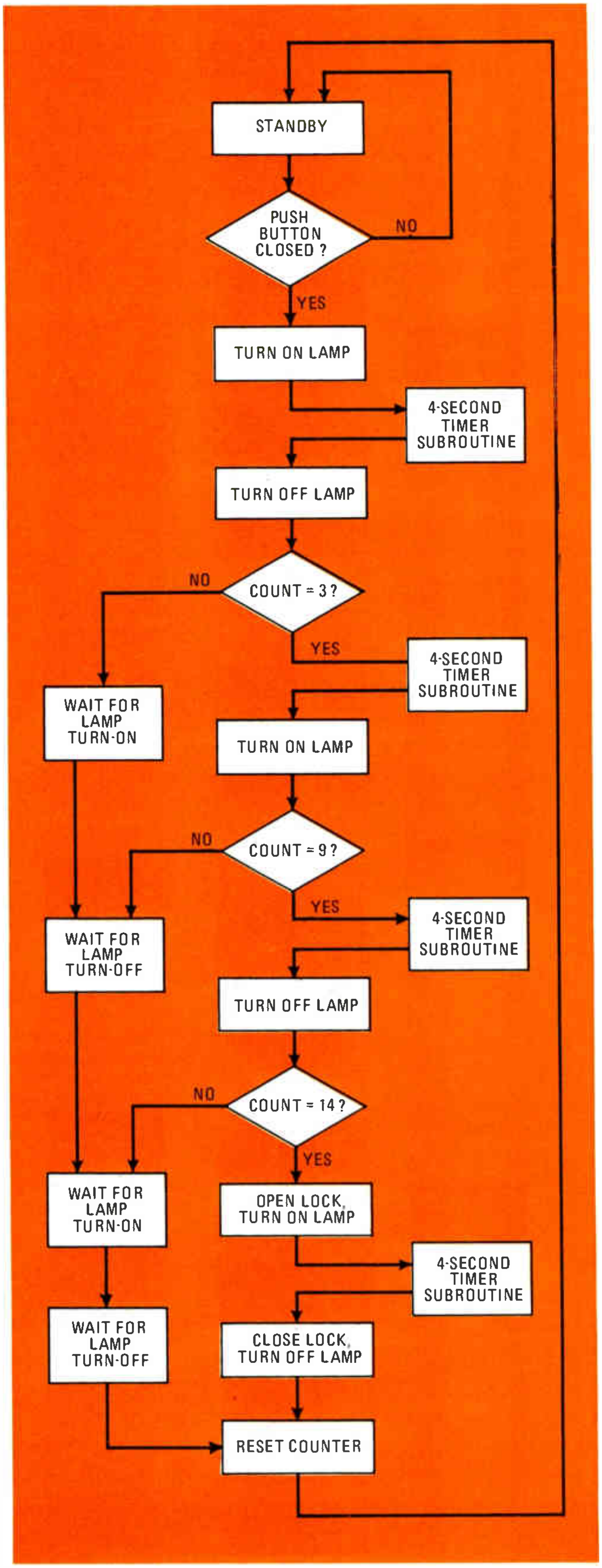
Because the diagram contains eight states, the sequential logic would require a minimum of three flip-flops, which together have eight combinations of on and off. The system control also would require input and output gates for these flip-flops, a four-stage binary counter, four more flip-flops, and a decoder, although all of these can be obtained as small- or medium-scale integrated circuits.

Another flip-flop or latch circuit is necessary to take the inevitable "bounce" out of the pushbutton contacts. Beyond these are a clock, which would be most easily made from an oscillator running at a kilohertz or so and another counter—more flip-flops—to divide the oscillator output down to the fractional-hertz level.

Finally, either the combination must be fixed when the lock circuit is put together, which calls for a rewiring job to change the combination, or additional complications— such as rotary switches on the protected side of the locked door—would have to be included in the design. (Driver circuits for the lamp and the electric lock are also required, but the microprocessor design will require them too.)

This list of parts that the electronic lock would require—nearly a dozen packages of small-scale and medium-scale integrated circuits—is intended to emphasize its complexity if it is designed with hardware logic. On the other hand, it is quite simple if programed for a microprocessor, which has its own counting capability.

In the Intel 8008 microprocessor, for example, the controller requires only an 85-byte program, for which a flow chart is shown in Fig. 6. The program can be stored in either an alterable or a read-only memory. In a ROM, at about 2 cents per byte, the incremental cost is $1.70.



6. Counting signals. The sequence of events in the electronic lock is defined in this flow chart, which describes exactly what happens from the internal viewpoint, as opposed to the external view, of the state diagram. Blocks in the flow chart are readily translated into a program routine in any machine code or symbolic code.

Furthermore, the combination can be changed simply by reprograming. The new program could be stored in a read-only memory, to be inserted in place of the old one, or in an alterable memory that is reloaded. In the same way, more complex combinations or additional functions can be added through programing.

Thus, new functions are inexpensive, once the basic cost of the microprocessor has been paid, and the hardware logic diagram shows why the microprocessor is so powerful. The most important parts of the electronic lock are the 16-line decoder and the gate elements that compare the decoder outputs with the previous state of the three sequential-logic flip-flops. But the bulk of the logic is in the counter itself, and the microprocessor can generate any counter sequence trivially—that is, the program itself is the counter.

Input/output controllers

To do anything useful, any processor, micro or otherwise, must have one or more input/output devices connected to it so that it can acquire data to process and it can dispose of the results. I/O devices may be as simple as lamps and switches or as complex as disk storage units, but for microprocessors, they fall generally into three distinct groups: serial-bit-stream devices, single-character devices, and block-transfer devices. The first class is not discussed further here because, for those devices, the microprocessor is its own I/O controller, but for the other two classes, external control logic is required.

Many designs for I/O systems are possible, and there are many tradeoffs between cost, speed, number of lines serviced, and so on. But all controllers share four common functions: buffering, address-recognition, command-decoding, and timing and control. All these functions can be included in a rather simple design.

Buffering is necessary in the path along which data is transferred in either direction between an I/O device and the microprocessor because the two units have separate clocks and therefore are not synchronized. Synchronizing, or equivalently controlling the I/O unit from the microprocessor clock, is not advisable because the connection between the two units may be lengthy and therefore subject to difficulties with noise and delays.

Address-recognition is necessary when (as is usually the case) more than one I/O unit is used with a microprocessor. Command-decoding is necessary for I/O devices that are capable of actions other than the transfer of data—for example, rewinding a tape drive. Finally, all of these functions require timing and control.

For a typical microprocessor system, the controller diagramed in Fig. 7 provides all four functions. It includes three buffer registers, which store input data, output data, and device status. A typical write sequence involves four steps:

First, the microprocessor sends out the address of the device in which it wants to write. This address travels along a common bus that also carries data, and serves the memory, as well as the I/O system. Therefore, the address is accompanied on separate lines by an address-command and an I/O request. The address-command identifies the signals on the bus as an address, and the I/O request directs it to the controllers instead of to the memory. A synchronizing signal strobes the address into the selected controller and effectively establishes a temporary link between the separate clocks of the microprocessor and the controller at the moment the address is transferred.

Second, the addressed controller sets its address flip-flop, which generates a ready signal to the microprocessor. All the signals sent out by the microprocessor went to all the controllers, but the address identified only one of them. That controller, with ready signal, thus acknowledges receipt of the address command and indicates that it is in a condition to begin operation.

Third, the microprocessor sends out a write command and a word or block of data—again with an I/O request and a synchronizing pulse. Only the previously selected controller responds to these signals. The data goes to the controller's storage register, and it returns another ready signal. The data goes to the controller on the same lines as the address, but the write command identifies it as data instead of an address. This step may be repeated as many times as needed to complete the write operation, and between write steps, the controller forwards the data to the device it is operating.

Finally, the microprocessor sends out another address command to select a different controller. This resets the address flip-flop in the previously selected controller and takes it out of operation until it is again selected.

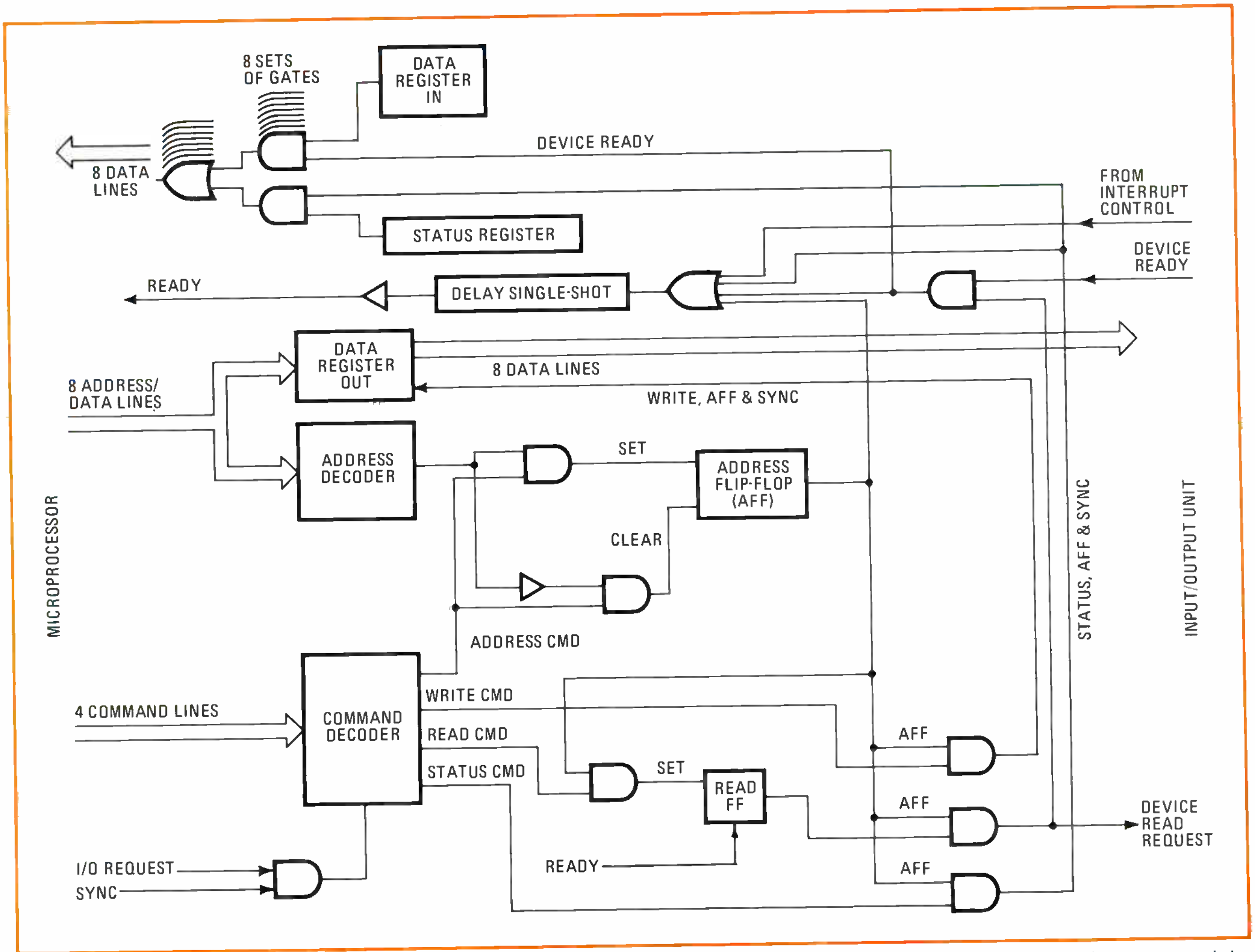
The first two steps of a read sequence are the same as those for write. But in the third step, the read command goes out, and the microprocessor waits for data to come back. The presence of data on the lines for the microprocessor to accept is announced by a ready signal. This cycle can be repeated as many times as needed—until a new controller is selected.

Generally, a read operation requires a delay while the mechanical device providing the data accelerates to its normal operating speed. The microprocessor can also request the controller to transfer its status information into the memory—an operation essentially identical to a read, except for the delay. The status is always immediately available in the controller, and finding it involves no mechanical processes.

Figure 7 shows the four commands—READ, WRITE, ADDRESS, and STATUS—as coming to the controller on four different lines. These could be encoded on two lines, or the four lines could be encoded with as many as 12 more commands if the I/O functions are to be expanded.

Interrupt

One such expansion might be the addition of interrupt capability to the system. In the example of the electronic combination lock, a loop at the start of the programed sequence represents the standby state. While in this loop, the microprocessor effectively runs around in circles waiting for something to happen—for someone to push the button. Similar standby loops are often incorporated in programs, but if the events they wait for are infrequent— less than once every 50 instructions or every 100 to 1,000 microseconds—the microprocessor could be doing useful work while waiting for the external event. That event must be able to cause the microprocessor to change its course of action. This capability,



7. Input/output controller. This simple assembly provides all basic functions of any controller: buffering, address recognition, command decoding, timing, and control. These functions are required, regardless of its speed or how many lines it services.

available on some microprocessors, is called interrupt.

Interrupt is especially valuable in communications applications. Since the microprocessor often has no control over when data is to be transmitted or received, the capability to work while waiting is desirable.

Resolving an interrupt is a rather complicated procedure. First of all, once an interrupt has been recognized, the microprocessor can't afford to recognize any others until the first one is out of the way. (In large computers, interrupt priorities are sometimes installed so that a high-priority interrupt can bump a low-priority interrupt. Such complex design seems undesirable with microprocessors at present.)

Second, before the microprocessor can process an interrupt, it has to store its own state— that is, effectively to take note of where it was when it was interrupted so that it can pick up where it left off after the interrupt processing is finished. This involves transferring into a reserved part of the memory the instruction counter, which identifies the next instruction, the contents of the accumulator, and other key registers and flip-flops. The existence of only one such reserved area is the reason for recognizing only one interrupt at a time.

In general, the implementation of an interrupt system consists of replacing the wait loop in the program with an equivalent loop in hardware, which tests for the presence of an interrupt at regular intervals during machine operation. For example, the test might occur just before every instruction fetch so that the fetch is blocked if an interrupt has occurred.

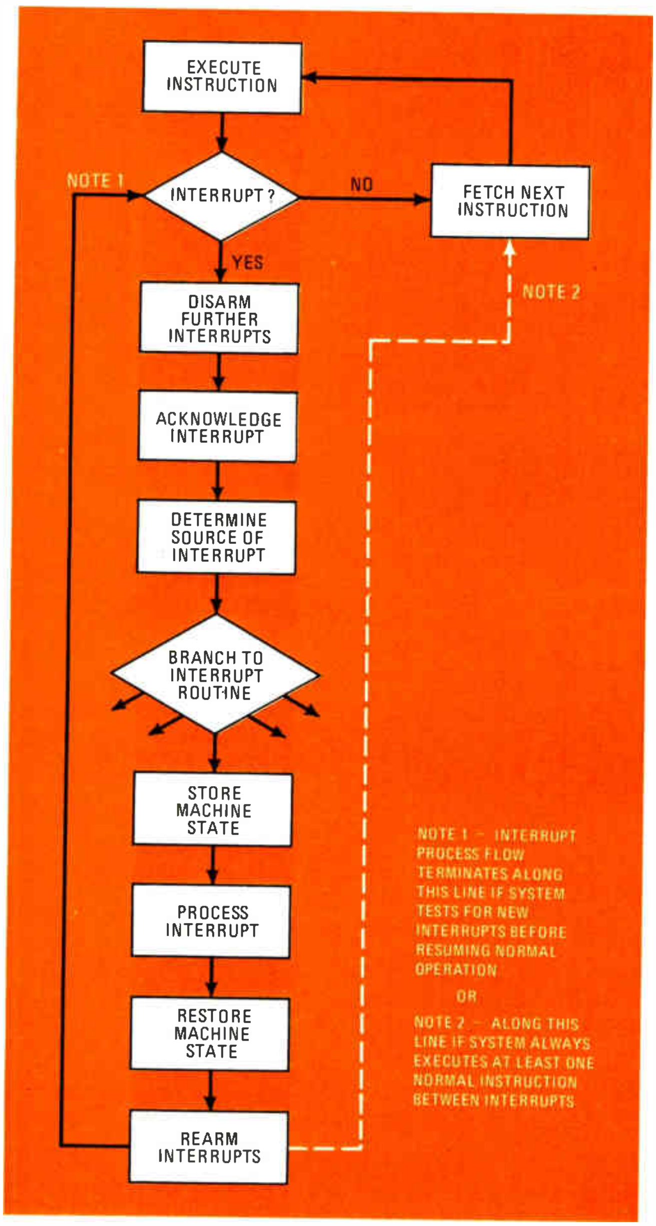
An interrupt-processing routine is shown in the flow chart in Fig. 8. The degree of complication varies widely from one microprocessor to another—some have processing interrupts that are more automatic than others. For example, the National Semiconductor GPC/P has a stack memory that can completely store the machine state in only five instructions. This highly efficient technique qualifies the GPC/P for excellent real-time process control.

Daisy-chain signal

After disabling further interrupts, as described previously, the microprocessor must acknowledge the current interrupt and determine its source. For this purpose, the interrupt-acknowledge line passes through all controllers in a "daisy-chain" fashion—the acknowledge signal passes from each one to the next until the source of the interrupt stops it. By this means, I/O priority is established by proximity to the microprocessor. Arrival of the interrupt-acknowledge signal triggers the sending by the controller to the microprocessor of its address, from which the microprocessor determines the location of the routine to service the interrupt. In some systems, the controller can send, not its own address, but the actual address of the routine, so that the microprocessor can reach the routine via an indirect jump instruction; this is called a vectored interrupt.

In all interrupt routines, the machine state must be stored before anything else happens. Then, after much ado, the interrupt itself can be processed. When it is finished, the previous steps must be undone—the machine state is restored, and the interrupts are re-enabled. Depending on how the word "disabled" is defined, new interrupts that occurred during the previous interrupt process may have been ignored totally, or they may merely have been kept waiting. In a completely interrupt-oriented system, when re-enabled, the disabling signal can start the whole interrupt-resolving cycle again before the microprocessor can get back to its main routine. If such new interrupts are unlikely, the microprocessor may get an automatic chance to execute one more instruction in its main program before checking again for interrupts.

By adding the logic shown in Fig. 9, the previously described I/O controller can be easily modified to work on an interrupt basis. Usually the interrupt signal is the result of something that happens in the controlled I/O device, although it can be an event in the controller itself. Either way, the signal sets the flip-flop FF_1, and sends an interrupt request to the microprocessor. The microprocessor's acknowledgment passes, daisy-chain fashion, through all controllers via gate G until it reaches the one that originated the request, where G is blocked by the ON state of FF_1. The trailing edge of the acknowledge pulse resets FF_1, and the turning-off action sets another flip-flop, FF_2, which, in turn, opens gates admitting the controller's address to the data lines. FF_2 also generates a ready signal to the microprocessor, and the ready, delayed, turns off FF_2.



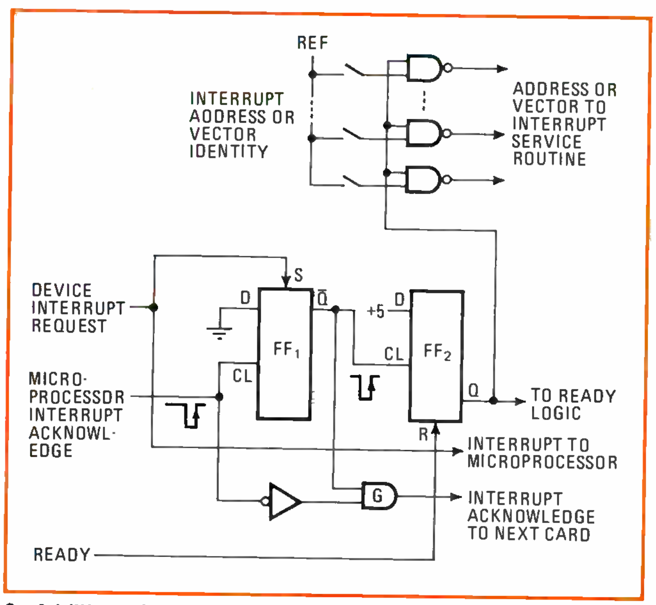
8. Sleeve puller. A microprocessor need not stand idle while waiting for an external event—if it can keep track of what it was doing when the event finally occurs. This flow chart outlines how it can mark its place in a secondary routine while processing an interrupt.

When interrupts aren't wanted

Because the entire process of handling interrupts may require many hundreds of microseconds, external events that occur, on the average, more than once every 4 or 5 milliseconds, will severely impede the main program if they depend on interrupts to obtain service. Therefore, if progress in the main program is important, or if many interrupts are expected, another technique should be used to service the external events.

An example of a process that can't depend on an interrupt for service is the refreshing of a cathode-ray-tube display. Suppose that the display has a capacity of 30 lines at 60 characters per line—a total of 1,800 characters to be refreshed 60 times per second. Refreshing requires 108,000 characters per second to be delivered to the display, or one character every 9.2 microseconds.

Many high-speed I/O processes, such as the preceding example, can tolerate relatively slow processing if the



9. Additional logic. These logic blocks must be added to the simple input/output controller of Fig. 6 to enable it to handle interrupts.

data transfer to and from the unit can be fast. These processes can therefore make use of a direct memory-access channel, or DMA, the next step up in complexity and performance from a simple interrupt.

A DMA channel in a microprocessor system requires a few more controls than those in the individual I/O-device controllers, which are not affected directly by their connection through a channel to memory instead of to the processor. The microprocessor obtains access to its own memory through these channel controls in the same way that the input/output controllers do, and, since conflicts can arise, the channel's main function is to detect and resolve them. They are less likely to occur with microprocessors than with minicomputers and large computers, however, because the microprocessor usually runs slower than its memory, not faster. Conflicts in systems of any size are always resolved in favor of the input/output, because the device is usually in mechanical motion and can't afford much delay.

Once the channel is under way, the channel controller takes over the task of selecting addresses, I/O sequences, and data handling. As a result, both I/O and processing operations are expedited—the first because it is limited only by the memory cycle rate, not the instruction rate, and the second because the microprocessor need not pause in its own work to run an I/O operation.

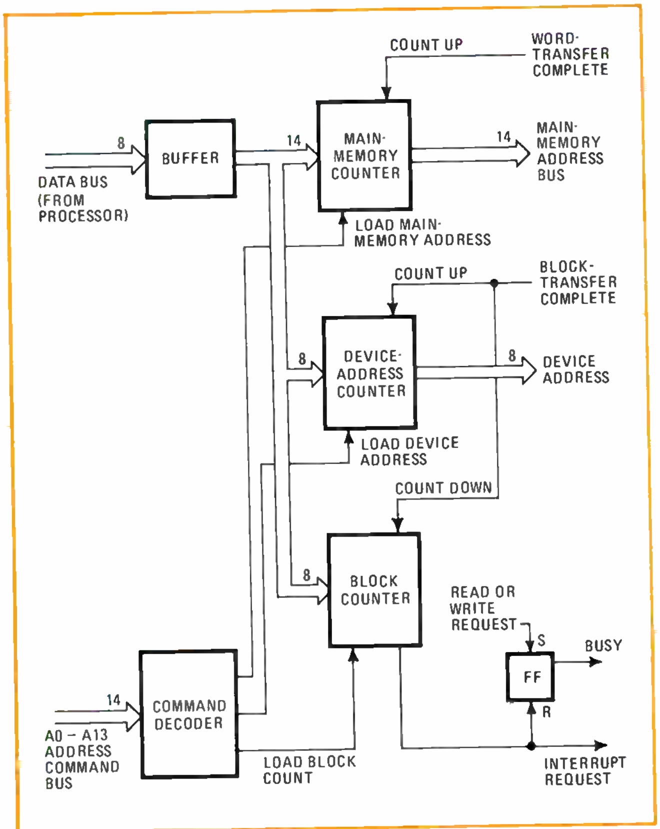
Block input/output

Channel input/output leads quite directly to block I/O, in which large blocks of data are transferred in or out of the microprocessor by a single command sequence. Additional logic in the I/O controller is required to work, not only with addresses in the main memory and addresses of individual devices, but also with addresses within the device—such as tracks and sectors on a disk drive, files on tape, and so on.

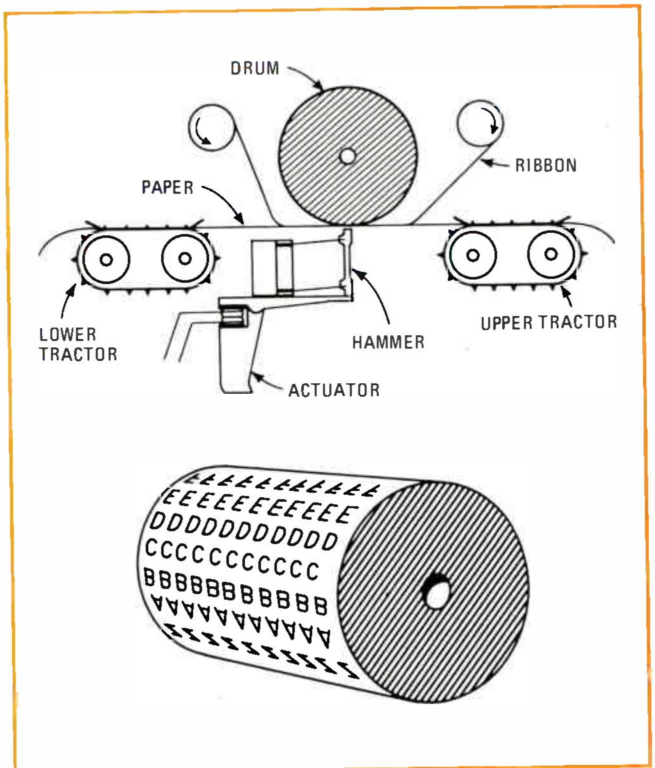
Three major elements (Fig. 10) must be added to a basic I/O controller to permit it to handle block input/output: an I/O device-address counter, a main-memory counter, and a block counter. At the start of an operation, the device-address counter is loaded with the device's internal address—such as the sector number—the main memory counter has the address to or from which the transfer of the block begins, and the block counter contains the number of blocks to be transferred. The first READ or WRITE command sets a BUSY flip-flop. As each word is transferred, the main-memory counter is incremented, and as each block is transferred, the block counter is decremented until it passes 0, generating a borrow signal. This signal resets the BUSY flip-flop and sends an interrupt signal to the microprocessor, which is thus informed that an I/O operation has been completed.

A drum-printer controller

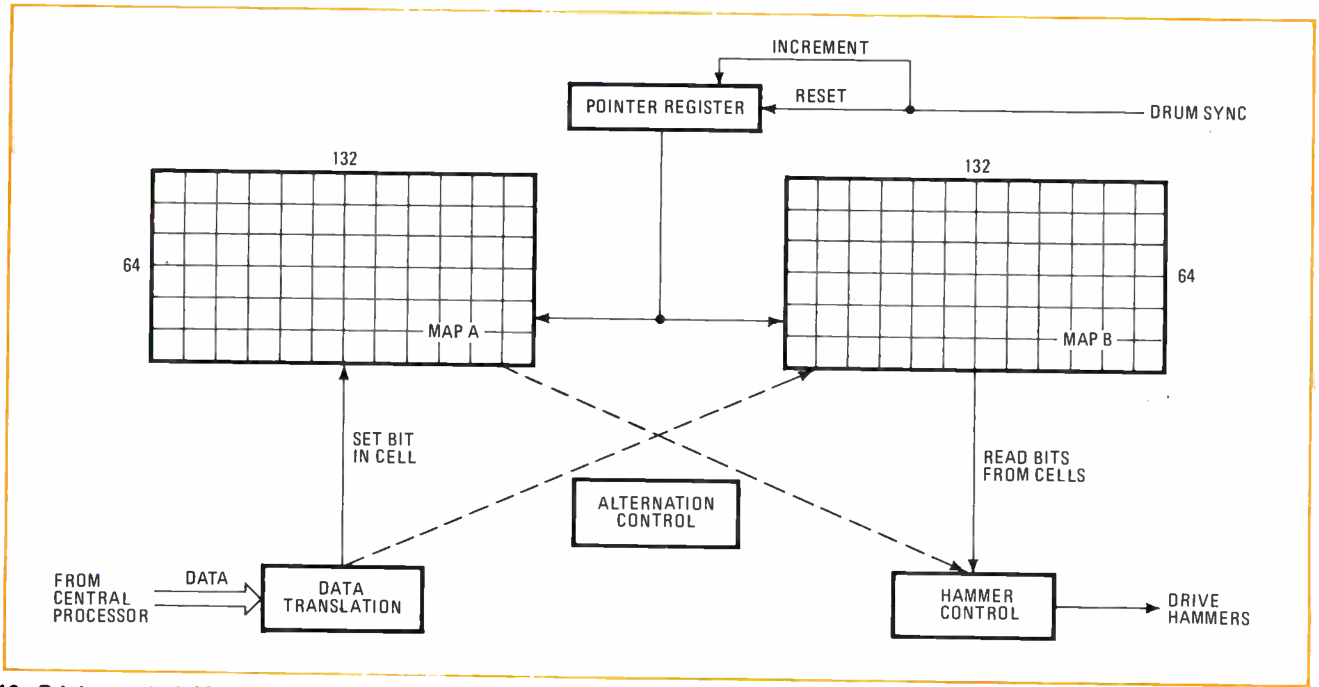
The preceding sections have shown how a few common logic-design problems can be solved with a microprocessor, and how controllers for use with microprocessors can be easily and quickly designed. Many of these concepts can be combined in the design of a controller for a drum printer that takes advantage of a microprocessor to control the format of the data transfer



10. Block input/output. To transfer large blocks of data to or from memory, this logic is added to the basic input/output controller. It must not interfere with other microprocessor tasks, yet it must work with both internal device addresses and with memory.



11. Drum printer. Rotating drum carries complete alphabet on its surface, repeated for each printing position across page. Separate actuator-hammer pairs for each position press the paper against the drum to pick up the imprint as the desired character passes.



12. Printer control. Microprocessor translates data from central processor into bits in map. These, in turn, identify the hammers to be actuated to print the data in the prescribed format. Two maps are used alternately; one fills with data while the other is printing.

between a larger central processor and the printer.

Microprocessors aren't suitable as controllers in every I/O application. For example, many magnetic-tape or disk units have data transfer rates that are far beyond the capabilities of any present or contemplated microprocessor. In fact, the fastest microprocessor now on the market is the National Semiconductor GPC/P, capable of a maximum of about 30,000 bytes per second, and the forthcoming Intel 8080 is limited to about 60,000. But since disks and tapes routinely spew forth data at hundreds of thousands and even millions of bytes per second, controllers for these devices must be built out of conventional logic circuits, and high-speed ones at that—emitter-coupled logic, in many cases—using microprocessors at best within the controller for certain process-monitoring tasks that do not involve data-handling.

But other I/O systems and subsystems are well suited for control by a microprocessor—among them, data-communications channels using telephone lines, card readers and punches, tape cassettes, floppy disks, and drum printers.

A typical drum printer prints a maximum of 132 columns of characters from a 64-character set at 1,800 lines per minute. To achieve this level of performance, the machine contains a drum (Fig. 11) with 132 complete sets of 64 characters in circumferential columns, and like characters in each set are lined up along an axial row. Close to its surface is a bank of 132 electromechanical hammers that can be driven toward the drum as it spins on its axis. But between the hammers and the drum is the web of paper upon which the printed characters are to appear, plus an inked ribbon to record the imprints.

As the drum turns, its position is monitored by the controller. As each of its character slugs to be printed in the 132 positions of a line approaches a point opposite the corresponding hammer, the hammer is driven forward— timed in such a way that as it reaches the limit of its travel, it prints in the desired position by pinching the paper and the ribbon between it and the drum when the desired character slug is exactly opposite it. When the drum has made one complete revolution, a complete line has been printed on the paper, and the paper moves up into position for printing the next line. To allow time for paper movement, the characters do not fill the entire circumference of the drum.

One common controller design contains 132 6-bit counters. The controller translates the data in each printing position into a particular counting step. Such a straightforward but complex controller is not necessary when a microprocessor is employed.

Instead, the data to be printed is loaded in the form of a map into a large area of the microprocessor's main memory. This area can be visualized as a rectangular array of bit cells, 132 wide and 64 high (Fig. 12). Each 64-cell vertical column corresponds to one of the 132 printing positions on the paper, and each of the 64 cells in the column corresponds to one of the characters in that position on the drum. Two such maps in the memory enable the processor to fill one while a line is being printed from the other, and their roles are reversed for alternate lines of printing.

At 1,800 lines and 1,800 revolutions per minute, the drum makes one revolution in 1/30 second; during this interval the central processor must provide the map with up to 132 characters. This is 3,960 characters per second or one character every 252 microseconds—a data rate that is well within the capabilities of a microprocessor.

The microprocessor, working as a controller, uses simple arithmetic and masking instructions to translate data received from the central processor into bits placed in the map. The character to be printed identifies the bit

Cranking up the microprocessor

Now that the engineer has read how to apply microprocessors to every-day design problems, assume that he orders one—from Intel, or National, or anybody. The microprocessor has an adequate quantity of read-only and read-write memory and all the necessary extraneous parts. Now, suppose that the engineer writes a program to fit his application; and assume that the program is right the first time and that it's been put into a programable ROM connected to the microprocessor system. Now, how does he start the machine?

Large general-purpose computers always come with software that helps load programs into the memory and ensures that the computer starts running the program when it is turned on. This software is so cleverly designed that it seems to melt right into the scenery. The rules followed in writing the program may have been imposed, in part, by the computer hardware, but some of them were imposed by the software. However, the microprocessor doesn't have any software like this.

To start any processor, some kind of number must be loaded into the program counter, which will then indicate the first instruction in the program, and the processor clock has to be started. In Intel's 4004 microprocessor, this is brutally simple—an external line, when grounded, forces the program counter to 0, and when the ground is removed, the clock starts running. If the first instruction of the program has been placed in memory location 0, grounding the reset line makes the program counter point to that first instruction, and removing the ground starts the processor.

The 8008 is also simple to start, but the process is not quite so straightforward. Essentially, the machine can be made to execute an instruction that is not in the program, but which forces the program to jump to a location whose address is a multiple of 8. Any address between 0 and 56 can be used; if the first instruction of a program is in that location, the processor starts running as soon as the jump has been executed.

Other microprocessors also have similar simple means of starting.

cell in the column of 64, and sets that cell to 1; all other cells in that column remain 0s. Successive characters in the line set corresponding bits in successive columns in the map.

When the map has been filled with bits corresponding to data to be printed, the map turns to the control of the spinning drum. Once per revolution, the drum generates a synchronizing signal that says the first character in the set of 64 is in a position to be printed anywhere it may be required along the line—possibly, but improbably, in all 132 positions at once. This synchronizing signal sets a pointer at row 1 in the map. If any of the 132 bits in that row is 1, the hammer corresponding to the bit position fires to print the first character in the proper column. The pointer then is incremented to row 2 as the drum continues to rotate into the next character position. This process is repeated for all 64 rows in the map and all 64 print positions on the drum.

But in reading out these map cells, the microprocessor can take, say, 8 bits at a time (assuming that it is an Intel 8008 or similar system). Thus, to print in 132 character positions, the microprocessor can take 17 memory accesses—16 of 8 bits each and one of 4 bits. (A standard line length for printers is 132 characters, but unfortunately, 132 is not divisible by 8.)

Meanwhile, the spinning drum passes one of the 64 character positions in $1/30 \times 1/64 = 1/1{,}920$ second, or about 521 microseconds. However, during this period, for accurately aligned smudge-free printing, all the hammers that are to be pulsed to print a given character must be pulsed within a 66-μs window. This ratio of 66 to 521 represents a rather relaxed duty cycle for the printer mechanism, allowing plenty of time for the hammers to settle back into position after firing, but during the window, the microprocessor must peel off 17 8-bit bytes from the map—less than 4 μs per byte. To handle this data rate, the microprocessor must have a DMA channel.

This printer-control algorithm can be coded for the Intel 8008 microprocessor or the new 8080 with only 72 bytes in the program. The memory maps—two—require 2,176 bytes. The 8008 isn't fast enough to run the hypothetical printer, but it can handle about 500 lines per minute, a respectable speed for some applications. The 8080, on the other hand, can handle about 5,000 lines per minute.

In an actual application, of course, a full controller would be required—with other functions, such as sequencing, vertical forms control, and various alarm functions. But the basic simplicity of a controller built around a microprocessor is apparent.

This design has several important aspects. No gate-level logic design was necessary, and no state diagrams were used. Also, only slight program changes would be necessary to control a printer with a larger or smaller character set, a different input code from the central processor, or even a more complex printer, such as a chain printer. □

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Closing the loop

Readers who wish to discuss microprocessor system design with the author may call Bruce Gladstone during business hours, Pacific Daylight Time, during the week of Oct. 15 at (213)872-0959.

Miller-effect integrators act as signal separator

by Dale Hileman
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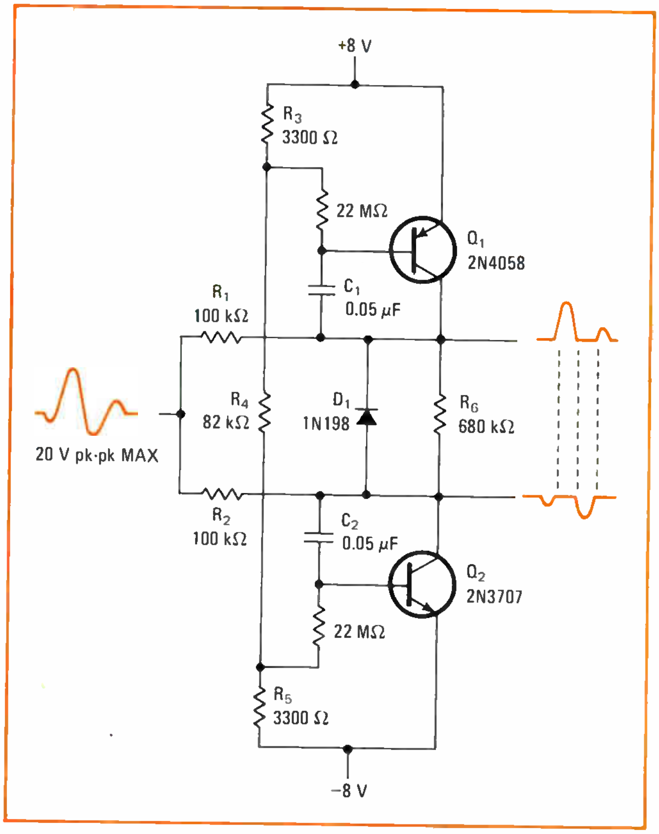
Complementary Miller-effect integrators are better than biased diodes for rectifying a signal and separating it into its positive and negative components. The diodes require enormous integrating capacitors when a dc level in the base line must be retained, and big capacitors commonly have leakage or polarization problems.

In the signal separator shown, each of the Miller-effect integrator stages serves as a half-wave rectifier. Together with two small 0.05-microfarad integrating capacitors, C_1 and C_2, they simulate a large effective capacitance that maintains the dc level of the signal's base-line potential.

Negative-going signal excursions cause transistor Q_1 to conduct, clamping the output to the base-line potential. Positive-going excursions, on the other hand, cut off transistor Q_1 and pass directly to the output. The operation of complementary transistor Q_2, which is the other integrator-rectifier stage, is the same as that of transistor Q_1, but signal polarity is reversed. A high-impedance load should be used to avoid an excessive voltage drop across either resistor R_1 or resistor R_2.

The voltage divider set up by resistors R_3, R_4, and R_5 holds the base voltages of both transistors close to their conduction threshold so that output signal transitions can be maintained near the base-line potential. Resistor R_6 acts as a collector load for both Q_1 and Q_2 to minimize the effect of their collector-emitter leakage current. Diode D_1 is included to minimize the effect of changing ambient temperature on this leakage current.

Signal separation is best at low frequencies, within the audio range and down to about 3 hertz. Even lower operating frequencies can be achieved by increasing the values of capacitors C_1 and C_2, but the rate of base-line integration becomes slower. □



Separating the ups and the downs. Signal separator employs complementary Miller-effect integrators to keep capacitor values low. The circuit permits input dc base-line potential to be retained so that it also is present at the output. Transistor Q_1 prevents negative-going inputs from reaching the output, while transistor Q_2 stops positive-going inputs. The circuit's load impedance should be kept high.

CATV transistors function as low-distortion vhf preamplifiers

by Paolo Antoniazzi
Societá Generale Semiconduttori, Milan, Italy

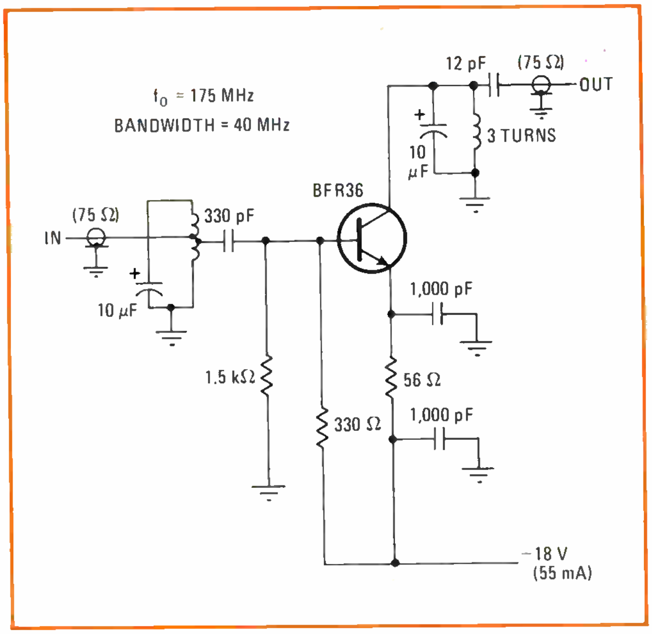
A standard cable-TV transistor makes an excellent vhf preamplifier, minimizing signal distortion over a wide dynamic range. Generally, FETs or MOSFETs are used rather than bipolar transistors because of the cross-modulation distortion created by the nonlinear behavior of the bipolar's base-emitter junction. CATV transistors, however, operate at currents of 20 to 80 milliamperes, so that their intrinsic emitter resistance is kept small and the effects of input-junction nonlinearities are eliminated.

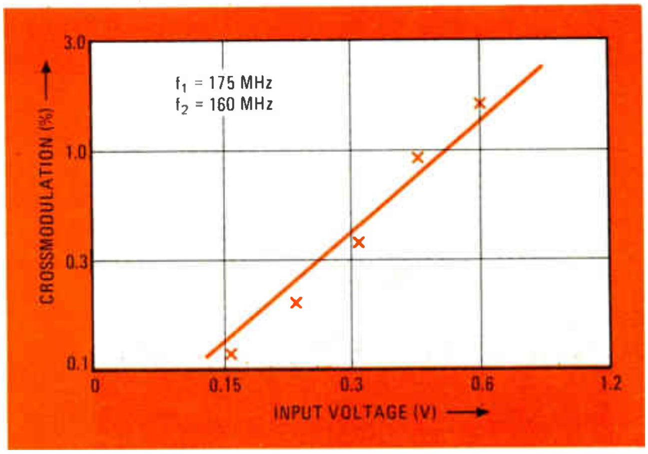
The single-stage antenna preamplifier shown is intended for mobile fm communications applications and is particularly suitable for use with double-balanced Schottky-diode mixers. It obtains 13 decibels of gain at 175 megahertz from a medium-power CATV transistor.

The circuit can handle 0.5-volt inputs with less than 1% cross-modulation, as indicated by the performance plot. Noise figure depends on how large the operating current is. But even for a transistor collector current of

50 mA, the noise figure is typically 5 dB or less.

The transistor used here is designed principally for line-amplifier applications. Its crossover frequency is 1.5 gigahertz, its operating current can range from 20 to 150 mA, and its feedback capacitance is typically 1.7 picofarads at a bias voltage of 15 v. □





Linear performer. Bipolar CATV transistor is heart of vhf antenna preamplifier that can process 0.5-volt inputs with under 1% crossmodulation. The nonlinearities that are normally associated with a bipolar transistor's base-emitter junction and that cause signal distortion are practically eliminated in the CATV transistor because of its high operating current. Circuit gain is 13 dB at 175 MHz.

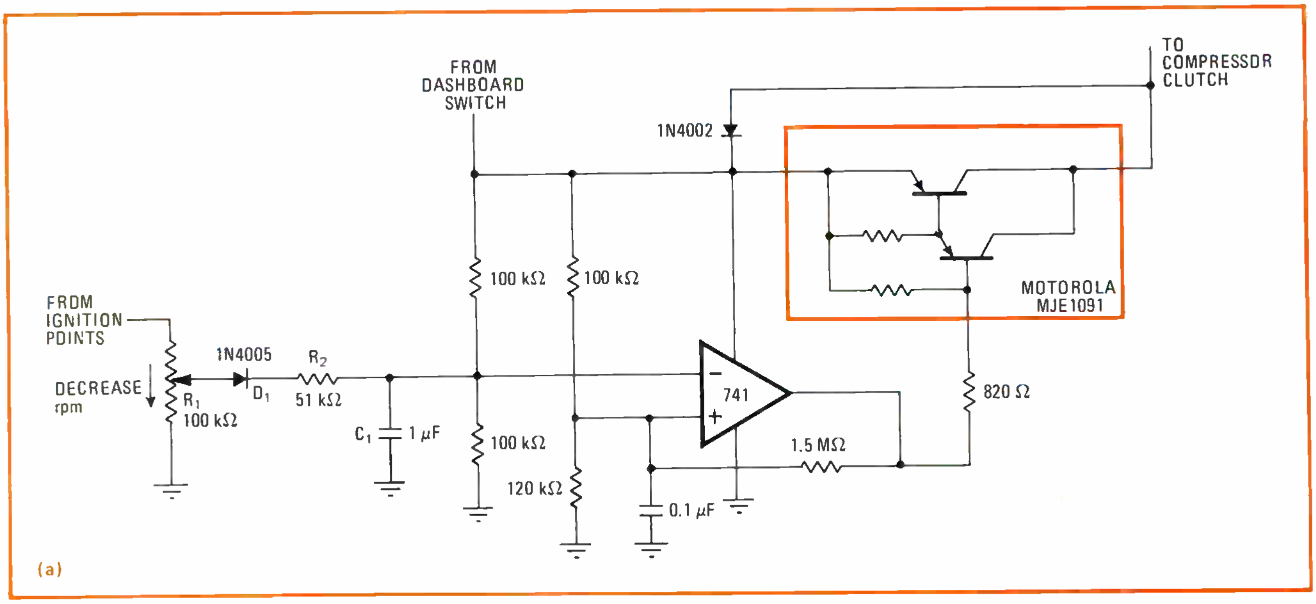
Electronic switch controls automobile air conditioner

by L.G. Smeins
Ball Brothers Research Corp., Boulder, Colo.

Stalling and overheating often plague an air-conditioned automobile in which the refrigerator compressor continues to run while the engine idles. The solution to the problem is simple—turn the compressor off when the engine is idling, and turn it on again when the car picks up speed.

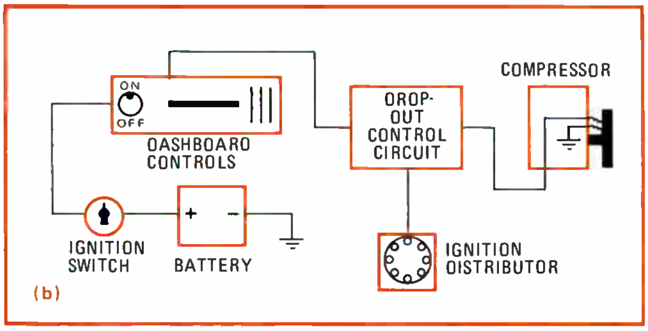
The control circuit shown in (a) does this by monitoring the engine's rpm and electrically disengaging the compressor clutch for as long as the engine is idling. The circuit works well for the electromagnetic compressor clutch found in most cars.

Compressor drop-out and pull-in are controlled by an operational amplifier that is connected as a Schmitt trigger and that drives a series bipolar switch. When engine rpm falls below the drop-out voltage level, which is determined by potentiometer R_1, power is removed from the magnetic clutch. Hysteresis in the Schmitt trig-



ger prevents the clutch from engaging again until the engine rpm is approximately double the drop-out rpm. The simple charge-pump pulse-rate network, consisting of diode D_1, resistor R_2, and capacitor C_1, performs the rpm sensing.

After the circuit is installed as suggested in (b), the drop-out point should be adjusted for optimum performance. To do this, first start the engine and let it idle with the air conditioner turned on. If the compressor clutch is not engaged, turn potentiometer R_1 (in the direction for decreasing rpm) until the clutch engages. Now turn this same potentiometer (in the direction of increasing rpm) until the compressor clutch just disengages. At this potentiometer setting, the compressor should turn on when engine rpm increases to approximately 1,700 and should turn off when the engine drops back to an idle. □



Keeping cool. Control circuit (a) monitors engine rpm and turns off air conditioner when engine drops to idle, preventing stalling or overheating. The operational amplifier is connected as a Schmitt trigger, whose hysteresis provides the voltage differential needed between compressor turn-on and turn-off. A bipolar switch drives the compressor's clutch. The circuit can be installed easily (b).

Digital-to-analog converter is built from low-cost parts

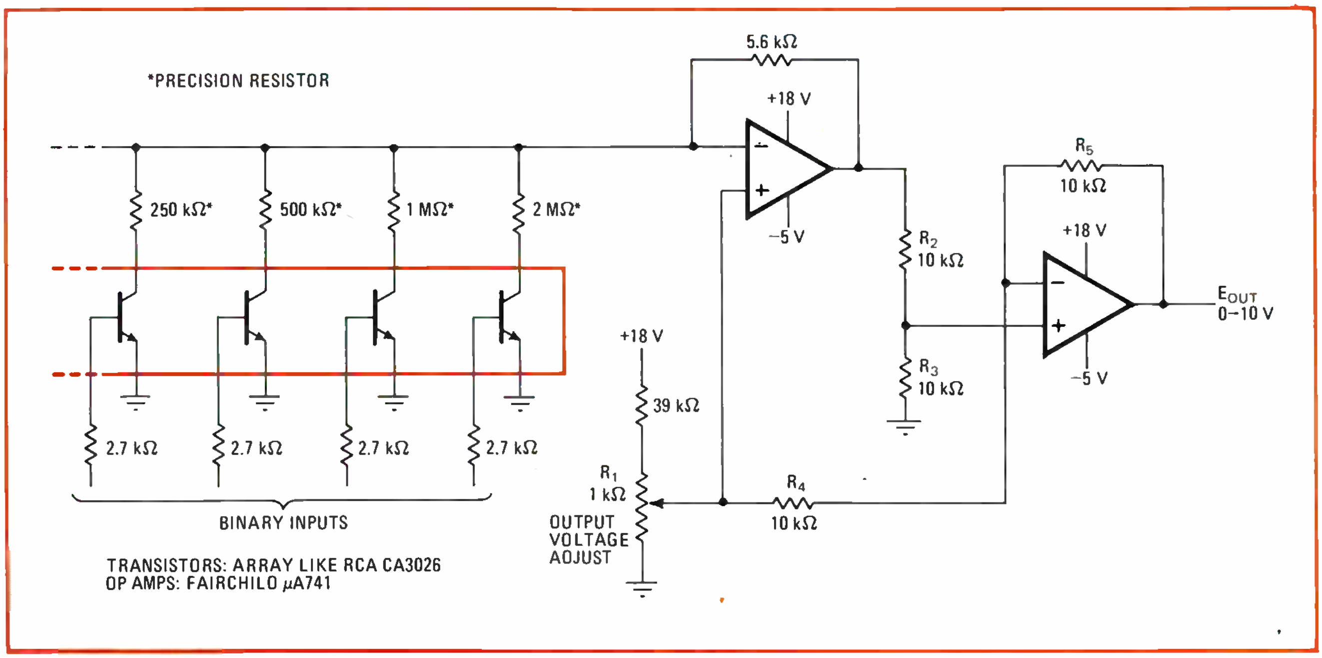
by Phillip J. Storey
Jands Pty. Ltd., Marrickville, N.S.W., Australia

An economical but reliable digital-to-analog converter can be made from readily available IC transistor arrays and general-purpose op amps. The converter is intended to interface with decimal or hexadecimal up/down counters, as well as directly addressed memories. It provides a positive-going output voltage that ranges from 0 to 10 volts and that can be used to control audio attenuators or light-dimmer units.

Each input transistor clamps its precision resistor to ground when a binary bit is applied to that input line. Input words can be up to 8 or 12 bits in length. Potentiometer R_1 allows the maximum output voltage to be varied about the nominal 10-V level. Additionally, as long as resistors R_2 through R_5 have at least a 1% tolerance, the output dc offset voltage will be only on the order of millivolts.

The converter works best within the frequency range of 3 hertz to 1 kilohertz, but can operate at clock rates as high as 100 kHz. However, output glitches become evident at the faster clock rate. □

Designer's casebook is a regular feature in Electronics. We invite readers to submit original and unpublished circuit ideas and solutions to design problems. Explain briefly but thoroughly the circuit's operating principle and purpose. We'll pay $50 for each item published.



Ready-made DAC. This digital-to-analog converter can almost be put together from a spare-parts box, since it is made up of components that are usually right on hand. Input words can be 8 or 12 bits long, and the positive-going analog output varies from 0 to 10 volts. If 1% resistors are used in the output stage, the output offset voltage is within millivolts of zero without any prior adjustment.

How optoelectronic components fit in the optical spectrum

As optoelectronic applications multiply, optical sources, detectors, and transmission media are becoming increasingly available; this guide relates the more important of them by their operating wavelengths

by Lyman Hardeman, *Communications & Microwave Editor*

☐ Many optoelectronic devices that till recently were the playthings of a few curious researchers have by now become standard building blocks to a good many design engineers. And as the growing demand further lowers prices, still more EEs will want to exploit the interaction of light and electronics in industrial and consumer as well as military equipment.

A convenient approach to surveying the optoelectronic technologies and devices that are available today is to categorize them as optical sources, optical detectors, and materials through which optical waves are transmitted. The portion of the electromagnetic spectrum over which they function extends from ultraviolet wavelengths of a few nanometers, through the visible spectrum of about 400 to 700 nm, and far into infrared wavelengths that measure up to tens of thousands of nanometers (see foldout chart on p. 115).

Optical sources

The most important sources of light are the sun, various man-made lamps, lasers, and light-emitting diodes.

The sun operates as a blackbody, or thermal, radiator which emits broadband optical energy due to its inherent temperature. But in fact any substance is a blackbody radiator and emits light with a peak intensity that gets stronger and shorter in wavelength as temperature increases (see Fig. 1). At room temperature (300° K), the wavelength of peak light intensity of a blackbody radiator is about 10 microns (micrometers), while at 6,000° K, the peak occurs around 0.5 μm. The sun's peak corresponds to a temperature of 5,900° K.

Tungsten lamps are the chief sources of man-made visible light based on blackbody radiation principles. Depending on the amount of electrical power dissipated across its filament, the typical lamp will radiate with a blackbody temperature ranging from 2,500° K to over 3,000° K. The broadband nature of this radiation, however, is the major factor that reduces the lamp's over-all efficiency in the visible spectrum to only about 3%.

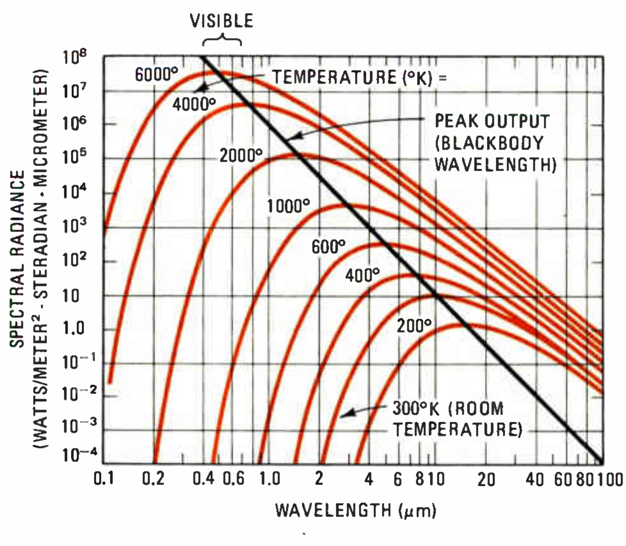
Thermal radiators are also very important in infrared applications—and becoming more so as the security barrier imposed on military infrared technology in World War II has gradually been lowered. In the last few years, many nonmilitary applications have emerged that exploit the natural infrared radiation of such sources as thermally polluted water, diseased crops in a field, or forest fires. In these applications, the sources are blackbody radiators and serve as inputs for highly sensitive remote sensors placed in aircraft or satellites.

Other artificial light sources include arc and glow discharge lamps, and fluorescent tubes. Almost all of these lamps emit in or near the visible spectrum, and each has its own applications niche. The arc and glow discharge types, for instance, are generally efficient sources of high-intensity light that serve both as illuminators in the visible spectrum and as exciters for laser sources.

Coherent sources

The only source of coherent light—the laser—yields extremely high radiance. But of the hundreds of different types of lasers that have been evaluated since the device was first shown to work in 1960, only a few have left the laboratory and entered general use.

Today's most common lasers are based on gasses such as carbon dioxide, helium-neon, argon, and krypton, or else are solid-state, using mainly either gallium-arsenide semiconductors or neodymium-doped yttrium-alumi-



1. Blackbodies. Substances emit broadband electromagnetic energy depending upon their temperature. At room temperature, the wavelength of peak intensity is in the infrared region, at about 10 micrometers, while at 5,900°K (about the temperature of the sun) peak intensity falls at just about the middle of the visible spectrum.

TABLE: LASER SUMMARY				
TYPE	PRIMARY WAVELENGTHS (μm)	TYPICAL EFFICIENCY (%)	TYPICAL POWER (W) CW/PEAK	COMMENTS/PRINCIPAL APPLICATIONS
Argon	0.49 0.52	0.1	5/100	Emits at visible blue-green; used in cutting films in artwork design; efficiency and wavelength make it useful as pump for dye lasers for tuning in the visible spectrum.
He-Ne	0.63 1.15 3.39	0.01	0.1/2	Primary spectral line at 0.63 micrometer convenient and inexpensive source of red light for precision distance measuring, communications, and plasma physics studies.
Nd: YAG	1.06 1.30	3	50/1,000	High-power laser that is easy to control; used in cutting and welding and has potential in communications.
CO_2	10.6	20	200/75,000	Practical high-power laser; used extensively in cutting and welding; possible source for nuclear fusion
HeCd	0.44 0.33	0.5	0.1/2	Recently became commercially available for applications requiring blue light; is being considered for use as light source in facsimile equipment.
Ruby	0.69	1	5/50	Material used in first laser demonstrated in 1960; used some in cutting and melting.
GaAs	0.91	1	0.04/1	Promising solid-state laser for communications, but must improve reliability.
Krypton	0.64	0.1	5/100	Source of red and green light.

num-garnet. Primary operating wavelengths of each of these sources, along with their main application features, are summarized in the table.

Lasers are finding the bulk of their commercial applications in manufacturing and the construction industry. Here, they are useful for drilling holes, cutting, measuring precise distances, and surveying. But as optical component performance and modulation techniques advance, lasers will be used more in such areas as communications, optical data storage, and pollution control.

LEDs offer lower costs, higher speed

Light-emitting diodes have also made remarkable inroads the last few years. They are found in displays for everything from digital panel meters to pocket calculators. Their low cost, high reliability, and switching speeds on the order of a few tens of nanoseconds also make them attractive for use in optical isolators and as transmitters in fiber-optic communications systems.

While light-emitting diodes can be made from many semiconductor materials, gallium-arsenide-phosphide and gallium-phosphide diodes are much the most advanced. The wavelength of GaAsP LEDs can theoretically be varied from about 560 to 910 nanometers by growing crystals of varying ratios of concentration of arsenide and phosphide. But practical GaAsP devices—those used in most of today's LED displays—are constructed to operate in the red region, at 655 nanometers, a wavelength that represents the optimum tradeoff between the device's operating efficiency and the response of the human eye. Bandwidth of the light emitted from GaAsP devices is approximately 30 nm.

GaP diodes, however, are being made in increasing quantities, for green and yellow as well as for red displays. GaP is always doped, partly to increase its illuminating efficiency and partly to extend the bandwidth or alter the wavelength of the light it can emit. Doped with nitrogen, it will emit a broad range of wavelengths in the green and yellow portion of the visible spectrum. Doped with zinc-oxygen, it emits red light.

Another important type of LED is made from GaAlAs and is found in fiber-optic communication systems. The operating wavelength of this semiconductor is determined by the particular combination of aluminum and arsenide chosen. In these devices, practical efficiencies of approximately 3% are achieved over a range of wavelengths from 800 to 900 nm.

Optical detectors

Light sensors fall into three basic categories—photoemitters, photoconductors, and junction devices. In addition, several broadband temperature-sensing devices, such as the thermocouple, bolometer, and Golay cell, are used in light measurements, but these serve mainly laboratory and calibration purposes.

The photoemissive-type light sensor measures light by converting the energy of incident photons directly into free electrons, which are then accelerated in a vacuum under a strong electric field. Applications are chiefly in the visible and ultraviolet region—examples are the photocathode coating at the input of photomultiplier tubes, image-converter tubes, and low-light-level image intensifiers.

The more popular photoemissive materials today are silver-cesium oxide (AgCsO), cesium antimonide (CsSb), potassium-cesium-antimonide (K-Cs-Sb, referred to as a bialkali photoemitter) and sodium-potassium-cesium-antimonide (Na-K-Cs-Sb, a trialkali). Recently, GaAs photoemitters have become available and have stirred much interest among electro-optic system designers mainly because of their high sensitivity, especially at wavelengths between 600 and 900 nm.

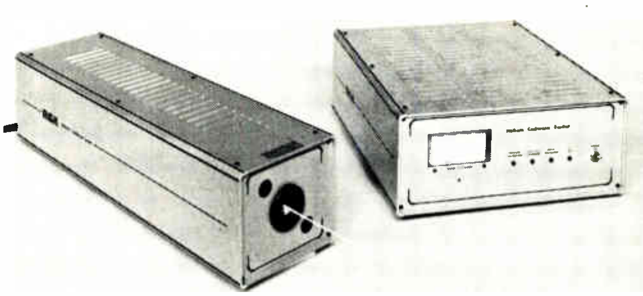
A convenient measure of performance of a photoemissive-type detector is its quantum efficiency, or ratio of output electrons to input photons. The theoretical maximum of one electron per photon defines a quantum efficiency of 100%. The quantum efficiencies for several commercially available photoemissive materials are plotted in Fig. 4 as a function of wavelength. The S-code numbers refer to standard devices defined by the Electronic Industries Association.

Both the quantum efficiency and the long wavelength cutoff of a photoemitter are determined by the semiconductor material it uses. Short wavelength cutoff is determined primarily by the cutoff wavelength of the window material through which light must pass before interacting with the photoemitter in a vacuum.

Photoconductors for longer wavelengths

As seen in Fig. 4, most photoemissive materials have a long-wavelength cutoff near the infrared edge of the visible spectrum, in the 600-800-nm region. Photoconductive-type detectors extend these detectable wavelengths well into the infrared range.

In a photoconductive detector, incident photons cause an increase in the current from an external biasing circuit to flow through the detector. The detector



2. Commercial lasers. Numerous lasers have been introduced in the past few years at prices below $3,000. The He-Cd unit shown can be operated at one of two spectral outputs (442 nm or 325 nm) and is expected to find applications in facsimile recording systems.

may be either intrinsic, with its sensing properties inherent in the photoconducting material itself, or extrinsic, in which case one material—usually germanium—is doped with one of a group of elements to make it sensitive to light at longer wavelengths.

Intrinsic photoconductors include lead sulfide (PbS), lead selenide (PbSe), indium arsenide (InAs), and indium antimonide (InSb), all of which operate in the visible spectrum and to longer wavelengths out to about 3 to 5 μm at room temperature. The long-wavelength sensitivity of these detectors is increased when they are cooled to the temperatures of dry ice and liquid nitrogen. InAs and InSb are generally more expensive than PbS and PbSe, but take only microseconds instead of milliseconds to turn on.

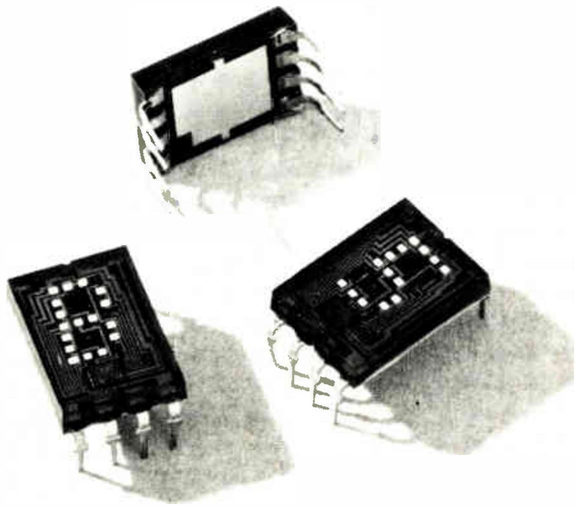
For applications in the visible spectrum—in camera light meters, home furnaces, and automatically operated street lights—cadmium sulfide (CdS) and cadmium

Photometry-radiometry units

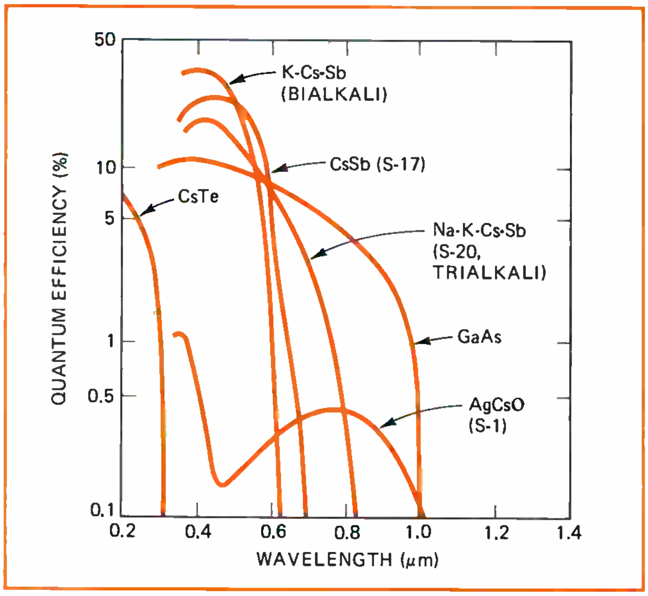
The many terms that have been developed to define properties of propagating radiant energy are summarized in the table. For a detailed discussion of the units of photometry (light radiation normalized to the response of the human eye) and radiometry (radiation at any spectral frequency), and how these quantities are measured, see *Electronics*, Nov. 6, 1972, p. 91.

Definition	Radiometric			Photometric		
	Name	Symbol	Unit*	Name	Symbol	Unit*
Energy	radiant energy	Q	joule	luminous energy		lumen-s
Energy per unit time=power=flux	radiant flux	P	watt	luminous flux	F	lumen
Power input per unit area	irradiance	H	W/m^2	illuminance	E	lm/m^2 (lux)
Power output per unit area	radiant exitance	W	W/m^2	luminous exitance	L	lm/m^2
Power per unit solid angle	radiant intensity	J	W/steradian	luminous intensity	I	candela
Power per unit solid angle per unit projected	radiance	N	W/m^2 steradian	luminance	B	candela/m^2

*All units are metric.



3. Display breakthrough. Advances in semiconductor production techniques in the last few years have helped bring down the costs of GaAsP and GaP light-emitting diodes so that they are now widely used for display applications ranging from digital panel meters to pocket calculators. Recent alphanumerical digits come in many colors and sizes, some with built-in drive circuitry.



4. Photoemitter response. Photoemitter-type detectors are used at untraviolet and visible wavelengths. Material performance is typically compared in terms of quantum efficiency—the ratio of actual electron output to the maximum output possible determined by photon flux. S-code numbers refer to standards designated by the Electronic Industries Association.

selenide (CdSe) are also used extensively and are supplied by several manufacturers. CdS has the greater sensitivity, CdSe responds at longer visible wavelengths, and both function at room temperature.

Two other intrinsic photoconductors—mercury cadmium telluride (Hg-Cd-Te) and lead tin telluride (Pb-Sn-Te)—have been developed more recently as detectors to operate to wavelengths out to about 14 μm when cooled to liquid-nitrogen temperatures (77° K). Such a spectral response makes these detectors attractive for use with the CO_2 laser, which emits at 10.6 μm.

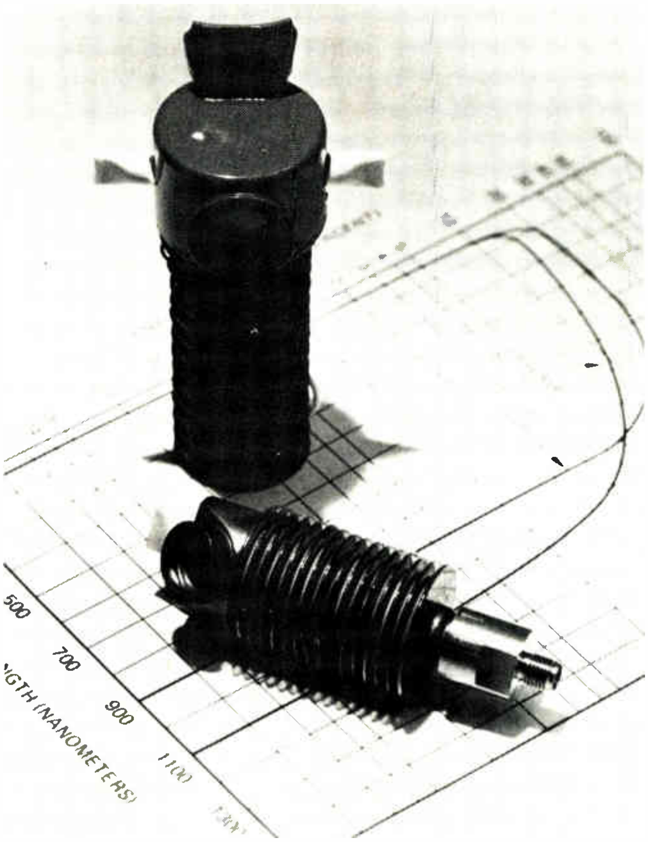
Extrinsic photoconductors must usually be cooled to liquid-nitrogen temperatures or cooler and can be sensitive at still longer infrared wavelengths. Most practical extrinsic photoconductors employ a germanium host crystal. Depending on dopant and operating temperature, infrared wavelengths to over 100 μm can be detected (see foldout chart).

Junction-type detectors

Light-sensing devices that depend on a semiconductor pn junction include photovoltaic devices, photodiodes, and phototransistors. In the photovoltaic sensor, a voltage is generated across the junction as a function of the light impinging on the junction. The photovoltaic cell, or simply photocell, is usually made of selenium or silicon and is most notably used in space, where the relatively high cost of the device is offset by the fact that it is the only self-generating light sensor available (i.e., one that requires no external power supply).

Photodiodes and phototransistors are finding increasing popularity at visible wavelengths. Because of their faster response and the high gains achievable when biased in a transistor circuit, these devices are competing more and more with photomultipliers operating to wavelengths as long as about 1.1 μm.

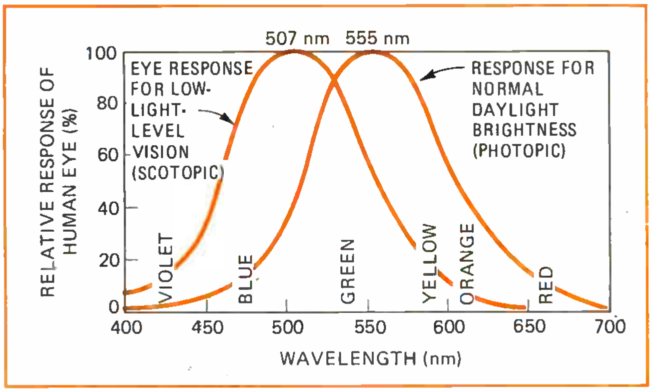
5. Photomultiplier edge. To stay half a step ahead of recent developments in solid-state detector technology, makers of photomultiplier tubes have recently introduced units with improved photocathode materials to achieve unprecedented combinations of speed, broad bandwidth and high quantum efficiency. Applications include optical-character readers and fiber-optic communications.



Reverse-biased silicon photodiodes typically respond to reset times of about 100 ns. Other semiconductor materials, including germanium, indium arsenide, and mercury-cadmium-telluride, are also used in making photodiodes, mainly to extend response to longer wavelengths, but often at a loss in response speed.

Seeing the light

As evident in the spectrum chart and the discussion so far, the wavelengths to which the human eye is sensitive form a middle reference area in the over-all optical spectrum. As a photodetector, the human eye has some peculiarities that become important in the context of photometry.



6. Day and night. Peak optical response of the human eye shifts about 50 nm as the eye adjusts from the brightness of normal daylight (photopic vision) to nighttime starlight levels (scotopic vision). There is no color perception under scotopic conditions.

The retina contains two types of receptors, responsive to two different ranges of wavelengths (Fig. 6). In daylight, one set of receptors responds to wavelengths from about 400 to 700 nanometers, with a peak response centered in the green region at 555 nanometers. This is the eye's light-adapted or photopic response.

When adapted to darkness, the other set of receptors comes into play, with a peak response at 507 nm. This dark-adapted or scotopic eye is color-blind, whereas the light-adapted eye is able to discriminate between color wavelengths. Photometric units of light intensity (see "Photometry and radiometry defined," p. 111) are weighted by the photopic eye's normalized response.

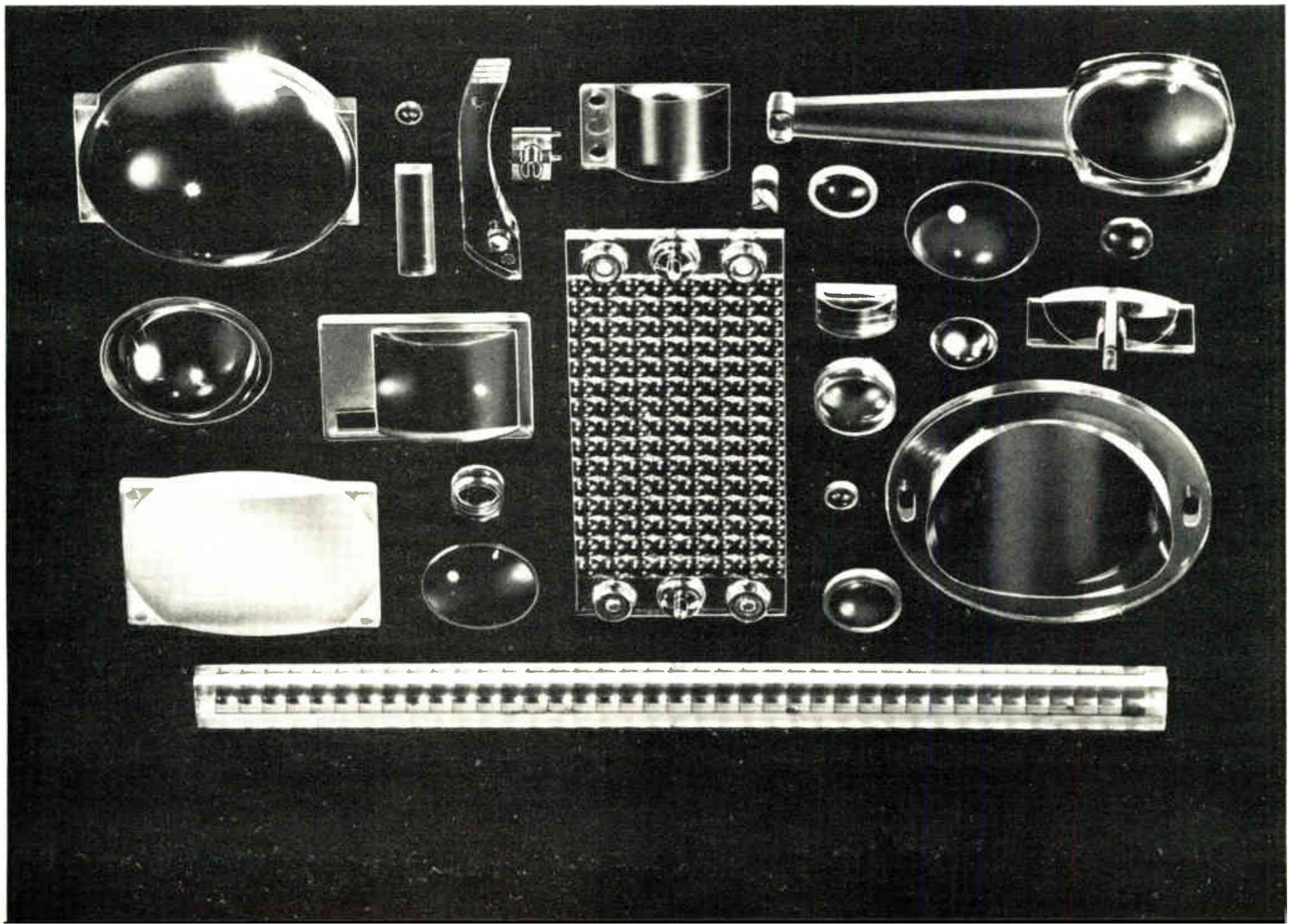
Transmission materials

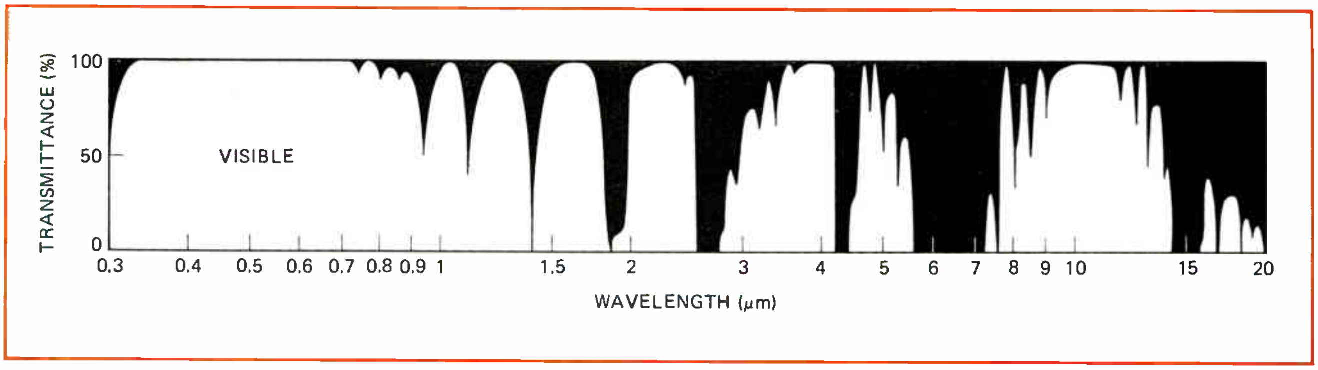
Light travels between a source and a detector through a transmission medium which may substantially alter the light's properties and usually passes only a portion of the optical spectrum. Transmission materials include glass, plastics and other transparent compounds, and function as protective windows, lenses, or optical filters.

In the visible portion of the spectrum, common soda-lime glass is used extensively as a window material. Its transmittance is very nearly 100% over the entire visible range, but falls off quite rapidly on each end (30% transmittance cutoff points are approximately 350 and 3,000 nm).

Injection-molded plastics, however, are ousting glass in many applications in the visible spectrum [*Electronics*, July 3, 1972, p. 77]. While plastic is more susceptible to temperature and abrasion than glass, its low cost of

7. Plastic optics. For an increasing number of production applications, the low cost of molded plastic lenses and windows more than offsets their high-performance limitations when compared to glass or other optical transmission materials.





8. Atmospheric windows. Transmittance through 1,000 feet of atmosphere is high throughout the visible spectrum, but periodically falls to zero in the infrared region between 1 and 20 micrometers. Window from about 8 to 13 μm is region of special interest to equipment designers; it peaks at about 10.6 micrometers, which is also the wavelength of the CO_2 laser.

production more than compensates for these limitations in many commercial and industrial electro-optic systems. The most popular plastics—acrylic, polystyrene, and polycarbonate—transmit over the entire visible spectrum, and some plastics become transparent again at the very long infrared wavelengths past 50 to 100 μm.

Widening the window

Since glass and plastic are opaque to ultraviolet wavelengths below about 350 nm, more exotic window materials must be found for equipment operating in the ultraviolet region. For this purpose, fused quartz, sapphire, and lithium or magnesium fluoride are commonly used.

Fused quartz passes ultraviolet wavelengths as low as 180 nm, besides being transparent at all visible wavelengths. It is relatively inexpensive and is commercially available from several manufacturers. Sapphire (Al_2O_3) and lithium fluoride (LiF) are more expensive. Sapphire is the most abrasion-resistant of all windows and has good ultraviolet transmitting properties to 180 nm, and lithium fluoride is most attractive for applications requiring transmittance at wavelengths down to about 104 nm.

As for far-infrared wavelengths beyond about 4 μm, one optically good material is sodium chloride, NaCl. Windows or lenses made of NaCl transmit IR wavelengths to a little beyond 20 μm, but because they absorb moisture from the air, must be frequently replaced or stored in dessicators to keep them dry.

A more durable group of IR transmission materials is the commercially available line called Irtran, developed by Eastman Kodak Co. The spectral transmittance of these materials is approximated on the foldout chart, and they are made of MgF_2, ZnS, CaF_2, ZnSe, MgO, and CdTe respectively for Irtran-1 through Irtran-6.

Other infrared-transmitting materials include barium fluoride, cesium iodide, and thallium bromide. Barium fluoride is often used in systems operating at 10.6 μm, the wavelength of frequently used CO_2 lasers. Cesium iodide and thallium bromide both transmit at wavelengths to about 50 μm.

Atmospheric properties

Depending on its wavelength, light energy is selectively scattered, absorbed, or refracted as it passes through the earth's atmosphere. These effects can be severe in optical communications, infrared radiometry, and, in fact, viewing by the human eye, whenever the atmospheric path extends more than just a short distance.

For gas molecules and particles that are extremely small in relation to the light wavelength, the degrading process is known as Rayleigh scattering. Such scattering is the cause of the blue of the midday sky and the red of sunsets. Rayleigh scattering is wavelength-dependent, increasing with shorter wavelengths, and it has a negligible effect on infrared wavelengths longer than about 1 μm.

For larger aerosol particles, the process is called Mie scattering and is relatively independent of wavelength. The nonselective nature of Mie scattering is what makes fog and clouds appear white. Its effect on visibility is to reduce contrast to the point where an object's outline can no longer be resolved. Visibility in haze, then, is commonly defined as the distance at which contrast is reduced below 2%.

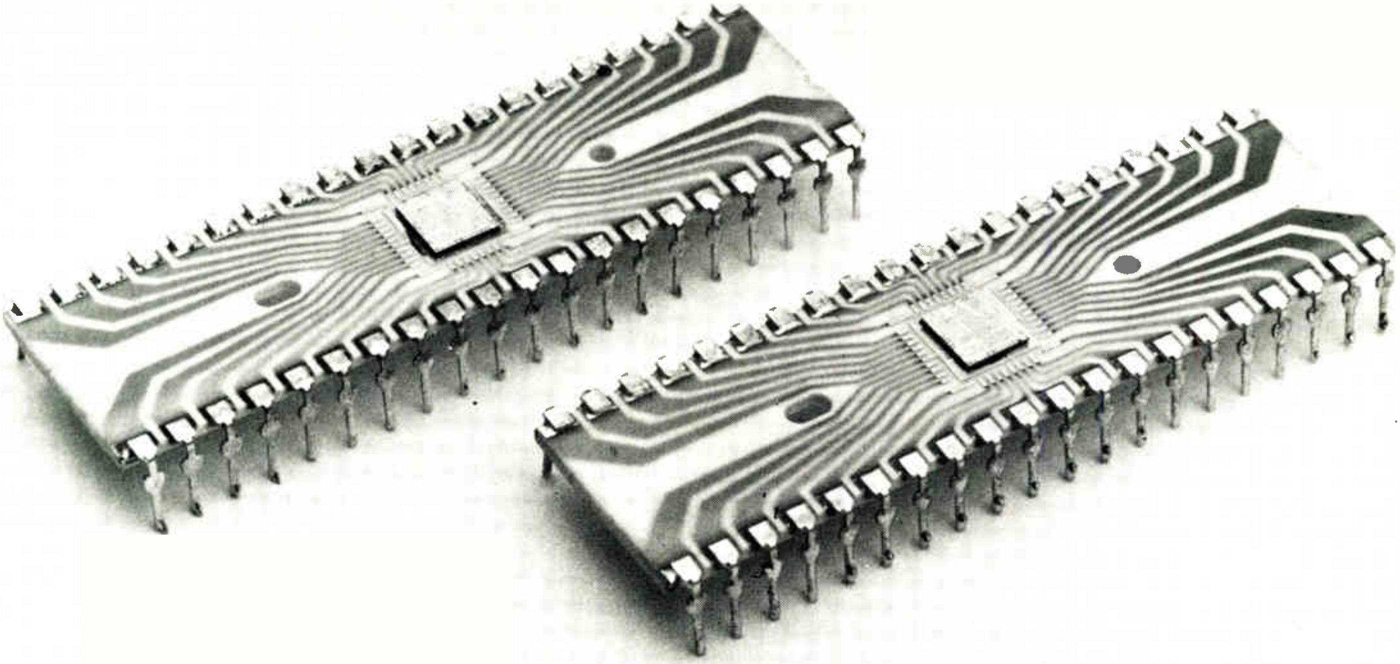
Attenuation through the atmosphere is never constant. It depends on such parameters as temperature, pressure, and amount to water vapor and other impurities. However, a typical attenuation as a function of wavelength is shown in Fig. 9. The attenuations shown are for a 1,000-foot atmospheric path, at sea level, containing relatively little moisture and impurities. The curve identifies the important atmospheric window in the visible region from 400 to 700 nm. It also shows the 6-μm-wide window centered at about 11 μm, which is of much current interest to infrared systems designers.

Tight fit

In conclusion, it's interesting to note the relationship between the (humanly speaking) most important source, detector, and transmission medium found in nature. The peak spectral output of the sun (about 555 nm) coincides with the center of a major optical window in the earth's atmosphere. The peak response of the human eye is conveniently adapted to this wavelength. □

ACKNOWLEDGMENT

Electronics gratefully acknowledges the assistance of the numerous individuals, especially technical staff members at Bell Telephone Laboratories, Murray Hill, New Jersey, and at RCA's David Sarnoff Research Center, Princeton, New Jersey, who provided inputs for this report and the foldout chart that follows.



Single-layer packaging slashes ceramic-DIP costs in half

By eliminating two layers of material from the traditional package, device manufacturers are reducing the costs and boosting the reliability of the resulting ceramic packages

by James Barnett, *American Microsystems Inc., Santa Clara, Calif.*

☐ A new ceramic packaging technique offers the integrated-circuit manufacturer the best of two worlds—the cost advantage of plastic and the reliability of ceramic. The package is a single-layer ceramic structure, rather than the traditional three-layer configuration, and the id is sealed by epoxy (Figs. 1 and 2).

The single layer of ceramic means a cheaper package, nd adhesive sealing assures that the package can be used in the event that an assembled device proves to : defective. The cost of a reliable 24-lead ceramic ckage has been cut to about half the cost of the three-er package—and cumulative package yield has been reased from 0.70 to 0.95. Finally, test results, which e conducted according to applicable military re-ements, are so promising that manufacturers hope new packaging concept will meet the stringent spec-tions of military applications.

ie new package, termed SLAM (for single-layer met-tion), has proved to offer as good or better environ-al and performance characteristics than the current try standards. Better yet, this new package can be ssed with existing production equipment. And the sary ancillary equipment costs a good deal less vhat would be required to convert to other competing packaging techniques—including plastic.

Single-layer packages in several different product types were evaluated with about an equal number of three-layer-packaged devices for control to determine the field reliability that could be expected. Only one single-layer device failed in more than half a million hours of tests. Analysis indicated that the failure was caused by electrical-test damage and not by any inherent deficiency in packaging.

1. Cost-cutter. Single-layer ceramic package, shown above in a 40-lead version prior to wire bonding and sealing, reduces ceramic content and eliminates processing steps required in a three-layer structure, lowering price in volume by about 25%. The reputation of ceramic packages for reliability is retained.

Down-bonding

Abandoning the traditional triple-layer package meant that the bonding geometry was also changed. In the conventional DIP (Fig. 3a), each lead wire leaves the chip and rises to the same or to a slightly higher elevation to attach to the lead frame. But in the single-layer package, the top surface of the die becomes the highest point in the unsealed package (Fig. 3b). Since the lead

SINGLE-LAYER vs THREE-LAYER PACKAGE A COST COMPARISON Cost items / 24-lead packages	Three-layer ceramic	Single-layer ceramic
Package cost from supplier Lid	$.70 .05 (Kovar)	$.50 .02 (alumina-ceramic)
Materials subtotal	$.75	$.52
Typical cumulative yield at final test	0.7 (eutectic-sealed lid)	0.95 (adhesive-sealed lid)
Yield cost	$1.07	$.55

descends from the chip surface to the substrate floor, lead attachment is called down-bonding. To prevent short circuiting, the edge of the wire must be prevented from touching the scribe line at the die edge.

The wire is bonded first to the package-lead metalization and then to the die pad. The bonding tool preloads the wire, thereby developing a compressive force upon the package-lead metalization bond (Fig. 3c). This improves the strength of the bond.

SLAM measures up

Test results have disclosed no bond failures. Pull strength is comparable to that of conventional bonds, within experimental limits. After the final seal heating, it was found that three-layer packages experienced a 40% decrease in average bond strength versus a 20% decrease for the adhesive-sealed, single-layer package.

The bonds were also temperature-cycled and subjected to thermal shock tests in accordance with the tough MIL-STD 883, Condition C, Method 1011. The test requires temperature cycling 200 times from −65°C to +150°C, liquid-to-liquid. Again, there were no failures of the 5,760 bonds in the 67 devices tested.

Two methods of sealing the die cavity were developed. In an earlier method, a plated Kovar ring was placed about the periphery of the package cavity, and a conventional gold-plated Kovar lid was soldered to it. Hermeticity tests, which were conducted according to MIL-STD 883 at 10^{-8} atmosphere cubic centimeters/second and beyond, showed no signs of leakage. But, despite the success of the tests, further reductions in component and processing costs seemed possible. Accordingly, epoxy-sealing was attempted and found to achieve the desired objectives.

However, epoxy attachment of a ceramic lid required that chip contamination be avoided. After an intensive search, in which hundreds of epoxy glues and sealants were examined, researchers finally found an epoxy that not only is contamination-free, but it also provides a hermetic seal equal to the metal seals.

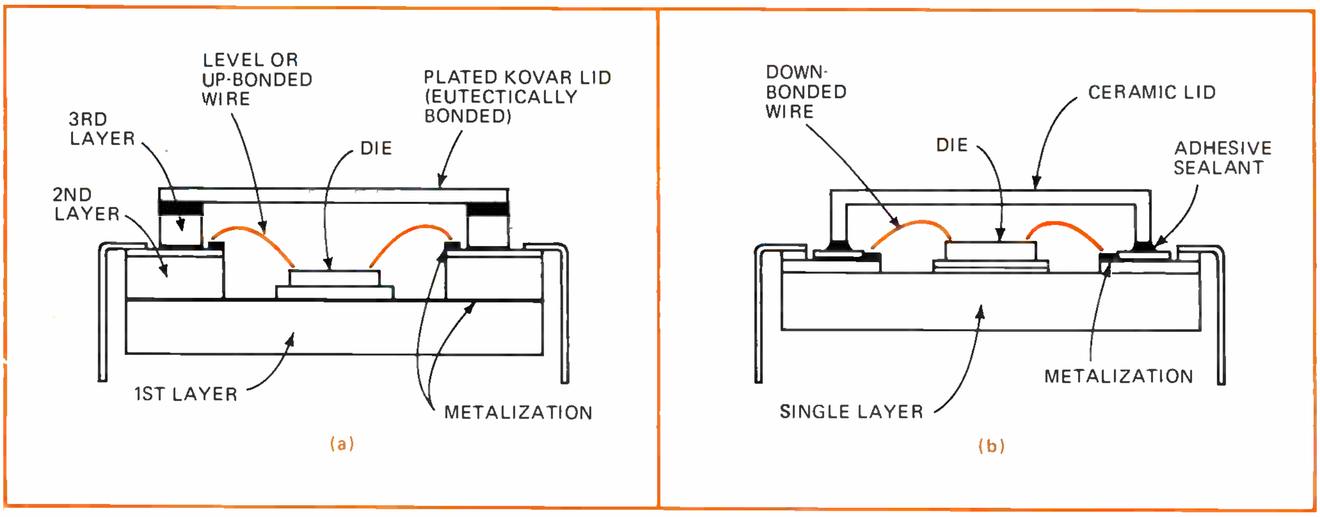
Long-term reliability testing has disclosed no detectable difference between the field performance of the epoxy-sealed device and the device sealed by soldered metal. In addition to the cost advantage of the epoxy ceramic lid, 2 cents vs 5 cents, bond wires cannot short to the nonconductive lid.

Seal passes shear tests

Customer skepticism as to the ultimate strength of an epoxy seal stimulated an investigation of ultimate shear strength. A shear load of 200 pounds per square inch, applied at the edge of the lid, failed to produce detectable lid movement with respect to the substrate. Any failures of devices subjected to this test were not caused by broken seals. And subsequent hermeticity-testing of these devices disclosed no loss of seal performance.

Would the epoxy adhesive degrade circuit performance? In worst-case tests, passivated devices were first sealed conventionally and tested for control purposes. Single-layer packages with chips protected by vapor-deposited passivation and unpassivated chips in both metal- and adhesive-sealed packages were tested for performance, reliability, and device contamination. A

2. Fewer layers. Three-layer package (a) and new single-layer package (b) are shown in cross-section. Note that the die no longer sets in a cavity in the single-layer package. Bonding wires descend from the chip to the package floor. This is known as down-bonding.



Single-layer DIPs are available

American Lava Corp. has tooled for a limited volume of 22- and 40-lead ceramic packages. The maximum volume of current facilities is estimated at 200,000 units a month for the 40-lead version.

Kyoto Ceramic Co. is delivering several hundred thousand large-lead-count single-layer packages per month in both side-braze and top-braze lead configurations. Kyoto, which has been building single-layer packages in volume since September 1971, is now tooled for 16-, 18-, 24-, 28- and 40-lead packages and lids.

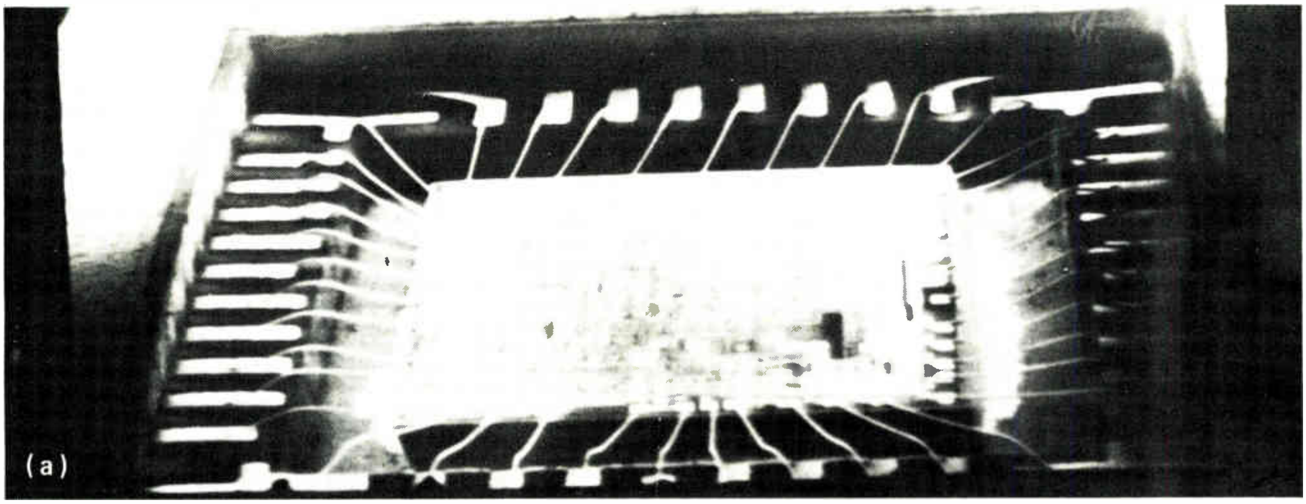
microprobe analysis of the surface of each die after test cycling disclosed that no carbon was detectable in either package type. Absence of carbon confirmed that no significant amount of epoxy migrated from the seal area to the die surface. A more sensitive Auger analysis of dice that had been sealed both ways showed a reproducible carbon-to-nitrogen ratio of 2.7 and 9.2 for the metal and the adhesive seals, respectively.

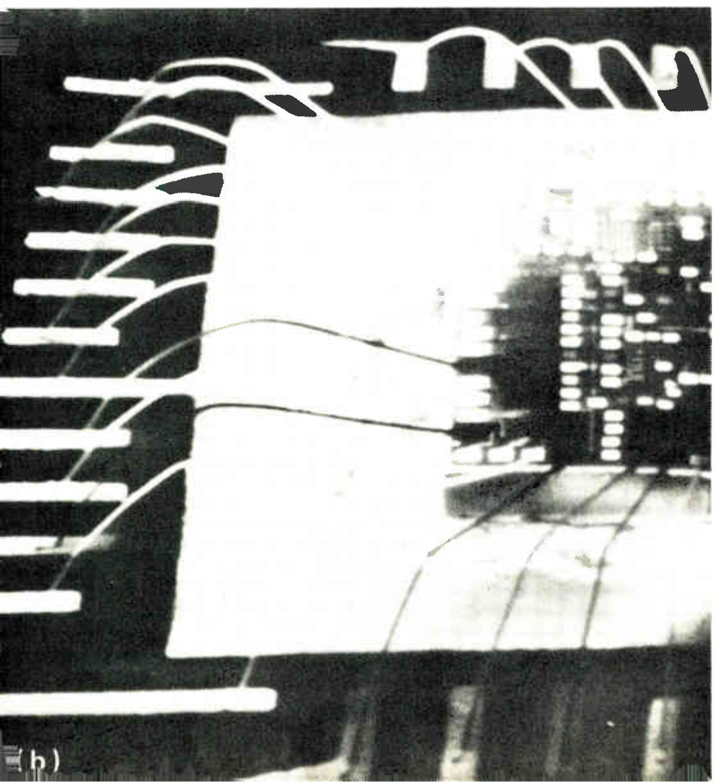
In yet another test, large amounts of epoxy were deliberately placed on the surface of the dice in a lot of single-layer adhesive-sealed packages. The dice were then subjected to a standard C-V (capacitance-voltage vs temperature) test. This test, which would have revealed the presence of migrating ionic species, failed to show any such contamination at temperatures as high as 300°C.

Package reusability

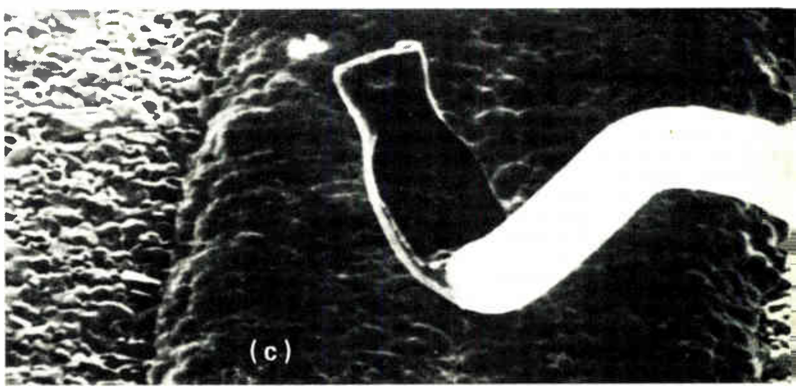
The high yield of the single-layer package (table, p. 120) is a direct result of the reusability of the package. Because the epoxy adhesive can be unbonded and unsealed rapidly, a defective die can be removed and replaced after final test.

Such reusability greatly enhances final yield, as is amply demonstrated in the table in comparing the yield costs for the single-layer and three-layer packages. For three-layer conventional packages, the raw cost might be multiplied by approximately 1.4 to include final test-yield losses, but with the single-layer technique, this factor is only 1.05, again thanks to package and lid reusability. □





3. The old and the new. Microphotograph (a) depicts a three-layer package with leads "up-bonded" from the chip to the metalized pads on the second layer of the package. In (b), chip is attached to a single-layer package. Each bond wire leaves the chip bond pad and forms an arch, which develops a compressive force that enhances the bond strength on the metalized pad on the package floor. The bond interface at the metalized pad is shown further magnified in (c).



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Varying beam thickness in CRT display systems

by P.V.H.M.L. Narasimham
Indian Institute of Technology, Kanpur, India

Though computer-driven CRT displays have many programable parameters, including intensity, blinking, and dashed- or dotted-line generation, beam thickness is not among them, except indirectly through the display's brightness control. Thickness variability can, however, be provided if the control circuit shown is inserted in the display's stroke vector generator. The circuit superimposes equal-amplitude sine and cosine waves on the generator's X- and Y-deflection ramp signals.

When the CRT beam is stationary, the sine and cosine waves produce a circle. As this circle is moved by the generator ramp signals, a straight line with the thickness of the circle's diameter is displayed. The thickness of the stroke can be programed through digital control of the sine and cosine wave amplitudes.

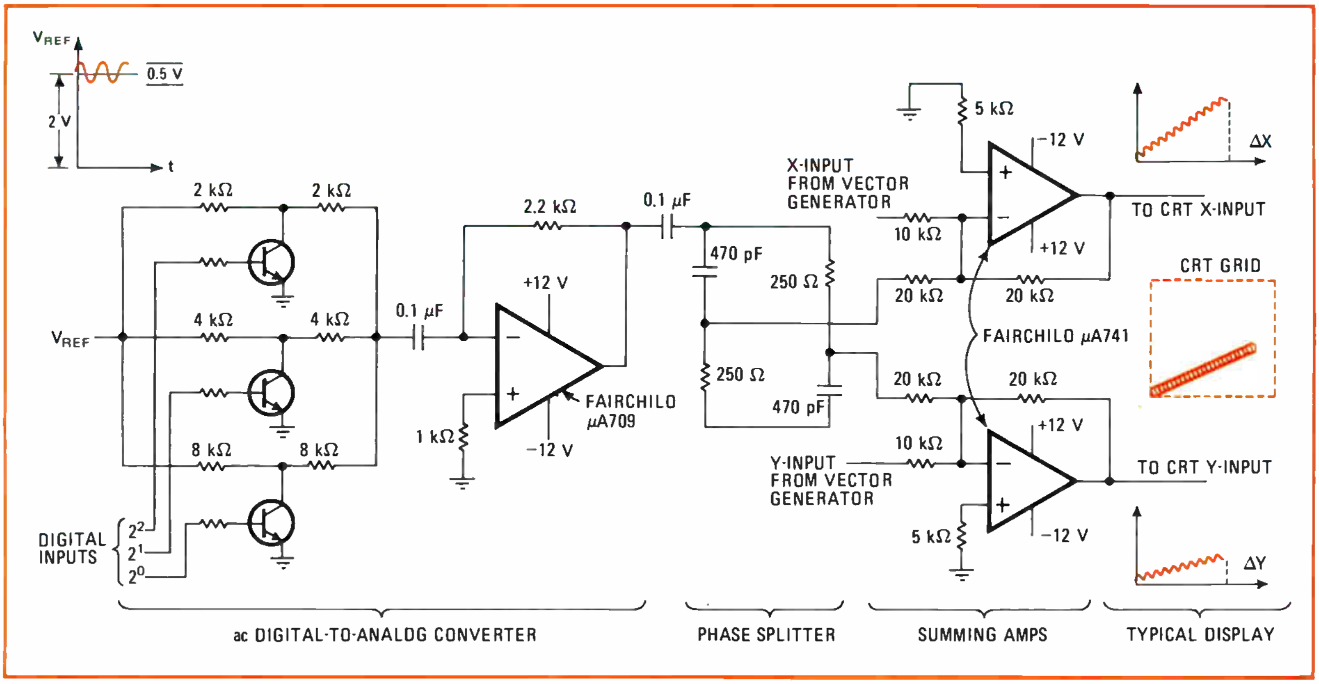
Since a circle is symmetrical, the stroke thickness will be independent of the slope of the stroke. The circles, however, must be closely spaced to prevent ragged edges from being produced in the display. The frequency of the sine and cosine waves, therefore, must be high enough to complete a full circle before the generator ramp signals displace the beam by a distance that is equal to the diameter of the cathode-ray spot.

The stroke vector generator must be the constant-rate type, so that the velocity at which the beam moves over the CRT screen is constant, no matter the length and slope of the stroke being generated. The beam displacement rate for only an X or Y increment is then equal to the displacement rate for any combination of X and Y increments. If the displacement is in either the X or Y direction alone, the corresponding ramp slope will be maximum.

To find the minimum signal frequency of the sine and cosine waves, the maximum X or Y ramp signal slope must be known, as well as the X and Y deflection sensitivity, and the cathode-ray-spot diameter. Suppose these values are 0.01 volt per microsecond, 1 centimeter per volt, and 0.01 cm, respectively. This means that a 0.01-cm displacement can be produced by a 0.01-V signal in 1 μs (for a slope of 0.01 V/μs). The period of a full sine or cosine cycle must then be 1 μs at most, making the minimum signal frequency equal to 1 megahertz. For this case, the maximum stroke thickness is limited to 2.5 millimeters; beyond this, the circles become conspicuous.

In the thickness control circuit given, a 1-MHz sine wave is employed as the reference input to a three-bit digital-to-analog converter, permitting the sine-wave amplitude to be digitally controlled. The phase splitter then produces the sine and cosine waves, which are superimposed on the vector generator's X and Y ramp signals by a pair of op-amp summers. These summing amplifiers drive the X and Y inputs of the CRT display, producing straight-line segments the thickness of which can be varied digitally. □

Controlling display thickness. Circuit converts CRT beam thickness to a digitally programable display parameter. Beam thickness is controlled by superimposing sine and cosine waves to create a circle with a diameter that can be varied in response to a digital input.



Automatic test setup checks thermal resistance

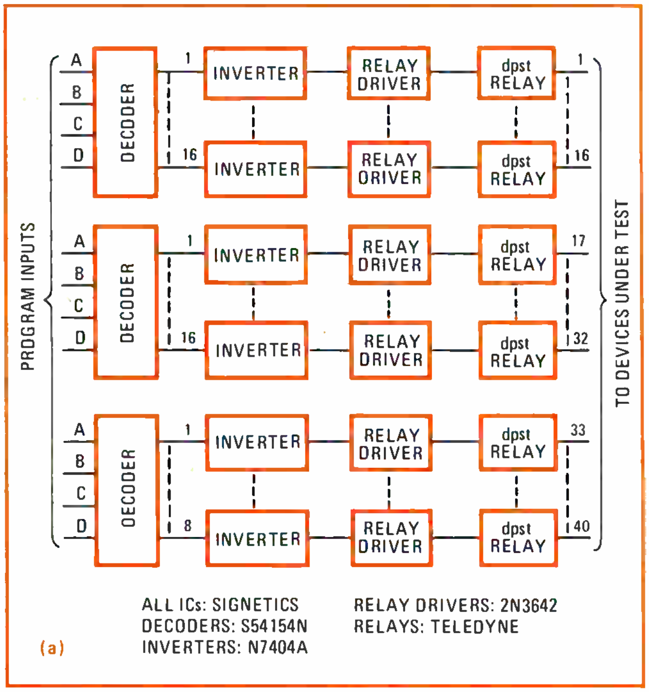
by Robert W. Bolvin
Signetics Corp., Digital Products, Sunnyvale, Calif.

Measuring the thermal resistance of microelectronic devices is usually a tedious one-device-at-a-time operation—it takes a long time to calibrate temperature-sensitive elements, to apply power to individual devices for long stabilization periods, and to calculate the thermal resistance. But with the technique described here, testing time can be cut significantly so that the thermal resistance of 40 devices can be determined in the time it previously took to measure just one device.

The equipment primarily includes an automatic dc digital IC tester, a special sequencer circuit, a modified oven setup, a liquid bath, and a high-current power supply.

The sequencer allows the thermal resistance of a large number of devices to be measured almost simultaneously. As noted in the block diagram (a), three 4-line-to-16-line decoder/demultiplexers interpret the program inputs from the automatic IC tester. These decoders provide a total of 40 output lines, one for each device being tested. Each output feeds a NAND inverter gate, a relay driver transistor, and a double-pole single-throw relay.

The circuit of (b) shows the hookup between the relay and the device under test, which, in this case, is a simple resistor/diode die. When a relay is activated by a program input, its contacts switch from their normally closed position to a normally open one. The test sequence here is designed to find diode slope with changing temperature, as well as forward voltage drop both before and after a power soak period.



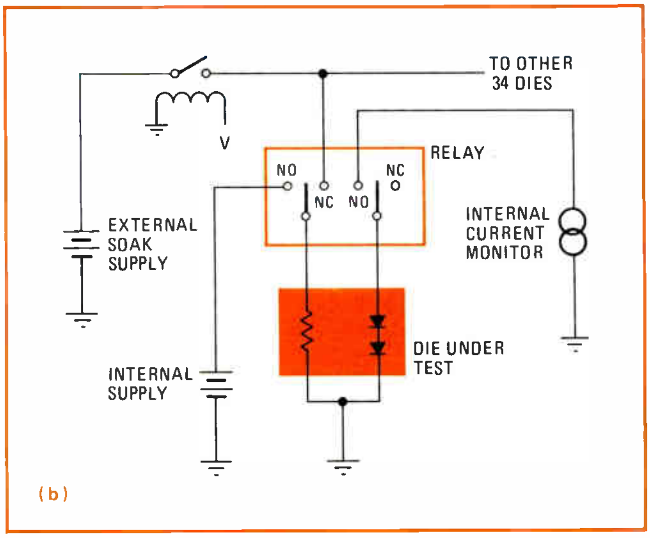
Forward voltage drop is measured at six temperatures covering the expected operating temperature range, and diode slope is measured without any supply voltage applied. The dies are then brought to a specified test temperature for initial forward-voltage readings, before being exposed to a power soak period of 15 minutes. (This is long enough to allow the devices to stabilize at a constant junction temperature.) At the end of the soak period, each device is sequentially removed from the external "soak" supply and re-energized by an internal supply to determine what forward voltage it has because of power dissipation.

All the information needed to compute the slope and thermal resistance of each device is now available: the forward voltage at six temperatures, the initial forward voltage at a specified test temperature, the power applied, and the final forward voltage due to heating from the power applied.

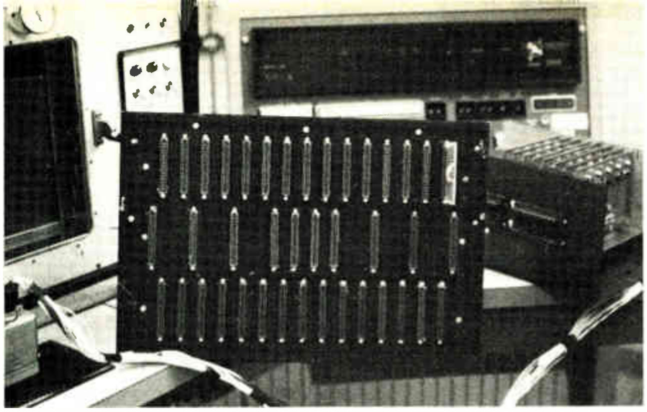
The photos show the special door used for mounting the dies and their holders; it fits the oven and the tub employed for the liquid bath. To find the thermal resistance between a device's junction and ambient temperature, the door is placed in the oven. To measure thermal resistance between junction and case temperatures, the door is placed upside down in the liquid bath. The sequencer circuit is also mounted on the door, but can be removed by disconnecting the edge connectors on the front of the door.

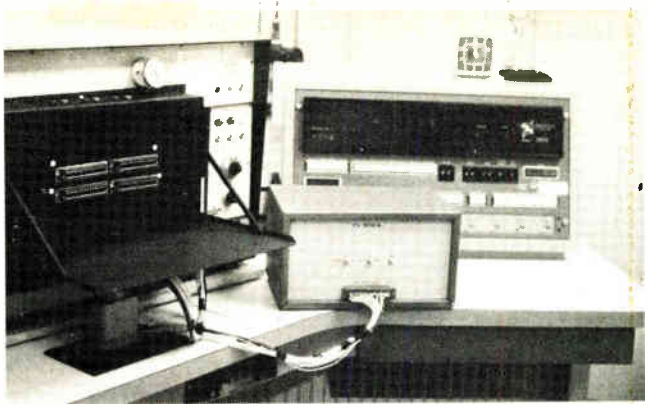
The bath is made up of a stainless-steel tub that rests on two hot plates. Cooling is achieved by forcing carbon dioxide through copper tubing at the bottom of the tub. To obtain high temperatures, from 25°C to 125°C, the liquid used is ethylene glycol; for cold temperatures, from 25°C to −55°C, the liquid is Freon.

Only the extreme tips of the leads to the devices under test should be soldered, so that little or no heat sinking is provided by the solder joints. Also, it is a good idea to put cutouts in the pc board around the holder for each test device, to improve the flow of air and liquid around it. □



Sequencing circuitry. Sequencer (a) enables the thermal resistance of 40 devices to be determined at the same time in response to program commands from an automatic tester. In this case, resistor/diode dies (b) are measured for slope and forward voltage drop.





Mounting. Devices to be tested are mounted on modified door (left photo), which fits an oven (right photo) as well as a heating/cooling bath.

Oscilloscope triggered sweep: another job for IC timer

by Robert M. McDermott

U.S. Army Korea Support Command, San Francisco, Calif.

For less than \$10, you can add a triggered sweep to upgrade the low-cost type of oscilloscope. The circuit, which essentially consists of an IC timer and an op amp, can be powered from the scope's supply and fits on a small pc board that can be placed inside the scope.

When an input signal from the scope's vertical amplifier rises above the circuit's trigger-level voltage setting, the op amp switches, causing its output to go from $+V_{CC}$ to $-V_{CC}$. This voltage change is coupled to the trigger input of the IC timer as a negative spike, which sets the flip-flop and cuts off the discharge transistor.

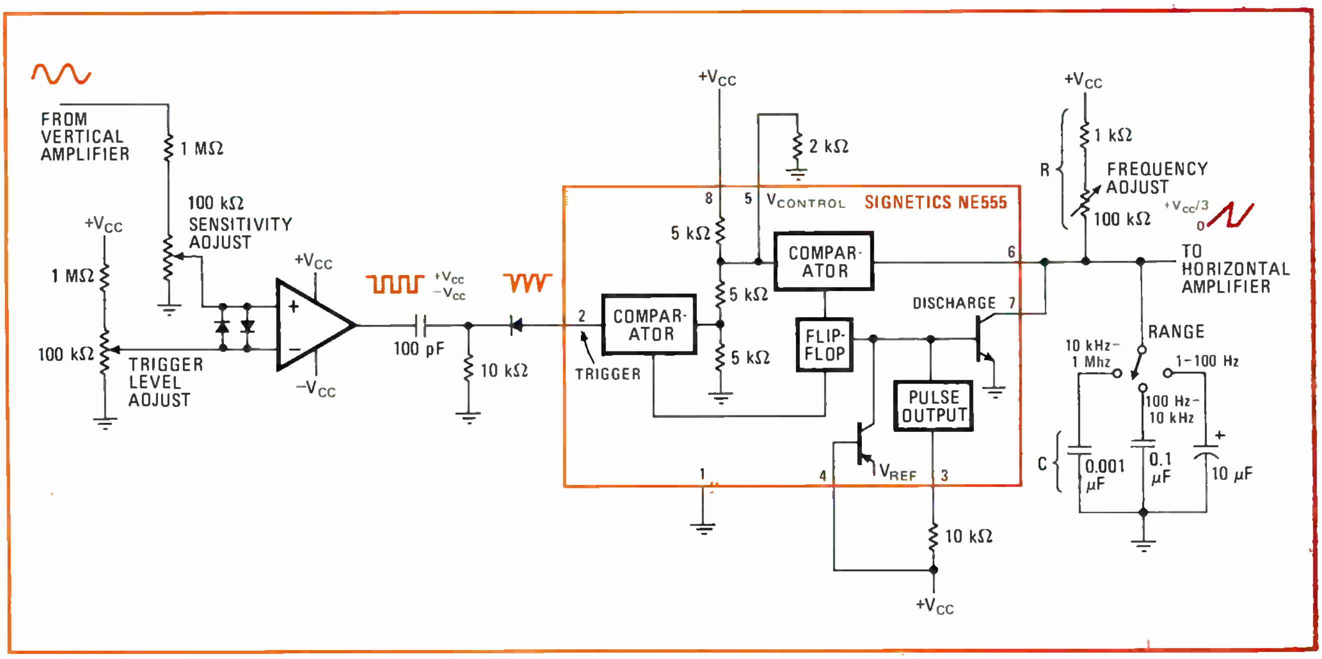
The switch-selected timing capacitor, C, now charges exponentially through timing resistance R until capacitor voltage reaches the level of control voltage existing at pin 5 of the timer. (Timing period is 0.4RC, and control voltage level is $0.33V_{CC}$.) The circuit's output frequency will be 2.5/RC and, in this case, can be varied from 1 hertz to 1 megahertz.

Once capacitor voltage is equal to the timer's control voltage level, the flip-flop resets and the output transistor discharges timing capacitor C. Pulses occurring before the flip-flop resets do not affect the circuit's output voltage. The flip-flop controls the discharge transistor and can only be reset by the timer's comparator, which is operated by the capacitor and control voltages.

Over-all cost can be reduced still further if the variable controls for trigger level and input sensitivity are replaced with fixed components. □

Engineer's Notebook is a regular feature in Electronics. We invite readers to submit original design shortcuts, calculation aids, measurement and test techniques, and other ideas for saving engineering time or cost. We'll pay \$50 for each item published.

Add-on triggered sweep. IC timer holds down the cost of adding a triggered sweep to an economy oscilloscope. The circuit's input op amp triggers the timer, setting its flip-flop and cutting off its discharge transistor so that capacitor C can charge. When capacitor voltage reaches the timer's control voltage ($0.33V_{CC}$), the flip-flop resets and the transistor conducts, discharging the capacitor.



Engineer's newsletter

For three pins, you can multiply, divide, square . . .

A powerful new tool for the analog system designer is the multiple-function integrated circuit made by half a dozen or so semiconductor manufacturers. In a single package, it combines standard dual or quad op amps or comparators or transistor and/or diode arrays, giving more flexibility with fewer power supplies for a variety of amplifier, filter, oscillator, and signal-conditioning jobs.

Another, less standard, multiple-function block is Intech's **mathematical module, which can be programed to give a wide range of single-quadrant computations:** multiply, divide, square-root, square, square a ratio, raise a voltage ratio to an arbitrary power, and so on. The circuit contains a log, log ratio and antilog circuit, plus a reference voltage source, and simplifies interconnection since **all the operations can be gotten by simply programing three pin connections with two resistors.**

A bipolar switch may be a better bet than a FET

When you need a transistor switch, don't automatically specify the low-noise field-effect device. Although noisier and less linear, **a bipolar switching transistor is good enough for many signal-processing needs—and costs much less.** Packaged arrays of four or more bipolar transistors may cost half as much as FETs. And for those applications where stability is necessary, as in data multiplexing and digital-to-analog systems, some of these bipolar transistor arrays are prewired to accept differential inputs, and some contain an on-chip compensating diode. Furthermore, **bipolar transistors can handle higher power levels, allowing them to process signals over a broader dynamic range.**

Getting the signal past the noise

Although complementary MOS circuits are known best for their ability to operate in portable equipment at moderate speeds with low power consumption, communications system designers are beginning to look into that technology's noise immunity as well. **C-MOS logic circuits can operate in noise levels as high as 50% to 75% of supply voltage,** making them good components in crosspoint switches, for level-detecting and wave shaping in modem applications, and in data acquisition systems as voltage comparators or for low-level analog-to-digital conversion.

Tweezing picoamps from instrumentation amplifiers

Getting the full performance out of an instrumentation amplifier (extracting picoamperes from large common-mode voltages) is not so easy. Here are some shielding tips that have saved many a low-level system: **(1) ground the input circuit at one and only one point—preferably at the source;** (2) don't use a standard coax shield to carry input signals—an independent shield is much better; **(3) if the signal source is elevated above ground potential, don't ground the input cable shield—instead, connect it to the low side of the signal source.**

For bulls in china shops

Designers who've cracked more ceramic substrates than they'd care to admit **because their model-shop drill press is too slow to handle the material** will want to check out the miniature high-speed drill from Aremco Products, Inc., Box 145, Briarcliff Manor, N.Y. It develops 30,000 rpm and **can drill holes 0.005 to 0.250 inch in diameter in ceramic substrates up to 3 inches thick.**

There's never been a klystron quite like our TH 2054. Specifically designed for industrial and scientific RF-heating applications, it boasts a CW output of up to 50 kW of microwave power in the 2450 MHz ISM band, at a highly economical electrical efficiency of better than 60%.

Keeping both the microwave-heating system maker and the eventual industrial or scientific user in mind, we've designed an extremely rugged tube, capable of operating into processing loads whose RF impedance may randomly vary over quite a wide range. At the same time, to lower amortization costs, we built in long-life features such as a dispenser cathode and an ion pump.

Whatever the size of your microwave-heating job, look to THOMSON-CSF to supply the tube you need. In addition to the TH 2054 Klystron, we have 1.5 kW and 5 kW magnetrons, available in ready-to-use power packs, if desired. For complete information on all these tubes, just circle the appropriate number on the Reader's Service Card, or contact us directly.

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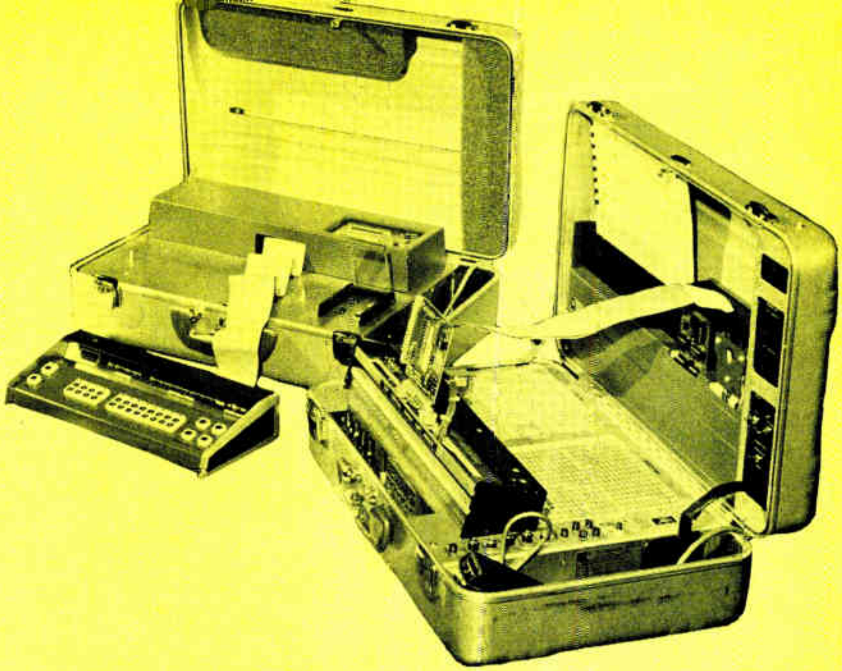
New products



Portable tester checks LSI arrays

Low-priced unit includes microprocessor that runs routines at rates up to 1 MHz

by George Sideris, San Francisco bureau manager

Isolating faults in products made with MOS chip sets and other large-scale logic arrays often demands long, unique sequences of data words and control pulses. To check the subassembly cards of an electronic cash register, for example, may require exercising runs that simulate the operations of a microcomputer and asynchronous peripherals, such as indicators, printers, and tape or disk recorders.

But programable testers capable of testing whole families of chip-set assemblies and systems need not be big and expensive. Data Test Corp. proves that with a portable unit suitable for both factory-testing and field use. Priced at $6,950, the Datatester 2400 (above, at right) contains a high-speed TTL microprocessor that runs test routines at step rates from 1 hertz to 1 megahertz. It is programed with small, plug-in cards carrying up to 4,096 words in PROMS or EROMS (field-programable or erasable read-only memories). Each card can store the test routines for a family of small systems.

Writer. A companion portable unit, the 2400-PDS program development station (above, at left, with keyboard taken out), is an optional $5,950 accessory. It also serves as a high-speed, general-purpose PROM writer (pulse-programer). The test programs are first entered into a random-access memory in a high-level language equivalent to Fortran. They are checked on a display and debugged by running them through the Datatester, while the tester exercises, for instance, subassemblies that are known to be good. Then, the PROM card is plugged in, and the programs in the RAM are automatically written into the PROMs. Users who don't want this aid may have software and cards prepared by Data Test's service subsidiary or, since the PROMs are standard devices, use their own PROM preparation equipment. Software is also available in the field through a time-shared computer service.

Repertoire. Unlike the minicomputers ordinarily used in programable test systems, the book-sized microprocessor in the Datatester 2400 doesn't do arithmetic computation. It has a hardwired repertoire of 16 test-oriented instructions, which are executed at high speed (300 nanoseconds cycle time). The instructions organize the test words, introduce delays for nonsynchronous peripheral simulations, check responses for go/no-go testing, and the like. The instructions include three unassigned types which may be used as no-operation delays in a routine or to actuate external equipment. Two provide memory "escapes" that can erase routines written in the PROMs and cause the program to jump to newly written routines.

The escapes and a special delay command are two of the more unusual features of the Datatester's software set. The latter causes the processor to go into a waiting loop, programable from 1 microsecond to 99 seconds. Loop, nested-loop, and jump commands allow a few short routines to be put together into loops as long as 65,536 steps and to endlessly recycle the loops when long, repetitive test sequences are required for such operations as card-probing for solder bridges or thermal intermittent failures.

An MOS LSI card assembly can, as a rule, be tested with a fraction of a PROM page (256 12-bit or 16-bit words). Victor Ivashin, the Datatester 2400's designer, demonstrates this with a 70-word routine that completely exercises an HP-35 pocket calculator. Adapted from the HP-35 maintenance manual, the routine gives a visual go/no-go output on the calculator display. If a no-go indication is seen, the operator sets digital switches to repeat that step while the board is probed to find the fault. The PROM card's total capacity of 16 pages (4,096 words) can control testing of as many as 30 models of a commercial system, Ivashin estimates.

Tailored. From the processor, the test words go through a plug-in "personality card" that tailors the words for special tests. The calculator's card, for example, carries a gate that generates a memory strobe pulse. For peripherals testing, Data Test supplies cards that serialize the test data words and develop the standard ASCII bus control terms. Only six TTL circuits are used to serialize the data and align the data codes and control pulses.

Personality-board outputs are sent through buffers to the bottom half of the test system, which is similar to the Datatester 2000, a pin-programed logic tester. The pinboard is used to establish test clock rates, assign processor outputs to test connector pins, and so forth. Also carried over from the Datatester 2000 are the utility electronics, including level translators, pin drivers, clock generator, and four power supplies programable from −30 to +30 volts.

The system tests two-phase and four-phase MOS and all types of bipolar logic and discrete or mixed-logic assemblies at clock rates to 1 MHz. The microprocessor can be programed to print or display results of logic-comparison tests on external equipment. In fact, Ivashin says, it can run other test equipment, such as digital voltmeters.

Once a fault is isolated to a card, a probe with a built-in counter is used to isolate faults on the card. While the board is exercised, transitions are counted at each wiring node and compared with known good counts until the fault is located.

Displayed. Among the features of the 2400-PDS simulator are a capacitive keyboard and a display that shows memory addresses and words. The RAM can be cleared with a wipe of the hand across the keyboard and one button. Words are displayed as they are keyed into the RAM. A switch, kept under a safety lid, actuates the PROM writing cycle. Writing rate is 10 seconds per memory page, or less than four minutes per 4,096-word card. At this speed, some PROM programing links may not fuse (the links are generally nichrome traces on the PROM chip). A PROM-RAM compare cycle detects unfused links, which are "burned" again semiautomatically.

The keyboard is connected to the programer and the programer to the test system through ribbon cables so they may be used remotely. Data Test is considering a phone-coupling accessory that would enable software transmitted to the field from a time-shared service to be entered directly into the RAM.

Data Test Corp., 822 Challenge Dr., Concord, Calif. 94520 [338]

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Circle 131 on reader service card

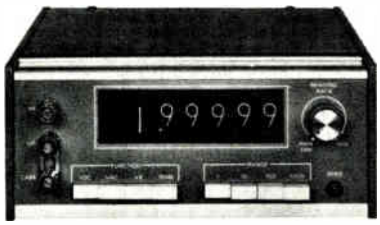
Instruments

$750 multimeter has 5½ digits

Unit offers sensitivity to tens of microvolts, built-in BCD outputs

It wasn't so long ago that good-quality 5½-digit multimeters were selling for $1,000 and up. Now, Keithley Instruments has put on the market a $750 instrument that offers such significant features as sensitivity down to tens of microvolts and built-in binary-coded-decimal outputs, in addition to 5-digit precision and a basic accuracy of within 0.005%.

The sensitivity of the multimeter, designated the model 190, makes it easy to monitor small-signal variations. Its 5-digit precision, the company points out, is especially useful when performing such laboratory measurements as checking regulation on a 15-volt power supply requiring resolution to ±100 μV. Other



capabilities include 100% overranging, 1,000-megohm input resistance, and a high-level dc stability that permits long-term measurements to be made with less than 0.002%/°C variations.

Designed as a multipurpose instrument for laboratory, development design, and production-test applications, the 190's wide measurement capabilities eliminate frequent range-changing, particularly when signal variations cover two or three decades. A total of 13 ranges is available—four ranges each of ac and dc voltage and five ranges of resistance. Ac and dc voltage capability covers eight decades from 10 μV least-significant digit (1 V full range) to 1,600 V. In resistance modes, the 190 covers nine decades—from 10 milliohms least-significant digit (1 kilohm full range) to 20 megohms.

Short-term accuracy of the 190 is within ±(0.005% of reading + 0.005% of range), and long-term accuracy (90 days) includes an additional 0.01% of reading, which allows for aging of precision resistors.

The BCD digital outputs and controls are factory-installed, and tested TTL outputs are complete—no extra-cost circuit cards are needed. The front-panel reading-rate control on the 190 enables the user to vary the print rate from 1 to 10 seconds per reading. An output-hold control can be used to retain data in the display and the digital output when simultaneous readings must be recorded from several measurements.

Keithley Instruments Inc., 28775 Aurora Rd., Cleveland, Ohio 44139 [351]

Signal generator covers 3.6 to 6.5 gigahertz

The model VS-340 sweep/signal generator covers the 3.6 to 6.5 gigahertz range in two bands. The low band covers 3.6 to 4.3 GHz, and the high band covers 5.825 to 6.525 GHz. Sweep width is variable from 0.5 megahertz to 700 MHz with an rf output of +10 decibels into a 50-ohm load. Flatness of sweep is ±0.1 dB over any 50-MHz interval and ±0.5 dB over the full frequency range. The VS-340 contains crystal-controlled markers at 5, 50, and 100 MHz. Price is $4,650.

Texscan Corp., 2446 N.1 Shadeland Ave., Indianapolis, Ind. 46219 [355]

Recorder converts scope to a logic analyzer

Inexpensive single-beam oscilloscopes and X-Y monitors soon can also serve as multichannel logic analyzers and digital waveform-storage oscilloscopes. B.J. Moore, president of Biomation Corp., says his firm will start delivering in January a scope accessory to perform these functions.

Although Biomation calls the $1,950 instrument the model 810D digital logical recorder, it is conceptually akin to the Hewlett-Packard logic analyzer with its built-in display [*Electronics*, April 26, p. 139, and Sept. 27, p. 152] and to a multichannel waveform display recently developed by Digimetrics Inc. [*Electronics*, Aug. 16, p. 30].

However, Biomation's 810D converts a low-frequency scope to a high-frequency analyzer. Pulse trains from a maximum of eight channels are captured, converted into X, Y, and Z video-drive signals, and refreshed 150 times a second on the scope display. Nearly any scope with a bandwidth of 1 megahertz or more can show, for example, whether data and control signals on an eight-line computer bus are properly aligned. The presentations look like logic timing diagrams. The stored samples are also available from the recorder as 8-bit digital words at word rates of 2 to 500 kilohertz.

The recorder can handle high-speed logic outputs, such as TTL outputs, as well as slow pulse trains. The outputs are connected to the front panel and sampled at intervals set by a 10-MHz time base in the recorder from 100 nanoseconds to 50 milliseconds. A sampling threshold, which determines the logic states of the displayed waveforms, is adjustable from -10 to +10 volts. The threshold-selector picks standard MOS and bipolar switching thresholds, and a potentiometer at the rear of the case is adjustable to other thresholds. Inputs are rated at 50 picofarads and 1 megohm to reduce loading of MOS sources.

The instrument samples continuously, holding 256 samples from each input in a 256-word shift register. The recorder switches into a video framing mode when triggered by an event on the eighth input or by an external trigger. The trigger control can be set to display as many as 128 samples prior to the trigger and the remainder of the 256 samples after the trigger. A latch on each channel serves as a "glitch-catcher"—it captures a transient shorter than the sample time.

In the display-drive mode, the register-recirculation frequency drops to a rate that causes the recorder to transmit the samples in bit-serial form during a 4-millisecond display-frame time. The resulting refresh rate of 250 Hz makes the display tube appear to be a storage tube. The display may be expanded up to five times in tle X axis for close examination of pulse widths and alignments. Pulse-voltage levels are not measurable because any pulse above the sampling threshold is shown high and any below is shown low.

Biomation Corp., 10411 Bubb Rd., Cupertino, Calif. 95014 [352]

Sound-level meter package includes recorder, calibrator

For measuring and recording sound levels on location and in the field, a self-contained package includes a Scott Instrument Laboratories type 452 sound-level meter and a compatible millivolt recorder with a 4½-

inch-wide chart. The unit measures in the 40- to 140-decibel range. The recorder plugs into the meter, a hand-wound spring drives the chart, and a battery powers the amplifier. The package includes a calibrator.

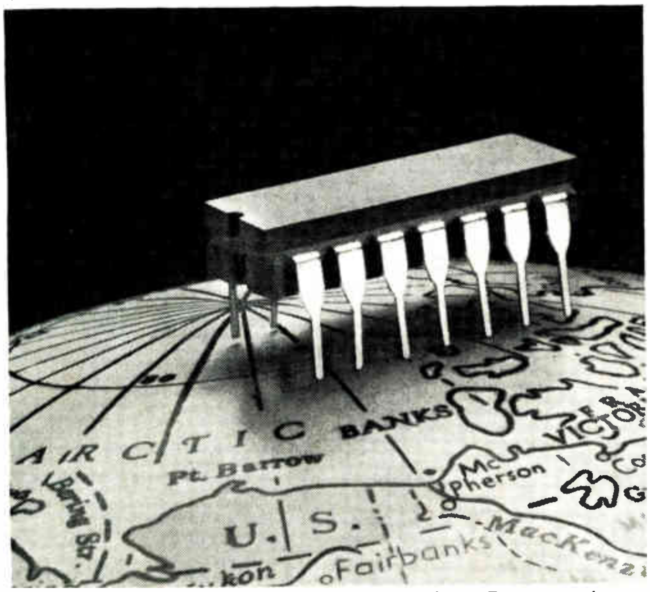
Esterline Angus, P.O. Box 2400, Indianapolis, Ind. 46224 [353]

Flatbed plotter operates to 40 inches per second

The series 2000ADS flatbed plotter provides accuracy to within ±0.005 inch and a ±0.001-in. resolution. The device makes use of magnetic and electrical forces to move the head across the paper at a maximum velocity of 40 inches per second. Applications include aircraft and automotive fields. The unit uses a Sewyer-principle motor, and thus eliminates cables, gears and lead

RCA COS/MOS in low cost ceramic.

RCA now offers COS/MOS in a new low cost ceramic package. So you can select, from our complete line of COS/MOS circuits, an IC package to meet your exact needs for performance and price.



Our new CD4000AF Ceramic IC's feature electrical characteristics identical to the present AD and AK series weld seal ceramic COS/MOS circuits. You get a completely hermetic package designed to operate over the full military temperature range of −55°C to +125°C... at a commercial price.

Compare the prices of our new ceramic IC's. If you've needed the temperature range and hermetic features of ceramic, but couldn't afford

TYPE NO.	FUNCTION	AF PRICE (1000+)
CD4001AF	Quad 2-input NOR gate	$ .98
CD4011AF	Quad 2-input NAND gate	.98
CD4013AF	Dual "D" master-slave Flip-Flop	2.03
CD4020AF	14-stage binary/ripple counter	5.90
CD4027AF	Dual J-K master-slave Flip-Flop	3.14
CD4029AF	Presettable up/down counter	7.94
CD4042AF	Quad clocked "D" latch	4.23
CD4046AF	Micropower phase-locked loop	5.63
CD4047AF	Monostable/Astable multivibrator	3.75

the price, now you can discover the digital world of COS/MOS in RCA's new low cost ceramic package.

Our complete line of COS/MOS CD4000AF Series Ceramic IC's, in 14-lead or 16-lead dual-in-line packages, are available at your local distributor. Or you can order them direct from RCA.

For complete pricing and data sheet write: RCA Solid State, Section 70J-11, Box 3200, Somerville, N.J. 08876. Or phone: (201) 722-3200.

RCA Solid State
products that make products pay off

International: RCA, Sunbury-on-Thames, U.K., or Fuji Building, 7-4 Kasumigaseki, 3-Chome, Chiyoda-Ku, Tokyo, Japan. In Canada: RCA Limited, Ste. Anne de Bellevue 810, Canada.

screws normally needed for such plotters.

Xynetics Inc., 6710 Variel Ave., Canoga Park, Calif. 91303 [356]

Digital megohmmeter built for insulation testing

A miniature digital megohmmeter is designed for general-purpose insulation testing. Designated the model 15100 Minimeg, it can be used on circuit breakers, transformers, switchgear, and insulators; the unit can be used for both spot-reading and time-resistance tests to determine insulation quality when installing equipment or drying out

moisture, and, after installation, to detect possible failure. Test voltage is fixed at 500 v dc, and there is a factory-preset current limiter. Three ranges are provided, from 0 to 20, 20 to 200, and 200 to 2,000 megohms. A range from 0 to 200 ohms is provided for continuity testing. Price is $495.

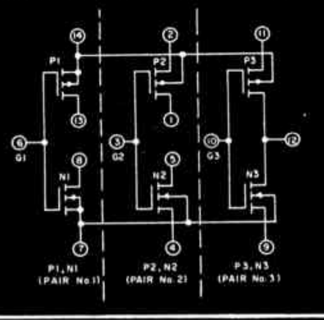
ITT Jennings, 970 McLaughlin Ave., San Jose, Calif. 95116 [354]

Pen-size logic probe tests C-MOS circuits

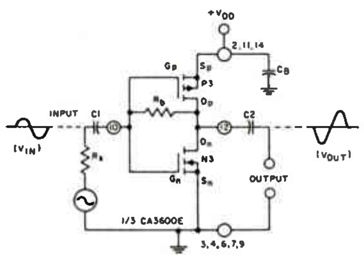
Compatible with C-MOS circuitry, the model LP-570 pen-size logic probe uses three-light displays to indicate logic levels. The probe is used universally for 5 to 15 v dc logic, and logic thresholds are nominally 70% of the supply for a logic 1, indicated by a red display, and 30% for logic 0, indicated by a white display. The deadband between these two states is indicated by no display. Pulse signals as fast as 100 nanose-

Linear COS/MOS... RCA's CA3600E premieres

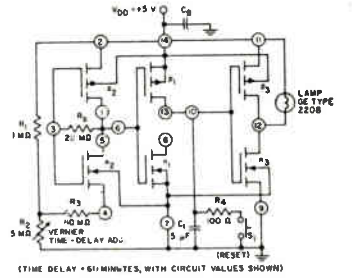
CA3600E schematic diagram



CA3600E transistor pair biased for linear-mode operation



Analog timer using CA3600E



Meet the linear IC with the advantages of COS/MOS. The new RCA CA3600E Transistor Array... three pairs of complementary enhancement-type MOS (p-channel/n-channel) transistors on a single chip.

The CA3600E is designed for a great variety of applications requiring virtually infinite input impedance, wide bandwidth, matched characteristics, lower power consumption and general purpose circuitry.

And that's not all. With the new CA3600E you get performance advantages that include square-law characteristics, superior cross-modulation performance, and a greater dynamic range than bipolar transistors.

Whether you're working in timing, sensing and measuring or any other applications, or if you're tired of fighting beta variation in your bipolar circuit, let your "linear" imagination run wild. The features offered in the new CA3600E COS/MOS Linear IC are too good to pass up.

- ☐ Virtually infinite input resistance/100 gigohms
- ☐ Each transistor rated for operation up to 15V and 10 mA
- ☐ Low gate-terminal current/10 picoamps
- ☐ No "popcorn" (burst) noise
- ☐ Matched p-channel pair/gate-voltage differential ($I_D = -100uA$) ... ±20mV (max)
- ☐ Stable transfer characteristics over a temperature range of −55°C to +125°C
- ☐ High voltage gain/up to 53dB per COS/MOS pair.

Supplied in the 14-lead dual-in-line plastic package, the CA3600E is available in production quantities from your local distributor or direct from RCA.

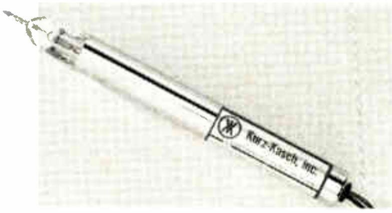
For complete data sheet/application note write: RCA Solid State, Section 70J-11, Box 3200, Somerville, N.J. 08876. Or phone: (201) 722-3200.

RCA Solid State

products that make products pay off

International: RCA, Sunbury on Thames, U.K., or Fuji Building, 7-4 Kasumigaseki, 3-Chome, Chiyoda-Ku, Tokyo, Japan. In Canada: RCA Limited, Ste. Anne de Bellevue 810, Canada.

Circle 137 on reader service card

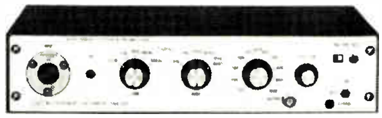


conds are indicated by a blue display. Price is $79, and a memory option is available for $10. Delivery is from stock.

Kurz-Kasch Inc., Electronics Division, 2876 Culver Ave., Dayton, Ohio 45429 [357]

Differential ac preamplifier measures low-level noise

The model DAM-6 differential ac preamplifier is a general-purpose instrument for measuring EKG, EEG, and other low-level and low-noise



potentials. Features include a gain of 100 to 1,000, a 100-kilohertz bandwidth, 500-megohm input resistance, and high- and low-frequency filters. Common-mode rejection is 50,000 minimum at 60 hertz. A built-in calibrator is also provided. Price is $355.

W-P Instruments Inc., 2600 State St., Hamden, Conn. 06517 [359]

Multichannel data system covers −10 to +10 volts

A multichannel data-acquisition system provides signal conditioning, data storage and playback for 14 narrow-band voltage inputs covering the range from −10 to +10 volts. Two additional channels are reserved for self-calibration at zero and full scale. The system has a resolution of 1 millivolt, and accuracy to within 2 mV. It can be, optionally, supplied with more input channels

The Macrodata MD-16

The industry's first low-cost calculator tester!

Macrodata's new low-cost MD-16 Calculator Set Tester is a dedicated bench-top test system that performs both functional and parametric testing of single or multiple chip calculator sets. Designed to be equally useful to the manufacturers of calculators or calculator chips, it can be used for engineering characterization, wafer probing, final package testing, as well as incoming inspection. It does it all at a fraction of the cost of large universal test systems.

The new MD-16 provides the most cost-effective approach for testing solid-state calculator sets yet to be introduced. It tests continuously in the "zero overhead" technique, reducing test time and increasing throughput. In a dedicated application, it can maintain the same kind of throughput as is possible with larger universal test systems that cost up to 10 times more.

So if you'd like to cut your costs and boost your production and profits by being sure of your chip quality both *before and after* assembly — the MD-16 offers you the only low-cost solution.

For more information, use the reader service card, and for a demonstration, call us directly.

Macrodata

MACRODATA

Macrodata Corporation, 6203 Variel Avenue, Woodland Hills, California 91364, Phone: (213) 887-5550, Telex: 65-1345

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Circle 139 on reader service card

by counting clock pulses from the oscillator. When it reaches the programed count, the circuit resets itself. It may also be triggered externally and synchronized to an external clock.

Eight separate pulse trains may be obtained from the counter. Interconnecting the counter pins establishes binary increments of 1 to 255 times the interval given by the RC value. Since the XR-2240's inputs and outputs are compatible with TTL and DTL logic levels, further programability may be achieved by the use of external logic controls, as well as hard-wiring or switches. In astable operation, the circuit will generate up to 256 separate frequencies or pulse patterns.

Another novel feature of the XR-2240 is a low-power extension output. When two timer units are cascaded, this output serves as a supply input to the following timers. Because it is active only during outputs of the primary unit, the power extension cuts supply drain drastically.

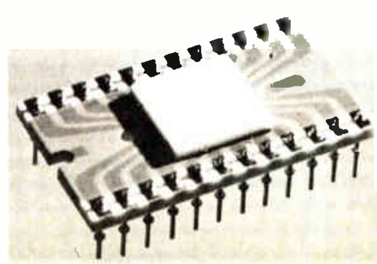
The XR-2240 uses single supplies from 4 volts to 15 V, drawing about 4 milliamperes of supply current at 5 V. Typical stability during supply variations is 0.07% per volt. Typical temperature stability is 30 parts per million/°C. Timing accuracy is within 0.5%, with maximum timing error no more than 2%.

Prices in 16-pin dual in-line packages in quantities of 100 and up are: $5.75, molded plastic; $6.60, ceramic packages with commercial specifications; and $12.25, ceramic with military specifications. Single units cost $8.60, $9.85, and $18.30.

Exar Integrated Systems Inc., 750 Palomar Ave., Sunnyvale, Calif. 94086 [412]

Rhythm generator is arranged as a ROM

A single-chip rhythm generator fabricated with nitride Planox MOS technology is designated the M250. It is arranged as a ROM with an in-



Dialight sees a need:

(**Need:** The right switch for the right price.)

See Dialight.

For the switch buyer, choice of function and esthetics, reliability, ease of mounting, and low cost are his prime concerns. He may need a pushbutton switch for panel, sub-panel or snap-in mounting. He may need a choice of bezels with or without barriers in black, gray, dark gray or white. He may need a legend that's positive, negative, or hidden until energized . . . one that's white when "off" and red, green, amber, blue or light yellow when "on" . . . or colored both "on" and "off." He may need a highly reliable switch proven in thousands of installations . . . available in momentary or alternate action . . . N.O., N.C. or two circuit (one N.O., one N.C.) or for low level, low voltage and current applications . . . that accommodates a T-1¾ bulb with midget flanged base, incandescent, in voltages from 6 to 28 V. Matching indicators with same front-of-panel appearance are also available. These are some custom needs he may face, and these switches are some off-the-shelf answers from Dialight.

New products

ternal automatic row decoder that enables the 32 rows to be scanned one at a time. By means of an appropriate program, it is possible to introduce 12 rhythms driving eight single outputs. The output can directly drive eight blocking oscillators, simulating percussion instruments. Price ranges from $22.50 to $15, depending on quantity; a one-time mask price of $500 is applicable for orders of less than 2,000 pieces.

SGS-ATES Semiconductor Corp., 435 Newtonville Ave., Newtonville, Mass. 02160 [415]

ROM adds batch capability to desktop calculator

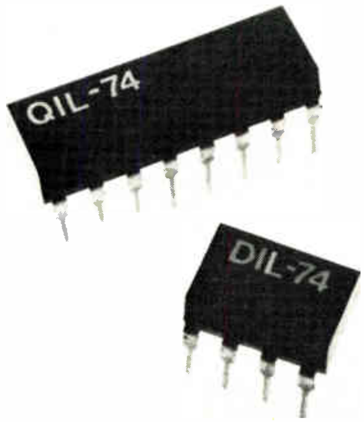
A plug-in read-only memory block adds batch capability to the H-P model 9830A desktop calculator. Programs can be stacked and executed consecutively without further instructions from the keyboard. The model 11278B ROM is used in either of two modes. In the card mode, it is

used with the 9869A calculator card reader to interpret H-P educational Basic cards. In the batch mode, the calculator will process data and program statements from ASCII-input peripheral devices. Price is $485, and delivery is from stock.

Hewlett-Packard Co., 1501 Page Mill Rd., Palo Alto, Calif. 94304 [418]

Quad opto-isolator is housed in 16-pin DIP

A quad opto-isolator called the ILQ-74 contains four independent infrared LEDs end npn phototransistors in a 16-pin DIP. Each quad channel has a 12½% minimum current transfer ratio and a low leakage current of 5 nA. Breakdown voltage



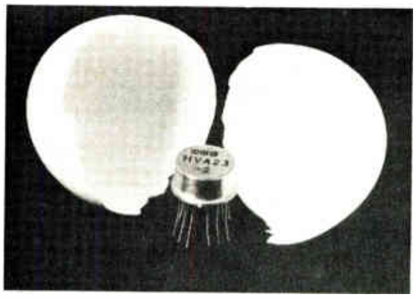
is 1,500 volts. A dual version called the ILD-74 is packaged in an eight-pin mini-DIP. Price in 1,000-lots ranges from $1.70 to $3.30, depending on type.

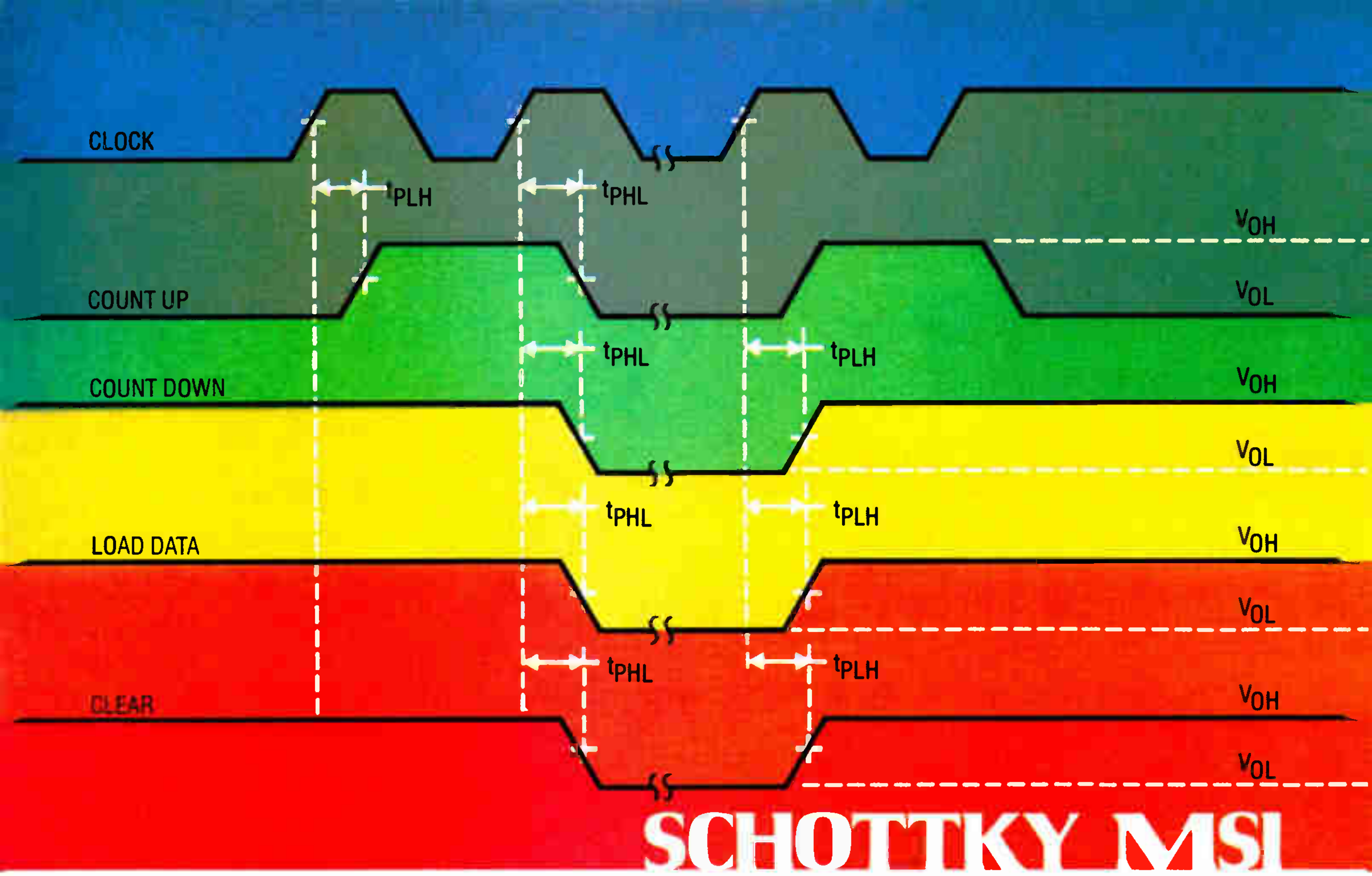
Litronix, 19000 Homestead Rd., Cupertino, Calif. 95014 [417]

Hybrid amplifier operates into video frequencies

A subminiature hybrid amplifier is capable of operation from dc to video frequency ranges and was originally developed for critical applications in airborne radar and display systems. Other applications include video data summation and pulse amplification. Called the model HVA-23-2, the unit is grounded for rf shielding, and noninverting input is available for low-frequency noise rejection and dc biasing networks.

ILC Data Device Corp., 100 Tec St., Hicksville, N.Y. 11801 [419]





Unsurpassed versatility.

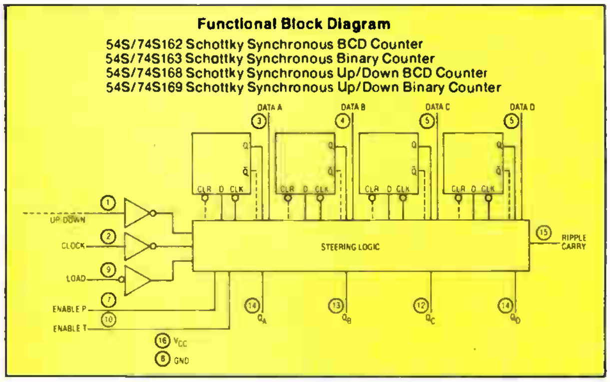
Perform your counting functions synchronously ...with TI's new Schottky counters.

Advanced Schottky technology brings you four new high-performance, universal, synchronous counters. Each one can expand your design horizons.

TI's Schottky counters are predictable. All counter functions – counting, programming or clearing – are synchronized with the clock's positive going edge.

These universal counter building blocks are particularly useful for implementing high speed synchronous counting of any desired bit length — without external gating or output counting spikes. The internal look-ahead circuitry extends the count frequency range to 70 MHz typically. Miscounting during the load and enabling operations is eliminated due to the fully independent clock circuitry.

The S168 and S169 are unique up/down counters intended for use whenever bidirectional counting is required. The S162 and S163 are pin-compatible Schottky versions of the standard series 54/74 functions of the same number.



Whether your counting application is a new state-of-the art design or upgrading an existing system, one of TI's Schottky counters can make it happen.

TI Schottky synchronous counters are available in both industrial (0 to 70°C) and full military (55 to 125°C) temperature ranges in 16-pin plastic, ceramic or ceramic flat packages.

For data sheets or a copy of TI's new Schottky applications brochure write: Texas Instruments Incorporated, P. O. Box 5012, M/S 308, Dallas, Texas 75222

TEXAS INSTRUMENTS

INCORPORATED

84135

Packaging & production

Sputterer priced under $30,000

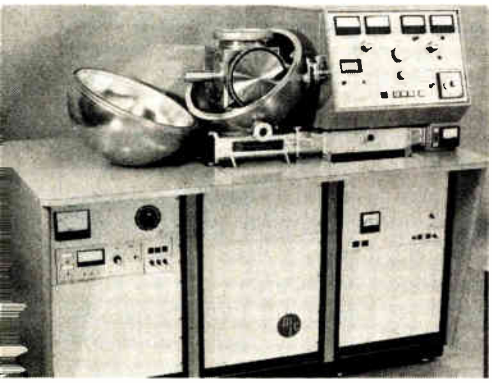
System with production capability uses turret head, automatic tuning

Full production capability for less than $30,000—that's the promise of a turret-head sputtering system for thin-film work that was introduced this week by Materials Research Corp. at the Vacuum Show in New York City.

According to the company, the system incorporates features of equipment that sold for $45,000 a year ago. Materials Research also says that, despite the system's capability to handle production-quantity throughput, it retains the instrumentation features of an R&D system.

Called Sputtersphere because of the spherical shape of the vacuum sputtering chamber, the machine can perform rf multitarget sputtering, rf bias sputtering, rf sputter etching, substrate cooling, and substrate heating to 600°C. It is equipped with automatic fine-tuning, parallel loading/unloading, an automatic vacuum interlock, and electrically operated vacuum valves.

The turret-head design eliminates cross-contamination, shuttering, and pallet transport—the last by rotating the targets and etch plate concentrically over a fixed heated/cooled rf-biased etch station.



The stainless-steel automatic interlock eliminates target conditioning and significantly increases the number of production runs. This throughput enhancement comes about because pallets of substrates may be transferred in and out of the vacuum chamber with a minimum loss of vacuum.

Automatic tuning not only simplifies operation but lessens the possibility of damage to the rf generators due to manual tuning.

Additional standard equipment includes a 1¼-kilowatt rf power supply with automatic load control, a high-efficiency rf matching network for sputtering, bias sputtering and sputter-etching with automatic load timing, and a 6-inch semiautomatic vacuum system.

Materials Research Corp., Equipment and Instrument Division, Orangeburg, N.Y. 10962 [391]

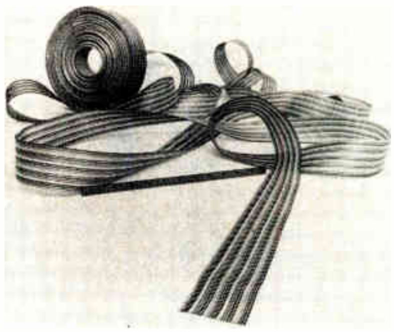
Printed-circuit connectors withstand high temperature

A family of printed-circuit edge-board connectors, available with from six to 210 contacts in a choice of double or single rows, is offered with several terminal styles. All will operate continuously at 250°C. Applications include burn-in operations and wherever else elevated temperatures tax the performances of connector insulators and contacts.

Masterite Industries, 2841 Lomita Blvd., Torrance, Calif. 90505 [396]

Ribbon cables are from 2 to 100 conductors wide

A line of flat conductor cable now includes ribbon cable, which is available in widths containing two to 100 conductors. The cable is designed for cable-to-connector applications and a variety of transmission-line interconnection systems. The round conductors, which may be either solid or stranded, are available with color-coded polyvinyl-chloride insulation in sizes 22 to 28 AWG. Multiple

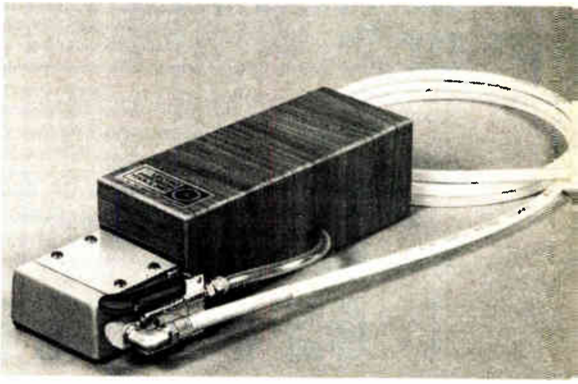


twisted-pair conductors are also available. Price of the ribbon cable is about 1 cent per conductor foot.

Hughes Connecting Devices, 500 Superior Ave., Newport Beach, Calif. 92663 [393]

Lead-cutter can handle 1,200 components an hour

Called the Accu-Speed IV, a lead-cutter handles up to 1,200 hand-fed components per hour without af-

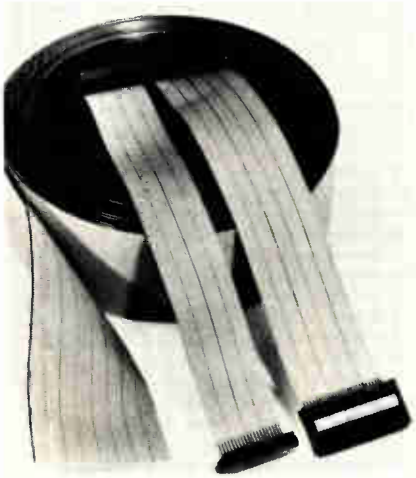


fecting electrical characteristics. The unit can cut several types of components without the need for changing dies. Cutting area is 0.900 by 1.100 inch. The machine is air-operated and fits any standard air line from 40 to 150 lbs. Price is $124.50.

Lectro Precision Tools Inc., 14901 Minnetonka Industrial Rd., Minnetonka, Minn. 55343 [394]

Mounting sockets include guides for IC leads

A design that aligns integrated-circuit leads directly with contact pockets, even if the leads are wire on 0.050-inch centers. A complementary line of insulation-piercing connectors is also available. The



cable is called Blue Streak after a colored stripe that runs its length to indicate polarity. Another colored stripe marks every fifth conductor. The cable ranges in price from 1 cent a conductor-foot and up, and is available in 100-foot reels with 14, 16, 20, 26, 34, 40, and 50 conductors.
Ansley Electronics Corp., Old Easton Rd., Doylestown, Pa. 18901 [397]

Connectors are designed for CATV systems

For applications in cable television, a series of connectors is said to exceed the Federal Communications

Commission's requirements for radiation suppression. Each connector contains a permanent integral radiation sleeve, and the cable sheath connection is made via the inner surface of the sleeve. Several versions are available to suit particular CATV needs.
Jerrold Electronics Corp., 200 Witmer Rd., Horsham, Pa. 19044 [375]

When spray or dip coatings fail...

Parylene works.

You are looking at magnified cross-sectional views of copper conductors on a circuit board . . . and why parylene protection brings the highest reliability to electronic circuitry.

The spray-applied urethane coating (top photo) bridges the channel between conductors, and offers scant protection at the edges. Urethane, silicone, epoxy . . . liquid coatings are uneven, and can produce potential failure points.

Parylene forms a thin and even coating, whatever the configuration, however complicated or delicate or densely populated. Without bridging. Without pinholes, voids, bubbles. We call it a conformal coating. From conformality comes reliability.

Parylene conformal coatings can be applied in precisely controlled thicknesses from 0.002 to 3 mils. *In one step.*

Parylene is applied at *room temperature.* No heat, no melting, no cure. No coating shrinkage. In other words, no discomfort for delicate components.

Parylene provides better barrier protection than urethanes, silicones or epoxies. It is extremely resistant to chemical attack, exceptionally low in trace metal contamination, and compatible with all electronic solvents. Dielectrics are excellent.

Parylene has qualified under the stringent requirements of MIL-I-46058C; it does so with a 0.6 mil coating—parylene excels in the micro-electronic virtue of thinness.

Parylene conformal coatings have shown excellent cost effectiveness in many applications. On delicate, sophisticated and complex circuitry, in hybrid circuits and components, they may be the most cost effective answer for long term reliability.

Union Carbide invented the parylene system. The method is gas phase deposition, which is the only route to the reliability of conformal protection. Various patents apply; commercial use of the patented technology is licensed.

You can get complete information on parylene by writing for our 16-page brochure: Union Carbide Corp., 270 Park Ave., Dept. RB36, New York, N.Y. 10017. Further investigation will no doubt indicate a trial run, which we can perform at reasonable cost. If you would like to discuss that or any other related matters, please call Bill Loeb at (212) 551-6071.

UNION CARBIDE PARYLENE

Circle 155 on reader service card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PHILIPS
Mini-computer by Philips, 1973
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Philips considers your reputation
Circle 156 on reader service card

Communications

Analyzer speeds data tests

Instrument isolates errors to modem, line or terminal by combined measurements

Making many measurements at the same time, on the same data, a new data-error analyzer from Hewlett-Packard Company helps speed tests of modems, data channels, complete data-communications systems, and low-speed memories.

Designated the 1645A, the instrument uses a combination of measurements to troubleshoot a variety of malfunctions. It makes bit-error-rate and block-error-rate measurements even in the presence of dropouts. These measurements are autoranging and direct, requiring no recalculation or interpretation. The receiver locks automatically onto the signal, detects and counts dropouts, and relocks after interruptions. The information is stored after each measuring sequence and can be called out on the light-emitting-diode display.

At the same time, and on the same data base, the company says, the 1645A has measured peak-to-peak time jitter and total peak distortion, the sum effect of jitter and bias—percentage time asymmetry of marks and spaces in the transmission. These values are stored and available on the display. Jitter and peak-distortion values are also available to the user at a front-panel connector for study with an oscilloscope, spectrum analyzer, or voltmeter.

Threshold misalignment in a modem receiver can be quickly detected by the presence of skew in the errors, i.e., errors weighted towards 1s or 0s. The 1645A automatically analyzes the errors it detects and, on command, displays percentage of skew.

It also detects clock slips by comparing the count from a feed-forward register with that from a feedback register; if there is error only in the feed-forward register, then the cause is a clock slip, i.e., a phase shift larger than a bit period. When this is detected, the instrument counts it, automatically resynchronizes, and blanks the error-rate collector for whatever time the clock was perturbed. Thus, the instrument is not only immune to errors caused by phase hits; it also detects and analyses them.

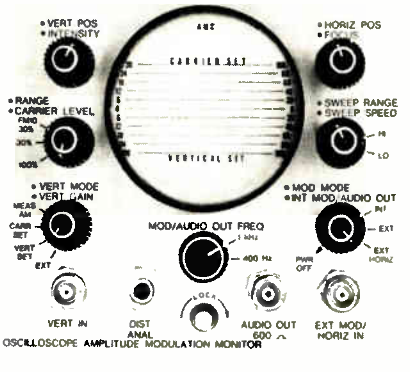
The data-error analyzer consists of an independent transmitter and receiver in one unit. One analyzer can make loop-around tests; end-to-end measurements can be made with two. Test-pattern length can be set from 10^2 to 10^9 bits, or the instrument can be set to run continuously. Tests may be commanded one at a time, or automatically sequenced. The transmitter provides pseudo-random and mark/space patterns that exceed CCITT requirements, and a long sequence of 1s or 0s—2^{20}-1—can be called up.

Interfacing to systems is through rear-panel plug-in cards. Standard is an RS232C connection. U.S. price of the 1645A is $2,150. Delivery time is estimated at less than 90 days.

Inquiries Manager, Hewlett-Packard Company, 1501 Page Mill Rd., Palo Alto, Calif. 94304 [401]

Module gives service monitor an a-m capability

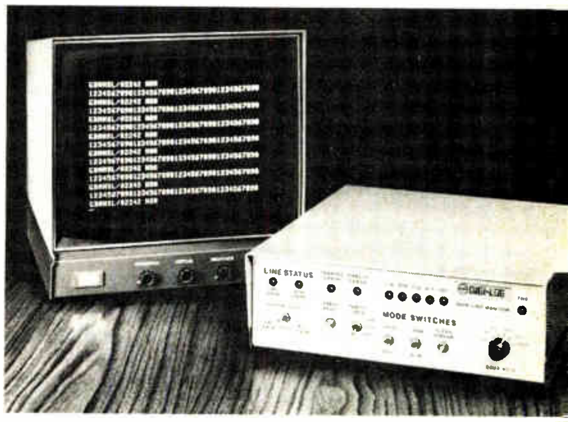
An a-m module is designed to be added to the Singer FM 10-C and FM-10 two-way radio service monitors, enabling them to service both fm and a-m systems. The module, called the OAM-1, displays recovered audio on an oscilloscope so that transmitter problems can be checked and percentage of modulation measured. The OAM-1 measures a-m up to 95% with accuracy to within 10% and generates a-m from 0% to 30% with 3% distortion. Price is $648, and delivery time is 8 weeks.



Singer Instrumentation, 3211 S. LaCienega Blvd., Los Angeles, Calif. 90016 [405]

Line monitor displays data between EDP devices

The series 400 line monitor is an ASCII device that displays line and data information flowing between two EDP units. The information may



be shown on either a video monitor or an ordinary TV set. In the line-monitor mode, the information displayed includes alphanumeric equivalents of normally transparent control signals. Price ranges from $1,100 to $1,470, depending on configuration.

Digi-Log Systems Inc., Babylon Rd., Horsham, Pa. 19044 [404]

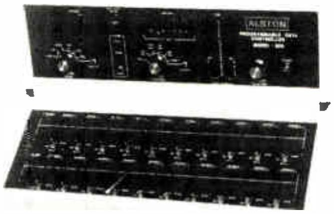
Level-measuring set covers 200 Hz to 2 MHz

A level-measuring set for the range of from 200 hertz to 2 megahertz, called the PSM-8, checks critical performance parameters during the manufacture of telecommunications devices like channel modems, filters, and two- and four-pole networks. It

can also be used for undersea-cable testing and other monitoring operations. The modular system adapts easily to different test and measurement applications. Price of the basic set of tuning unit, generator, and receiver is $12,680, and options are available.

W&G Instruments Inc., 6 Great Meadow Lane, Hanover, N.J. 07936 [403]

Data controller polls telephone traffic



Telephone traffic data is automatically polled by the model 820 programable controller, which obtains data from up to 20 remote locations. Two output ports offer access directly onto teletypewriter or CRT displays or, by dataset or magnetic tape, to a computer for further calculations. An X-Y peg matrix permits programing dial-up numbers. Cost is about $200 per station.

Alston Division, Conrac Corp., 1724 S. Mountain Ave., Duarte, Calif. 91010 [406]

Terminal is aimed at CATV applications

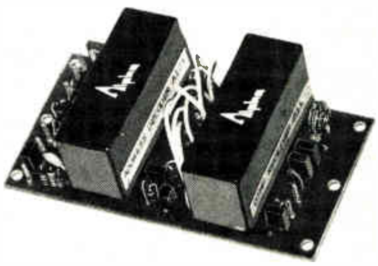
The IT 800 NL intelligent terminal is specifically aimed at cable-television applications. The unit is a dual-input color-character generator with minicomputer capabilities for the display of newswires and locally

originated data. The model 800 will display data in full- or split-screen formats and can show a page at a time, in which items are stored and then spilled onto the screen at 300 words per minute. Price is $4,250.

Megadata Corp., 10 Evergreen Pl., Deer Park, N.Y. 11729 [407]

Decoders are compatible with Touch Tone format

A line of Touch Tone-compatible decoders is designated the 600 series Selectone. The units are field-programable to decode any two-, three-, four-, seven-, or 10-digit number and will also activate up several single-digit commands after the access number has been decoded. The receiver portion of the model 600 will accept any of the 16 possible Touch Tone combinations,



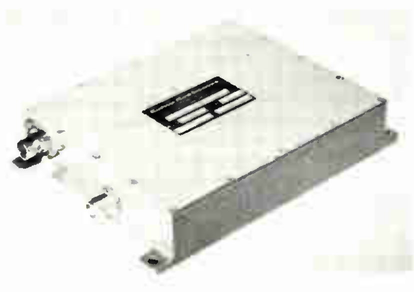
making the number of possible 10-digit number codes exceed 1 trillion.
Alpha Electronic Services Inc., 8431 Monroe Ave., Stanton, Calif. 90680 [408]

Multiplex, microwave systems aimed at industrial jobs

The MS-228 microwave radio relay system with a frequency band of 2 GHz, and the MX-128 multiplex radio are aimed at the industrial microwave market. The MS-228 provides plug-in modular construction while the MX-128 is fully synchronous and designed for low-density applications. The MX-128 is a single-sideband suppressed-carrier frequency-division unit; it uses CCITT frequency allocations and is compatible with existing high-density equipment.
Collins Radio Co., 1200 N. Alma, Richardson, Texas 75080 [409]

Airborne TV transmitter offers high-output capability

Efficiencies in the order of 25% allow power outputs of 10, 15, and 20 watts minimum to be attained with the series VT-4900L with less than half the heat dissipation of other types of L-band video transmitters for airborne applications. The 40-ounce units provide a peak deviation of ±6 MHz and are factory-set to any frequency in the range of 1,435 to 1,540 megahertz or 1,710 to 1,850 MHz, with a stability of within ±0.03% under all combinations of input voltage variations and environmental conditions.



Emhiser Rand Industries, 7721 Convoy Court, San Diego, Calif. 92111 [410]

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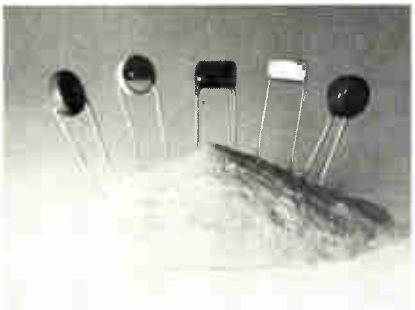
Newport Laboratories B.V., P.O. Box 7759, Schiphol—0, Holland, Tel: 020-45-20-52

New products/materials



A family of Novaloy epoxy powders serves a variety of uses for electronic sealing and coating applications. The 6500- and 6400-series powders are heat-cured solid materials that provide a fusing temperature of 125°C and controlled flow to eliminate pinholes or sagging. The materials also provide resistance to abrasion and good adhesion properties.
Polymer Products Division, Amicon Corp., 25 Hartwell Ave., Lexington, Mass. 02173 [476]

High-alumina-content ceramic thick-film integrated-circuit substrates fabricated from dry tape are available in various configurations that include holes or scoring, as specified. The substrates, designed for LSI and hybrid packages, offer thermal shock resistance, easy metalizing, and good thermal conductivity.
Diamonite Products Division, U.S Ceramic Tile Co., Shreve, Ohio 44676 [477]

EZ-cast 521 is a single-component liquid molding compound for use in making molds for ceramic or plastic casting. The material requires no mixing or measuring and has an almost indefinite pot life. It hardens to a tough, pliable rubber-like composition after a cure at 300°F. Price is $30 per gallon.
Aremco Products Inc., Box 429, Ossining, N.Y. 10562 [478]

For use in optical instruments and sensor applications, Parylene conformal coatings allow control of coating thickness and uniformity, and they provide tough pinhole-free coatings as thin as 0.004 mil. The material, which resists most solvents and corrosives, exhibits good dielectric characteristics. It can be applied

New products/materials

in a one-step deposition.
Union Carbide Corp., 270 Park Ave., New York, N.Y. 10017 [479

Soft-solder-clads using a variety of base metals and solder alloys are for application in microelectronics, including preforms and lead frames. The combinations range from a single-clad to as many as five cladding layers. The process yields materials of uniform wetting characteristics, as well as uniform deposition.
Polymetallurgical Corp., 262 Broadway, N. Attleboro, Mass. 02761 [480]

Square and rectangular substrates are among those being offered with white or black glazed or unglazed 96% alumina and 99.5% aluminum-oxide substrates. The latter units provide surface finishes of 4 microinches or better as fired. Both are offered in a variety of sizes, shapes and hole patterns.
Comco Inc., 9421 Telfair Ave., Sun Valley, Calif. 91352 [372]

Designated Abletherm 511, thermally conductive epoxy preforms are said to offer good adhesion to normally difficult-to-bond materials. The preforms are basically an adhesive so that they eliminate the time and mess encountered in mounting nonadhesive thermal conductors. The material is nonflowing and will withstand continuous exposure to 300°F and intermediate exposure to 400°F. The material cures for 45 minutes at 350°F.
Ablestik Laboratories, 833 W. 182nd St., Gardena, Calif. 90248 [373]

An epoxy adhesive paste, which is resistant to temperature cycling, produces thermally conductive bonds between heat sinks and power devices and in fabricated heat sinks. Material 1520 is a thixotropic paste and can also serve as an electrical insulator. Low shrinkage is offered, as well as the ability to bond to a number of substrates. The two-part material is available with several hardeners for room-temperature and heat cure. Price is $31.50 per gallon.
Castall Inc., Weymouth Industrial Park, E. Weymouth, Mass. 02189 [374]

New literature

Modem. International Communications Corp., 7620 N.W. 36th Ave., Miami, Fla. 33147. An 8-page data sheet describes the Modem 4600/48, a 4,800-bits-per-second dataset that has a simplified type of manual equalization. Included are details of the unit's remote-control test features, which permits an operator at one site to test the full system. Circle 421 on reader service card.

Gases for electronics. A guide to gases and gas-handling equipment used in the electronics industry has been issued by Matheson Gas Products, P.O. Box 85, East Rutherford, N.J. 07073.The brochure includes information on gases and materials-handling for silicon chemical vapor deposition, etching, diffusion, and production of light-emitting diodes. [422]

Mercury sliprings. Descriptive literature about Rotocon mercury sliprings is available from Meridian Laboratory Inc., 2415 Evergreen Rd., Middleton, Wis. 53562. The sliprings are designed for power and control applications at speeds to 30,000 revolutions per minute, and they are said to have no resistance deviation at speeds above 600 rpm. Standard models are available with 2 to 160 terminals. [423]

Diodes. A four-page brochure published by Raytheon Co., Special Microwave Devices Operation, 130 Second Ave., Waltham, Mass. 02154, describes p-i-n and n-i-p diodes. Eight types in the series are used in rf control applications through Ku band and have switching speeds of less than 5 nanoseconds. Each can be bought in either p-i-n or n-i-p version to provide a choice of biasing polarity. [424]

Reed relays. Struthers-Dunn Inc., Lambs Rd., Pitman, N.J. 08071. A two-page illustrated bulletin gives full design information on a new half-DIP reed relay, which has its pins centered so that two relays can be inserted in a single socket. Bulletin B/3201 tabulates coil characteristics, contact ratings, and life expectancy. It gives socket diagrams and full-dimension drawings, and options are discussed. [425]

Telemetering. Solid State Electronics Corp., 15321 Rayen St., Sepulveda, Calif. 91343, has published a 32-page catalog describing its line of telemetering products, including voltage-controlled oscillators, fm discriminators, frequency-to-dc converters, amplifiers, and other units. All have a miniaturized, ruggedized design and are recommended for industrial and military applications. [426]

Temperature controllers. A 20-page brochure is being offered by West Instrument Division, Gulton Industries Inc., 3860 N. River Rd., Schiller Park, Ill. 60176, that describes the line of analog and digital solid-state temperature controllers. [429]

Amplifier. A brochure for system engineers describes characteristics of logarithmic amplifiers and is available from American Astrionics, 291 Kalmus Dr., Costa Mesa, Calif. 92626 [430]

Printed-circuit boards. A four-page bulletin is available from Webtek Corp., 4326 W. Pico Blvd., Los Angeles, Calif., that provides information on a line of products especially for use in the production of printed-circuit boards. [433]

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New books

Minicomputers for Engineers and Scientists, Graninc A. Korn, McGraw-Hill Book Co., 303 pp., $17.75.

Recent new developments in minicomputers and the vast growth in their market—resulting largely from their versatility—present technical people with difficulty in choosing and using only what they need. This book will assist potential buyers to understand the literature distributed by minicomputer manufacturers, to choose their equipment intelligently, and use it efficiently.

The book is comprehensive and reasonably well written. The rather steep price is almost justified merely to get the set of tables in the back of the book—the most extensive this reviewer has seen in one place. And, many additional tables are included in the text.

The book is divided into seven chapters. Korn first describes where and how minicomputers are used, as well as the basics of digital computers—including such topics as binary, octal, and hexadecimal notation, alphanumeric codes commonly used in minicomputers, logic and arithmetic techniques, and memory. Then he presents a generalized discussion of the design and operation of a basic minicomputer—sort of a combination of the major features of the principal models now on the market. In Chapter 3, the author gets a little more specific, describing the operation and programing techniques without reference to symbolic languages or the assembly programs required to convert a program into a form that the computer can use. Since most minicomputers are most efficiently programed in symbolic languages, however, Chapter 4 gets down to the nitty-gritty of using a minicomputer—machine language is too detailed and tedious for even the most efficient clerk to work with, and the higher-level languages such as Fortran, although easiest to use for programs, require cumbersome compiler programs that don't fit easily in the limited memory space that most minicomputers have available. In Chapter 5, the author deals with what he calls "the most important

single feature of the new minicomputers . . . their ability to interact inexpensively with devices in the outside world"— such as analog-to-digital and digital-to-analog converters, transducers, and controllers. He discusses interrupts, direct-memory access, block transfer of large amounts of data, noise compensation, and input-output software. Korn treats in general terms the comparative architectures of minicomputers with 8-, 12-, 16-, and 18-bit word lengths, and then describes in considerable detail Digital Equipment Corp.'s PDP-11 series and gives some information on Data General's Nova series and GRI Computer Corp.'s GRI-909. (Other companies' products are also mentioned from time to time in the book.) Finally, Chapter 7 discusses numerous applications.

The tables in the back of the book include a table of powers of 2 up to 2^{100} (a number of 31 digits, or more than one nonillion) and down to $2^{0.001}$ to 15 places; powers of 10 and mathematical constants in octal notation, exhaustive octal-decimal conversion tables going to nine octal digits, six-place octal fractions and eight-place decimal fractions; powers of 16 in decimal notation; hexadecimal addition and multiplication tables; and tables of Teletype and ASCII codes. —Wallace B. Riley

Recently published

Cybernetic Engineering, John F. Young, John Wiley & Sons Inc., 153 pp., $11.95.

Design of Modern Transistor Circuits, Maurice Yunik, Prentice-Hall Inc., 365 pp., $16.

Electronic Display and Data Systems, C.J. Richards, McGraw-Hill Inc., 460 pp., $22.50.

Frequency Synthesis, V.F. Kroupa, John Wiley & Sons Inc., 295 pp., $27.50.

Guide to Electronic Measurements and Laboratory Practice, Stanley Wolf, Prentice-Hall Inc., 494 pp., $14.95.

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compl w / plot boards
X BAND BEACON 400 W PULSE AN/DPN-62
X BAND AUTOTRACK 50KW PULSE B-47
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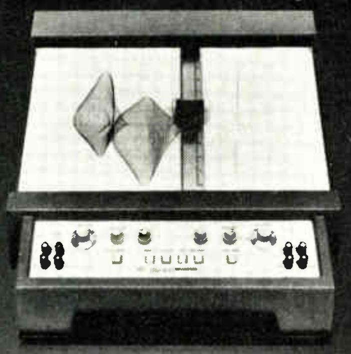

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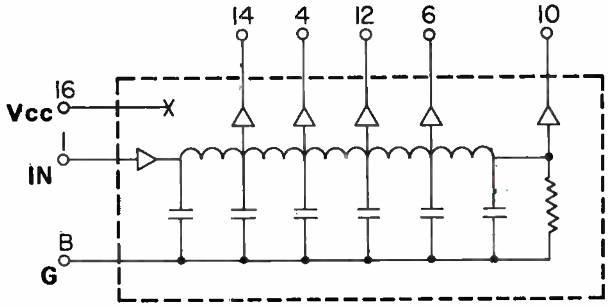

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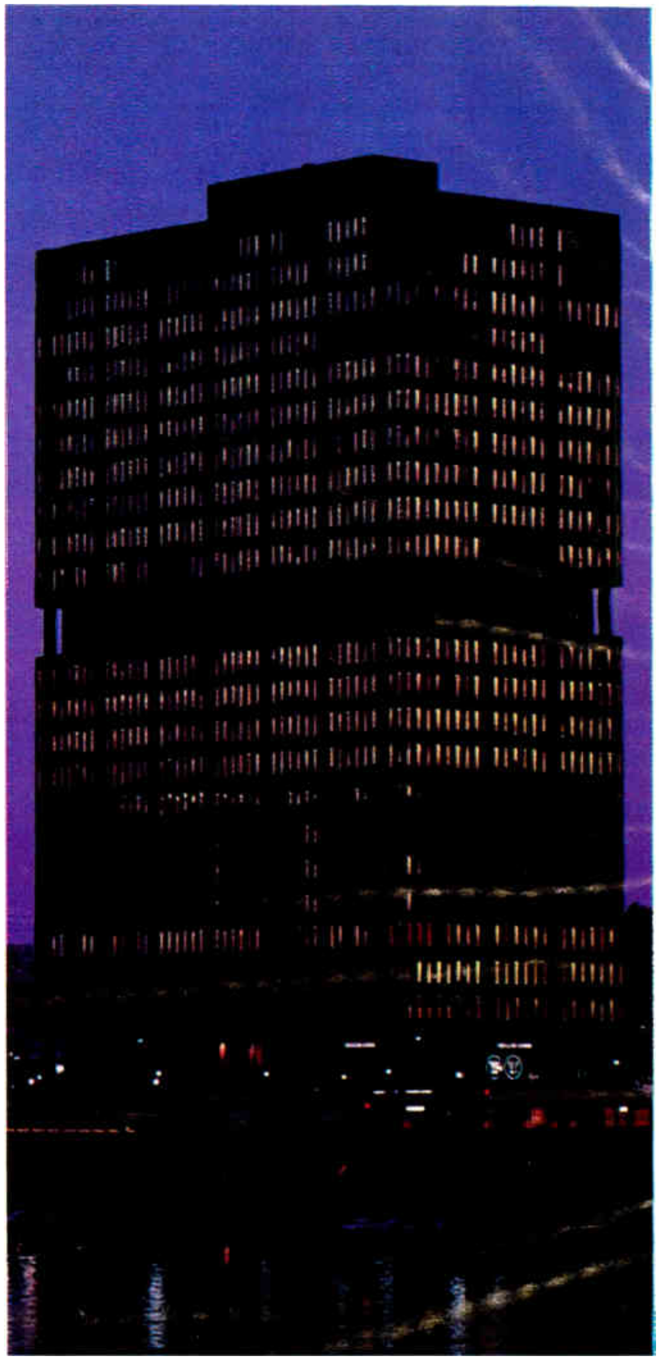
This home saves fuel by using environmental energy—with a Westinghouse heat pump. Amazingly efficient way to heat and cool—it "borrows" energy from the outside air. It's a machine to make heat flow: into the house in winter, out of the house in summer.



This building has a Westinghouse system that recycles energy. Fuel energy saving: 14%. It collects and stores the "waste" heat produced by the lighting system, and uses it to heat the building. Most winter days, no additional heat is needed. In summer, the system reduces office heat, so air conditioning takes less power.

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Westinghouse 12000 hour Krypton-filled Street Lighting Lamps

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Petroleum and You (A History of the Former)

Chapter Five: Threshold of a New Horizon

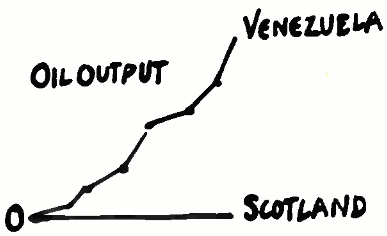
The advent of the automobile wrought unparalleled changes which made themselves felt throughout the entire spectrum of the industrial world within a few short years.* And none was to know greater upheaval than the petroleum industry, for as a consequence an oft-neglected product of the refinery—gasoline—was to emerge as the very bread and butter of the industry, which explains why people in the oil business have always had such a hard time getting anybody to drop by for brunch.

And of course the automobile required not only gasoline, but a host of lubricants, greases and motor oils without which it would soon grind to either a halt or a standstill, depending on the skill of the driver. Thus, an ever-increasing demand for petroleum was triggered. Exploratory ventures were undertaken, and by 1900 "It's a gusher!" had become a familiar cry throughout California and the Southwest. Not only that, a year later oil was discovered.

In the meantime an Englishman named William Knox D'Arcy completed negotiations to establish an oil industry in Persia, and later contracted to supply fuel oil to the Royal Navy. This was the same William Knox D'Arcy who had previously made a fortune gold-mining in Australia, not to be confused with the William Knox D'Arcy who owned a tobacco shop on Edgeware Road and who usually overcooked his vegetables.

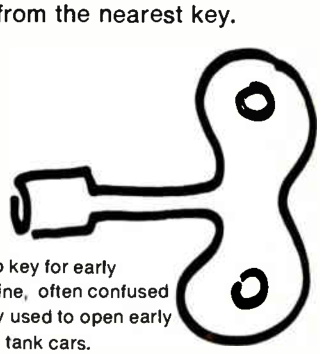
Overcooked carrots from kitchen of the wrong William Knox D'Arcy.

In the Western Hemisphere substantial oil discoveries in 1914 in the Lake Maracaibo area soon made Venezuela a name to be reckoned with, especially for poor spellers. Within a decade and a half the country ranked second only to the United States among the world's oil-producing countries, not to mention an even higher ranking among the non-oil-producing countries.



Seven-year comparison chart in which Venezuela comes out looking extra good.

The First World War accelerated even more the spiraling demand for petroleum. The airplane came into prominence, first as a means of reconnaisance and later as a weapon, joining the growing family of vehicles that depend upon petroleum for their lifeblood. Ships, by this time, ran almost exclusively on fuel oil. And modern-thinking proponents of the diesel-powered submarine were making significant inroads against advocates of the less-efficient wind-up submarine, which tended to go very fast at first but then gradually ran down, often leaving the crew stranded miles from the nearest key.



Wind-up key for early submarine, often confused with key used to open early railroad tank cars.

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*Some historians contend that these years were not short at all, pointing out that 1908 in particular was well above average height.

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