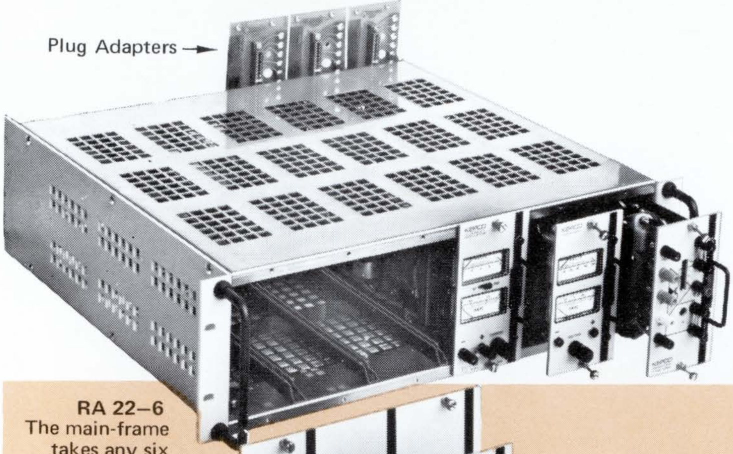
VOL. 29 NO. 2
FEBRUARY 1970

CHILTON'S THE ELECTRONIC ENGINEER

Drs. Frederic P. Heiman (l.) and Steven R. Hofstein, developers of the first MOS IC



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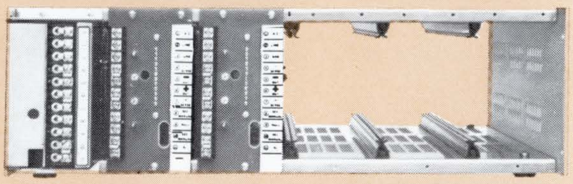
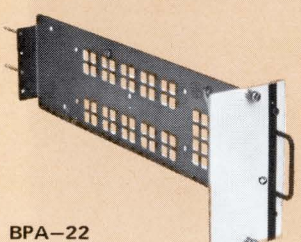
RA 22–6
The main-frame takes any six modules or combinations.

FILLER PANELS
To fill up slots temporarily left empty.

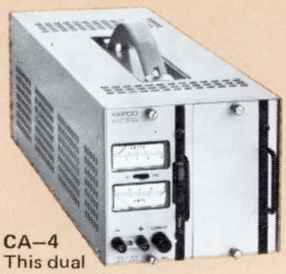


This is the rear of the 6-unit, rack mountable housing, RA 22–6, showing the location of the plug adapters, PC–2, which interface each model's male PC connector to an easy-to-use barrier strip. There is space for a bolt-on overvoltage protector (shown mounted on the left-hand slot). If you look carefully, you can see the coding pins which you can use to uniquely encode each slot so that no one can get the supplies mixed-up.



BPA–22
This is a blank slide assembly which you can use to mount your own circuits—or the lower-cost, unmetered Kepco power modules.

CA–3
Use this single unit housing to convert any of the plug-in supplies and amplifiers to a self-contained bench model.



CA–4
This dual housing will permit you to custom-make your own dual supplies. No tools or soldering; just plug in the supplies and plug-in the line cord!

CA–5
A 3-unit housing provides you with considerable flexibility in your choice of voltage or current regulators or, perhaps, a three amplifier manifold.

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Kepco's CC Series programmable current regulators feature a capacitorless output circuit that responds to load changes at speeds up to 2 μsec/V. A 10-turn current control with dual range sensing, operate a low-noise integrated control amplifier to provide exceptional stability and resolution. Regulation is 0.0005% for line, 0.005% for load.

MODEL	AMPS	VOLTS
CC 7–2M	0–2	0–7
CC 15–1.5M	0–1.5	0–15
CC 21–1M	0–1	0–21
CC 40–0.5M	0–0.5	0–40
CC 72–0.3M	0–0.3	0–72
CC 100–0.2M	0–0.2	0–100

PRICE: $195.00

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OPERATIONAL POWER

The OPS modules, with the suffix BTA are equipped with an operational patch panel for summing and feedback components. Gain is in excess of 0.5×10^6 V/V with an offset voltage coefficient $<20\,\mu$V/°C. The fast-slewing unipolar amplifier is perfect for digital control or any rapid-fire programmed testing.

MODEL	VOLTS	AMPS
OPS 7–2BTA	0–7	0–2
OPS 15–1.5BTA	0–15	0–1.5
OPS 21–1BTA	0–21	0–1
OPS 40–0.5BTA	0–40	0–0.5
OPS 72–0.3BTA	0–72	0–0.3
OPS 100–0.2BTA	0–100	0–0.2

PRICE: $179.00

PCX-MAT

VOLTAGE REGULATORS

The PCX module, with the suffix MAT, sports a metered front panel with a 10-turn, high resolution voltage control. The low-noise integrated control amplifier regulates the output to better than 0.0005% for line, 0.005% for load. A multiterminal rear barrier-strip, interfaced with the printed circuit plug, provides access for remote control facilities.

MODEL	VOLTS	AMPS
PCX 7–2MAT	0–7	0–2
PCX 15–1.5MAT	0–15	0–1.5
PCX 21–1MAT	0–21	0–1
PCX 40–0.5MAT	0–40	0–0.5
PCX 72–0.3MAT	0–72	0–0.3
PCX 100–0.2MAT	0–100	0–0.2

PRICE: $168.00

For complete specifications and application notes – Write Dept. DH–19

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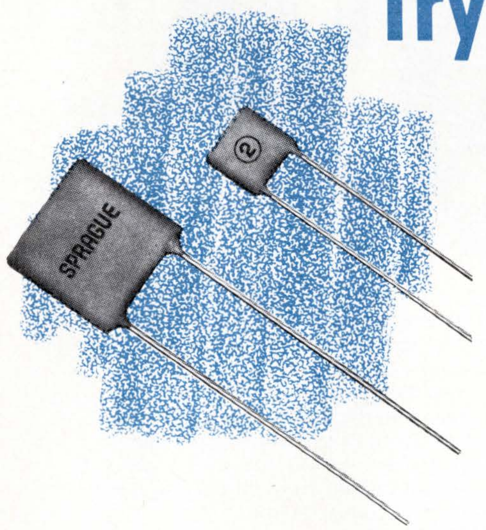

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CHILTON'S THE ELECTRONIC ENGINEER

Feb. 1970 Vol. 29 No. 2

COVER

Back in 1962, Drs. Federic P. Heiman and Steven R. Hofstein, then working for the RCA Electronic Research Lab, made the first integrated circuit that employed metal-oxide semiconductors (MOS). The historical note on MOS ICs serves as an introduction to the course on that subject, which starts in this issue and will continue for several consecutive issues.

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THE ELECTRONIC ENGINEER

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Address Mail to: 56th & Chestnut Sts.
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4CX600F	26.5							
4CW800B	6.0	890	5-PIN SPEC.	Liquid	3000	0.6	750 W	WIDEBAND AMPLIFIER SERVICE
4CW800F	26.5							
4CX600J / 8809	6.0	150	OCTAL SPEC.	Air	3000	0.6	750W	CLASS AB-1 LINEAR SERVICE

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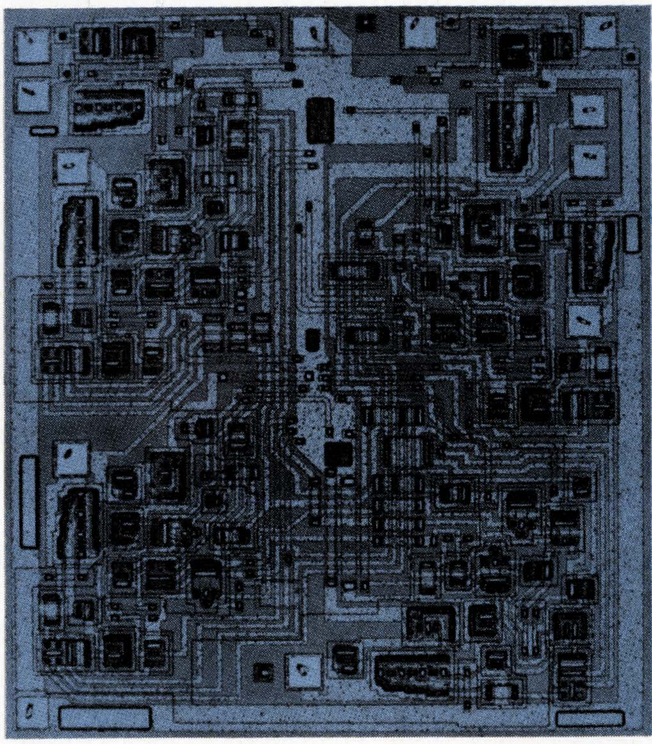

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MC7491A	8-Bit Shift Register
MC7492	Divide-By-Twelve Counter
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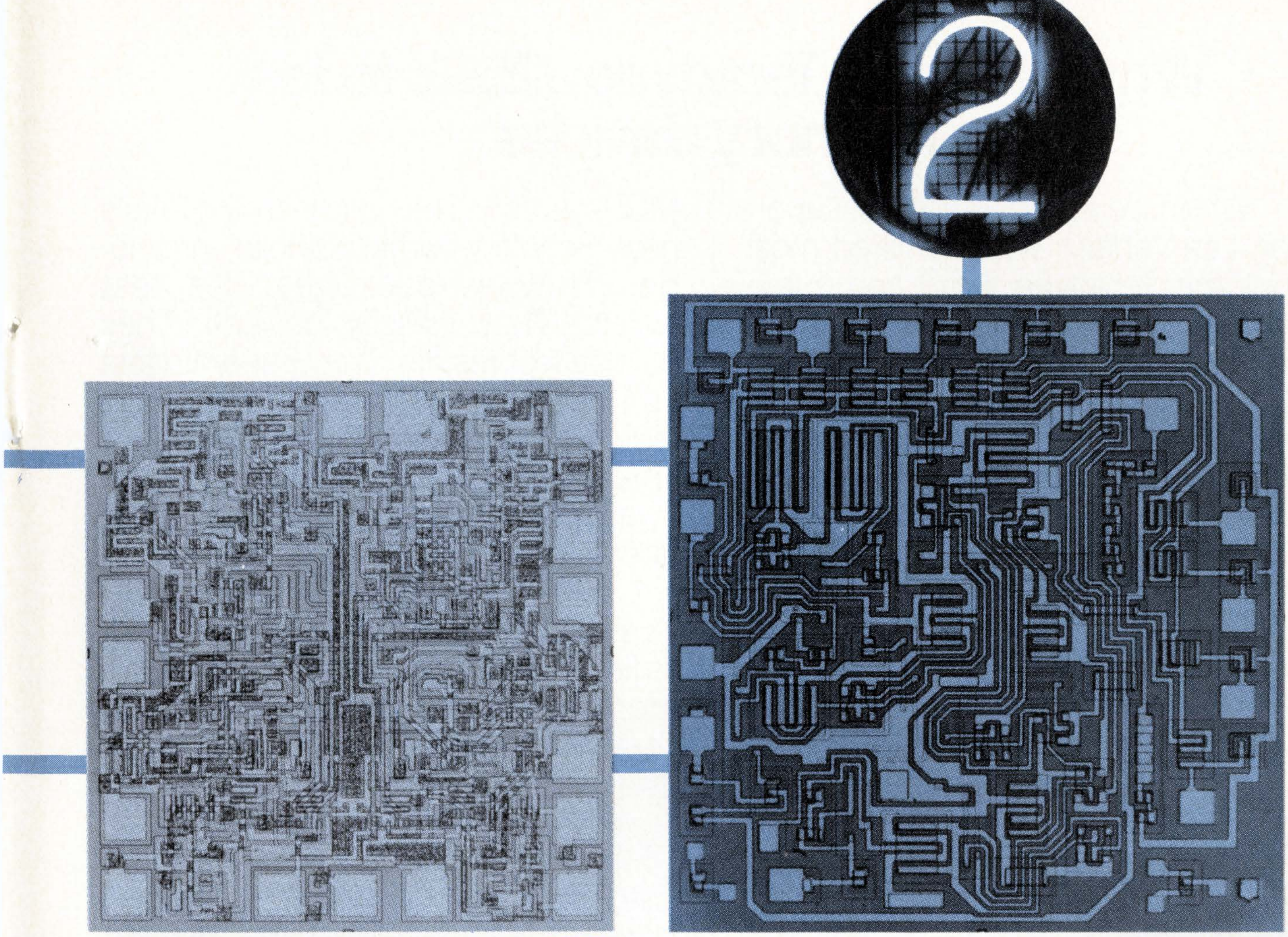

MC7475 MC7441A

with these MTTL complex functions

Now you can develop completely integrated readout systems with the intrinsic advantages of reduced circuitry, lower costs, and increased reliability. Design flexibility is yours when you consider the numerous configurations possible. For example, take one BCD-TO-DECIMAL DECODER AND HIGH-LEVEL DRIVER (MC7441A) and include a DECADE COUNTER (MC7490) to provide a basic counter-readout operation. Pin compatibility allows the two devices to be mounted side by side and no external logic or additional components are required. Additional decades may be added and the display can be provided with a sequential pulse train into the first decade for use as a multidigit counter or timer, or many other applications.

Or add a QUAD LATCH (MC7475) and the MC7490 can follow the input sequence and, at specified intervals, the count is strobed through the latch and presented to the MC7441A. In this way the display tubes are not continuously cycling and are easier to read at specific times. Provide a zero suppression circuit and all unused tubes will remain blank making it easier to read actual numbers.

And, by designing in four MC4004 16-BIT SCRATCH PAD MEMORIES you can expand the counter-readout concept to an economical multiplexing operation. In this case one driver is utilized to display a given number on the readout tubes thereby eliminating the sequential counting sequence.

These are only a few of many potential uses for the MC7490, MC7475 and MC7441A. Each device is a versatile design tool and can be used in varied applications to develop new systems or extend present ones.

Detailed specifications on these MTTL complex functions and a newly available application note "Direct Digital Display Using MTTL Complex Functions" are yours for the asking. Simply write to us at P. O. Box 20912, Phoenix, Arizona 85036 and ask for MOTOROLA TTL DESIGN KIT #1. Let Motorola's growing TTL capability work for you.

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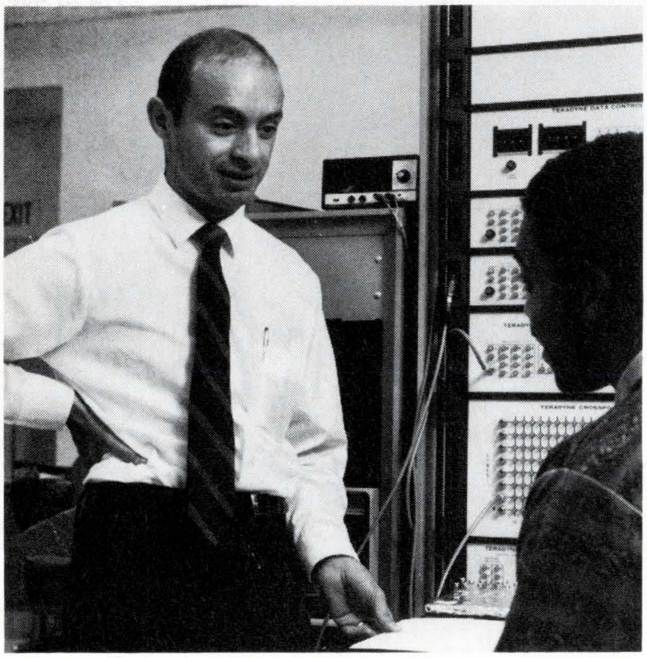
Why Intel uses Teradyne J259's to test memory devices

When we asked Intel's test supervisor, Les Vadasz, what he liked most about the Teradyne J259 computer-operated IC test system, he smiled and said: "It runs."

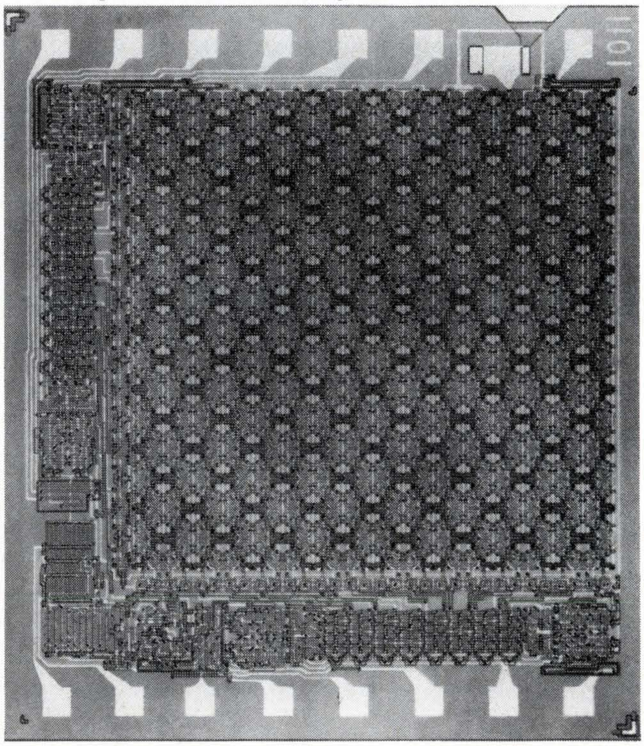


"Just running" is no small matter, as any IC producer can tell you. It's especially vital when you're testing 256-bit silicon-gate MOS memories like Intel's. When your devices are that exotic, you want the most unexotic test system you can find. One that doesn't go off the air once a week. One that doesn't need periodic calibration. One that "just runs."

How dependable are Intel's J259's? So dependable that Intel finds it hard to put a number on downtime, but estimates that less than *1 percent* of its test-facility downtime is attributable to the Teradyne systems.

And Intel's J259's work hard. They make as many as 10,000 functional and parametric tests on each 256-bit MOS memory. They also test all of Intel's new Schottky-barrier bipolar memories. They test packages. They test wafers. They classify devices. They datalog test results. They generate test summary sheets and distribution tables. Since everything is done on a time-shared basis, it all adds up to an awesome test capability per J259, hour after dependable hour.

Intel's new lines of memory devices mark the company as a leader in its field. So does its choice of test equipment—equipment that, in the best Teradyne tradition, "just runs."



Teradyne's J259 makes sense to Intel. If you're in the business of testing circuits—integrated or otherwise—it makes sense to find out more about the J259. Just use the reader service card or write to Teradyne, 183 Essex St., Boston, Massachusetts 02111.

Teradyne makes sense.

EDITORIAL

MOS is ripe, but tender

You wouldn't think it was that long ago, but more than seven years have passed since Drs. Hofstein and Heiman made the first integrated circuit with metal-oxide semiconductors (MOS) at the RCA Labs. Yet only in the last two years have commercial MOS integrated circuits taken hold in the market.

Compare this evolution to that of the MOS' predecessor, the bipolar integrated circuit. It was in 1958 that Dr. Kilby made the first IC at Texas Instruments, a germanium mesa structure that bears no resemblance to modern ICs. The following year, Dr. Hoerni developed at Fairchild the Planar® structure that made today's ICs possible. It took only three years—thanks largely to the impetus provided by the Minuteman contract—for commercial RTL circuits to appear on the market. By 1965 (seven years after Kilby's invention), every other electronic engineer in this country was using, or was planning to use, bipolar ICs.

With the ever faster rate of development that characterizes our industry, why is MOS taking longer to take hold than bipolars? There are two main reasons. First, at the time of their invention, bipolar ICs had behind them ten years of semiconductor technology developed for discrete transistors—a background MOS didn't have. Second, and more important, MOS ICs were almost smothered in their crib by too much love, by an almost blind belief that they would enjoy an even faster development than that of bipolar ICs.

I am referring to the Victor calculator, a premature attempt to integrate MOS ICs in large scale for a commercial piece of equipment. This joint attempt, started very hopefully back in 1966 by General Microelectronics and Victor Comptometer (a manufacturer of business machines), floundered and cost GME its corporate life. Why did it fail? It depends on whom you ask, but it is clear that both manufacturer and user wishfully underestimated the problems they knew existed. The manufacturer (General Microelectronics, later absorbed by Philco-Ford) knew that MOS suffered from surface problems, an inversion layer produced by migrating ions that blocked the electric field—but hoped they could be solved in production in the same way they were solved in the laboratory. The user, on the other hand, did not have the experience with MOS necessary to foresee the serious implications of those problems. It trusted the technology on the strength of its promise.

We can ill afford another Victor calculator today. That traumatic experience was enough to make many designers of digital equipment freeze when it came to evaluating MOS for new designs. We see now, however, a thawing of that attitude. Standard MOS ICs, such as shift registers, have become so popular and reliable that many non-electronic engineers order them the way they order, say, a relay. On the other hand, many manufacturers of custom MOS ICs find that the best way to promote MOS is to teach the technology to the prospective user. A few manufacturers of digital equipment, such as Four Phase Systems in California and Viatron in Boston, are so committed to MOS that the electronic portion of their digital machines will depend almost entirely on MOS ICs, or even MOS LSI. To back up this effort, their top engineering staff has had extensive experience in MOS technology, acquired at manufacturers such as Fairchild and RCA, respectively.

We hope the new MOS designs succeed. To help them, we are starting in this issue a course on MOS integrated circuits, which will cover the basic MOS structures, digital and linear designs, and applications and testing of these circuits. We feel the time is ripe for a course, because, even though THE ELECTRONIC ENGINEER (as well as most other electronic magazines) have reported on the advancements of MOS technology as they happened, many of these developments invariably turn up in blind alleys and cease to be significant as soon as they are published. Our course, on the other hand, will bring you up to date on the established technology, and will provide a practical view oriented to the application, rather than the design, of MOS ICs.

To the new MOS designers, we devote our course. To the experienced designers, our best wishes for success, particularly with such ambitious designs as Viatron and Four Phase systems have started. The industry needs their success, because just as the failure of the Victor calculator gave MOS in 1966 a bad name it didn't need, the failure of these modern systems will give it a bad name it doesn't deserve.

Alberto Socolovsky
Editor

It happened last month . . .

The editors of THE ELECTRONIC ENGINEER have sifted through the various technical and significant happenings of the past month and selected the items that would be of the most interest or use to you.

Nod for solid-state relays . . . A recent unofficial communique by the Navy Electronics Lab in China Lake, Calif., recommends that all new designs for the Navy should use, whenever possible, solid-state relays. Considering the apprehension with which designers have been using solid-state relays until recently, this communique is quite a step forward. Pioneered by Teledyne, solid-state relays are being increasingly accepted, and are now manufactured by almost half of the electromechanical relay makers.

Plastic DIPs still cause concern . . . even though the troubles that several users had back in Sept. 1968 with plastic packages (the bonds were lifting up during thermocycling) have been corrected, the Loveland Div. of Hewlett-Packard has decided to plug plastic-packaged dual-in-line ICs into sockets, rather than solder them directly to printed circuit boards. It gives two reasons for this action. First, it avoids thermal shock to the IC. Second, it keeps solder fluxes away from the leads of the IC, where it might reach the chip. Even though the instrument manufacturer does not have a scientific confirmation of this fact, it assumes that the reliability of the plastic package will be higher when plugged into a socket.

Rolling their own . . . Tektronix Inc., a manufacturer of oscilloscopes and other test equipment, has set up a modern production line to manufacture those integrated circuits that it cannot get from IC vendors. For its ICs, Tektronix has decided on a package similar to the one used by Signetics, a silicone transfer-molded package with a buffer to isolate the chip from the molding material.

Cheaper ICs . . . A new TRIM (for Tri-mask) structure, based on the use of lateral transistors, is said to be simple, inexpensive and easy to build. The emitter and base regions are encircled by a collector region, and a large collection region which extends beneath them. Transistors occupy less than 500 square microns of silicon area. Resistors as high as 50 kilohms have been formed within 600 sq. microns. A total of only three masks are used to produce the transistors and metallization layer. Work was done at Bell Labs.

MTBF figure for instruments . . . Now that integrated circuits are solidly entrenched in commercial instruments, some instrument manufacturers want to call to your attention that their equipment is more reliable, thanks to the fewer number of parts it uses. Two of them, Fluke and Exact electronics, are working out a reliability number for some of their new instruments, based on the mean-time-between failure (MTBF) of the component parts they use.

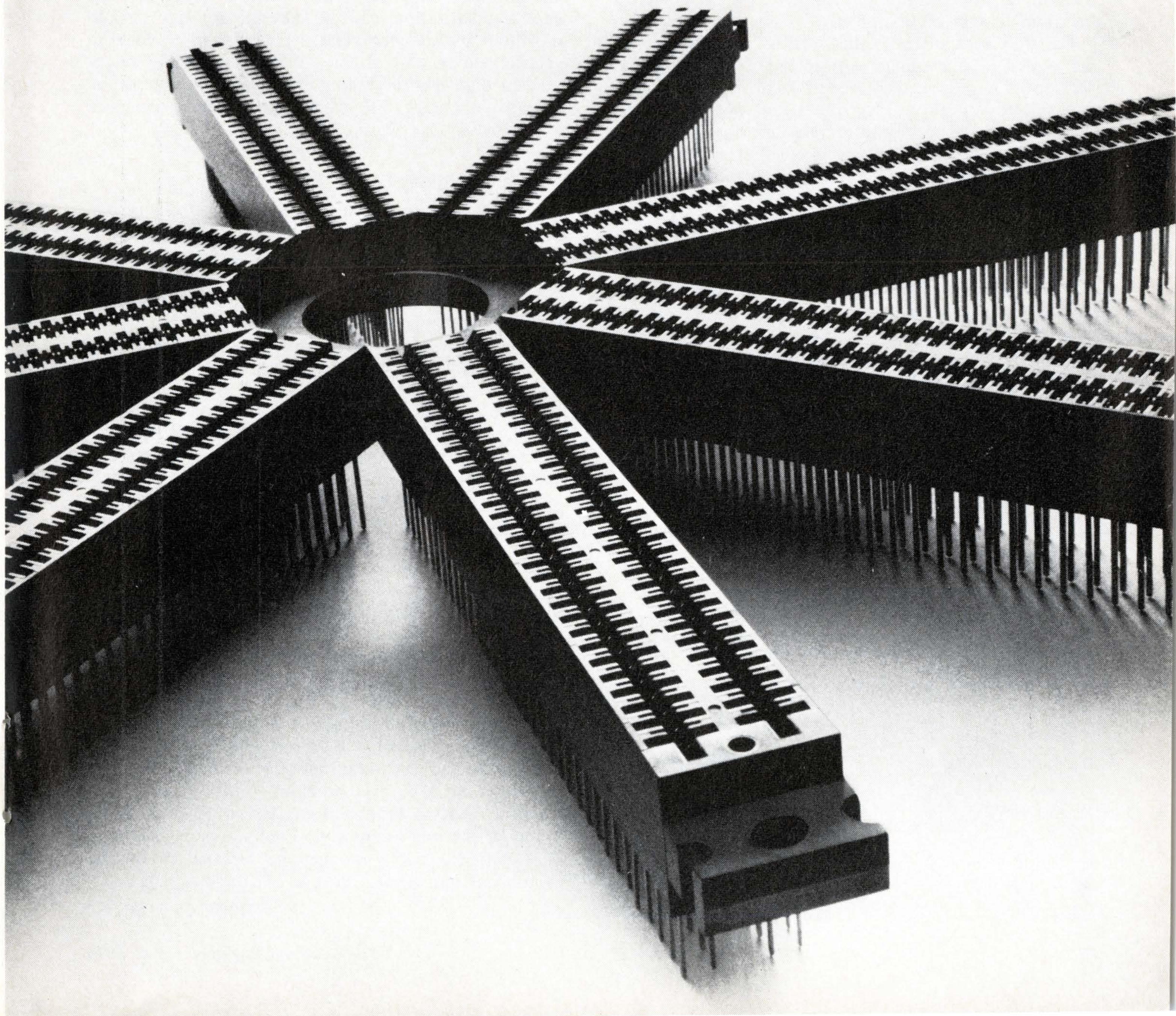
If the idea takes hold, we may have to worry about one more specification for instruments, namely, how long it takes to fail. Of course, the number will have to be referred to a definition of what a failure is. Theoretically, a failure occurs when an important characteristic of the instrument goes out of spec. Such a figure, therefore, will certainly cause a revision of the definitions for those specs.

Standards for wire bonds . . . The National Bureau of Standards has been working for some time to develop standards of measurement for semiconductor materials, and for fabrication methods relating to them. In addition to developing measurements to determine semiconductor resistivity (a parameter that varies with the method employed), carrier lifetime, and the thermal properties of semiconductor devices, they are also exploring some methods to standardize the evaluation of wirebonds, such as thermocompression bonds and the adhesion of beam leads.

Ceramic Switch . . . A tiny ceramic "sandwich" offers both piezoelectric and ferroelectric properties in the same material. Because of the two effects, the device can act as a switch or as a linear regulator to control the amount of current passing through it. A control signal to either element sets the level of gain or the on/off switch action. The amount of control will stay fixed even after power is removed. RCA, the developer, foresees widespread use in the consumer field for applications such as home appliances, lighting and heating systems, and industrial tools.

Fireproof TV sets . . . Apparently there are greater fire hazards in color TV sets than most of us realized. The National Commission on Product Safety has told TV set manufacturers to make sets more fireproof, primarily by improved insulation materials. Look for this to happen in other consumer electronic products.

Entry into data terminals . . . Tektronix, whose Model 611 readout terminal was very popular among computer terminal manufacturers, has made its own entry into the data terminal business, with a complete data terminal called Model 4002.



"Sandwich" has remote control possibilities

Piezoelectric and ferroelectric properties are combined in one material to give device its capabilities.

RCA has developed a new solid-state device that may lead to TV-type remote controls for home appliances, heating systems, lamps, office equipment and industrial tools.

The device is a tiny ceramic element whose electrical properties can be adjusted electronically to turn on, turn off, or smoothly vary the electron flow in a circuit, even from a remote location. Moreover, the device will "remember" its last setting indefinitely, even if power to the circuit is shut off completely.

The new component is the result of an interplay of two electrical phenomena—piezoelectricity and ferroelectricity. A piezoelectric material can transform mechanical motion into an electrical signal, and vice versa. A ferroelectric material can remain in a state of electric polarization indefinitely, much like a magnet retains its magnetic polarization. When a material contains both properties, a change in ferroelectric polarization changes the efficiency of the material's piezoelectric effect.

To take advantage of the interaction of the two effects, Dr. Stuart S. Perlman and Joseph M. McCusker of RCA designed a sandwich consisting of two ceramic wafers—each with ferroelectric and piezoelectric properties—bonded together by epoxy.

When an ac signal (for instance, a radio signal) is applied to one wafer, the wafer vibrates because of its piezoelectric properties. These vibrations are transmitted through the epoxy to the second wafer which converts them back to an electric output signal.

The amplitude of the piezoelectric output signal can be raised or lowered by subjecting either wafer to a control pulse, thereby changing the amount of ferroelectric polarization in the wafer and thus its piezoelectric efficiency. Since the wafers are made of a stable ferroelectric material, the output signal is stable and changes only when the polarization is changed.

Ferroelectric device can give a complete on/off switching function or anything in between and it can be controlled from a remote point. Many consumer applications are seen for the device.

Two versions of the device have been developed. One, an adaptive resonant filter, responds only to input signals in a narrow frequency range. The other, designated an adaptive ferroelectric transformer, responds to input signals covering a broad frequency spectrum.

Both versions of the device use wafers made of ceramic lead zirconate/lead titanate material. The wafer's polarization can be altered in any desired magnitude by applying voltage pulses that produce an electric field typically 10 to 45 V/mil. of wafer thickness. In this way, the output signal of a device can be changed in analog fashion over a dynamic range of approximately 60 dB.

More about the device

The solid-state adaptive (analog storage) device is a resonant band-pass electronic filter with adaptable voltage gain. That is, the voltage gain-frequency transfer characteristic can be "set" to different values of attenuation by an "adapt" signal and will retain that "setting" after the adapt signal has been removed.

Ferroelectric materials are used as the dielectric in a filter structure composed of two capacitors bonded together so that resonant mechanical vibrations established in one (the input resonator) are coupled to the other (the output resonator). Converse and direct piezoelectric effects generate the mechanical vibrations and the output voltages, respectively. Ferroelectric effects in either capacitor provide the analog storage capabilities.

The acoustical coupling mechanism employed in the device design results in electrically stable device characteristics. Previous ferroelectric adaptive devices used unstable field effect coupling mechanisms which lead to unacceptable device performance.

These filters have electronic Q values near 100 at resonant frequencies in the range 10^2 to 10^7 Hz. The voltage gain-frequency characteristic has a maximum value at resonance of about 0 to +10 dB. Application of a voltage adapt pulse (100 to 300 V) of low energy (mJ) to either side of the filter can adapt the entire gain characteristic to any value between 0 and about −60 dB within an arbitrary switching time (limited to a practical range of roughly 1×10^4 to 10^{-5}) as determined by the pulse amplitude. Voltage gain "settings" are electrically stable and can be reproduced by the same or an equivalent sequence of adapting pulses.

(*continued on page* 14)

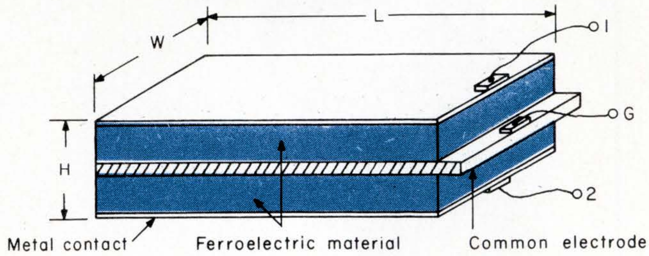
(*continued from page* 12)

Flexible design capability is one of the paramount properties of these adaptive resonant filters. Use of different filter materials, modes of mechanical vibration, types of mechanical mounts, filter structures and electrode configurations makes possible filter designs covering a broad spectrum of filter characteristics.

Adaptive resonant filters are particularly suited for application to system control and remote control circuits where only a few adaptive or control devices are required. Remote control of volume, chroma and tint in a color TV receiver, electronic control of processing equipment, lighting, or heating systems, and small-scale computer applications, as in speech recognition systems, are a few examples.

Large-scale memory arrays employing adaptive resonant filters are unlikely unless individual selection of devices during switching is possible. Matrix-type selection circuits are generally unsuccessful for ferroelectric devices because such devices lack the threshold-type switching characteristics required.

This "sandwich" exhibits both piezoelectric and ferroelectric properties. Because of these two properties, it can act as switch or limiter and will stay in its last setting until given a "signal" to change.

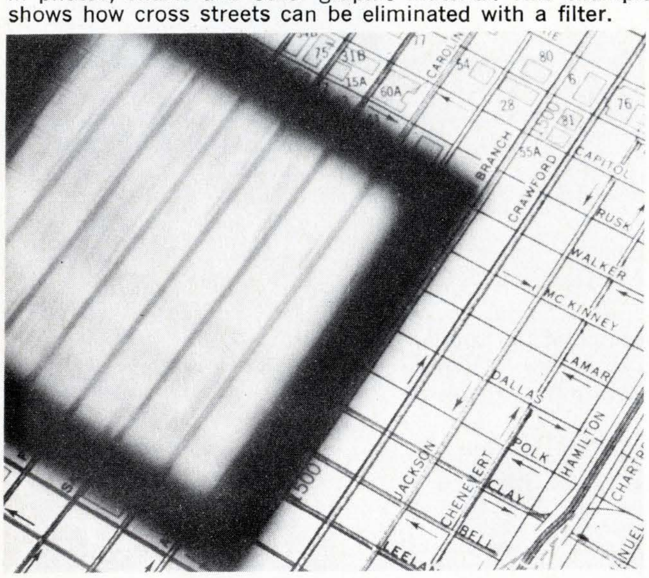


Special filters aid pattern recognition

A computer-processed, 35-mm slide can be coded to pass desired images, while rejecting others. The experimental filter, developed by IBM's scientists, is an offshoot of their work on the kinoform, a computer-produced slide which can form 3-D images similar to those produced by holograms.

When a pattern such as crosshatch is viewed through one type of kinoform filter slide, for example only lines that are parallel to the horizontal edge of the slide can be seen; all others are rejected. As the slide is rotated, the first set of lines disappear and vertical lines become clear.

A filter produced by computer can reveal hidden patterns in photos, charts and other graphic material. This example shows how cross streets can be eliminated with a filter.



This type of filter could help seismologists detect planes of underground strata in seismographic plots. Most of the jumble of confusing lines, "noise," would be rejected, revealing only important lines that show the existence of underground rock formations.

Another form of this filter can be coded to recognize objects of different sizes and shapes—such as certain types of cell. For example, a biologist could look through the filter and see only a field of bright spots—each spot representing a cell of the size and shape that he seeks. An electron scanner could be placed behind the filter to count the number of objects the filter had highlighted.

Also, the filter could be used to monitor small parts in an assembly plant. A part that was broken, the wrong size or out of alignment would not produce a spot as it passed under the filter. The absence of a spot could trigger a photo-scanner to ring an alarm or actuate a mechanism to remove the part from the line.

These filters could also be used in such applications as ZIP-code readers and similar automatic reading devices for computers. The filters are made the same as kinoform 3-D slides. In coding the filter to recognize a certain object, such as a cell, a mathematical description of the cell's size and shape is fed to a computer. The computer then simulates, mathematically, how light waves would be scattered by the cell and how these scattered waves would expose a sheet of film placed near the cell. The scattered light waves would create a pattern on the film similar to a ripple-filled puddle. This pattern is plotted by the computer and transferred to a 35-mm slide, hence producing the filter. The work was done by IBM's Process Industry Development Center in Houston, Tex.

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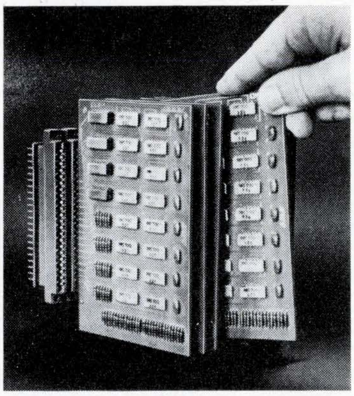
Circle 16 on Inquiry Card

15 nano-second memory...



there's a lot behind it

For one year we have been quietly mobilizing the industry's most capable semiconductor memory team. Personnel from all disciplines to design, assemble, test and volume produce the fastest, most reliable memory systems.

Here are the results:

1. Our memories are the world's fastest —15 nsec. access and 10 nsec. cycle times.

2. Our designs are pre-evaluated and optimized by computer simulation.

3. Our chips are individually packaged in proven, low-cost, ceramic Dual-In-Line packages and mounted on standard P/C cards.

4. Our cards are fully functional and incorporate our own logic support circuits to enhance system performance and minimize overhead circuit requirements.

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We design our memories to be modularly expandable and we supply them in ECL and TTL compatible configurations. Our products reflect total capability...The kind of capability that puts a lot behind us, including the competition.

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32 x 8	$768.00	AMS 0328E	AMS 0328T
32 x 9	$845.00	AMS 0329E	AMS 0329T

*Delivery on TTL—one month.

ADVANCED MEMORY SYSTEMS, INC., 1276 HAMMERWOOD AVENUE, SUNNYVALE, CALIFORNIA 94086, TEL. (408) 734-4330

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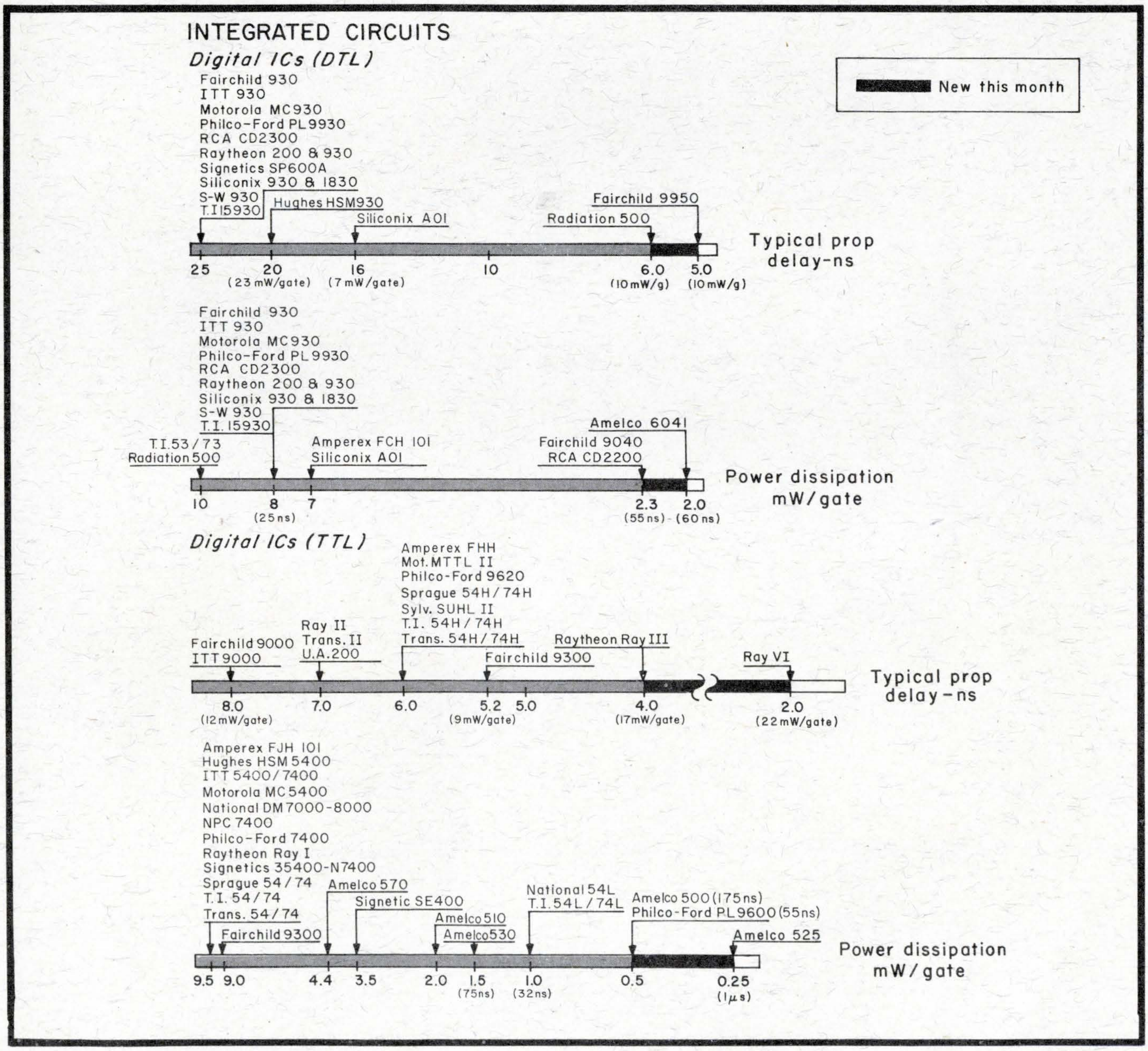
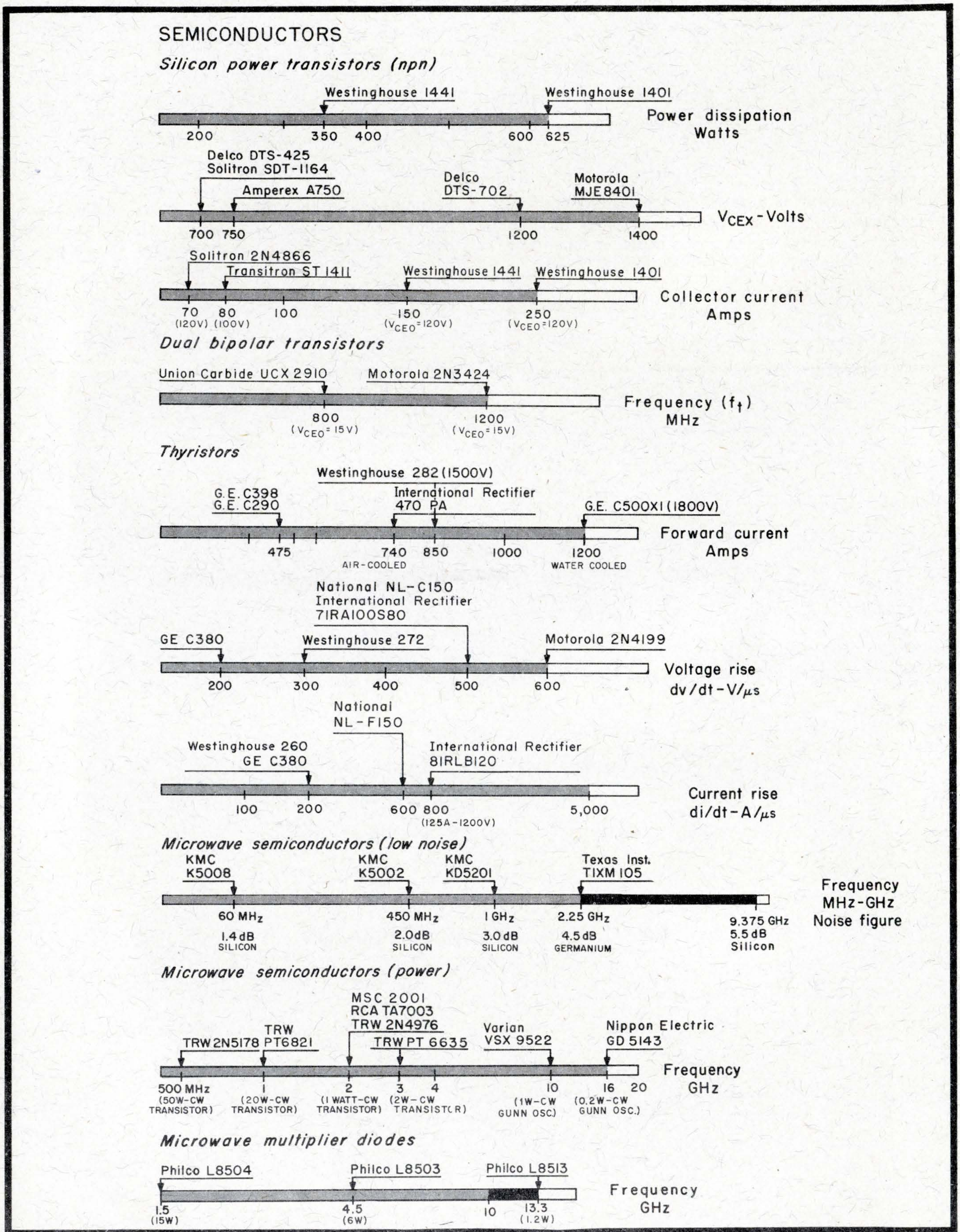
A word of caution

Keep in mind the tradeoffs, since any parameter can be improved at the expense of others. If there is no figure-of-merit available, we either include other significant parameters of the same products, or we provide additional bar graphs for the same products.

Do not use these charts to specify. Get complete specifications first, directly from the manufacturers.




SEMICONDUCTORS
Silicon power transistors (npn)
Westinghouse 1441
Westinghouse 1401
200 350 400 600 625
Power dissipation Watts
Delco DTS-425
Solitron SDT-1164
Amperex A750
Delco DTS-702
Motorola MJE8401
700 750 1200 1400
VCEX - Volts
Solitron 2N4866
Transitron ST 1411
Westinghouse 1441
Westinghouse 1401
70 (120V) 80 (100V) 100 150 (VCEO=120V) 250 (VCEO=120V)
Collector current Amps
Dual bipolar transistors
Union Carbide UCX 2910
Motorola 2N3424
800 (VCEO=15V) 1200 (VCEO=15V)
Frequency (ft) MHz
Thyristors
Westinghouse 282 (1500V)
G.E. C398
G.E. C290
International Rectifier 470 PA
G.E. C500X1 (1800V)
475 740 850 1000 1200
AIR-COOLED
WATER COOLED
Forward current Amps
National NL-C150
International Rectifier 71RA100S80
GE C380
Westinghouse 272
Motorola 2N4199
200 300 400 500 600
Voltage rise dv/dt-V/µs
National NL-F150
Westinghouse 260
GE C380
International Rectifier 81RLB120
100 200 600 800 (125A-1200V) 5,000
Current rise di/dt-A/µs
Microwave semiconductors (low noise)
KMC K5008
KMC K5002
KMC KD5201
Texas Inst. TIXM 105
60 MHz 1.4dB SILICON
450 MHz 2.0dB SILICON
1 GHz 3.0dB SILICON
2.25 GHz 4.5dB GERMANIUM
9.375 GHz 5.5dB Silicon
Frequency MHz-GHz Noise figure
Microwave semiconductors (power)
MSC 2001
RCA TA7003
TRW 2N4976
TRW 2N5178
TRW PT6821
TRW PT 6635
Varian VSX 9522
Nippon Electric GD 5143
500 MHz (50W-CW TRANSISTOR)
1 (20W-CW TRANSISTOR)
2 (1 WATT-CW TRANSISTOR)
3 (2W-CW TRANSISTOR)
4
10 (1W-CW GUNN OSC)
16 (0.2W-CW GUNN OSC.)
20
Frequency GHz
Microwave multiplier diodes
Philco L8504
Philco L8503
Philco L8513
1.5 (15W)
4.5 (6W)
10
13.3 (1.2W)
Frequency GHz

SPEAK UP

The electric shock hazard

Sir:

In the recent article "Would you put that probe on your sick grandmother?" [**The Electronic Engineer,** July 1969, page 39] a statement indicates we manufacture an instrument that "can shut off the power if there is more than a set amount of leakage." The editor's note identifies this instrument as our Camsafe "for power lines"

Unfortunately, perhaps, the Camsafe is not designed to turn off the power at any setting. Basically, the Camsafe substitutes for the patient. It measures and indicates the maximum current that would flow through the patient.

We all wish it were possible to make an instrument that could adequately replace human judgment in this situation. However, there is no complete agreement on what exact level of current leakage is critical and indications are that leakage critical under extreme conditions (e.g.: catheter or implanted electrodes) might not be as critical in other applications.

The Camsafe, incidentally, was not designed just to check power outlets, although it is used for that purpose; nor was it intended only for testing our Versascribe cardiograph. It can be used on any electrical equipment and, we feel, provides the best means presently available for determining current leakage. The increasing use of electro-medical instrumentation is making the potential problem of electric shock hazard more important every day and we compliment your publication on bringing this problem to the attention of your readers.

We are vitally interested in this matter and, for this reason, want to set the record straight in regard to our Camsafe.

Howard O. Burr
Communications Manager
Cambridge Instrument Co. Inc.
Ossining, N.Y.

Use the right CAD program

Sir:

In the article "Tables of CAD programs" [The Electronic Engineer, July 1969, p. 59] you state that documentation for the TRAC program is not available to the general user. This is not true. The only restriction on the dissemination of the TRAC documentation is that it may not be given to foreign nationals or governments without the approval of the Harry Diamond Laboratories.

A two volume report titled "Transient Radiation Analysis by Computer Program (TRAC); Volume 1, User's Guide; Volume 2, Theory and Flow Graphs" is available, subject to the above restriction, from the undersigned at the Harry Diamond Labs.

It should also be noted that: NET-1R does not run on the MANIAC 11 computer, the entire section should refer to the NET-1 program, not to the NET-1R; CIRCUS, SCEPTRE, and TRAC are available for the IBM 360 series of computers; CIRCUS has an extensive plot section; both CIRCUS and TRAC have some assembly language subroutines.

Robert Puttcamp
Research Physicist
Department of the Army
Harry Diamond Labs
Washington, D.C.

EDITOR'S NOTE: With the corrections Mr. Puttcamp points out, the tables for CAD programs look like this:

Computer Compatibility

Program	Operational on Computers	Language and size of source deck	Minimum word memory
CIRCUS	UNIVAC 1107/1108 IBM 360 IBM 7094	FORTRAN IV	
	GE 625/635		
	CDC 6600	5500 cards	32k
Gen. Network Analysis	UNIVAC 1107/1108	FORTRAN IV 3000 cards	65k
MISSAP III	CDC 3600	FORTRAN IV 2000 cards	32k
NET-1	IBM 7094	FAP	
	IBM 7040/7044		
	MANIAC II	30,000 cards	32k
Okla. Std. Analysis	IBM 7090/7094	FORTRAN IV 2000 cards	40k
PREDICT	IBM 7090/7094	FORTRAN II PAP 10,000 cards	32k
SCEPTRE	IBM 7090/7094 IBM 360 CDC 6600	FORTRAN IV 15,000 cards	32k
STRAP	IBM 7090/7094	FORTRAN IV	32k
TAG	IBM 7090/7094	FORTRAN II 12,000 cards	32k
TRAC	IBM 7090/7094 IBM 360	FORTRAN II 1500 cards	32k
ECAP	IBM 360	FORTRAN IV	
	IBM 1620		
	IBM 7090/7094		
	UNIVAC 1107/1108		32k

Main Program Features

	Dc initial condition	Dc component variation	Ac analysis	Transient analysis	User's manual	Mathematical description	Plotting capability	Branches (max)	Nodes (max)
CIRCUS	X	X		X	X	X	X	400	200
Gen. Net. Analysis	X	X	X	X	X		X		30
MISSAP III	X	X	X	X	X		X	100	
NET-1R	X			X	X			600	100
Okla. Std. Analysis	X			X		X		60	
PREDICT				X	X	X	X	300	100
SCEPTRE	X	X		X	X	X	X	300	100
STRAP	X			X	X	X	X	300	100
TAG	X	X		X	X	X	X		100
TRAC	X	X		X	X	X	X	100	60
ECAP	X	X	X	X	X			400	100

Are You Going to Buy a New Scope This Year?

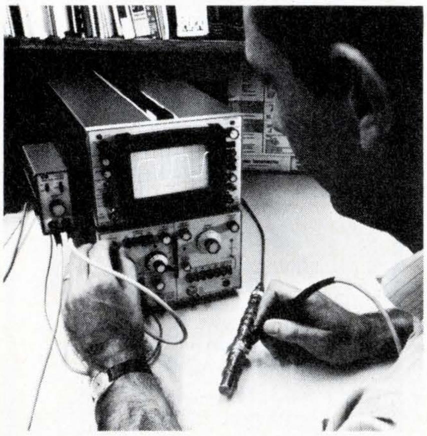
First, you'll want to know a scope's bandwidth and sensitivity. But beyond "horsepower," aren't there other things just as important? For example:

Does the scope have the latest technical innovations; so it's technically best now... and looks like it will be best in the future? **Leadership!**

Does the scope incorporate performance features that give me accurate measurements, easily? **Useability!**

Can it solve my measurement problems today, tomorrow and next year, economically? **Value!**

You're now going beyond specs and specmanship, and investigating the area of a company's design



philosophy — the "X" quantity you get in every instrument you buy.

Let's look at HP's record.

In the general-purpose, laboratory oscilloscope area, HP announced the first 180 Series Scope over three years ago. Today, it is your best answer to high frequency measurement problems! And here's why.

How about HP 180 leadership?

1. The HP 180 Scope was the first all-solid-state scope to be introduced — July, 1966.

2. It is the only high-frequency scope utilizing mesh-dome technology to increase, simultaneously, CRT bandwidth and CRT viewing area (instead of shrinking the CRT display area or extending tube length).

3. It is the only solid-state scope that has a fully documented, environmentally specified military version.

4. It is the only high-frequency system that has a rack version only 5¼" high.

5. It is the only system that offers direct read-out TDR with 35 ps rise-time (1815A plug-in).

6. The HP 181A is the only mainframe that offers both variable persistence, and flicker-free storage — and it is the only storage scope in the 50 MHz and above frequency area.

7. The HP 180A and the 181A Mainframes are the only system-oriented mainframes to have field-proven, solid-state plug-ins — now 9 — that cover 50 MHz and 100 MHz real-time, as well as 12.4 GHz sampling and 35 ps TDR.

8. This year HP announced the Performance Champ — the 250 MHz, 10 mV, real-time 183A System:

A. The only 250 MHz ($<$1.5 ns rise-time), general-purpose real-time system.

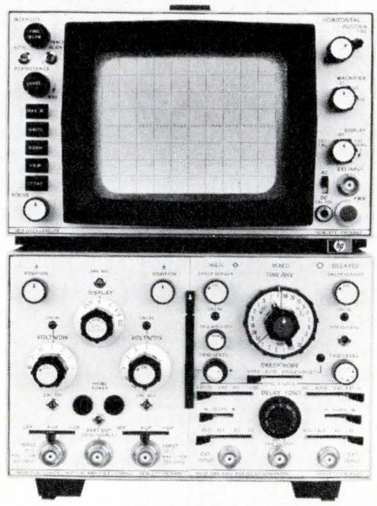
B. The only real-time scope with 1 ns/cm sweep speed.

C. The only scope with 4 cm/ns writing speed.

How about HP 180 useability?

Some of the innovations above have contributed to useability. Here are some additional useability features:

1. Important contributions have been made in simplifying controls: Single-control triggering for the 250 MHz time base; selective use of push-buttons; exclusive HP mixed sweep control; single switch signal averaging in the sampling plug-in to reduce noise and jitter.

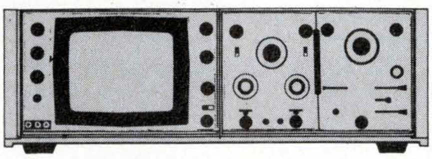


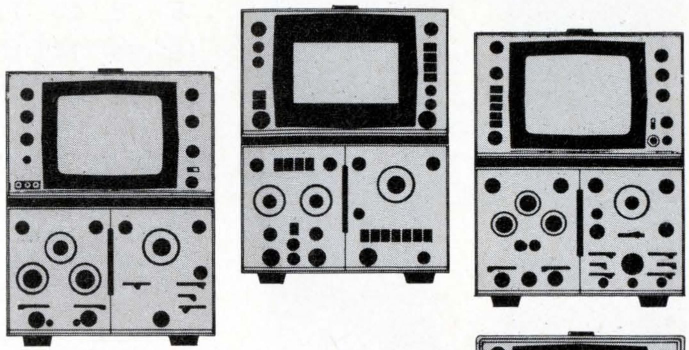
2. The calibrator built into the 183A Mainframe gives you 1 ns rise time at 2 kHz or 1 MHz, with 50 mV or 500 mV amplitude. Now you can check time, amplitude and pulse response — as well as compensate probes.

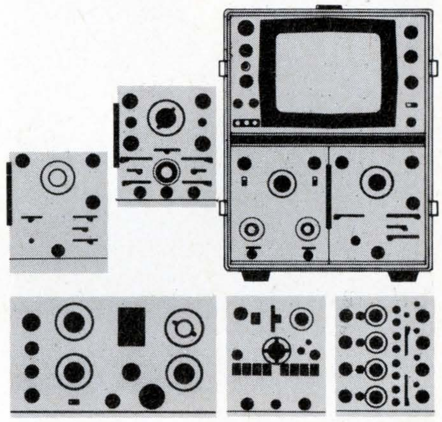
3. The 50 Ω input system has been adopted for both the 100 MHz and 250 MHz vertical amplifiers — to eliminate the bug-a-boo of capacitive distortion. If you're in these frequencies, chances are you're wanting a 50 Ω impedance match. If not, you have a choice of ultra-low capacitance passive or active probes.

4. Carry the rugged 180 Scope anywhere you need it — with plug-ins, weight is only 30 to 35 pounds. Put it

The Performance Champs







on your bench without crowding—the scope's front panel is less than the size of this page. (Like we said, the rack model is only 5¼" high.) But this mini-size doesn't mean a mini-CRT—its 8 x 10 cm area is 30% to

100% larger than most other high-frequency scopes.

How about HP 180 value?

Capability of solving today's and tomorrow's measurement problems is a real gauge of worth, or value. To prevent mainframe obsolescence in the 180 Series, HP has adopted a design philosophy of driving the CRT vertical plates directly from the vertical plug-in. Unlike some other scopes, the delay line and all vertical amplifier elements are contained in the HP vertical plug-ins.

HP's design approach keeps the full capability of the CRT available to future plug-ins, so you can take advantage of tomorrow's technology in today's mainframes.

This philosophy—no built-in mainframe limitations—is illustrated by the design approach used in the new 183A Mainframe. A unique HP design provides a CRT with a real-time bandwidth beyond 500 MHz. Today, IC technology limits the vertical amplifier to only 250 MHz, real-time. Tomorrow, higher bandwidth vertical amplifiers will be available. When they are, HP will have them. And, you can use them in your 1970 183A Mainframe – because you have direct plug-in access to a 500 MHz CRT! (Compatibility with "old" plug-ins? The 183A Mainframe will take all 11 of the existing 180 Series plug-ins—and they'll meet their specs.)

Doesn't this philosophy make sense? We think so.

What other plug-in scope can offer you these values—at these prices? For example: A 50 MHz laboratory system, with plug-in versatility, complete, $2065. A 250 MHz system, $3150.

This is the year of the big change. Everyone seems to have come up with a new scope. You have to make a decision. Should you continue down the same old road? Or is it time you took a look at another manufacturer?

The HP road means going with the demonstrated leader, a system that's been de-bugged for three years, a scope that will let you buy tomorrow's state-of-the-art plug-ins and use them in today's mainframes.

Because this is the year of the big change, your decision is important. You'll have to live with it for some time to come. If you're not convinced HP is best, try a side-by-side comparison with any scope.

Call your local HP field engineer to arrange a comparison. And remember to ask him about HP's new concept of oscilloscope service... have him show you HP's new video training tapes on the 180 System. For a complete, full-color brochure, write Hewlett-Packard, Palo Alto, California 94304. Europe: 1217 Meyrin-Geneva, Switzerland.

080/11

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OSCILLOSCOPE SYSTEMS

Circle 20 on Inquiry Card

CALENDAR

FEBRUARY

8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28

Feb. 10-12: NEPCON '70 West, Anaheim Convention Ctr., Anaheim, Calif. Addtl. Info.—NEPCON '70 West, Industrial & Scientific Conference Management, Inc., 222 West Adams Street, Chicago, Ill. 60606.

Feb. 12-14: 2nd National Conf. & Exposition on Electronics in Medicine, Fairmont Hotel, San Francisco, Calif. Addtl. Info.—Mr. Jerry Brown, Nat'l Expositions Co., 14 West 40th St., New York City, N. Y.

Feb. 18-19: Instrumentation Fair, International Hotel, Los Angeles, Calif. Addtl. Info.—Instrumentation Fair, Inc., c/o Larry Courtney Co., 16400 Ventura Blvd., Encino, Calif. 91316.

Feb. 18-19: The Era of Thermosets (RETEC), Park Plaza Hotel, New Haven, Conn. Addtl. Info.—Wm. H. Smith, Waterbury Companies, Inc., 835 S. Main St., Waterbury, Conn., 06720.

Feb. 18-20: Int'l Solid State Circuits Conference, Sheraton Hotel, Univ. of Penna., Phila., Pa. Addtl. Info.—T. Bray, Gen'l Elec. Col., Bldg. 3, Rm. 261, Electronic Park, Syracuse, N. Y. 13201.

Feb. 25-27: AMA Conference—Annual EDP Conference, Americana Hotel, New York. Addtl. Info.—AMA News Relations, American Management Association Bldg., 135 W. 50th St., New York, N. Y. 10020.

MARCH

1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

Mar. 9-12: EIA Spring Conf., Statler Hilton, Washington. Addtl. Info.—Electronic Industries Assoc., 2001 Eye St., N.W., Washington, D.C. 20006.

Mar. 17-20: 1970 Symposium on management and Economics in the Electronic Industry, University of Edinburg, Scotland. Addtl. Info.—IEEE, Inc., 345 East 47th Street, N.Y., N.Y. 10017.

Mar. 23-26: 6th Internation, Aerospace Instrumentation Symposium, College of Aeronautics, Cranfield, Bedfordshire. Addtl. Info.—A. C. Vickery, Ardoyne House, High St., Watton-at-Stone, Hertfordshire.

Mar. 23-26: IEEE 1970 Int'l Convention, New York Hilton and the New York Coliseum. Addtl. Info.—IEEE Inc., 345 E. 47th Street, N.Y., N.Y. 10017.

Mar. 24-26: 11th Symposium on the Engineering Aspects of MHD, California Institute of Technology, Pasadena, Calif. Addtl. Info.—Lance Hays, Chairman, California Institute of Technology, 4800 Oak Grove Drive, Pasadena, Calif. 91103.

'70 Conference Highlights

IEEE—Institute of Electrical and Electronics Engineers Int'l Convention & Exhibition, March 23-26; New York, New York.

WESCON — Western Electronic Show and Convention, Aug. 25-28; Los Angeles, Calif.

NEC—National Electronics Conference, Oct. 26-28; Chicago, Illinois.

NEREM—Northeast Electronics Research Engineering Meeting, Nov. 4-6; Boston, Mass.

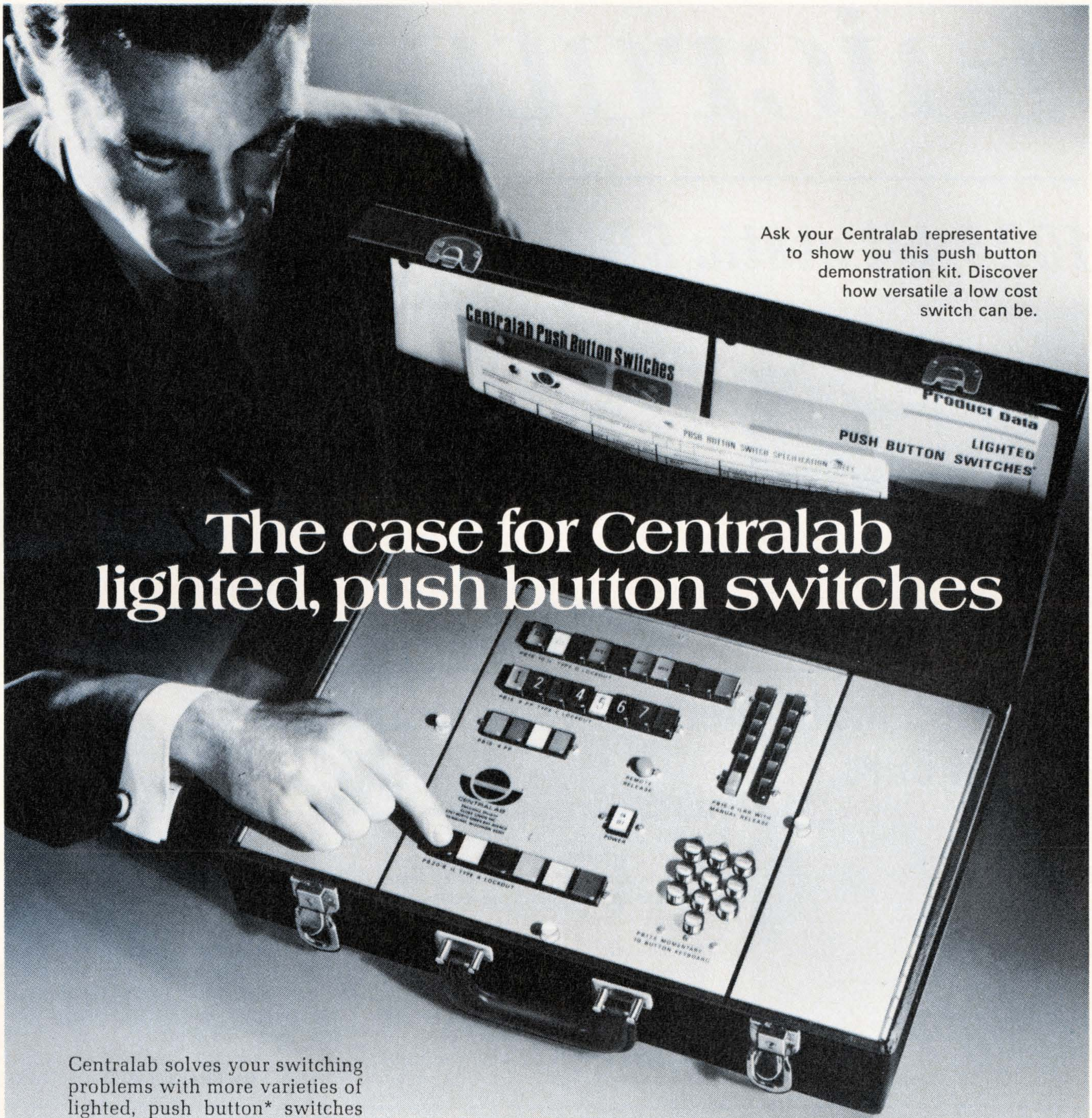
Call for Papers

Aug. 25-28: WESCON, Los Angeles. Deadline for letters proposing sessions for WESCON is March 14, 1970. Under WESCON's technical program policy, the call is for "session units," as opposed to individual papers. Under the plan, proposers should suggest a specific session topic, the scope it would cover, and proposed speakers for each of four papers within the session. This proposal should be in letter form, and addressed to E. W. Pappenfus, Technical Program Chairman, WESCON, 3600 Wilshire Blvd., Los Angeles, Calif. 90005.

Aug. 31: Fifth Annual ACM Urban Symp., New York. Submit five copies of paper to Paul R. DeCicco, ACM Urban Symp. Chairman, Polytechnic Institute of Brooklyn, 333 Jay St., New York, N.Y. 11201, by April 15.

Sept. 21-25: 5th Intersociety Energy Conversion Engineering Conf., Las Vegas, Nevada. Submit abstracts of 100 words or less by February 1 and manuscripts by April 1, to ENERGY—70, Box 9123, Albuquerque, N. Mexico 87119.

Ask your Centralab representative to show you this push button demonstration kit. Discover how versatile a low cost switch can be.



The case for Centralab lighted, push button switches

Centralab solves your switching problems with more varieties of lighted, push button* switches at lower cost. Individual standard modules for printed circuit board or panel mounting are available in two, four, six or eight pole, double throw designs. Standard functions are momentary, interlocking and push-push. Each assembly is available with row-to-row locking as a space saving feature; remote release capability and lockout are also available. There's an almost infinite number of combinations of modules with 10 mm, 15 mm or 20 mm spacing to meet a variety of requirements.

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Your Centralab representative is ready to present his case for Centralab lighted, push button switches. He has the answers to your switching problems. Call him today or write: Switch Sales Manager, Centralab Electronics Division, Globe-Union Inc.

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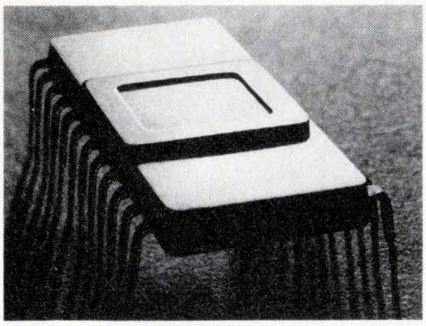
1024-bit static ROM



The Philco® MOS 1024-bit read-only memory has a *static* output data level. It remains valid as long as an address is present.

That means you can address it as slowly as necessary to be compatible with your output device, and the extra expense of clock generators and drivers is eliminated.

Bit pattern, 128 8-bit words; access time, typically 2 μs; cost in 100-piece lots, less than 4 cents per bit.

The pMS1024C static ROM is packaged in a 24-lead hermetic DIP. Samples available now in character generator form.

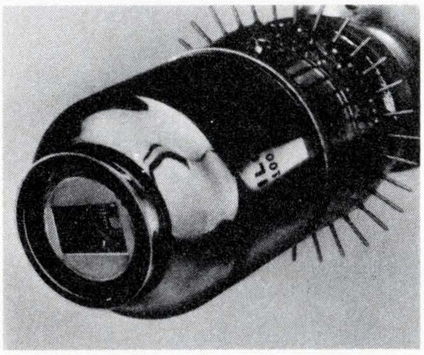
And for high-speed applications, try our *dynamic* ROM . . . comparable costs and access times less than 1.0 μs.

CIRCLE 6 ON READER SERVICE CARD

COMING SOON FROM PHILCO-FORD

- MSI 9300 Series
- New MOS memory products
  256-bit RAM
  2048-bit static ROM
  2240-bit static character generator ROM
- PL7751 Differential wide-band memory sense amplifier
- Schottky-barrier diodes in new packages

Our InSb multi-element IR detectors are all ours.



Because Philco® detectors are made entirely in-house. The whole assembly . . . detector array, liquid nitrogen- or cryostat-cooled dewar with cooled filter, and matching current-mode preamp.

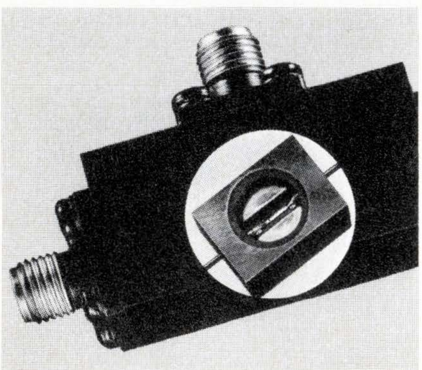
What does this mean to you? Your interface problems are eliminated. You also gain from the start-to-finish quality control. By growing our own InSb, for example, we control impurity levels for maximum sensitivity and low noise performance.

And we've been doing these things for over 10 years . . . long enough to have more InSb photovoltaic detectors in the field than anyone else.

Take a look at some of the specs . . . elements as small as .05 mm x .05 mm with element spacing .025 mm for high resolution, detectivity approaching theoretical limits, linear arrays of more than 100 elements, and detector impedance of 10 megohms or more.

CIRCLE 7 ON READER SERVICE CARD

UHF to Ku band. How's that for broadband switching?



That's what you get with our new Philco® P9800 Series coax switch assemblies.

And switching performance over any part of that range is better than just about any narrow-band switch assembly you can find.

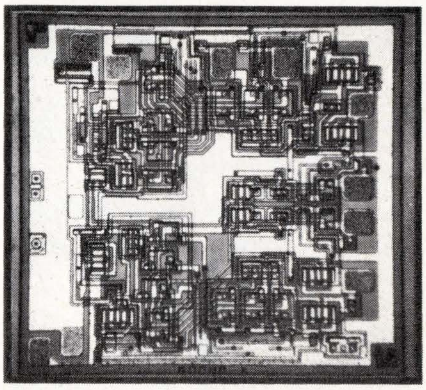
The secret? The P9800 Series employs our new L8370/L8380 Series integrated switch modules. These hermetically sealed modules eliminate the package parasitics which limit the broadband performance of conventional semiconductor diode switches.

These new modules, which are also available separately, permit switching ratios in the order of 50 db over the specified operating frequency range with switching speeds down to 10 nanoseconds.

You can get the new P9800 Series switch assemblies with integral hybrid drivers to solve your control circuit interface problems. In addition, units designed to exhibit linear attenuation or other special characteristics can be supplied as required.

CIRCLE 8 ON READER SERVICE CARD

Second-source 7400 T²L with a difference.



We can make immediate deliveries on all these digital devices, but that's not the whole story. These are Philco® 7400 Series T²L circuits with Cerdip proved hermetic packaging—the T²L package of the future . . . today.

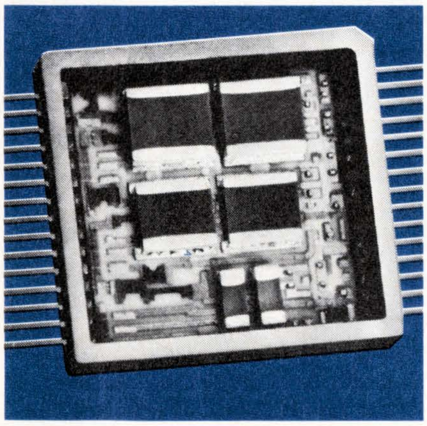
There's more to the story too . . . like the extra glassivation step that protects the circuit against damage, and gives an added measure of reliability; and clamp diode inputs for greater noise immunity and freedom from ringing.

All the items listed are in stock now, with 7 more MSI types due in the immediate future, and 10 more scheduled in the months ahead.

CIRCLE 9 ON READER SERVICE CARD

DEVICE	DESCRIPTION
PD7400	Quad 2 Input Pos. Nand Gate
PD7401	Quad 2 Input Pos. Nand Gate with Open Collector Output
PD7402	Quad 2 Input Pos. NOR Gate
PD7404	Hex Inverter
PD7405	Hex Inverter with Open Collector Output
PD7410	Triple 3 Input Pos. NOR Gate
PD7420	Dual 4 Input Pos. Nand Gate
PD7430	8 Input Pos. Nand Gate
PD7440	Dual 4 Input Pos. Nand Buffer
PD7450	Expandable Dual 2 Wide 2 Input And-Or-Invert Gate
PD7451	Dual 2 Wide 2 Input And-Or-Invert Gate
PD7453	Expandable 4 Wide 2 Input And-Or-Invert Gate
PD7454	4 Wide 2 Input And-Or-Invert Gate
PD7460	Dual 4 Input Expander
PD7470	JK Flip-Flop
PD7472	JK Master Slave Flip-Flop
PD7473	Dual JK Master Slave Flip-Flop
PD7474	Dual D Type Edge Triggered Flip-Flop
PD7475	Quad Bistable Latch
PD7476	Dual JK Master Slave Flip-Flop with Preset and Clear
PD7482	2 Bit Binary Full Adder
PD7483	4 Bit Binary Full Adder
PD7491A	8 Bit Shift Register

Need analog MSI? Call a Philco Hybrid Hunter.



Want to microminiaturize a circuit now designed for discrete components? Need more voltage, current, or power capability than you can get from monolithic integrated circuits?

Then you need an AMSI by Philco. Here's an example of an AMSI hybrid circuit now in volume production at our Spring City hybrid facility. It's a triple detector circuit, contained in a 1 x 1-inch all-hermetic flatpack made by Philco-Ford. Look what's inside:

- 13 thick-film resistors, in values from 3.9K to 182K ohms. All resistors are 1% tolerance, low TCR.
- 6 capacitors, in values from .033 to .33 μfd. All capacitors 1% tracking with temperature.
- 19 active PNP and NPN devices, with V_{be} and V_{ce} matching ± 5 millivolts.

When you need AMSI, call a Philco Hybrid Hunter. Just show us your circuits . . . and give us a month. We'll have prototype hybrid circuits on your desk. They will be ready for production in one of the most experienced hybrid facilities in the country. And they will be priced competitively.

CIRCLE 10 ON READER SERVICE CARD

BAY SOUNDINGS

"One picture is worth a thousand words." "As pretty as a picture." And so forth. But whatever else a picture may be, this one happens to be proof that CAD is alive and well at Fairchild Semiconductor.

We saw this photo during a recent visit there and thought the pretty colors would interest our artist types. But we also spoke with Control Data Corp. to find the story behind the picture. And the story, it turned out, proved once more the adage (terribly paraphrased) that "Behind every beautiful picture stands an ambitious technical program."

You're looking at a Micromatrix device which Fairchild calls a 4659 dual, 8-bit, resettable latch. But this name isn't important, at least not to CDC, which doesn't call it that at all. To CDC, the circuit is one of five—file register, I/O register, timing chain, adder, and a high fan-in—built specially for their Alpha I computer system.

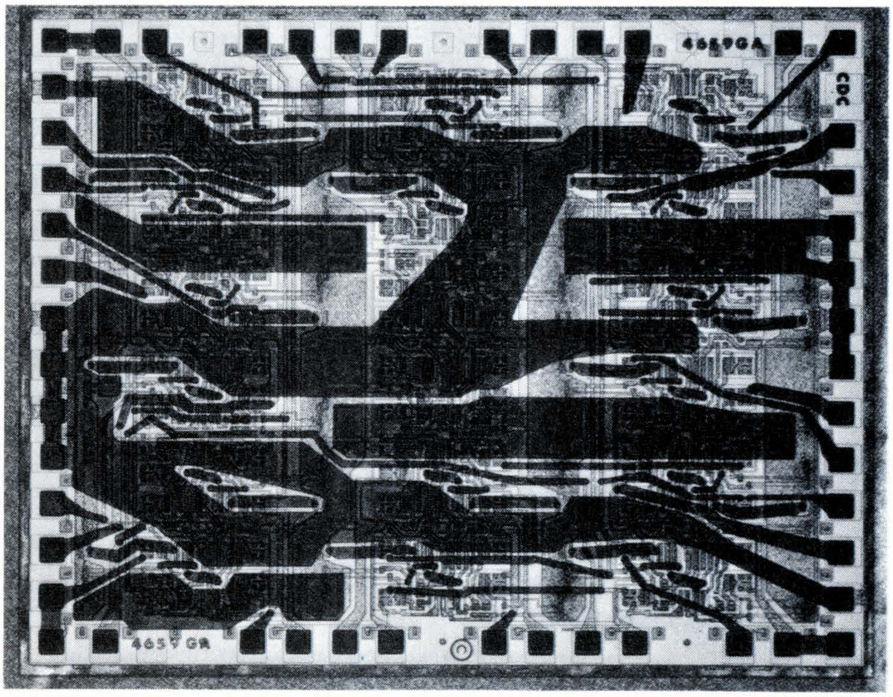
The fourth-generation Alpha I is a CDC-developed machine for military applications in on-line, sensor data processing. CDC claims that the Alpha family—with its extensive use of LSI devices—represents a significant advance over present militarized computing systems.

OK, but how did Fairchild get into the act? Well, computers don't just pop up overnight. Alpha I started about three years ago, and CDC's original survey resulted in Westinghouse's being named as the device supplier. Westinghouse, you may recall, departed the IC business a bit more than a year back. And left CDC holding the bag.

What then? Why, another survey of course, to find a new source for the Westinghouse-designed arrays. Interestingly enough, Texas Instruments no-bid the job, and Signetics ended up with a "qualified" no-bid. But Motorola, Fairchild, Raytheon, and Solid State Scientific did make offers. These suppliers were bidding on new devices as far as they were concerned (except that for Fairchild, two arrays were modifications of existing Micromatrix designs). All bids were pretty much bunched, which is also interesting, but CDC felt that Fairchild had an engineering edge over the other bidders, and had fewer bugs to work out.

Fairchild has already delivered fifteen prototypes of two devices. The devices are per the specs, they work well, and CDC is happy again.

Sheldon Edelman
Western Editor—San Francisco



Circle 24 on Inquiry Card→

WELCOME

This column welcomes new companies or new divisions in the electronics industry.

Mostek and Sprague: A dynamic duo

Mostek Corp., a new advanced electronic components supplier that specializes in the design and manufacture of MOS/LSI circuits, possesses professional engineering talent which promises to make it a fighting competitor in its field.

The story began back in March of 1969 when L. J. Sevin and Louay Sharif, formerly of Texas Instruments where they formed the core of the MOS group, sought the help of New Business Resources in Dallas as a midwife in securing capital and management skills to set up a new firm. The result was a joint venture agreement between Sprague Electric Company and Mostek. Mostek agreed to establish its 15,000-sq. ft. manufacturing center in the IC facilities of Sprague in Worcester, Mass., and was given access to Sprague's research and development efforts and its sales force. The design and marketing center was established in Dallas, Texas, and plans for a second manufacturing center in Dallas are under way.

Louay Sharif, formerly manufacturing manager with Texas Instruments, will hold the same position with Mostek. L. J. Sevin served previously with Texas Instruments as engineering manager and will now be department manager of the MOS division. According to Berry Cash, marketing manager, "Mostek offers a highly-qualified, well-experienced staff with excellent engineering talent directed toward custom business. It is difficult to compare our products with those of other companies, for Mostek's strength lies in custom design and custom services rather than catalog products. Emphasis will be placed on an understanding of system problems, imaginative MOS/LSI designs, and the pursuit of custom business."

Mostek has designed 16 different MOS arrays since June. Half of these designs are featured in catalog products, and half in custom business. Initial marketed products include a random access memory (256 bit—256 words x 1 bit per word); a read only memory (character generator, 64 characters, 5 x 7 dot matrix); shift registers (dual 128 bit static accumulator and dual 256 bit dynamic accumulator); and an asynchronous buffer memory (32 words x 8 bits per word, serial or parallel input, serial or parallel output).

Mostek is very satisfied with the progress of its company and with its reception by Sprague. The agreement comfortably complements both parties, for while Sprague enjoys the addition of a new line of MOS products, Mostek secures the benefits of Sprague's wide semiconductor technology, facilities and business services.

Circle 362 on Inquiry Card

From hybrid circuits to linear testing

Nova Devices Inc., a private corporation, is housed at 15G Sixth Road, Woburn, Mass. Only a few months old, the company is presently involved in custom chip and wire production of thin- and thick-film hybrid circuits. Its sphere, however, also encompasses a specialized testing and evaluation service for linear ICs, utilizing a computer-controlled system that was specifically designed to test linear devices. The equipment has the capability of automatically testing and computing distributions of standard linear IC circuit parameters as well as calculating their drift coefficients. The company already has some contracts to do sophisticated testing for temperature classification, incoming inspections and comparative evaluations of circuits made by second sources.

In the near future, Nova plans to begin producing high performance amplifiers and A-D and D-A converters for both military and commercial applications. It also plans to do automated probing of IC at elevated temperatures which would eliminate much of the rework now necessary in the production of military hybrid circuits. The company's first product, expected to be available by the end of January, will be a hybrid FET op-amp.

The founders of Nova Devices, Inc. have experience in both the systems and solid-state worlds. Two of them, Douglas R. S. Sullivan and Robert C. Petersen, were respectively operations manager for linear ICs and in charge of all manufacturing of linear ICs at Transitron Corp. The third founder, Dr. M. A. Maidique, was a consultant at Transitron and other firms in the Boston area on linear circuits and their applications. The combination of microcircuit background with emphasis on thin- and thick-film processing and circuit design background seems a promising one for this new firm.

Circle 363 on Inquiry Card

Our past can forecast your FUTURE.

You may be interested, as many of us are, in checking your daily horoscope. However, past accomplishments are usually due to individual talents, rather than to a zodiac reading.

Link Engineers have devoted their time to going about the business of being first—first in advanced electronics technology. Our Advanced Technology personnel developed the Spacecraft Television Ground Data Handling System which reproduced every photograph of the moon's surface resulting from the Ranger, Mariner and Surveyor missions. Our Transportation Products group is chartered to work in four technical fields concerning transportation—traffic control, railroad and rapid transit, cargo and container identification and aircraft ground control. Our Ordnance personnel have produced eleven systems for the Apollo mission alone, while also contributing heavily to Saturn and other projects. Beyond these achievements, Link engineered the Lunar Module Mission and Apollo Mission flight simulators—used to train the people who extended man's parameters to the surface of the moon.

Quality and superiority in advanced products comes first with Link. That's where you come in. Opportunity is unlimited. And, the San Francisco Peninsula embodies all the excitement of the California way of life for you and your family. Forward your inquiry to Mr. Richard Nadzam, 1105 Kern Avenue, Sunnyvale, California 94086. We are an equal opportunity employer.

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Getting rich

Getting rich or bust! Four experts who've had the course tell you about forming your own company—what to do; what to avoid; and what you should be.

John McNichol, Assistant Editor

Dr. K. C. Black outdid himself as ringmaster in the big center ring of the IEEE's NEREM annual Wednesday evening get-together. Dr. Black of the Scientific Analysis Corp. was able to assemble four speakers on "The New Enterprise—Its Life Cycles," who put on, if not the greatest show on earth, certainly the hit of the meeting.

The Providence Ballroom was packed with entrepreneurs, would-be entrepreneurs, and those with dreams of glory, eager to hear pearls of wisdom (and affluence) from the four speakers: Nicholas DeWolf, Teradyne, Inc.; Dr. Robert H. Brooks, Harbridge House, Inc.; Malcolm Hecht, Unitrode Corp.; and Dr. Edward B. Roberts, MIT's Sloan School of Management.

Geronimo-o-o-o

As co-founder, president and director of Teradyne, which was founded in 1960, Nick DeWolf has had ample time to evaluate the pitfalls of starting your own firm. Even if the prospective entrepreneur should have a brilliant idea (one that justifies production and is marketable), burning ambition and ready financing, DeWolf contended that he should analyze his own motives. Stating that the main reason for starting your own firm is "ego motivation, not simple greed," DeWolf categorized some of the subliminal motives as:

- The need to be fashionable
- The desire to be rich
- The fatherhood instinct
- Inability to get along with others
- A good idea
- The need for a sex substitute

In addition to the importance of sorting out your personal reasons and determining if they will sustain you over the long haul, DeWolf made a series of specific observations:

- Partners: "It's terribly important to get a good one who can handle the areas where you are deficient."
- Ethics: "I can't emphasize too strongly that you establish a set of ethical ground rules and be prepared to follow them for the rest of your visible, public career. It's very difficult to switch in midstream."
- The Acid Test: "Within that crucial three years you'll be busted or on your way."
- Advice: "If you know you're an entrepreneur, go ahead. But if you haven't started something by now, be careful, you may have more trouble than you suspect."
- The Silent Generation vs the SDS: "The country seems to have weathered the Silent Generation and, I suspect, the new hippie generation will be much better entrepreneurs. I've interviewed members of the Silent Generation—just out of college—who first ask me when they apply for a job about our pension plan."

After the conference, DeWolf was besieged by pros-

"The New Enterprise—Its Life Cycles" was this year's Wednesday's evening entry at NEREM. Organized by Dr. K. C. Black, Scientific Analysis Corp., the session was divided into four talks by experts on various phases of the high technology entrepreneur and firm. Not pictured here is Nicholas DeWolf, Teradyne, Inc., who held forth on the dangers of "going it alone." Dr. Black (left) is seated next to Dr. Robert A. Brooks, Harbridge House, Inc., who spoke on the survival of the entrepreneur as the business changes. Malcolm Hecht, Jr., Unitrode Corporation (right center), talked on the possibilities of continuing the entrepreneurial spirit by encouraging new businesses to start within the already existing corporate structure. Seated at the right, Dr. E. B. Roberts of the MIT Sloan School of Management analyzed the various characteristics of the successful high technology entrepreneur.

pective entrepreneurs asking for appointments to discuss their plans. After talking with them, he noted that most of them were about 30 years of age, "the magic age." If they're older, their kids are too old for him to make the move; if they're younger, they don't have enough experience or wherewithal."

DeWolf guessed that in half of the cases he had talked the potential businessmen out of their dream. "They would be miserable; they would have problems with their wives and kids; and, to top it off, they wouldn't get rich. It's much easier to lose as an em-employee of a large company. You don't have that much to lose; your car wouldn't be taken away from you."

Winding up with a series of perceptive comments, DeWolf observed:

- "You can't make an entrepreneur, but you can absolutely crush one. Well, one way to do it is too much education. There's too much formality, too much indoctrination, too much systemization—all of which destroy initiative."
- "By and large, technologists are miserable salesmen and, if you're not a good salesman, you might as well forget it."
- "You must have staying power. You must be able to negotiate, negotiate and negotiate until your opponent cries 'Uncle.' In my own case, poker playing in college was probably the most important single education I had in my life; we used to play for 12-hour stretches."

Shifting gears

Dr. Robert A. Brooks, formerly Assistant Secretary of the Army and now president of Harbridge House, addressed himself to the survival of the entrepreneur as opposed to the company's survival, "because companies are like angels: immortal and slightly uninteresting."

Dr. Brooks called for realism on the part of the technical entrepreneur to meet the second and most dangerous phase in the life of the company. Observing that as the first phase ends, which was a technically innovative and more casual period, the emphasis shifts to maintaining administrative functions to support the continuance of the product or service that by now should be firmly established. To meet this shift in emphasis, the entrepreneur can adopt any one of several strategies to handle the management of his business:

- He can do it all himself
- He can get out of the enterprise when the business role, as opposed to the technical role, becomes paramount.
- He can choose associates to aid him in this management phase.

Since, in most cases, the first option is self-defeating; the second option is painful at best; and the third implies a certain loss of control, Dr. Brooks propounded a "new Parkinsonian law, or a 'Son of Parkinson's law,'" that goes more or less like this:

Any technical innovator who is successful in starting a new company will lose operating control of it.

Mentioning such examples as Bill Lear, and others,

Dr. E. B. Roberts: "After 40 you won't form your own business because you're locked in with friends, the pension fund, and besides, the car pool would be difficult to break up."

who could not adopt the proper management attitudes, nor were they content to remain in a lesser role, Brooks suggested a corollary to the Son of Parkinson's law.

Any engineer or scientist with sufficient drive, ego, and self-confidence to start a company will have too much of these same qualities to voluntarily relinquish control at the proper time.

Despite the bleakness of the outlook for our budding entrepreneur, Dr. Brooks noted that the corollary has a silver lining: when the businessman "is dethroned, or possibly tossed out the front door, he is quite often accompanied by a large bag of money." He continued that this might be the "most profitable business strategy for the technical entrepreneur" since he can go through the whole cycle two or three times.

Dr. Brooks offered the engineer an alternative—"survival, even with reduced control," within his own firm. If the technical innovator is unusual, he may be able to make the transition from the first phase to the second phase of operating the company. Too often, "engineering curricula, both graduate and undergraduate, are structured for the most part on the assumption that their products will be technicians for the rest of their lives."

If he decides that he can't make the transition, then the entrepreneur should choose someone with a proven track record in the production-distribution phase in a similar firm, or someone who has made a reputation marketing new products within a large firm, or, least desirable, a staff expert with a brilliant record in administration or finance. A further complication is timing, bringing in this partner at the beginning, which has it dangers, or later when the scientist-businessman is up against the wall.

Dr. Brooks concluded by suggesting that "these strategies imply planning and action before he (the entrepreneur) is overtaken by events. If he does not act in this sense, he will be most surely acted upon."

Reproduction

If the high technology company is able to clear the hurdles Dr. Brooks mentioned, Malcolm Hecht, Jr., chairman of the board of Unitrode Corp., suggested that it might be faced with a new set of challenges. The company, which had succeeded despite its high risk birth, settles down to a stodgy and more comfortable existence. The penalties for this middle-aged outlook are loss of new product ideas and personnel, and a flattening out of the growth curve.

Speaking from his experience with Unitrode, Hecht recommended that "the entrepreneurial fires be kept burning" by assisting new firms to get started under the roof of the parent company. As a result, both the parent firm and the new entrepreneur will realize "ego satisfaction and financial rewards."

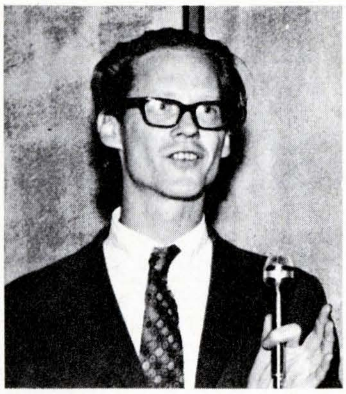
Hecht listed the following criteria as essential for Unitrode to support the new venture:

- The product must be allied to a product that the parent company understands. "It may be backward integration into a raw material area or a forward move into a more complex product."
- The potential entrepreneur must understand the technology and the market place.
- The concept must have a large enough potential to survive on its own.
- Most importantly, the new entrepreneurs must be not only good idea men, but good managers. "They must have integrity, hungry motivation, a certain amount of meanness, and the ability to take an overall look at the business."

Hecht went on to list five items that backers should furnish the new entrepreneurs: money; long term commitment; understanding and patience; some central services, such as legal, financial patent and personnel help; and management help. He suggested that these new businessmen talk to other entrepreneurs who have recently been through the process themselves.

As an example of how these theories may be turned

Malcolm Hecht, Jr.: "Entrepreneurs must have integrity, hungry motivation, a certain amount of meanness, and the ability to take an overall look at the business."



Nicholas DeWolf: "By and large, technologists are miserable salesmen, and, if you're not a good salesman, you might as well forget it."

into reality, Hecht cited Unitrode's experience with Powercube Corp., a subsidiary that they helped to form about two years ago. Powercube, maker of miniature, high power circuit modules, offered a patentable design, used some of Unitrode products, and appeared to offer an "exciting" market. Hecht continued that "we understood the market and liked the individuals" (former Unitrode employees). Agreeing with DeWolf that the first two or three years were the most crucial, Hecht stated that as the product showed a strong sales curve, Unitrode's experiment with Powercube has been a great success.

Our hero

Finally, Dr. Edward Roberts, who is with the Sloan School of Management at MIT as well as being a consultant, spoke on some aspects of the typical base company and what makes a high technology firm succeed or fail.

Perhaps most interesting was the picture that emerged from statistics on the typical entrepreneur. Dr. Roberts was able to point out certain characteristics that engineer-businessmen seemed to have in common.

The typical entrepreneur is young — averaging 32 years when he starts his firm. The youngest was a *wunderkind* of 24 and the oldest were two retiring MIT professors who set up their respective firms at 65.

Analyzing the sample, Dr. Roberts commented that by the time a man reaches 40, he will have started his own company or never do it. After that it is extremely unlikely that the engineer will take the plunge, not because of lack of drive or talent, but because it calls for total commitment and great vitality to get the new venture off the ground. "Family and societal ties are too strong; you're locked in with friends, the pension fund, and besides, the car pool would be too difficult to break up."

The second feature was the quality of education. Most entrepreneurs have a Master's degree, which is usually in engineering. There are some PhD's, "but they're better off at the university, because the typical PhD doesn't succeed that well as an entrepreneur." Dr. Roberts noted further that a degree — particularly a graduate degree—is highly important for the scientist (disagreeing with Nick DeWolf's premise) in order that he may both make his own contributions and understand the proposals of others to the technology.

Thirdly, Dr. Roberts stated that the average entrepreneur comes from a developmental background as opposed to a research background. "The successful entrepreneur has been mixing it up with the application of knowledge, not the creation of knowledge."

After the ball was over

Aside from the obvious interest produced by a session that promises riches to the audience (it was by far the best attended session at NEREM), it was evident that most engineers present were keenly interested in the mechanics of setting up their own company, and making it work. Although some were starry-eyed young men relishing the thoughts of a bright future, many had very clear and hard-nosed ideas about a product they wanted to make on their own; some were already faced with the problems of meeting a payroll.

Will they make it? More than 90% of them will never get off the ground, according to the concensus. Of these, many will not go beyond the talking stage, and the rest will fail to convince venture capital firms to lend them money. Of the less than 10% who will raise capital (some from friends and relatives, some from capitalists, some from both sources), about 80%, says Dr. Roberts, will be successful.

If you are in the 10%, you have our best wishes and an excellent chance.

Dr. Robert A. Brooks: "Any technical innovator who is successful in starting a new company will lose operating control of it."

INFORMATION RETRIEVAL

Careers

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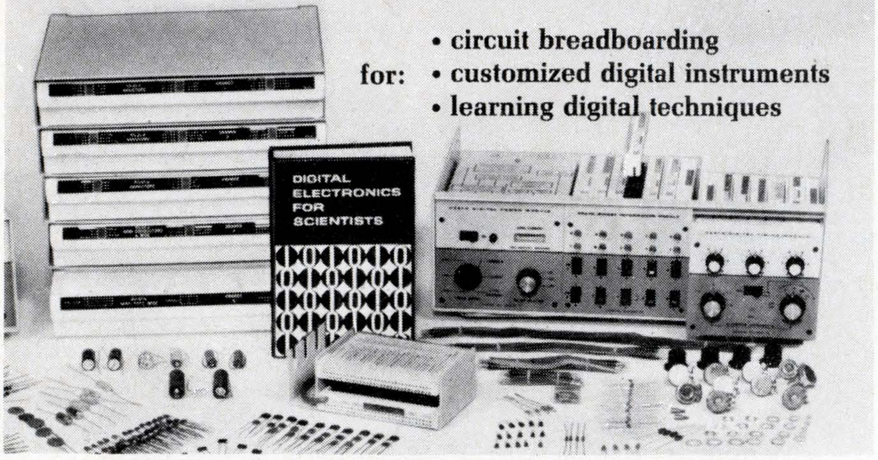

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Now . . . A Complete System to Enable You to Get the Most Out of Digital Electronics. Here is a system that is revolutionizing instrumentation in labs and classrooms throughout the world. The basic design concepts of Professors H. V. Malmstadt and C. G. Enke combined with the engineering of Heath's scientific instrument group have resulted in the unique 801 Analog Digital Designer (ADD) and the EU-51A breadboard and parts group. This versatile system can perform equally well in constructing high performance research-quality instruments, in performing hundreds of experiments in the teaching laboratory, in rapid testing of new digital ideas, or in interfacing to computers.

Start . . . By Learning the New Digital Electronics. Drs. Malmstadt and Enke have written a pioneering new text "Digital Electronics for Scientists" (published by W. A. Benjamin, Inc.) that provides a systematic introduction to the digital circuits, concepts and systems that are basic to the new instrumentation — computation revolution. The book is written for engineering and science students and for practicing engineers, scientists, and technicians so that all may effectively utilize the startling recent advances in digital electronics.

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Guide to INTEGRATED CIRCUITS

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PRODUCT SEMINARS

This column lists product seminars that electronic companies offer to users of their products.

Operator's Seminar: Feb. 16-20, Canton, Mass. Geared toward the use and operation of Instron's precision materials and testing instruments. Instron Corp., Instron Training Center, 2500 Washington St., Canton, Mass. 02021.

Circle 364 on Inquiry Card

Communications ICs Application Seminar: Feb. 17, Phila., Pa. The day before the International Solid State Circuits Conference The Electronic Engineeer magazine will sponsor a seminar highlighted in the morning by six papers on the new ICs for communication (i-f limiters, agc amplifiers, rf amps, etc.) and in the afternoon by a "hands on" workshop session. For information, price and registration forms see page 123.

Maintenance Seminar: Feb. 23-27, Canton, Mass. Geared towards the care and upkeep of Instron's precision materials and testing instruments. Instron Corp., Instron Training Center, 2500 Washington St., Canton, Mass. 02021.

Circle 366 on Inquiry Card

Operation and Maintenance 7600 Magnetic Tape System: Mar. 2-6, Denver, $180. Requires a strong electronics background with emphasis on solid state circuitry, familiarity with modulation/demodulation techniques, filters and digital circuitry. The objective of the course is to prepare the operator/technician for operation, calibration and repair of the complete tape system. Honeywell Inc., Test Instrument Div., Box 5227, Denver, Colo. 80217.

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General Instrument Seminar: Mar. 2-13, North Wales, Pa., $100. Subjects in this program are presented from the viewpoint of equipment usage in industry. Discussions and workshop experiences on both measurement and control of such regulated process variables as temperature, pressure, flow, pH and conductivity contain both practical and theoretical subject materials. Leeds & Northrup Co., Sumneytown Pike, North Wales, Pa. 19454.

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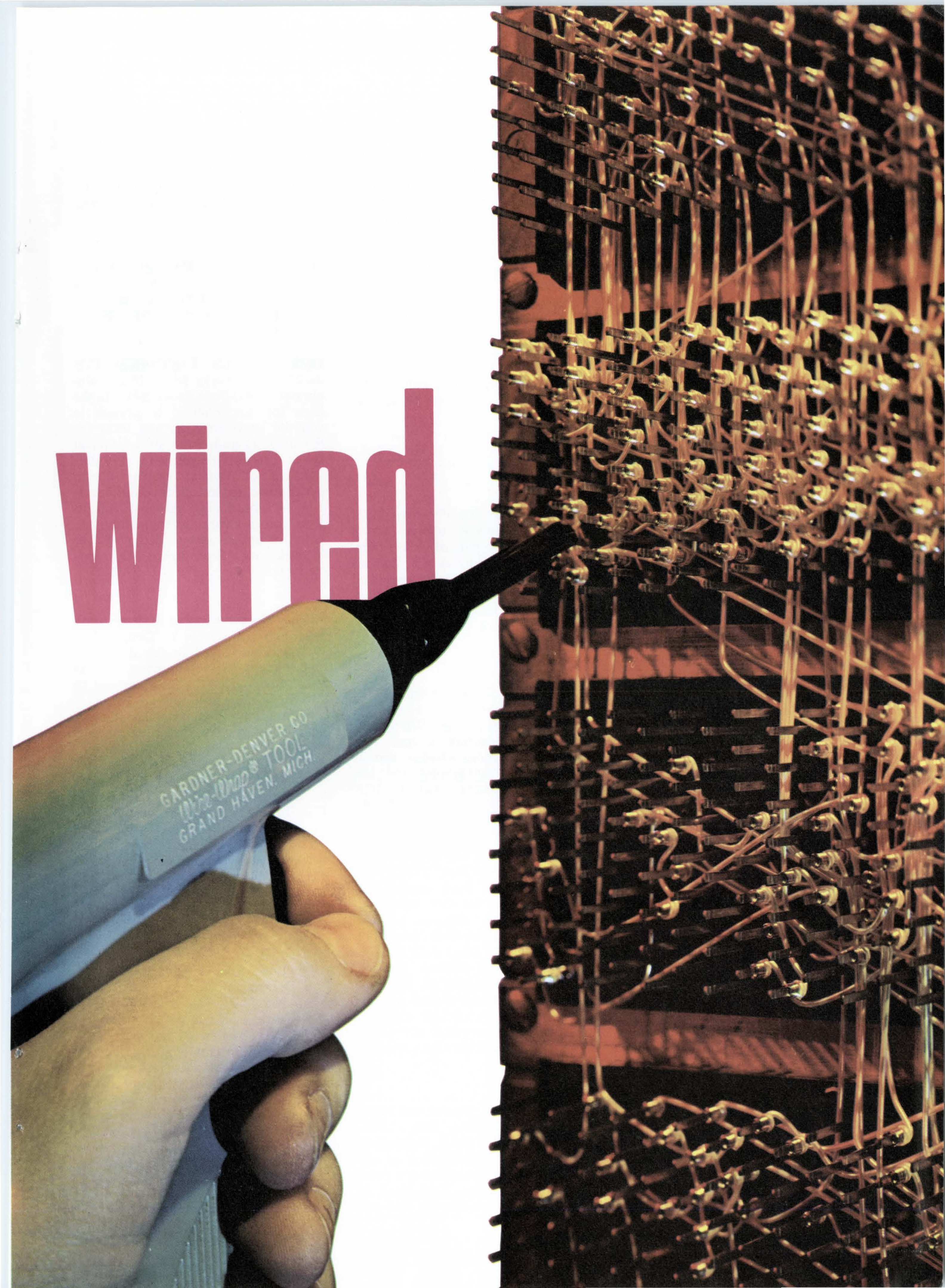
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COURSES

How to Make Money with ICs: Feb. 16-19, Phoenix, $500. As an independent consulting company, ICE is able to present the pros and cons of processing and fabrication techniques as practiced throughout the IC industry. With this knowledge the attendee may relate these practices to those at his company and apply the most desirable practices effectively. ICE Corp., 4900 East Indian School Rd., Phoenix, Ariz. 85018.

Electronic Components: Feb. 19-20, Univ. of Wisconsin, $70. Under the supervision of John T. Quigley. University Extension, Univ. of Wisconsin, Dept. of Engineering, 432 North Lake St., Madison, Wis. 53706.

Reliability: Feb. 20, Phoenix, $175. This one-day course follows (but is not an immediate part of) ICE's four-day basic engineering course, and offers material more directly associated with the background and job assignment of each student. ICE Corp., 4900 East Indian School Rd., Phoenix, Ariz. 85018.

MOS Layout: Feb. 20, Phoenix, $175. This one-day course follows (but is not an immediate part of) ICE's four-day basic engineering course, and offers material more directly associated with the background and job assignment of each student. ICE Corp., 4900 East Indian School Rd., Phoenix, Ariz. 85018.

Design/Fabrication: Feb. 23-Mar. 20, Phoenix, $10,000. Each student will design and make his own bipolar IC using the shallow diffusion process. Designs are brought from schematic, through computer-aided mask making, to processing and finished package. This is an opportunity to design a completely functional circuit meeting specific requirements; all materials and facilities are provided. ICE Corp., 4900 East Indian School Rd., Phoenix, Ariz. 85018.

Integrated Circuits, Bipolar and MOS: Feb. 23-25, Houston; Mar. 23-25, Washington, D.C.; $295. Emphasizes the selection and specification of circuit types. The program makes a point of identifying design limitations of digital and linear ICs for you, and will help you to recognize the differences between ICs and their discrete counterparts. RCA, Institute for Professional Development, Box 962, Clark, N.J. 07066.

Optical Character Recognition: Feb. 23-25, New York, $250. C-E-I-R Inc., Sub. Control Data Corp., 5272 River Rd., Washington, D.C. 20016.

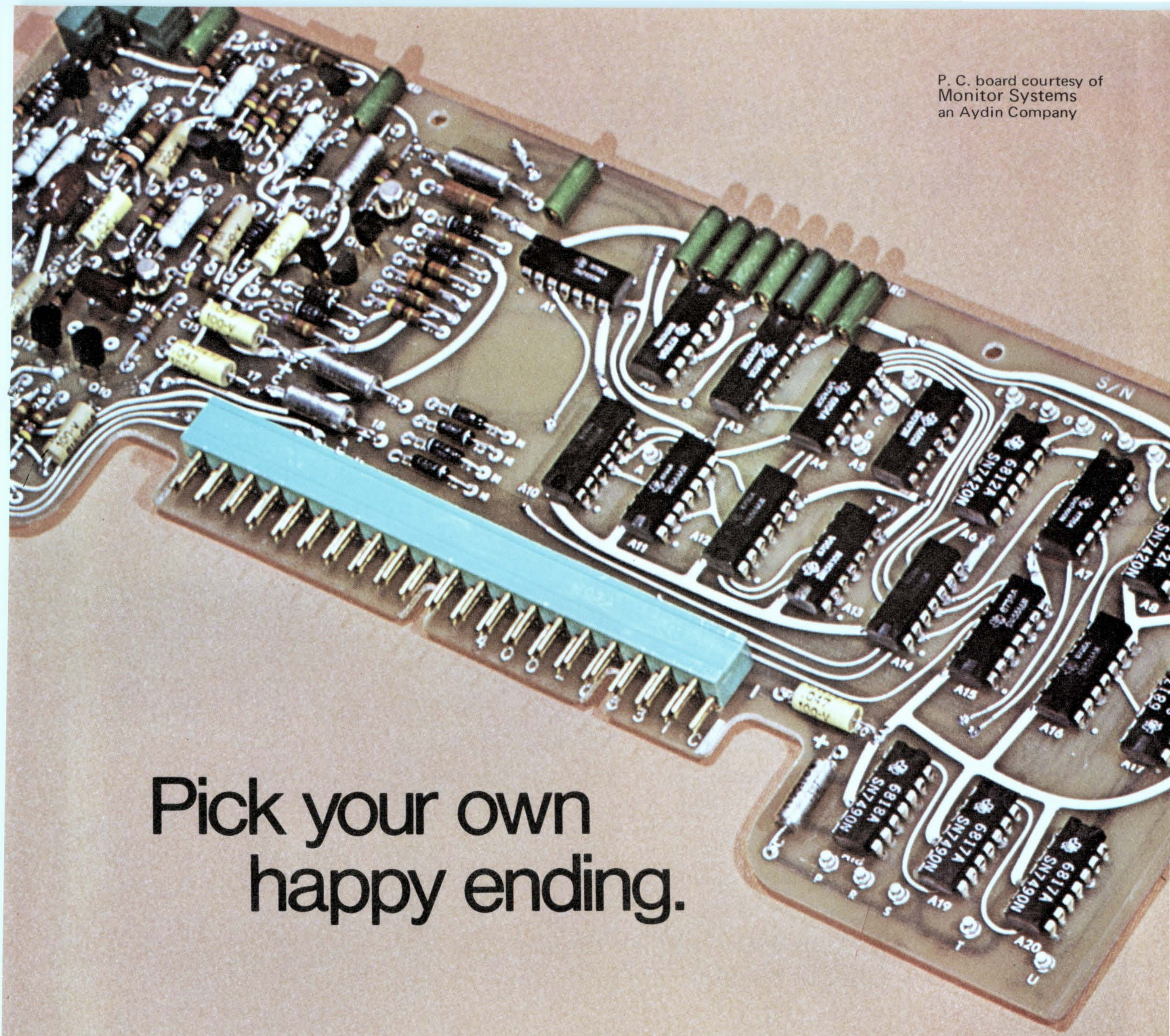
Optical Systems Engineering: Feb. 23-27, New York; Mar. 16-20, Rochester; $395. Four major aims are the basis for this seminar: to present to you the latest concepts and tools for the analysis and synthesis of optical systems; to provide you with an understanding of optical system design parameters; to introduce data necessary for interfacing systems; and to give you a working foundation of skills for optical system design. RCA, Institute for Professional Development, Box 962, Clark, N.J. 07066.

Applied Communication Systems Analysis: Feb. 24-March 5, Tampa, Fla. If you are engaged in the design or management of communication systems, this course will be of interest to you. Its purpose is to provide you with a broad view of the principles of communication systems design. Topics to be covered include radio propagation, information theory, analog and digital modulation and coding. Dr. George W. Zobrist, Dept. of EE., Univ. of S. Fla., Tampa, Fla. 33620.

Selection of Time-Sharing Systems: Feb. 25-27, Minneapolis, $250. C-E-I-R Inc., Sub. Control Data Corp., 5272 River Rd., Washington, D.C. 20016.

Digital Systems Engineering: Mar. 2-6, Detroit, Mich.; Mar. 9-13, Huntsville, Ala.; $390. Here is a program designed to help you obtain an understanding of digital design principles. In addition to studying the central processing unit of a digital computer, you will be introduced to interfacing techniques which involve such subjects as sampling theory, analog-to-digital and digital-to-analog conversion, as well as modern encoders. RCA Institutes, Institute for Professional Development, Box 962, Clark, N.J. 07066.

Continued on page 51



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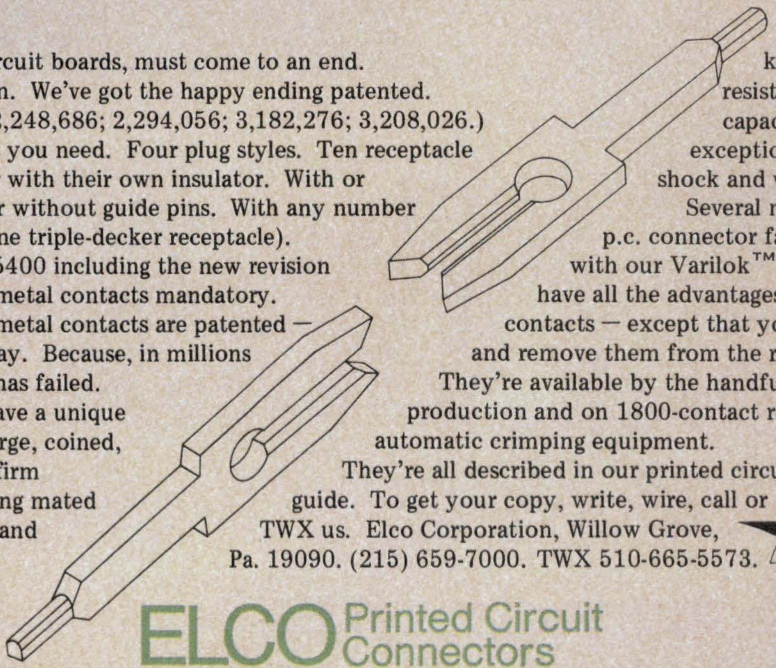

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Our Varicon™ metal-to-metal contacts are patented — and famous, in their quiet way. Because, in millions of operating hours, not one has failed.

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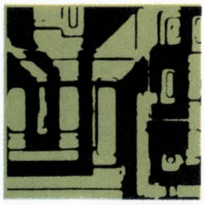
They're all described in our printed circuit connector guide. To get your copy, write, wire, call or TWX us. Elco Corporation, Willow Grove, Pa. 19090. (215) 659-7000. TWX 510-665-5573.

ELCO Printed Circuit Connectors

To make a Quad Latch that's both R/S and D compatible,



Fairchild's new MSI 9314 Quad Latch is a versatile, high-speed device that can be used in any application requiring a single-input D-type latch or an R/S-type latch. It has no undefined states in the R/S mode. Its unique multi-function capabilities make it useful in a number of applications: four-bit storage latches, contact bounce eliminators, multi-input active high set/reset latches, counting and holding display systems, eight-bit addressable latches, A/D conversions, zero and ones catching storage.

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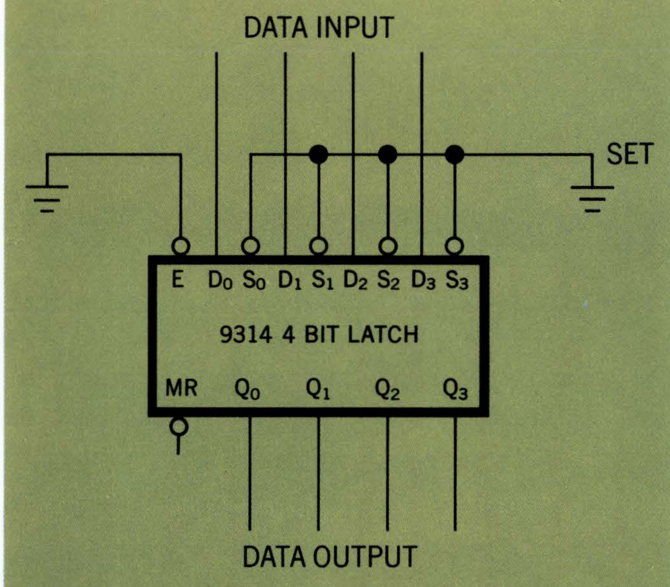

9314 Connected in D-mode

To order the 9314, ask for:

PART NUMBER	PACKAGE	TEMPERATURE RANGE	(1-24)	PRICE (25-99)	(100-999)
U6B931451X	DIP	−55°C to +125°C	$19.40	$15.50	$13.00
U6B931459X	DIP	0°C to + 75°C	9.70	7.75	6.50
U4L931451X	Flat	−55°C to +125°C	21.35	17.05	14.30
U4L931459X	Flat	0°C to + 75°C	10.70	8.55	7.15

To order the 9308, ask for:

PART NUMBER	PACKAGE	TEMPERATURE RANGE	(1-24)	PRICE (25-99)	(100-999)
U6N930851X	DIP	−55°C to +125°C	$25.40	$20.20	$17.00
U6N930859X	DIP	0°C to + 75°C	12.70	10.10	8.50
U4M930851X	Flat	−55°C to +125°C	27.95	22.20	18.70
U4M930859X	Flat	0°C to + 75°C	13.95	11.10	9.35

you have to get serious about MSI family planning.

We put together a family plan by taking systems apart. All kinds of digital systems. Thousands of them.

First we looked for functional categories. We found them. Time after time, in a clear and recurrent pattern, seven basic categories popped up: Registers. Decoders and demultiplexers. Counters. Multiplexers. Encoders. Operators. Latches.

Inside each of the seven categories, we sifted by application. We wanted to design the minimum number of devices that could do the maximum number of things. That's why, for example, Fairchild MSI registers can be used in storage, in shifting, in counting and in conversion applications. And you'll find this sort of versatility throughout our entire MSI line.

Finally, we studied ancillary logic requirements and packed, wherever possible, our MSI devices with input and output decoding, buffering and complementing functions. That's why Fairchild MSI reduces–in many cases eliminates–the need for additional logic packages.

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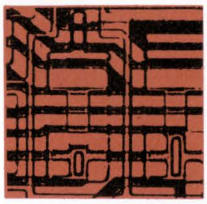
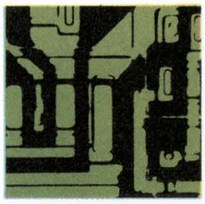
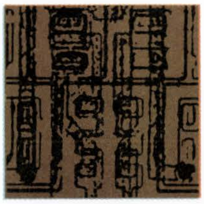


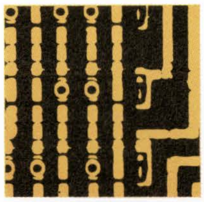
OPERATORS
9304 – Dual Full Adder/Parity Generator



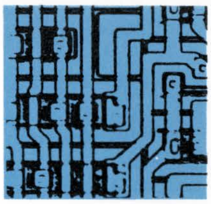
LATCHES
9308 – Dual 4-Bit Latch
9314 – Quad Latch



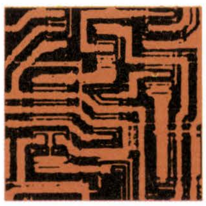
REGISTERS
9300 – 4-Bit Shift Register
9328 – Dual 8-Bit Shift Register



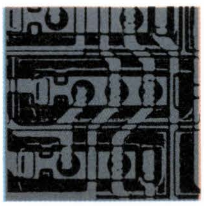
MULTIPLEXERS
9309 – Dual 4-Input Digital Multiplexer
9312 – 8-Input Digital Multiplexer



DECODERS AND DEMULTIPLEXERS
9301 – One-Of-Ten Decoder
9315 – One-Of-Ten Decoder/Driver
9307 – Seven-Segment Decoder
9311 – One-Of-16 Decoder
9317 – Seven-Segment Decoder/Driver



COUNTERS
9306 – Decade Up/Down Counter
9310 – Decade Counter
9316 – Hexidecimal Counter



ENCODERS
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FAIRCHILD SEMICONDUCTOR A Division of Fairchild Camera and Instrument Corporation Mountain View, California 94040, (415) 962-5011 TWX: 910-379-6435

COURSES

Logic Design: Mar. 2-6, Boston; Mar. 16-20, Phoenix; $395. You will be provided with the numerical and matrix tools required to select the most straightforward, practical approach to digital circuit design. Currently available numerical and graphical design methods will be illustrated to increase your logic design effectiveness. RCA, Institute for Professional Development, Box 962, Clark, N.J. 07066.

Design of On-Line Computer Systems: Mar. 4-6, Minneapolis, $300. C-E-I-R Inc., Sub. Control Data Corp., 5272 River Rd., Washington, D.C. 20016.

Data Communications Systems: Mar. 4-6, Los Angeles, $250. C-E-I-R Inc., Sub. Control Data Corp., 5272 River Rd., Washington, D.C. 20016.

Computer Operations for Third Generation Machines: Mar. 9-11, Minneapolis, $250. C-E-I-R Inc., Sub. Control Data Corp., 5272 River Rd., Washington, D.C. 20016.

Design of Data Communication Systems: Mar. 9-12, New York, $325. C-E-I-R Inc., Sub. Control Data Corp., 5272 River Rd., Washington, D.C. 20016.

Digital Communications: Mar. 2-6, San Francisco; Mar. 9-13, San Diego; $395. Develops the practical design criteria of digital communication hardware. Various modulation techniques and optimum coding schemes are presented. You will be introduced to practical applications of information theory in the field of digital communications. RCA, Institute for Professional Development, Box 962, Clark, N.J. 07066.

Expanding Use of Computers in the 70's: March 30-April 1, UCLA; $100. The course will look at the many ways in which the computer will affect society during the next ten years: massive increases in the number of computer installations in industry, the economic impact of the effective use of computers and the use of the computer as an everyday control in finance and manufacturing. Engineering and Physical Sciences Extension, UCLA, Box 24902, Los Angeles, Calif. 90024.

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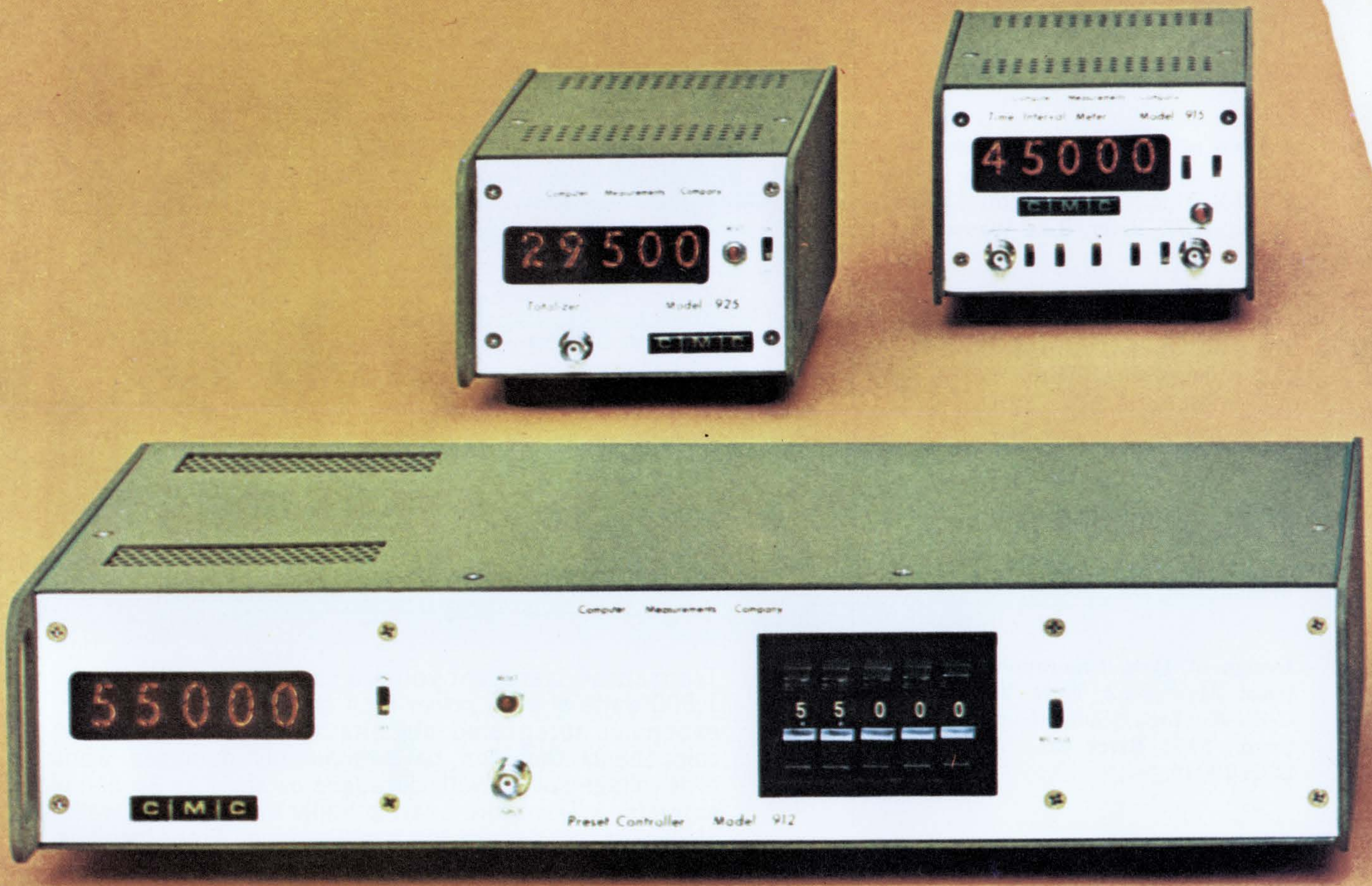
Circle 33 on Inquiry Card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THE ELECTRONIC ENGINEER

MOS integrated circuits A six-part course

A bit of history p. 56
Part I of MOS course p. 58

Integrated circuits that use MOS transistors have had an interesting and oftentimes troubled history. Now, however, the technology has come of age and you are going to see more and more MOS circuits in tomorrow's digital equipment. Our course on MOS ICs will present, in six installments, the foundation that you need to take advantage of all that this new technology promises.

Background on MOS

An integrated circuit made with MOS transistors consumes less power and is smaller than the same circuit made with bipolar transistors. On the other hand, the bipolar circuit is faster and can drive more current. Therefore, most designers of logic systems tend to use both types, and somewhere, they must interface the two.

Interfacing, however, creates problems because MOS and bipolar are two different breeds. A MOS transistor is a voltage-controlled device—it compares more closely to a vacuum tube than to its bipolar counterpart.

The point of all this is that many MOS ICs made today use higher supply voltages and logic than those used by bipolar ICs. In a conventional MOS logic gate, therefore, you have to change the voltage by a greater amount to distinguish between a 1 and a 0 than you have to with a bipolar gate.

The obvious solution is to make MOS devices that operate with the voltages compatible with those of bipolar circuits.* Such a device, combined with efforts to improve other MOS parameters and to design "all-MOS" digital equipment, has lead to several different constructions. This is the first topic of our course: the basic structures.

---

*Of course, you could design the bipolar circuit to work with the larger voltage swing, but this degrades operating speed because, given the same load capacitance, it takes longer to go from 0 V to 7 V than it does to go from 0 V to 3 V.

COURSE ON MOS INTEGRATED CIRCUITS

The first MOS

A historical look at MOS—where it's been and who developed it.

By **Alberto Socolovsky,** Editor

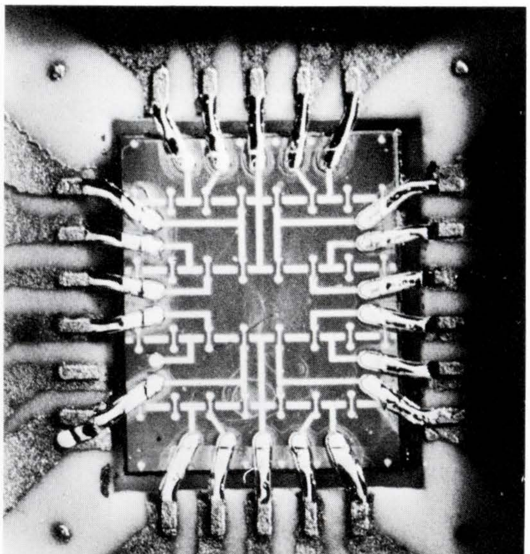
Who made the first MOS integrated circuit? Undoubtedly, Drs. Steven R. Hofstein and Frederic P. Heiman, who working under the direction of Thomas O. Stanley, head of the Integrated Electronics Group at the RCA Electronic Research Lab in Princeton, N.J., were the first to succeed in late 1962 in integrating a multipurpose logic block of 16 MOS transistors into a silicon chip, 50 x 50 mils. They reported their success at the 1962 Electron Devices Meeting in October, 1962.

While it is clear who made the first MOS IC (the subject of the course that starts in this issue), the origin of the MOS transistor seems to have faded into the annals of semiconductor history. Looking for the developer of the insulated-gate field effect transistor takes us as far back as 1926, to the work of J. E. Lilienfeld in the U.S., and later to 1935, when Oskar Heil of Germany obtained British patent 439,457 on a thin-film, field-controlled semiconductor.

The first discrete FET was not MOS

Indeed, the first field-effect transistors were made of thin films, and the groundwork for integrated circuits made of such transistors was laid out by J. Torkel Wallmark in 1959 who, while working for the RCA Labs, visualized the possibility of implementing logic functions for computers, which he called "integrated logic nets," with long strings of such transistors, batch fabricated. As it turned out, another scientist at the RCA Labs, Dr. Paul K. Weimer, was successful in implementing Wallmark's ideas with field-effect transistors made with thin films of cadmium sulfide and cadmium selenide, deposited on insulating substrates.

At a different cradle of semiconductors, Bell Laboratories, a group working under M. M. Atalla was working in the late 1950's on *discrete* insulated-gate field-effect transistors, using the now popular combination of

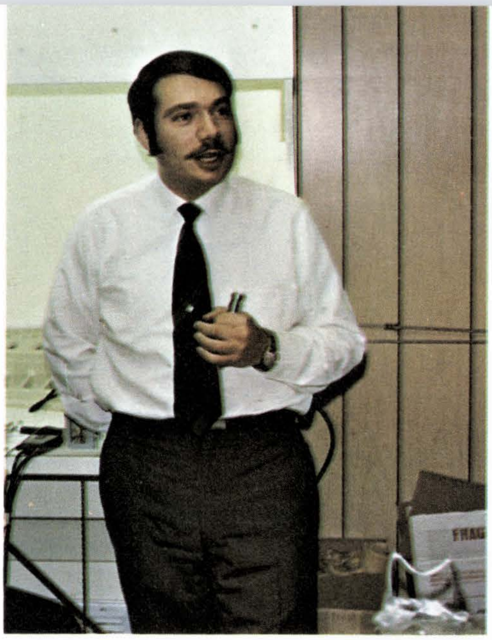


The first MOS IC, made by Hofstein and Heiman at RCA Electronic Research Lab, was an array of eight pairs of n-channel transistors, interconnected as two 4-input gates.

silicon as the semiconductor and silicon dioxide as the insulator. The ideas and work developed by Atalla, Wallmark and Weimer, bore fruit in the first MOS IC.

Prior to their work on MOS integrated circuits, both Drs. Hofstein and Heiman developed the first discrete MOS transistors that could be mass produced. Dr. Heiman obtained a patent (assigned to RCA) on how to use the n-type inversion layer in a p-enhancement MOS as a channel, while Dr. Hofstein patented the offset gate structure used in early MOS transistors, later replaced by the now popular dual gate. As a matter of fact, the transistor was known in the early days as the "Hofstein-and-Heiman metal-oxide-semiconductor field-effect-transistor," which gave way to the acronym MOS FET. Unlike the names of Esaki and Gunn, those of Hofstein and Heiman did not stick to their semiconductor.

At the time Hofstein and Heiman made that first MOS integrated circuit, the Research Labs of RCA were also trying to make integrated circuits with thin-film FETS. These two efforts, although parallel, had quite different objectives. The application for the MOS ICs was going to be, as indeed it is today, digital circuits for computers. The application for the thin-film FETS, on the other hand, was for an electro-optical usage—a solid-state vidicon. Since the work on thin-film FETS started first, many of the techniques now used to make MOS ICs were actually developed for the thin-film effort.



Dr. Steven Hofstein: "The impact of MOS integrated circuits of digital computers was one of the few predictions made in 1963 that came through. At that time, TV was a big business—computers were not."

The pioneers move

Where are these pioneers now? Thomas O. Stanley is staff vice president of Systems Research at the RCA Labs, and J. Torkel Wallmark, who went back to full-time teaching in Sweden, comes back to the RCA Labs during sabbatical leaves. From Bell Labs, Dr. Atalla went to Hewlett-Packard Asso., where HPA's line of GaAs readouts were developed under his direction; he has recently moved to the Microwaves and Optoelectronics Div. of Fairchild, as general manager. Steven R. Hofstein is president of Princeton Electronic Products, Inc., a company he started early in 1968 to develop a system for storing images. Dr. Heiman joined him at PEP early in 1969. As for Dr. Paul K. Weimer, he is head of Self-Scan Device Research at RCA Labs, where he has successfully perfected several versions of the solid-state vidicon, using thin-film FETS.

Thomas O. Stanley: "We worked on MOS because we wanted to develop a reproducible IC technology to implement J. Torkel Wallmark's concept of universal logic gates."

It is interesting to note that, even though RCA Labs made the first integrated circuits with MOS, the company was not the first to market them (although it did market quite successfully, discrete MOS transistors.) That distinction is held by General MicroElectronics (later acquired by Philco-Ford) and General Instrument, which offered the first commercial MOS ICs in late 1964.

Looking back, it could be argued that these introductions were premature, since the surface problems that plagued the first MOS ICs gave them a bad name and actually delayed their acceptance. On the other hand, those two companies took the brunt of the difficult task of marketing the new product, and developing applications. One of them, GME reaped none of the rewards. We feel that those problems have been mostly overcome, and that the applications of MOS ICs are only now starting to grow. To give their growth a solid base, we present this course.

INFORMATION RETRIEVAL
Integrated circuits, Semiconductors

MOS course—Part 1 The basic structures

Metal-oxide-semiconductor? That's what it used to mean. This part of our course describes the different structures we call MOS.

E. Marshall Wilder, Product Engineering Manager
Fairchild Semiconductor, Mountain View, Calif.

The acronym MOS has come to stand for a lot more than just metal-oxide-semiconductor. Today, these initials describe any integrated circuit made with enhancement mode, insulated gate, field effect transistors. The MOS technology is the newest major production technology in the semiconductor industry. The first MOS integrated circuits appeared in the market in small quantities in mid-1964, and, since then, many semiconductor companies have made substantial commitments toward the MOS market.

The p-MOS structure

As the initials imply, all of these devices had a metal-oxide-semiconductor layered construction at one time. The four functional parts of a MOS transistor are the source, the drain, the gate, and the substrate. The device is an almost ideal switch since, when the gate and source potentials are equal, no current flows between the source and the drain. However, when the gate voltage with respect to the source is raised to a critical level (called threshold voltage) the transistor turns "on" and current can flow from source to drain. The threshold voltage is negative on the gate of this type of MOS transistor, to establish an electrostatic field that inverts the n-material under the gate to a p-channel between the source and drain.

The metal referred to in MOS is almost always aluminum, usually between 1 and 2 μm thick, and deposited using an electron beam (EB) evaporator. The EB evaporator is used because cleanliness is extremely important in MOS processing and an EB system is currently the cleanest of the production evaporation systems.

The oxide in MOS is the gate insulator, silicon dioxide. This layer is grown on the silicon by high temperature oxidation (about 1200°C) of the silicon. Most manufacturers use an oxide thickness on the order of 1100 Å under the gate. This gate oxide is the most critical part of the device. Its thickness must be very close to the design value; it can have no "pinholes" or the device will be shorted; and it must be pure, or the device will be unstable electrically.

The semiconductor material is single crystal silicon that is doped n-type with phosphorus or antimony. The doping level is usually on the order of 10^{15} atoms/

cm^3, which is seven orders of magnitude below the density of the bulk silicon atoms. Diffused into this silicon are the source and drain regions. Both are boron doped and are from 2 to 4 microns deep.

An important point to note is the the MOS transistor is a self-isolating device, because all junctions are reverse biased during normal operation. This is extremely desirable when you make integrated circuits. Since you do not need isolation diffusions, the packing density of the transistors on a chip is extremely high.

With many MOS transistors on a chip, however, a parasitic problem can arise. The key to avoiding the problem is in the manufacturing process. A parasitic transistor is formed between two adjacent p+ regions when a high voltage metal line crosses them. Unless the "field" oxide under this line is thick enough, the high voltage inverts the surface of the n-type substrate and turns on the transistor that is formed. This parasitic transistor is exactly like a conventional transistor, except it has thicker gate oxide and, therefore, a higher threshold voltage.

The manufacturing process must provide a field oxide thick enough so that the thresholds of the parasitic transistors are above the maximum voltages in the circuit. Since these voltages are often above -30 V, the field oxide must be at least 1.5 μm thick. This oxide can be thermally grown, but it takes a long time. More often, the thick oxide is deposited. Methods of deposition include electron-beam evaporation, rf sputtering, and the thermal oxidation of silane. The last method is the most common because it is the cleanest and is quite reproducible. This reaction takes place at 400°C and is expressed as:

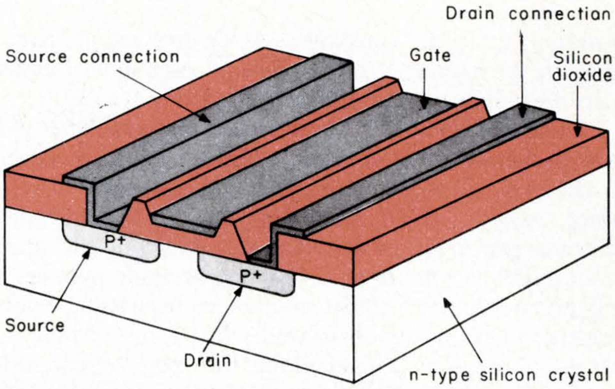
$$SiH_4 + 2O_2 \rightarrow SiO_2 + 2H_2O$$

The problems of N-channel MOS

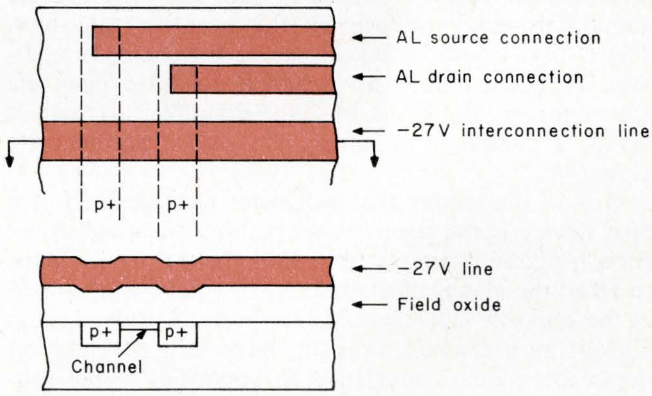
The structures described thus far have been p-channel MOS transistors. In addition, n-channel transistors can be and are being made using the same techniques. Integrated circuits made with n-channel transistors seem to offer advantages over the more usual p-channel devices. The most obvious advantage stems from the higher mobility of the charge carriers in an n-channel device.

P-channel transistors use holes for conduction. At normal field intensities, hole mobility is about 200 cm^2/(V-s). On the other hand, n-channel transistors use electrons to accomplish the charge conduction. Since electron mobility is 400 cm^2/V-s, twice that of hole mobility, an n-channel device will have one-half the on resistance or impedance of an equivalent p-channel device with the same geometry and under the same operating conditions. To put it another way, n-channel transistors need be only half the size of p-channel devices to achieve the same impedance. Therefore, n-channel integrated circuits can be smaller for the same complexity or, even more importantly, they can be more complex with no increase in silicon area.

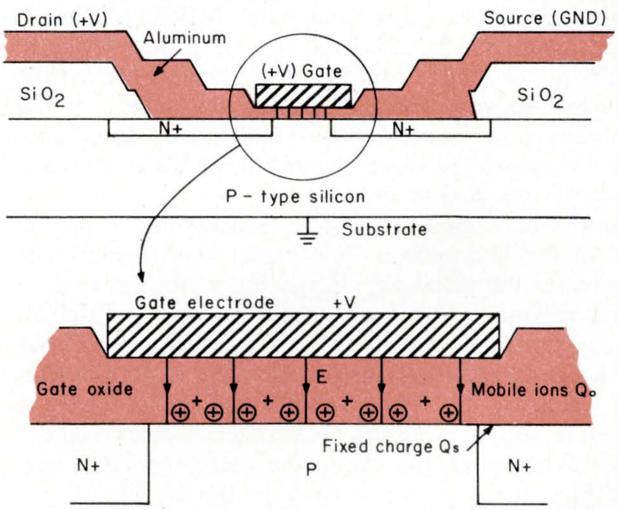
Along with greater packing density, n-channel circuits offer a speed advantage over p-channel circuits. This is a direct result of smaller junction areas since the operating speed of a MOS IC is largely limited by



The p-MOS structure. This device shows the conventional metal-oxide-semiconductor gate sandwich that gives the technology its name. Also apparent is the overlap between gate and source, and gate and drain. This overlap increases parasitic capacitances and limits the speed of devices with this structure.



A parasitic transistor can be formed when a high voltage interconnecting line crosses two p+ regions. In this case, if the field oxide is not thick enough, the −27-V line will turn on the transistor regardless of the voltage on the gate.



N-channel MOS with the fixed Q_{ss} charge, and Q_o charge of the mobile contaminants. Both charges add to give a resultant field that tends to make the device normally on.

internal RC time constants. A diode's capacitance is directly proportional to its size and n-channel junctions can be smaller than p-channel junctions.

Since the majority of MOS devices available today are p-channel, the obvious question is "how come, if n-channel offers size and speed advantages?" The answer, as you might readily expect, is that p-channel circuits are much easier to make. Most of the mobile contaminants (the dread of MOS processing people) are positively charged. Since n-channel transistors operate with the gate positively biased with respect to the substrate, these ions collect along the oxide-silicon interface. The charge (Q_o) from this layer of ions causes a shift in threshold voltage which tends to make the transistor normally on (current flows from source to drain with no voltage on the gate).

Beside the mobile positive ions, a fixed positive charge also exists at the oxide-silicon interface. This charge, caller Q_{ss}, results from various steps in the manufacturing process and also tends to make the device normally on. These two charges (Q_o and Q_{ss}) exist in p-channel devices too but the + ions are pulled to the aluminum-oxide interface by the negative gate bias. There, they cannot affect the device threshold. In addition, the fixed charge in p-channel tends to give you higher thresholds. While this is undesirable, it is not as severe a condition as having the device permanently biased on.

One of the factors that influences the threshold of a MOS device is the doping level in the silicon substrate. Increasing the doping level in an n-channel device helps to offset the effects of Q_o and Q_{ss} by establishing a field in the opposite direction. Theoretically then, you could convert an n-channel transistor back to a normally off device by adding enough p-type impurities to the substrate.

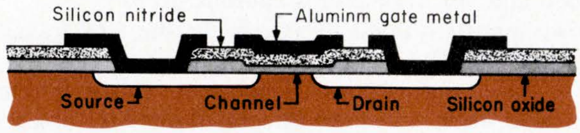
Unfortunately, this approach does not work with single polarity n-channel circuits, although it does work with complementary MOS (C-MOS). The reason it does not work in single polarity n-channel is because of something called the source bias effect.

While the mechanics of the source bias effect are too involved to be discussed here, basically, what it does is cause the threshold voltage of a MOS device to vary with the source voltage. With C-MOS this can be overcome because you can ground the source of the n-channel transistors so that the threshold stays constant. However, in single polarity devices the source is frequently not tied to ground.

Source bias effect is very dependent on the doping level of the bulk silicon. The higher the doping level, the greater the threshold change for a given change in source voltage. The result is that if you dope an n-channel device heavily enough to combat the Q_o/Q_{ss} field, the device is practically useless because its threshold is very unstable. So, today's n-channel devices have a moderate doping level and are, in fact, normally on devices. When used, the circuit designer provides a negative bias to the source to turn the device off.

All in all, this presents a fairly complicated picture. It is difficult to design circuits using n-channel (you need an extra bias supply for one thing) and it is difficult to control the process needed to manufacture them.

When the MOS technology was new, the process control needed for n-channel was just not available. Now, the process can be controlled but still not easily. The result is that today, n-channel cannot economically compete with p-channel.



The MNOS structure. Reducing the gate dielectric thickness below about 1000 Å is impractical since the dielectric then tends to have a high incidence of pinholes. The thin dielectric is also more subject to damage from static electricity. You can however increase the dielectric constant (and thereby reduce the threshold voltage) by using a silicon-nitride sandwich for the gate insulator. The Si_3N_4 about doubles the dielectric constant and cuts the threshold voltage of the device in half (from 3 to 6 V nominal to 1.5 to 3.0 V). The total mechanical thickness of the dielectric remains approximately the same. Since the threshold voltage is reduced, power supply requirements are also reduced for MNOS devices; they require +5 V and −12 V in normal operation.

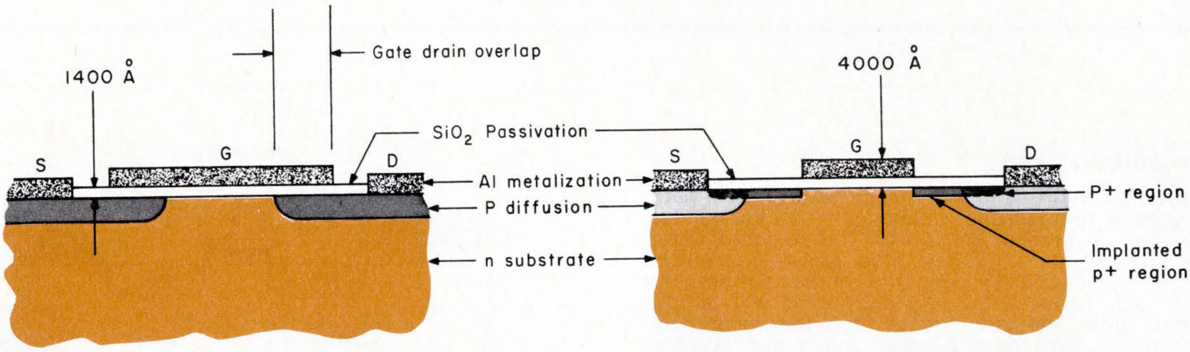
The nitride passivation also doubles the gain factor (k') of the device. (Gain factor is defined as the amount of output current relative to the voltage on the device. It's directly proportional to the dielectric constant of the gate insulator and inversely proportional to the insulator thickness.) The increased k' gives lower on resistance devices and a reduction in the size of the output device required to supply the 1.6 mA of a normal TTL load.

(Contributed by General Instrument Corp., Hicksville, N. Y.)

Threshold voltage

The threshold voltage of an MOS transistor is the most important, process-dependent, device parameter. It is desirable in most cases to have a process that produces low threshold voltages. An IC with low threshold transistors will operate at lower power supply voltages than a high threshold circuit (−5 V and −15 V for the low voltage circuits vs −13 V and −27 V for the high voltage circuits). This means cheaper system power supplies. An even more desirable feature is that the low voltage circuit is directly compatible with bipolar ICs; that is they require and produce the same input and output signal swings. This compatibility gives a system designer more flexibility. He can design using MOS and bipolar circuits without worrying about signal level shifting or interfacing.

In addition, low signal voltages also imply higher operating frequencies. If a voltage only has to swing



Diffused, passivated MOS FET. Note the gate overlap.

Diffused, passivated MOS FET using ion implantation to form crucial portion of source and drain. Note perfect alignment.

Ion implantation of MOS transistors improves operating speed by reducing the internal capacitance between the gate and source, and gate and drain. In the conventional diffused device, the gate must overlap the diffused regions to allow for photomask registration tolerances and for the lateral spread of the diffused ions.

With ion implantation, only a portion of the source and drain regions is diffused and then the gate is fabricated to the desired width (it can be about three times smaller than in the diffused transistor). A beam of boron ions is accelerated to high velocity and impinges on the entire wafer. Most ions striking the oxide regions penetrate the oxide layer and are deposited in the bulk silicon, doping these areas and forming the rest of the source and drain. Ions striking other regions are collected harmlessly by metallization layers. Alignment of the gate is automatic since the gate serves as the mask for the critical portions of the source and drain.

This alignment produces two to four times lower input capacitance and about 40 times less Miller capacitance, resulting in a device that is about five times faster than an equivalent diffused transistor.
(Contributed by Hughes Aircraft Co., Newport Beach, Calif.)

between 0 and —5 V, it can change state faster than a voltage swinging between 0 and —10V can.

The advantages of low-voltage MOS are apparent; the best method of making it, isn't. There are several ways of modifying processes and device structures to achieve lowered threshold voltages. The equation for threshold voltage, V_T, is:

$$V_T = \frac{X_o}{K_c}(Q_{ss} - Q_B) + \phi_{ms} + 2\phi_F$$

where

- ϕ_{ms} is the work function difference between the gate conductor and the bulk silicon.
- ϕ_F is the Fermi potential of the bulk silicon.
- Q_{ss} is the fixed surface-state charge density per unit area.
- Q_B is the charge per unit area within the surface depletion region at the onset of strong inversion.
- X_o is the gate dielectric thickness.
- K_c is the dielectric constant of the gate insulator.
- c_o is the permittivity of free space.

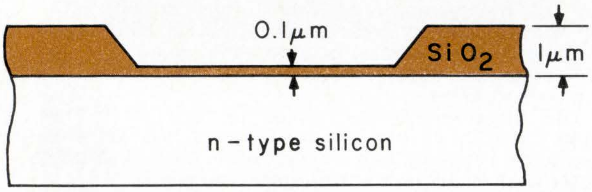
The MNOS structure

From the equation, you can see that if a gate insulator with a higher dielectric constant replaces the SiO_2, the threshold voltage of the resulting device is reduced. Several manufacturers are using this approach quite successfully. The material they use for the gate insulator is silicon-nitride, Si_3N_4. This nitride has a dielectric constant of 7, as opposed to silicon-dioxide's 3.9. The Si_3N_4 is usually deposited in an rf-heated reactor, with a combination of Si_1H_4 silane and O_2 gasses. The temperature is about 700°C and the process is similar to the standard pyrolitic deposition of silicon, SiO_2 and other materials. Unfortunately, the interface between silicon and silicon-nitride is very difficult, if not impossible, to control. For this reason a structure known as MNOS has evolved as a practical, low voltage MOS transistor. The gate insulator is a lamination of silicon-dioxide and silicon-nitride. The SiO_2-Si interface is well understood and easily controlled. The silicon-dioxide, about 400 Å thick, effectively separates the nitride from the silicon and the resultant gate insulator is slightly thinner than the pure SiO_2. These devices, called MNOS transistors, have threshold voltages about 2 V less than conventional MOS devices.

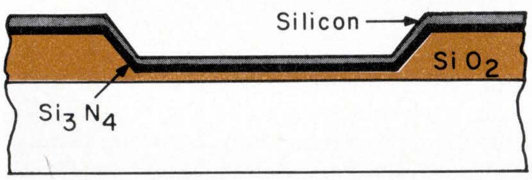
Another gate dielectric, which has been used with less success but does bear mentioning, is alumina (Al_2O_3). This insulator produces good threshold reduc-

The silicon gate

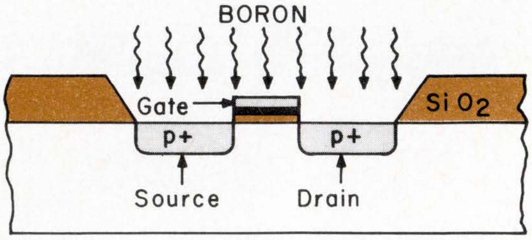
Intel Corporation combines silicon as the gate material with a nitride-oxide dielectric in its low-voltage MOS. The processing starts with the standard wafer of n-type silicon. The first step grows a layer of silicon dioxide (SiO_2) over the entire surface. An oxide etch removes this oxide in what will be the source, drain and gate areas. Then the wafer goes back into the oxidizing furnace and a thin layer of oxide is grown in the thick oxide opening. At this point the device looks something like this.



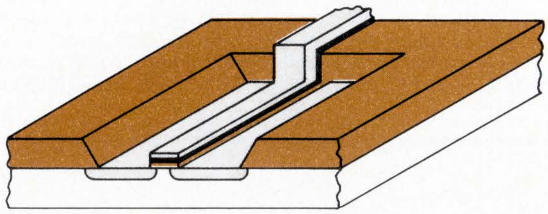
The next steps are back-to-back depositions. The first leaves a thin layer of silicon nitride (Si_3N_4) over the entire surface. This is followed by a layer of amorphous silicon on top of the nitride. You now have a structure that looks like this.



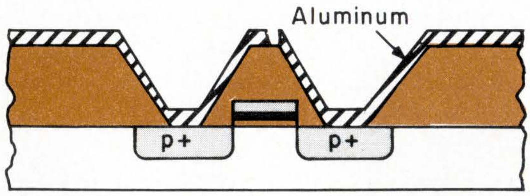
Photomasking techniques remove the silicon and nitride from the entire surface except for the gate area and where the silicon is to be used as an interconnect. Now another etch removes the thin oxide except under the silicon gate. The process then diffuses boron, a p-type impurity, onto the surface of the wafer. This step is shown here.



Boron diffuses rapidly into the silicon, but slowly in the oxide and nitride. Since the gate itself is the diffusion mask for the source and drain areas, close alignments of gate to source and gate to drain are maintained. The only overlap is due to the sideways diffusion of the boron in the silicon. A perspective view of the device after it leaves the diffusion looks like this.



Another layer of oxide over the entire surface follows. Openings for the connections to the source and drain are etched and aluminum is evaporated into these openings. Completing the interconnection patterns finishes the device and its final cross section looks like this.

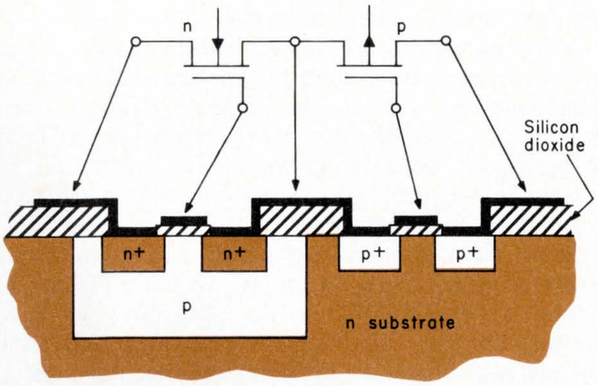


(Courtesy of Intel Corp., Mountain View, Calif.)

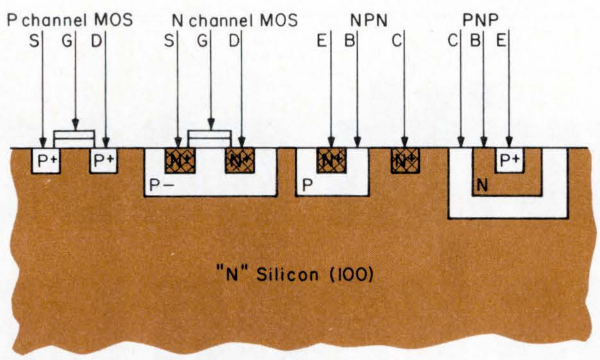
tions but is extremely difficult to deposit and to etch. A cross-section of a device of this type would be the same as the p-MOS structure with alumina replacing the silicon dioxide.

The Si-gate structure

In addition to the dielectric constant of the insulator, threshold voltage depends on the work function difference between the gate conductor and the silicon substrate. This is the ϕ_{ms} term in the threshold voltage equation that for an aluminum gate, p-channel transistor, is equal to -0.3 V. If, however, a material other than aluminum is used for the gate electrode, the threshold voltage changes with the work function. This approach has led several manufacturers to a device called a Silicon Gate Field Effect Transistor. This type of MOS transistor, (See box on page 62) uses a layer of deposited silicon as its gate electrode. This silicon



Complementary MOS. Cross-section of complementary-symmetry MOS transistors used by RCA in their COS/MOS ICs. Basically, the inverter circuit combines one p-channel, enhancement-type MOS transistor and one n-channel enhancement-type MOS transistor. The transistors operate in a "series" connection from a single power supply with their drains connected. Since in either logic state one transistor is off while the other is on, the quiescent power dissipation is very low. *(Courtesy of RCA, Somerville, N. J.)*



Combining complementary MOS and complementary bipolar transistors on the same substrate may give you the best of both worlds. This approach preserves the low static power dissipation of complementary MOS while giving an order of magnitude increase in operating speed. The illustration shows the cross section of one fabrication approach. *(Courtesy of Solid State Scientific Devices Inc., Montgomeryville, Pa.)*

On the threshold?

Three contenders are currently in the race for a MOS circuit with low (read bipolar compatible) threshold voltage. The first advocates the familiar metal-oxide-semiconductor gate construction, but on a silicon crystal with <100> rather than the more popular <111> orientation.

The second approach to bipolar compatibility uses an oxide-nitride sandwich for the gate dielectric. This is the MNOS structure of our text.

The third entry in the threshold sweepstakes (and there is a big purse waiting for the winner) is the silicon-gate MOS.

All three techniques do reduce threshold voltage. However, among the three rivals there are some important differences, particularly in the areas of feedback capacitance and packing density. Right now, the field looks like this:

	p-MOS on <111>	p-MOS on <100>	Si-gate	MNOS
threshold voltage	4-6 V	2-2.5 V	1.8-2.2 V	1.5-2.5 V
relative feedback capacitance	4	4	1	6
relative packing density	0.7	0.7	1	0.7
threshold voltage of field oxide	25 V	16 V	25 V	25 V

(Contributed by General Instrument Corp., Hicksville, N.Y.)

The problem with all three of these approaches is that they make an already complex process even more so. As is the case in all IC manufacturing, the most important word in the dictionary is yield. The winner in this contest is going to be the process that gives the best performance/yield tradeoff. Right now, a lot of the handicappers around the track like No. 3, silicon gate.

layer may be doped with impurities having various work functions, and in this way, you can give the transistor different threshold voltages.

The silicon gate technology is normally used to make p-channel integrated circuits. Here, you deposit the silicon gate layer over a 1200-Å thick, thermally grown oxide layer. A masking and etch step defines the gate geometry and the oxide is removed from the future source and drain regions. The dopant, boron, is then introduced to the source, drain and gate regions by a normal predeposition from a gaseous source. Thus, the gate silicon is heavily doped p-type silicon just like the source and drain, and the opposite type from the bulk. Building up the field oxide with deposited SiO_2 completes the device. Aluminum is evaporated and the interconnections are defined using standard photolithographic techniques. A device made like this, with a p-doped gate and an n-doped substrate, will have a threshold voltage 2 V less than a similar aluminum gate device.

As the MOS industry matures, many people believe that the silicon gate technology will be the one most widely used. Three main reasons point to this conclusion. The most important word in the semiconductor industry is yield, and the silicon gate technology produces high yields. There are more good integrated circuits on each wafer when the circuits are made of silicon gate transistors than there would be if a more conventional technology were used. The reason is that the gate oxide, the most critical portion of an MOS transistor, is covered up immediately after it is grown. The deposited layer of silicon protects this oxide from etchants, contaminants, and mechanical damage.

Secondly, silicon gate transistors can operate at higher speeds than conventional MOS or MNOS transistors. This is not because the gate is silicon, but because the gate is smaller than aluminum gates. There is no overlap of the gate conductor over the source and drain regions because the gate itself is the diffusion mask that defines the active edges of these p+ regions. Conventional MOS transistors must have an alignment tolerance built into the mask set. This usually produces a gate overlap of from 3 to 5 μm which increases the feedback capacitance between the gate and the drain. Increased feedback capacitance reduces the usable gain of the transistor.

A third big advantage of the silicon gate IC is its compatibility with other technologies. Since the gate oxide is covered as soon as it is grown, the wafer in process can go through additional high temperature oxidations and diffusions after the MOS transistors are formed. Therefore MOS and bipolar transistors can be designed and manufactured on the same piece of silicon. This presents many options to integrated circuit designers; it lets them use the right transistor for each job, rather than compromising performance or size because the right device couldn't be made.

Many manufacturers deposit another layer of oxide over the completed wafers that protects the aluminum interconnections from mechanical damage during assembly. This passivation also increases the reliability of the circuit, because contamination, which might be present in the package, cannot migrate to the active portions of the circuit.

Some manufacturers are considering two or more layers of metal interconnections. This hasn't happened yet and it is doubtful that it will, except for a few special designs. For one thing, silicon gate integrated circuits already have three layers of interconnections; the p+ diffusion, the silicon gate layer, which can be used for interconnecting points on the circuit, and the aluminum.

Even with only one layer of aluminum, it is obvious that in MOS technologies, more goes onto the silicon than goes into it. This will continue to be true as semiconductor processing is further developed.

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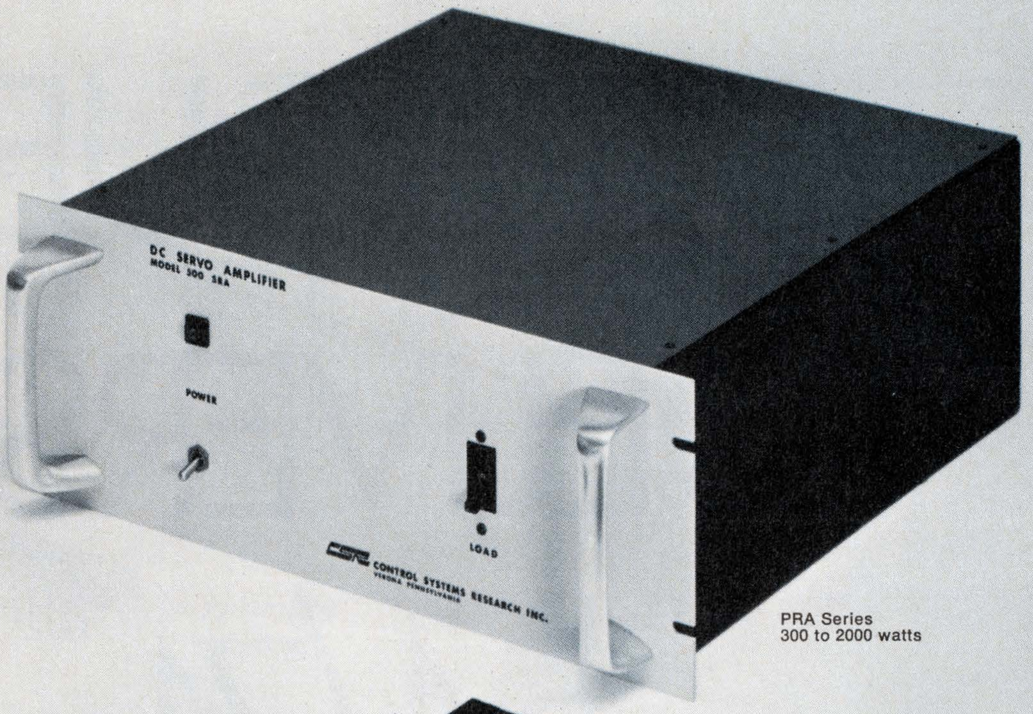

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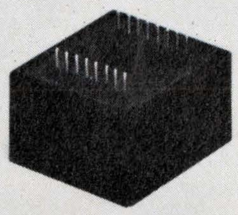

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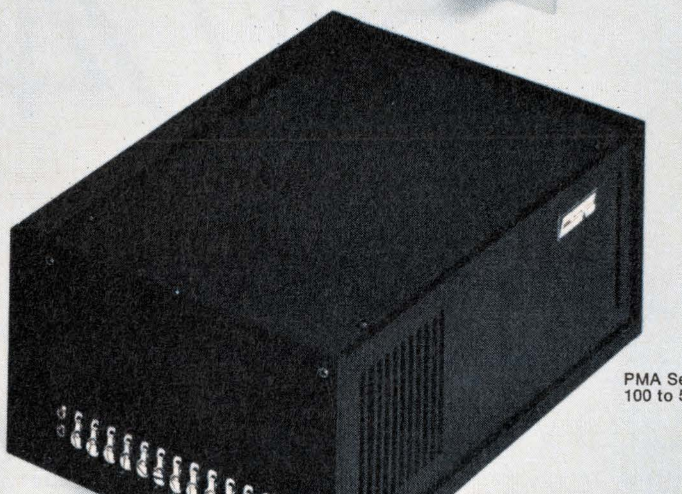

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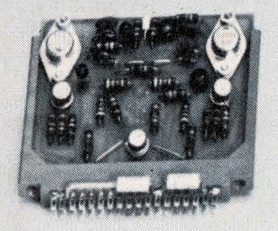

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DESIGN FEATURES

Circuit design: The op amp way

Circuits built around op amps are becoming more and more common. Now you can see how someone else attacks the job of creating some of these circuits.

By **C. J. Huber,** Senior Engineer,
Westinghouse Defense & Space Center, Baltimore, Md.

"Use 'off-the-shelf' linear ICS." That was the order when I had to design a replacement for an existing solid-state analog signal processor. The design parameters had to be investigated in terms of both temperature sensitivity and frequency response. The temperature effects were important since the system had a gain and dc stability requirement of 3% over the range −55° to 125°C.

The actual circuits designed all incorporate the Fairchild μA709 monolithic op amp. They include:

- a gain and offset amplifier and the variations:
  - sample and hold circuit
  - voltage converter (0-6 V input to 0-18 V output)
- an integrator (used as a sweep generator)
- an oscillator
- a synchronous demodulator

Before discussing these circuits, however, let me give you some analysis of the basic inverting and non-inverting amplifiers which should clarify some of the design procedures.

The inverting amplifier

The model chosen to represent the operational amplifier in all the ac circuits is shown in Fig. 1 (where $s = \alpha + j\omega$). By adding a feedback element Y_f, a load Y_L, and a series input element Y_1 to the op amp, we obtain the basic configuration for the small signal amplifier (Fig. 2) with the corresponding voltage gain expression.

$$\frac{e_o}{e_i}(s) = G(s) = \tag{1}$$

$$-\frac{Y_o Y_1 \left[A(s) - \frac{Y_f}{Y_o}\right]}{Y_L(Y_i + Y_f) + Y_L Y_1 + (Y_o + Y_f)(Y_L + Y_f) + Y_1(Y_L + Y_f) + Y_f(Y_o A(s) + Y_f)}$$

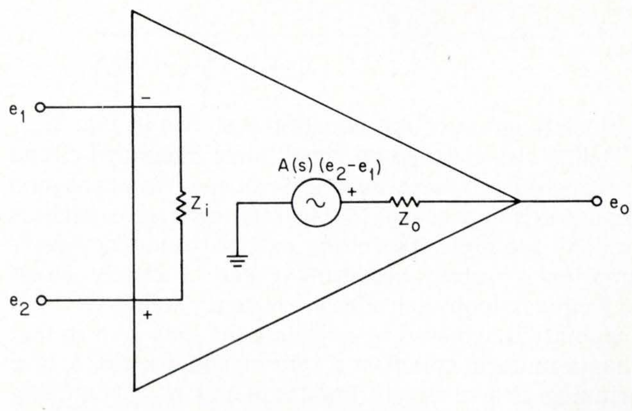

Fig. 1: **The simplified model** representing the operational amplifier used in the analysis of the designed circuits.

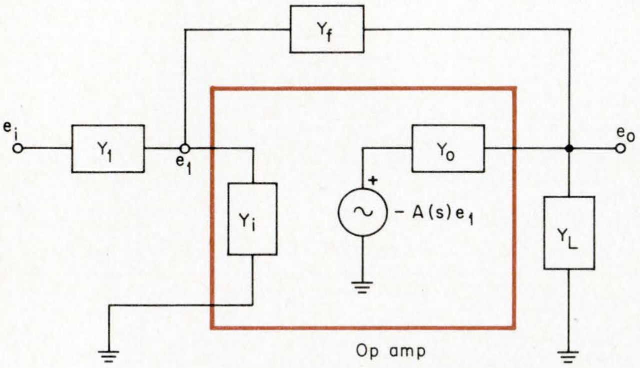

Fig. 2: One of the basic configurations in the design of op amp circuits is this small signal inverting amplifier. It shows the general series input element, feedback element, and load positioned around the op amp model.

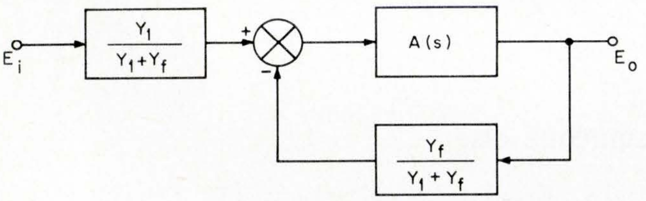

Fig. 3: This block diagram of the inverting amplifier shown in Fig. 2 clearly indicates the feedback loop that affects frequency stability.

If we assume that

$Y_i \approx 2.5$ micromhos

$Y_o \approx 40$ millimhos

$50\ \mu\text{mhos} \leqslant Y_f\ Y_1 \leqslant 1$ millimho

Y_L is comparable to Y_1 and Y_f

$$\frac{Y_f}{Y_o} \ll 1$$

then Eq. (1) reduces to:

$$G_V(s) \approx -\frac{Y_1}{Y_1 + Y_f} \cdot \frac{A(s)}{1 + \dfrac{Y_f}{Y_1 + Y_f} A(s)} \qquad (2)$$

A block diagram of this equation is shown in Fig. 3.

Unlike discrete type op amps, most integrated-circuit op amps do not have built in frequency compensation because it is impractical to integrate the large capacitors normally required. Therefore, external frequency compensation is usually necessary. Figure 3 clearly shows the feedback loop that affects frequency stability.

Stability is achieved by adjusting the loop gain so that it has a uniform rolloff at a rate of about 6 dB/octave beginning at a relatively low frequency and continuing until it crosses the 0-dB axis. Since there is a 90° phase shift associated with such a rolloff, the circuit cannot become unstable.

This adjustment also affects the bandwidth. For any particular gain, the closed-loop bandwidth can be maximized and, unlike the case with discrete amplifiers with fixed compensation, does not always have to be inversely proportional to the closed-loop gain.

If we assume $A(s)\big|_{s=0} \gg \dfrac{Y_f}{Y_1 + Y_f}$

then Eq. (2) can be used to determine the low frequency closed-loop gain. The result is the standard closed-loop expression:

$$G_V \approx A_{CL} = -\frac{R_f}{R_1} \qquad (3)$$

where $R_f = \dfrac{1}{Y_f}$, $R_1 = \dfrac{1}{Y_1}$. Rearranging Eq. (1), we can investigate the error incurred by using the approximation of Eq. (3)

$$G_V = A_{CL} \frac{1}{\left[\dfrac{(Y_1 + Y_o')(G_f + A_{CL})}{Y_o A'}\right] + 1} \qquad (4)$$

where

$$G_f = \frac{Y_f + Y_L}{Y_f}$$

$$Y_o' = Y_o + Y_f$$

$$A' = A(s) - \frac{Y_f}{Y_o}$$

$$A_{CL} = -\frac{R_f}{R_1}$$

Thus the term

$$\frac{(Y_L + Y_o')(G_f + A_{CL})}{Y_o A'}$$

should be much less than unity to minimize the deviation from $G_V = A_{CL}$ over the frequency range of interest.

If we compare Fig. 2, the amplifier circuit, with Fig. 3, the block diagram representation, and determine the contribution of E_o and E_i to E_1 for Fig. 2,

$$E_1 = \frac{R_f}{R_1 + R_f} E_i + \frac{R_1}{R_1 + R_f} E_o$$

Thus, the E_1 junction acts as the adder element in the block diagram of Fig. 3.

The preceding analysis is for a small signal amplifier and does not take into account the slew rate of the op amp. The slew rate limits the maximum rate of change of large input signals that the output can follow. It also defines the maximum frequency where full sine-wave output swing can be obtained from the amplifier. The slew rate (SR) is related to the peak sine-wave signal (A_p) at a given frequency (ω) by

$$SR = A_p\omega$$

The change in closed-loop bandwidth caused when an amplifier is driven beyond its slewing limit can be shown by performing a bandwidth versus signal level experiment. This involves plotting the effective closed-loop bandwidth versus the input level for large signals for a constant closed-loop gain and constant output.

The non-inverting amplifier

Another basic configuration is the non-inverting amplifier shown in Fig. 4. The corresponding model for this circuit is Fig. 5, and the voltage gain equation is:

$$\frac{e_o}{e_i} = \frac{A\,Y_o\,(Y_f + Y_1) + Y_f\,Y_i}{Y_f\,(Y_1 + Y_i) + Y_o\,[Y_f\,(A+1) + Y_1 + Y_i] + Y_L\,(Y_1 + Y_i + Y_f)} \quad (5)$$

When the same approximations are used as for the inverting amplifier, Eq. (5) reduces to

$$\frac{e_o}{e} \approx \frac{A}{A\,\dfrac{Y_f}{Y_f + Y_1} + 1} \quad (6)$$

The corresponding single-loop feedback block diagram for Eq. (6) is shown in Fig. 6.

When A is very large, Eq. (6) becomes

$$\frac{e_o}{e_i} = \frac{Y_f + Y_1}{Y_f} = 1 + \frac{R_f}{R_1} \quad (7)$$

which is the standard transfer equation for a non-inverting op amp.

If you compare the block diagram with the actual circuit, you can see that the differential input acts as the summing junction and the output is returned via the divider action of R_f and R_1. Thus the physical circuit closely resembles the block diagram.

Temperature and offsets

Both the inverting and non-inverting circuits have a resistor between the non-inverting input and ground. This resistor balances the input base currents to the transistors in the differential stage. In the inverting amp, the resistor R_2 has a negligible effect on the voltage gain equation but does affect the input impedance. For high forward path gain the input admittance is Y_2. At the non-inverting terminal the input admittance is

$$\frac{Y_i\,Y_f}{A\,Y_1}$$

The requirement for a balance resistor, R_2, comes from temperature tracking of the input bias currents. The base drive for each transistor is drawn through R_2 and through R_1 in parallel with R_f. Thus the difference in the two currents will appear as a differential signal and cause a corresponding signal at the output of the amp. In addition, the difference between the two v_{be} drops across the input transistors will cause an output offset voltage.

Equation (8) with Fig. 7 shows the effect of external components on the output offset voltage e_o due to the input offset voltage e_- and currents I_+ and I_-.

$$e_o = -R_f\,I_- + \left(1 + \frac{R_f}{R_1}\right) R_2\,I_+ - e_- \frac{R_1 + R_f}{R_1} \quad (8)$$

R_2 should be equal to $\dfrac{R_f\,R_1}{R_1 + R_f}$ to balance the output caused by the offset currents I_- and I_+, assuming that I_- will equal I_+. It is highly unlikely that I_- will equal I_+ and the difference is normally given on the op amp specification sheet. Since e_o, due to input offset currents, is a function of the size of the impedances, the difference between I_+ and I_- limits the size of impedances that should be used.

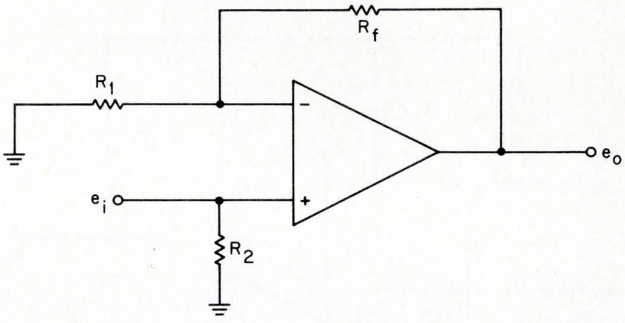

Fig. 4: Another basic configuration is this non-inverting amplifier. The corresponding model is shown in **Fig. 5.**

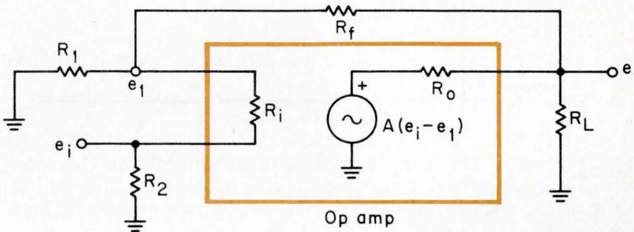

Fig. 5: This model for the non-inverting amplifier configuration is used to determine the voltage gain equation.

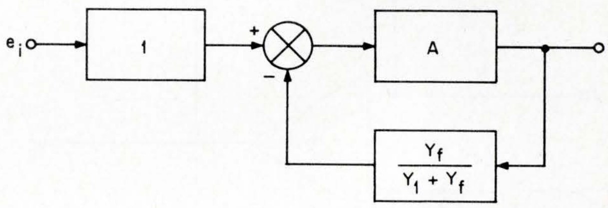

Fig. 6: The feedback loop affecting frequency stability is clearly seen in this block diagram representation of the non-inverting amplifier shown in Fig. 5.

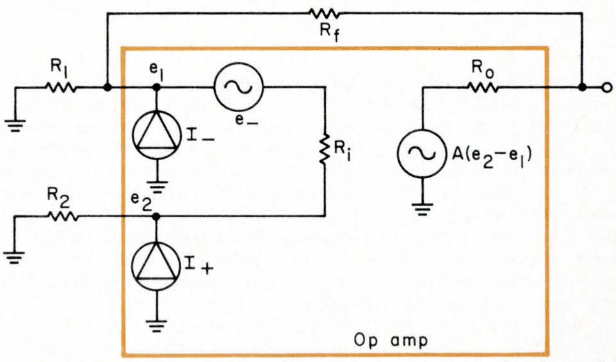

Fig. 7: The input offset voltage, e₋, **and currents,** I₊ **and** I₋, are indicated in this model of the inverting (or non-inverting) amplifier.

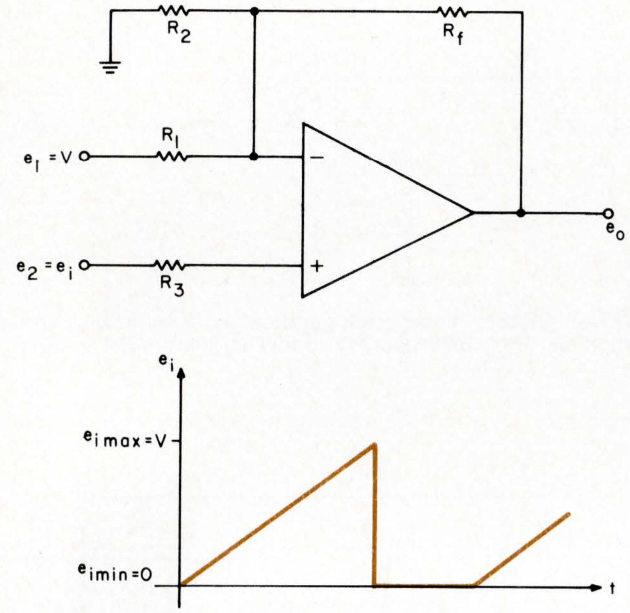

Fig. 8: One of the simplest circuits designed was this gain and offset amplifier. It served as a buffer and scale adjustment amp. Two variations of this circuit are shown in Figs. 9 and 10.

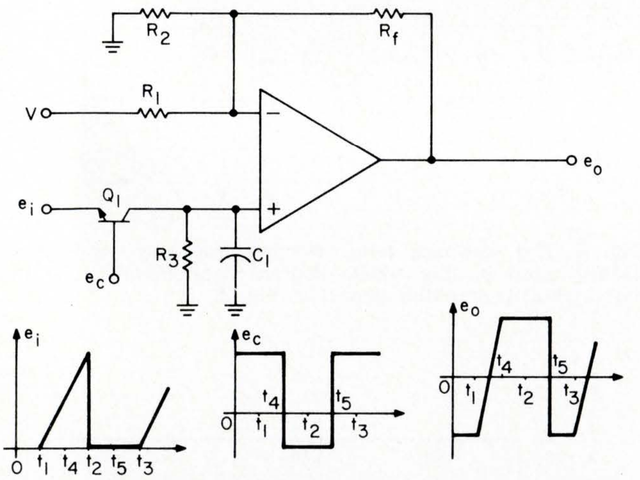

Fig. 9: This sample and hold circuit is one variation of the gain and offset amplifier. The circuit operates as follows: The input signal e_i is applied to the series transistor switch Q1, which then passes the wave to the non-inverting terminal of the op amp. At time, t_4, Q1 turns off and the charge on C_1 is trapped (the leakage paths consist of the back biased junction of Q1, the input impedance of the op amp, and the resistor R_3). The resistor R_3 is used to stabilize the input impedance and droop characteristics over the varying repetition frequency of the input, the varying hold time t_5-t_4, and the varying temperature. The actual circuit used 1% resistors with 50 ppm/°C temperature characteristics and a 1% polycarbonate capacitor with a temperature variation of −2% at −55°C and +0.8% at +125°C from its value at room temperature. The worst case gain variation was −1.3% at −55°C from room temperature value.

In addition, the use of high value resistors causes the output voltage drift (due to temperature variations) to be associated primarily with the input offset *current* drift. At the same time, the lower limit on output drift is determined by the input offset *voltage* drift. The point of crossover is determined by the closed loop gain and by the magnitude of the feedback resistor. Equation (8) can be used to find the output drift due to input offset current and voltage drifts.

The gain and offset amp

The preceding discussion had major effects on the designs used in the system. Now, a description of the operation and experimental results is presented for the various designs.

The simplest configuration was the gain and offset amplifier (Fig. 8) which, without the offset feature, served as an inverting or non-inverting buffer and scale adjustment amplifier. The circuit amplified the input e_2, which varied from 0 to $+V$ volts, while e_1 was used to offset the output to symmetry about 0 V. The relationship between e_o, e_1, and e_2 and R_1, R_2, R_3 and R_f is given in Eqs. (9) and (10):

$$\frac{R_f}{R_1} = \frac{e_{op}}{V}\left[\frac{e_{i\,max} + e_{i\,min}}{e_{i\,max} - e_{i\,min}}\right] \qquad (9)$$

$$\frac{1}{R_2} = \frac{R_f\left[e_{i\,max} - e_{i\,min}\right]}{2\,e_{op} - e_{i\,max} + e_{i\,min}} - \frac{1}{R_1} \qquad (10)$$

where e_{op} is the required output peak-to-peak swing and $V = e_1$ is the dc input voltage.

If R_1 is chosen to provide a low drain on e_1, then R_f and R_2 are uniquely defined and R_3 can then be chosen to satisfy the dc balance conditions. Two variations of this circuit are shown in Figs. 9 and 10.

Some other designs

The op amp also functioned as an integrator in the system (see Fig. 11). To understand its operation, consider transistor Q1 as a reset switch modulating the transfer from V to e_o. When Q1 is closed, ideally the transfer function is $\frac{e_o}{V} = 0$. When Q1 opens, the Laplace transfer function is $\frac{E_o}{V} = \frac{1}{sC_fR_1}$, as can be seen from Eq. (3) when R_f is replaced by $\frac{1}{sC_f}$. By considering $V = V{\cdot}u(t)$, a step function input, the output is

$$E_o = -\frac{V}{C_fR_1s^2},$$

which in the time domain is

$$e_o\,(t) = -\frac{V}{C_fR_1}\,t.$$

For the $V_{CC\,sat.}$ condition of Q1, $e_o = V_{CC\,sat.}$. Thus a low saturation voltage is required for approximately zero voltage between sweeps.

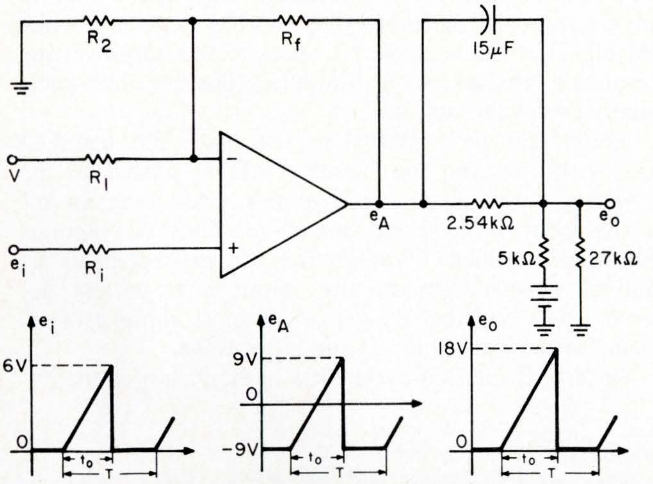

Fig. 10: Here is a voltage converter that satisfies an interface requirement for a non-inverted sweep of range 0 V to +18 V from an input sweep of range 0 V to +6 V. Since the op amp has an absolute maximum supply voltage rating of ±18 V, it cannot produce the full output swing directly. Instead, the output wave is offset to symmetry about zero, the gain is set for a peak-to-peak swing of 18 V, and this wave is shifted for an output swing of 0 to +18 V. The resistors actually used were 1%, 50 ppm/°C types while the capacitor was a 10% tantalum. Tests of the circuit showed a gain of 2.98 with a 0.7% variation over the range −55° to +125°C. The amp used 15-V, IN965 zener diodes to obtain a supply voltage of ±15 V. The dc drift at e_o was only 20 mV while the voltage at the zener diodes varied 2.2 V due to temperature characteristics of the zeners. Because a relatively high voltage swing was required, attention was paid to the effect that the slew rate had on the effective bandwidth. The wave period, T, varied over a 10 to 1 range while the ratio of t_o/T varied from 0.8 to 0.12 for the highest frequency. Most critical was the high frequency, low ratio case. Although the unit had a closed loop small signal bandwidth greater than 600 kHz, the high signal level output was limited to 67 kHz at room temperature with a reduction to 38 kHz at −55°C. This was enough to accurately pass the wave.

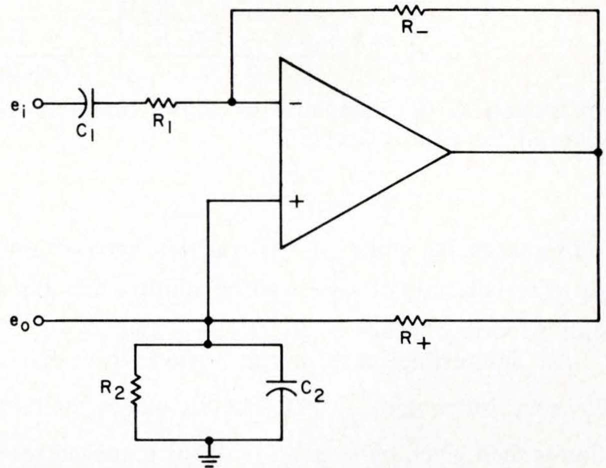

Fig. 12: The oscillator shown above was designed for a 900-Hz fixed frequency. Tests over temperature variation showed a −0.4% amplitude change and a +2% frequency change at −55°C. At +125°C, the amplitude varied +6% and the frequency −1% from room temperature values. While the frequency variation follows the general trend of the precision capacitors, the amplitude depends on the op amp saturation characteristic and is therefore more temperature sensitive. Variations due to changes in the power supplies were also recorded. For a +10% change the frequency varied −0.4 Hz, while for a −10% change it varied +0.3 Hz from a reference value of 899.3 Hz. The amplitude of oscillation varied directly with the power supply changes since the saturation characteristic of the output stage determines the amplitude. To improve this, back-to-back Zener diodes were added to the op amp output. The amplitude variations were then +0.4% for a +10% power supply variation, and −0.8% for a −10% variation. The use of temperature compensated Zeners would also improve the amplitude variation with temperature.

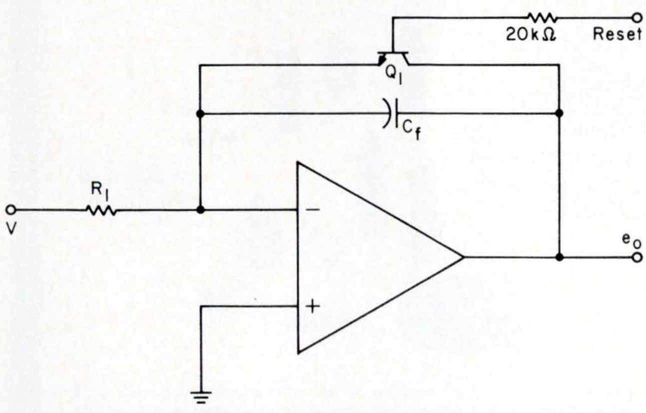

Fig. 11: The operation of this integrator, which uses 1% resistors with 50 ppm/°C temp. char., and a 1% polycarbonate capacitor, is fully described in the article. The circuit was tested over temperature variations using a high speed comparator in conjunction with a pulse width modulator. Results showed a −2% slope variation at −55°C and a 1% variation at +125°C from room temperature value. The sweep linearity was within 1% and the maximum error between the actual and computed sweep widths was 1% when nominal component values were used for computation.

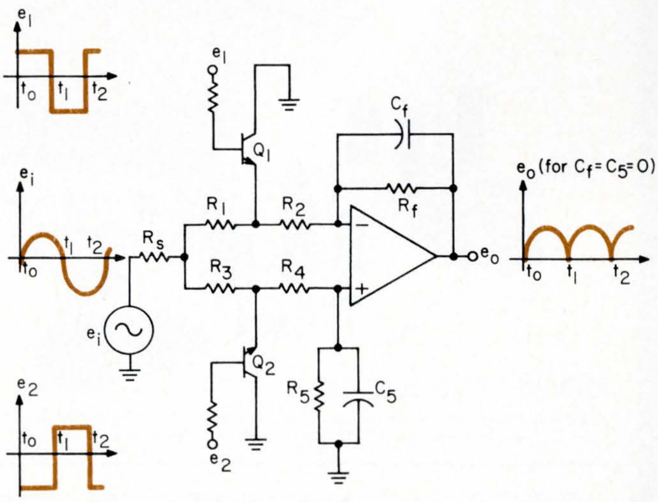

Fig. 13: This synchronous demodulator had a static linearity curve of ±1% for the range 0.02 to 3.5 V rms. Tests over temperature variations showed dc offset of −1 mV at room temperature became −2 mV at −55°C, and +3 mV at +100°C. The conversion gain varied −0.5% at −55°C, and +0.8% at +100°C as compared to the value at room temperature.

Another application of the operational amplifier was in an oscillator which used both positive and negative feedback to parallel and series RC networks respectively (Fig. 12). The governing equation is:

$$\frac{e_o}{e_i}(s) = \frac{-\left(\frac{R_-}{R_+}\right)\left(\frac{s}{C_2R_1}\right)}{s^2 + s\left[\frac{R_2C_2 + C_1R_1 - C_1R_2\frac{R_-}{R_+}}{C_2R_2\,C_1R_1}\right] + \frac{1}{C_1C_2\,R_1R_2}}$$

Inspection of the denominator shows that the coefficient of the s-term is zero if

$$\frac{R_2C_2 + C_1R_1}{C_1R_2} = \frac{R_-}{R_+}$$

This places the poles of the transfer function on the $j\omega$ axis. The ratio of $\frac{R_-}{R_+}$ can be adjusted for this condition for any values of R_1, R_2, C_1, and C_2.

An interesting case occurs when $R_1 = R_2$, and $C_1 = C_2$ for which $\frac{R_-}{R_+} = 2$. The frequency of oscillation is then given by $\omega = \frac{1}{C_1R_1}$. Thus a ganged resistor can be used for R_1 and R_2, and the frequency can be varied while maintaining the condition for oscillation constant.

A synchronous demodulator was also designed (see Fig. 13). Instead of a single-ended input amplifier, differential inputs were used on the op amp which improved the detected voltage by 6 dB and lowered the harmonic content.

The description of the circuit makes the assumption that $R_S << \frac{1}{2} R_1$ and $\frac{1}{2} R_3$. The input wave is split and applied to the emitters of Q1 and Q2. Transistors Q1 and Q2 are in an inverted configuration and have a nominal $v_{ce\,sat.}$ of 5 mV. The base drive signals e_1 and e_2 are synchronous with the input signal and are 180° out of phase with each other. During the interval of $<t_o, t_1>$ the signal at Q1 is shorted to ground while the signal at Q2 is allowed to pass to the non-inverting terminal, producing an amplified positive half-cycle sine wave at the output.

During the next interval of $<t_1, t_2>$ the signal at Q2 is shorted and the signal at Q1 is passed to the inverting terminal of the amplifier, producing an inverted positive half-cycle sine wave. Thus the input is full wave rectified. Through the use of capacitors C_f and C_5 we could smooth the output wave to any desired ripple and thereby get an average value proportional to the peak value of the input wave.

In fact, if the half-cycle time is much larger than $\frac{1}{R_fC_f}$, then

$$e_o(t) \approx -\frac{R_1}{R_f}\frac{2}{\pi}e_p$$

where e_p is the peak value of the input.

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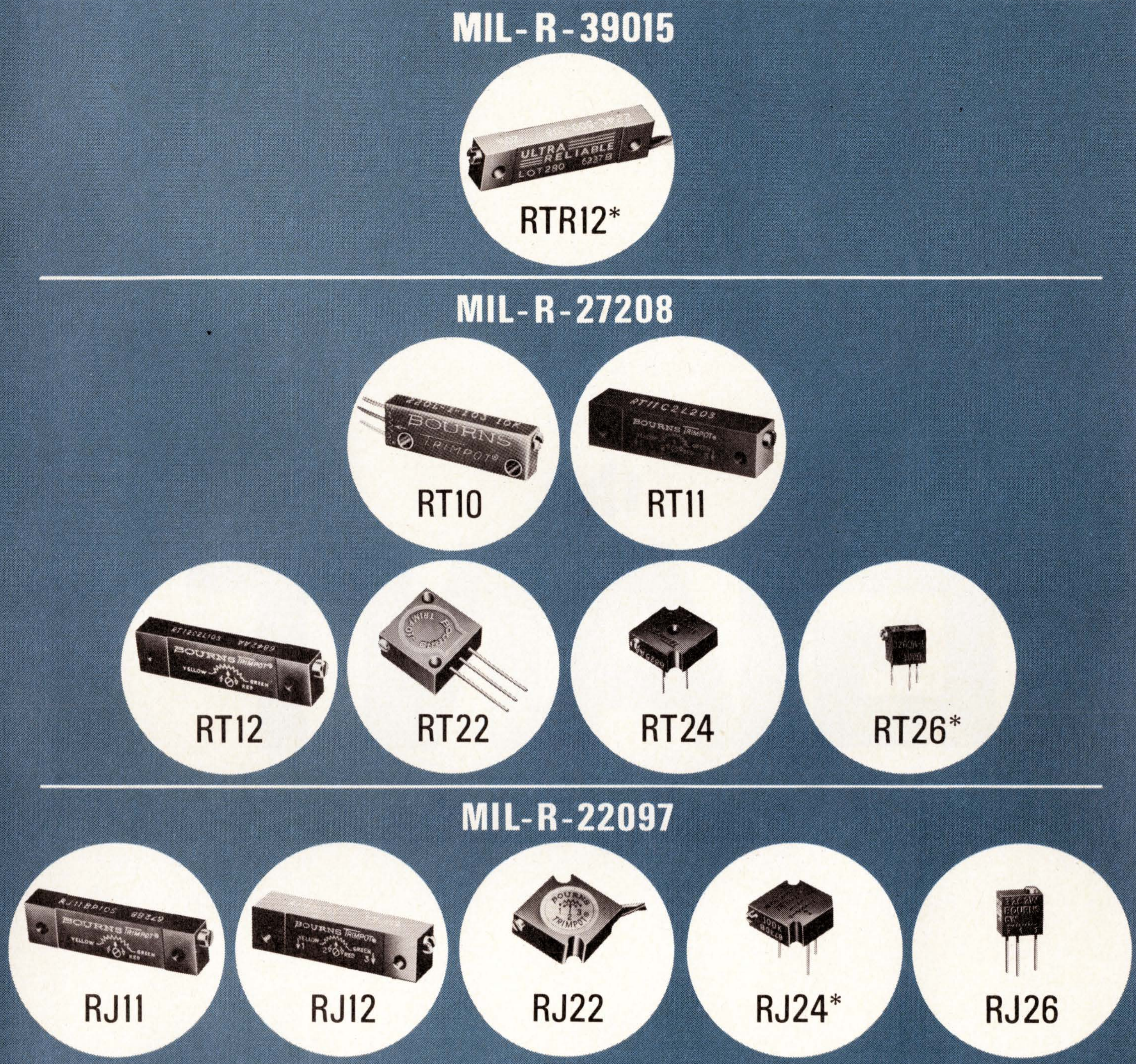

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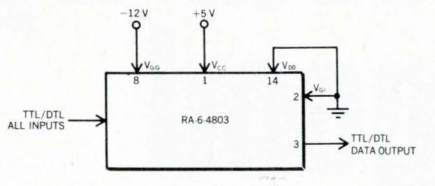

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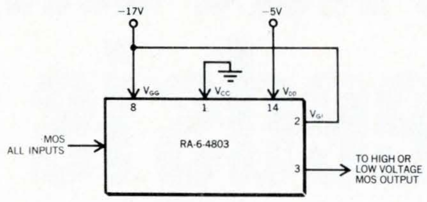

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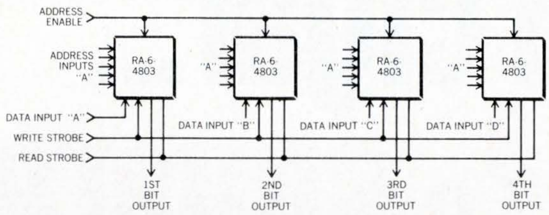
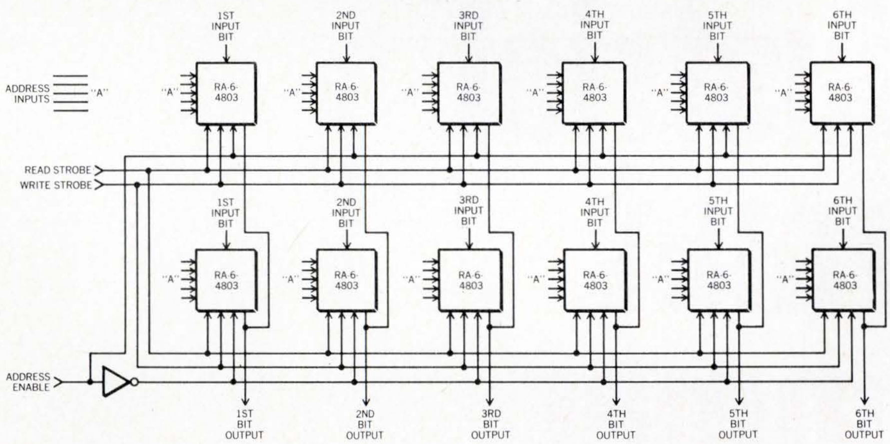


Block Diagram for 32 x 4 bit words



Block Diagram for 64 x 6 bit words

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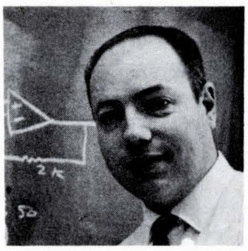

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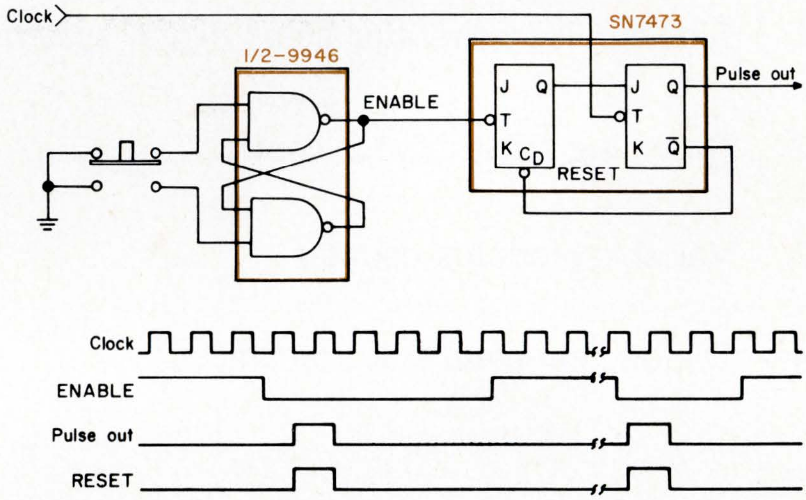
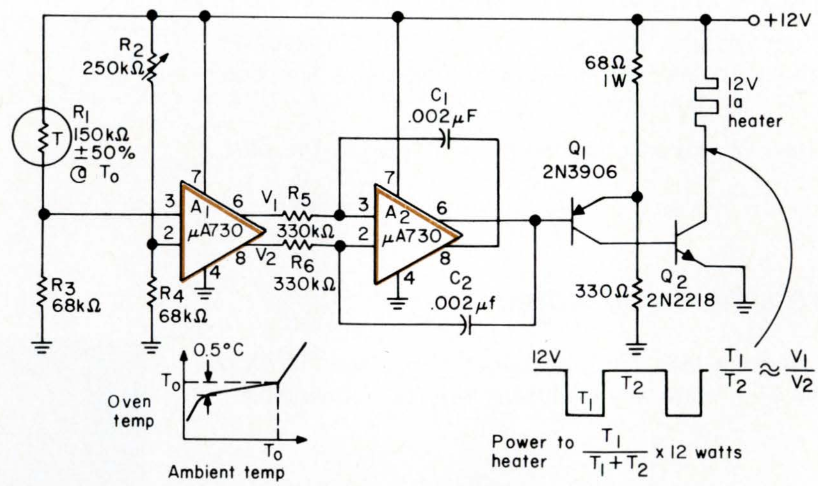
This circuit gives you such a capability. It uses the digital system's clock to provide one and only one pulse each time the ENABLE button is depressed, and thus eliminates the need for troublesome one-shots.

The illustration shows one half of a Fairchild DTμl 9946 quad, 2-input NAND gate used to eliminate the effects of the pushbutton bounce. A Texas Instruments SN-7473 dual, J-K, master-slave flip-flop generates the output pulse.



972 Switching-mode heater control

Dennis R. Morgan
General Electric, Syracuse, N. Y.



Here's a simple, inexpensive and efficient temperature regulator. The circuit's efficiency results from the variable-duty-cycle series switch, Q_2, which supplies power to the heating element.

Differential amplifier A_2 (Fairchild μA730) is a multivibrator running at about 1 kHz. Because the charging current for C_1 and C_2 is supplied through R_5 and R_6, the voltage difference between V_1 and V_2 controls the multi's duty cycle. Transistors Q_1 and Q_2 provide level change and drive for the 12-W heater.

Thermistor R_1 is the temperature feedback element, and R_1, R_2, R_3, and R_4 together form a bridge balanced at the reference temperature. These resistance values must be compatible with the bias current and common-mode voltage needs of A_1, another μA730. Amplifier A_1 is an error amplifier, and has a push-pull output to drive the controlled multivibrator, A_2.

The circuit is insensitive to noise and supply-voltage variations, and holds temperature to $\pm 1/4\,^{\circ}C$ over the operating range of the heater.

VOTE: for the one you like best.

973 Variable-modulus counter

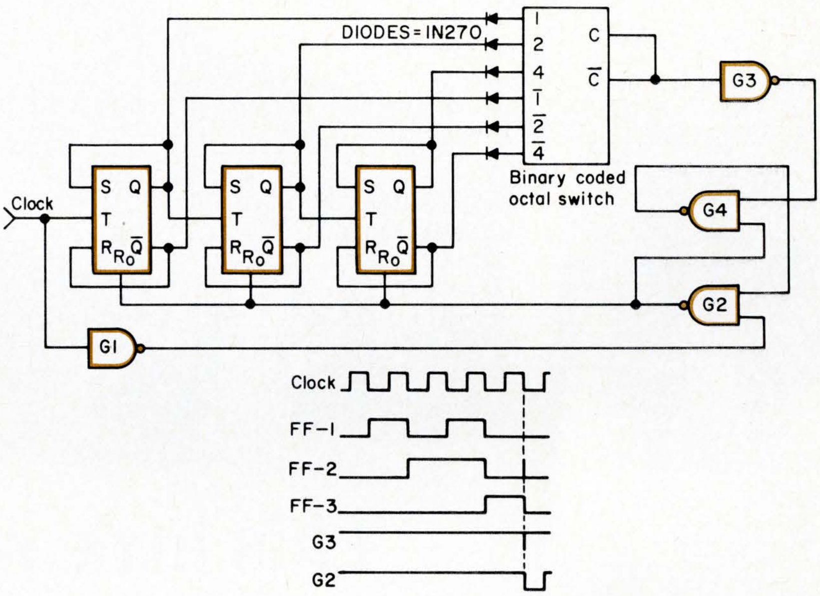
Ron Kostenbauer
Leach Corp., Azusa, Calif.

This variable-modulus counter uses as a divisor any number from one to eight. The circuit consists of inexpensive flip-flops, gates, and a binary-coded-octal switch.

The switch is a Digitran Model 8058, which has a circuit board for mounting the diodes; it also has complement outputs. Two Signetics 8424 dual, RS/T binaries, and a Signetics 8480 quad, 2-input NAND gate form the counter.

The thumbwheel switch sets the desired modulus and forces the flip-flops back to their 0 state. The latch ensures the flip-flops reset.

Should you wish a one to ten count, use a BCD switch with an additional flip-flop and two more diodes.



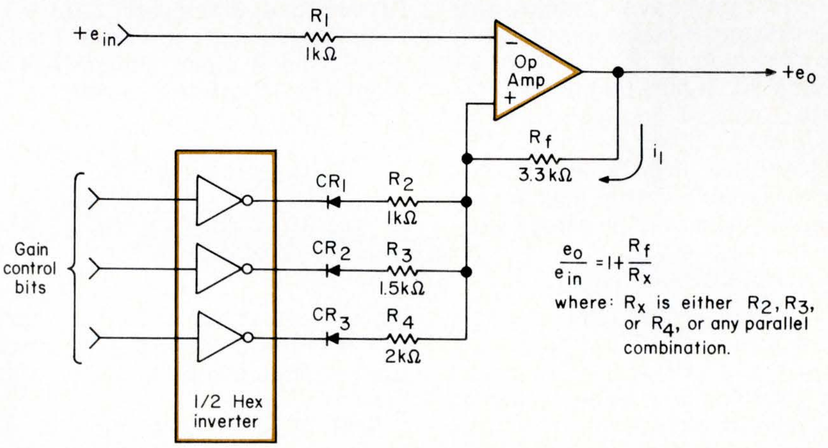
974 Digital gain control for op amps

William E. Peterson
ITL Research Corp., Northridge, Calif.

Try this unusual approach to control the gain of a linear amplifier; it solves many a problem in computer-controlled, analog systems.

The circuit uses an op amp in a non-inverting connection, so that its voltage gain is $1 + R_f/R_x$, where R_x is the resistance between the non-inverting input terminal and ground. If you restrict e_{in} to analog signals that are positive with respect to ground, then feedback current i_1 will always flow in the direction shown.

In the circuit diagram, R_x of the gain equation is replaced by R_2, R_3, and R_4. The hex inverter connects these resistors to ground either singly or in any combination, according to the drive supplied to it, and thus sets the circuit's gain.



If any inverter output is a logic 1 (about 5 or 6 V), then the diode in series with that output is reverse biased, and the associated resistor is not in the gain control loop.

The illustration shows eight (2^3) digital gain settings, but you can extend this number to whatever you need, simply by adding more inverters. And you can use any op amp or inverter that's handy.

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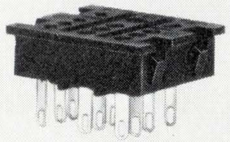
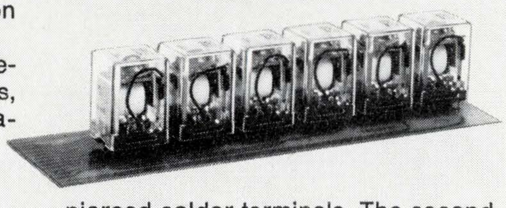


chines, machine tool controls and a host of other applications.

This relay has Underwriters' Laboratories component recognition (File E 22575—Magnetic Motor Controller) for 1/10 HP, 120V AC; 3 amperes, 32V DC resistive; 3 amperes, 240V AC.

Two sockets are available. The first snaps into a metal chassis and requires no retaining spring. It has



pierced solder terminals. The second is designed for use on p.c. boards. Both sockets can be furnished with a grounding lug.

KNP relays may be ordered with printed circuit terminals for direct mounting on p.c. boards. The assembly of six relays shown above requires a board space of only 6¾″ x 1″.

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Amplifiers

The operational amplifier in linear active networks, G. S. Moschytz, Bell Telephone Labs, Inc., "IEEE Spectrum," Vol. 7, No. 1, January 1970, pp. 42-50. Lower costs have allowed the increasing use of op amps in linear active networks design. The author discusses two-port characteristics, gain stability, and sensitivity of a non-ideal op amp and presents a unified approach to both inverting and non-inverting modes of amplifier operation.

Circuit Design

***Four ways to get active . . . with filters,** Harmon G. Washington, Motorola Inc., "The Electronic Engineer," Vol. 29, No. 1, pp. 50-55. The advent of inexpensive IC op amps has reduced the need for LC filters with large, expensive indicators. Now, you can design RC active filters with high Q and better stability characteristics —and at less cost—than is possible with conventional LC types.

A step-by-step active-filter design, J. Tow, Bell Telephone Labs, Inc., "IEEE Spectrum," Vol. 6, No. 12, Dec. 1969, pp. 64-68. If you have ever designed passive filters, you can now add a new line to your resume. This article gives you a five-step approach to active filter design and relates the steps to those you would take if you were using passive components.

Go push-pull for magnetic deflection, A. M. Hildebrant, General Electric Company, "Electronic Design," Vol. 18, No. 2, January 18, 1970, pp. 70-74. Temperature causes the deflection yoke resistance to change. By using a push-pull deflection system you can overcome this and other deflection yoke problems. This article describes a differential push-pull deflection system.

Desk-top calculators close the gap, Ivar W. Larson, Hewlett-Packard Company, "Electronic Design," Vol. 18, No. 1, January 4, 1970, pp. 114-116. Desk-top calculators can help you solve some of your design problems. You can get some idea of the calculators versatility from this article.

Improve receiver frequency stability, Charles E. Dexter, Watkins-Johnson Company, "Electronic Design," Vol. 18, No. 2, January 18, 1970, pp. 76-78. Wide tuning range receivers face the problems tuning dial inaccuracies and oscillator drift. This article describes a stabilizing method that will overcome these problems. It is called digital automatic frequency control, and can be accomplished for little more than the cost of a counter.

Communications

What's ahead in communications? J. C. R. Punchard, Northern Electric Labs, "IEEE Spectrum," Vol. 7, No. 1, January 1970, pp. 51-54. Without making detailed predictions, the author investigates possibilities for communications within the next 30 years. He suggests that economic and time factors may make simulation of nonexistent technologies worthwhile.

Components

***Mil-Std-220A for filters needs updating,** John E. Hickey, Jr., Managing Editor, "The Electronic Engineer," Vol. 29, No. 2, Feb. 1970, pp. 84-86. This military standard does not meet the needs for proper testing and evaluation of filters for power lines. What are some of the problems and what should be done? Some of the answers are here.

How to ruin pushbutton switches, Clyde J. Schultz, Switchcraft, "EEE," Vol. 17, No. 11, November 1969, pp. 37-39. Most of this article is on design, rather than on application, of switches in general. It contains two good tables comparing properties of materials for contacts and insulators, plus nine recommended practices for the design of switches. In addition, it lists several ways, most of them under the control of the switch designer, rather than the user, to burn such switches.

Computers and Peripherals

Standard read-only memories simplify complex logic design, Floyd Kvamme, National Semiconductor, "Electronics," Vol. 43, No. 1, Jan. 5, 1970, pp. 88-95. With large scale integration standard read-only memories are practical and can be economical, with small size. Memories with up to 2,048 bits per chip are now available with 4,096-bit units coming. How these work and methods of applying them to computers is described. This article is the 14th in a series.

MOS Memories, David Leonard, Texas Instruments, "EEE," Vol. 17, No. 11, November 1969, pp. 54-61. The article explains the operation of the now popular MOS memories—random-access, content-addressable, and read-only. It lists the size of these memories available today in the market, as well as some of their most important characteristics—such as speed and power dissipation.

Magazine publishers and their addresses

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Bipolar Memories, Melvin G. Snyder, Raytheon, Inc., "EEE," Vol. 17, No. 11, November 1967, pp. 62-67. Since, thanks to their speed, bipolar storage cells are most suitable for random-access memories, the article concentrates on this type of memories. Specifically, it explains a random access memory that is location addressable (a scratch pad memory). The systems described in the article use, as a building block, a 64-bit monolithic chip organized in 16 words by 4 bits. With several of these chips, the article shows how to put together scratch pads of up to 1024 bits (128 by 8 bits). The description of the system includes the addressable decoders and sense amplifiers, plus a curve showing the tradeoff in pins-per-package with word size, for different memory sizes.

Simple electroplating process allows high-density waffle-iron memory to be built easily, inexpensively, Peter Langlois, Nye Howells, and Alan Cooper, Standard Telecommunications Laboratories, "Electronics," Vol. 43, No. 2, January 19, 1970, pp. 107-109. Similar to the post- and film memory described in another article in this issue, is the waffle-iron memory described here. This memory uses square wafers of ferrite grooved to make an array of posts. A thick/film magnetic on a substrate is laid over the ferrite to act as the storage film.

Post-and-film memory delivers NDRO capability, low noise, high speed, but avoids problem of creep, Robert F. Vieth and Charles P. Womack, Litton Systems, "Electronics," Vol. 43, No. 2, January 19, 1970, pp. 102-106. Batch production of computer memories has been the aim of designers for many years. While ferrite cores have been good, the expense of stringing and their size have been limiting factors. This article describes a post-and-film memory that looks good for future memories.

Digital Design

Symmetrical ECL doubles IC NOR function efficiently, Hans-Wilhelm Ehlbeck and Herbert Stopper, AEG-Telefunken, "Electronics," Vol. 43, No. 1, Jan. 5, 1970, pp. 142-144. This article describes symmetrical emitter-coupled-logic ICs that provide two NOR functions with much lower propagation delay and power dissipation than standard ECL.

Convert digital data, A. H. Firm and M. M. Miller, RCA, "Electronic Design," Vol. 17, No. 26, Dec. 20, 1969, pp. 70-73. This is the third and final part of a series. In this part, one type of parallel-to-serial and two types of serial-to-parallel converters are presented. Truth tables, Karnaugh maps, and logic diagrams are shown.

Single-map method speeds design, Mitchell Marcus, IBM Corp., "Electronic Design," Vol. 17, No. 26, Dec. 20, 1969, pp. 66-68. Using the single-map methods instead of the multiple Karnaugh map method is faster for designing sequential logic circuits. The number of flip-flop rules is the same, but they are applied at different stages. The two techniques are contrasted by showing the design of a triple flip-flop both ways.

Integrated Circuits

***IC Ideas,** "The Electronic Engineer," Vol. 29, No. 1, pp. 65-71. Here are the 11 best IC applications published by us during a full year. These were selected by our readers through their votes.

MOS Course—Part I, The Basic Structures, E. Marshall Wilder, Fairchild Semiconductor, "The Electronic Engineer," Vol. 29, No. 2, Feb. 1970, pp. 58-64. This article, the first in a series on MOS, treats the various structures of the MOS device. Included is a tabulation of parameters for the different types of low-threshold MOS.

Need to design a switching regulator? Michael J. English, Instrumentation and Control Systems, Fairchild Semiconductor, "Electronic Design," Vol. 18, No. 1, January 4, 1970, pp. 106-111. Power supply regulation can be done using linear ICs. The design is relatively simple and gives you low cost and high efficiency. Basically an application article, the various circuits described use a μA723 IC.

A perspective on integrated electronics, J. J. Suran, General Electric Company, "IEEE Spectrum," Vol. 7, No. 1, January 1970, pp. 67-69. Just as the basic ground rules of IC design are being drastically changed so too is the internal structures of electronics businesses. LSI promises to bring even more challenges. This rather complete presentation touches almost all aspects of the technology.

Microwaves and Microwave Products

***Sweep measurements cut costs,** Walter White, Jr., Western Electric Co., "The Electronic Engineer," Vol. 29, No. 1, pp. 57-61. In the past microwave measurements were made with point to point measurements. This did not give a true picture of the system. You can do it faster and more accurately with sweep measurements.

Designing with microstrip is easy, Carl F. Klein, Johnson Service Company, "Electronic Design," Vol. 18, No. 1, January 4, 1970, pp. 100-104. Microstrip circuits can be designed once you know some of the fundamentals. The fundamentals are described and then you are shown how to design a microwave oscillator that is similar to a Colpitts.

Surface wave delay lines promise filters for radar flat tubes for television, and faster computers, J. H. Collins and P. J. Hagon, Autonetics, "Electronics," Vol. 43, No. 2, January 19, 1970, pp. 110-122. This is the concluding article of the series describing surface wave delay lines. This article explains how surface waves can decode signals, compress and expand waveforms, and modulate beams of electrons. Many applications other than radar, communications and navigation are foreseen for this "new component."

Solid-state microwave relay systems in Japan, Fumio Ikegami and Yasuaki Ninomiya, Nippon Telegraph and Telephone Public Corp., "IEEE Spectrum," Vol. 6, No. 12, Dec. 1969, pp. 48-56. Here is a history of how Japanese engineers have upgraded that country's microwave links with the advent of solid-state devices. The article includes some comparisons of failure rates of the solid-state systems vs the vacuum tube systems.

Systems

Wanted: Easy-on-the-eye displays, John Kessler, News Editor, "Electronic Design," Vol. 17, No. 26, Dec. 20, 1969, pp. 56-63. The need to consolidate and display masses of data in a simple form gives impetus to display research. The two classes of displays, graphic CRT computer terminals and large-screen, are differentiated. Progress and problems with such techniques as reusable photochromic film, magneto-optics, lasers, Schmidt optics, and fluid-film light-valve systems are treated. The cost is high, and developments in LSI and mini-computers will affect the future of these systems.

Test and Measurement

***Commercially available word generators,** Stephen A. Thompson, Western Editor, "The Electronic Engineer," Vol. 29, No. 1, pp. 47-48. This handy list is a useful guide to makers and lists the important parameters you should know about when buying a word generator.

***All word generators are not women,** Jerry Heyer, Mktg. Mgr., Crescent Technology Corp., "The Electronic Engineer," Vol. 29, No. 1, pp. 42-45. A relatively uncommon instrument, the word generator is often reinvented by test engineers. Learn how it works, and find out which of its operating parameters are important in your application.

Avalanche diodes permit in-service measurements of critical parameters in microwave equipment, Norman Ghasek, Int'l Microwave Corp., "Electronics," Vol. 43, No. 2, January 19, 1970, pp. 87-91. With avalanche diodes you can have a built-in noise source that will allow quick check-out of microwave equipment. Degradation can be spotted quickly without the need for bench tests. Parameters such as front-end noise, amplifier gain, and tracking of gain and phase are easily accomplished.

Computer-controlled testing can be fast and reliable and economical without extensive operator training, Matthew Fichtenbaum, General Radio, "Electronics," Vol. 43, No. 2, January 19, 1970, pp. 82-86. While computer testing is not new, it does require some decisions. Decisions that need to be made are based upon what you need tested now and possible future requirements. General Radio had arrived at some decisions about their needs—here is some of their thinking.

Miscellaneous

1970's Market Pacesetters, "Electronics," Vol. 43, No. 1, Jan. 5, 1970, pp. 101-136. A marketing type report covers the areas of computers, military, solid state, components and packaging, microwave, avionics, space, instruments, communication, and industrial. Included in this report is a 6-page color chart listing the dollar values of various electronic equipment types and components.

Transistorized ground-fault interrupter reduces shock hazard, Charles F. Dalziel, University of California, "IEEE Spectrum," Vol. 7, No. 1, January 1970, pp. 55-62. By shortening the duration of the current flow, this simple sensitive device reduces the hazard from low-voltage electric shocks in the home and industry. Various types of ground-fault interrupters are discussed as well as the results of animal and human shock incidents when protected by this device.

By 1980, you may need a doctorate, David N. Kaye, West Coast Editor, "Electronic Design," Vol. 18, No. 1, January 4, 1970, pp. 94-97. Here is a roundup of various editors ideas describing what you can look for in the 70's. Subjects covered are urban engineering, solid state in consumer products, the computer and its growth, microcircuits, microwaves and communications, and education. You can get some insight of what is expected to occur in the not too distant future.

Piezoelectric transducers, Don A. Berlincourt, Gould Inc., "Electro-Technology," Vol. 85, No. 1, January 1970, pp. 33-40. If you are not familiar with piezoelectric transducers then here is a chance to learn. This article explains some of the basics and describes some of the newest applications for these devices and materials.

Liquid crystals and their applications, James L. Fergason, Ted R. Taylor, and Thomas B. Harsch, Kent State University, "Electro-Technology," Vol. 85, No. 1, January 1970, pp. 41-50. Liquid crystals are a new way of changing electrical, mechanical and thermal energy signals into colored patterns. They can provide alphanumeric and graphic displays, and can operate from almost full light transmission to complete opacity. Right now the devices are still in early development stages.

Market trends in the electronics industry, Donald G. Fink, General Mgr., IEEE, "IEEE Spectrum," Vol. 6, No. 12, Dec. 1969, pp. 57-60. The author reviews the figures in the "EIA Yearbook—1969" and sees a significant trend. The one product area that has increased its percentage share of the market since 1958 was the industrial area. Mr. Fink suggests that the engineer who wishes to stay abreast of the changing electronics marketplace had better familiarize himself with the problems of the industrial user.

Airfield in the ocean . . . Floating electronic isle, John F. Mason, Military-Aerospace Editor, "Electronic Design," Vol. 18, No. 2, January 18, 1970, pp. 59-67. This article describes some of the electronic equipment that is aboard the aircraft carrier Franklin D. Roosevelt.

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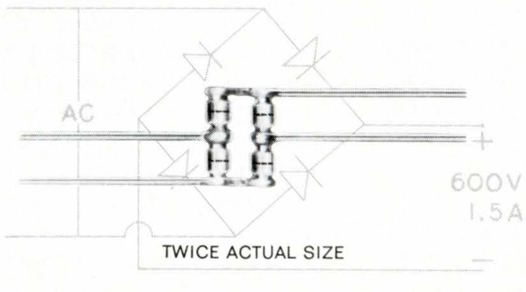

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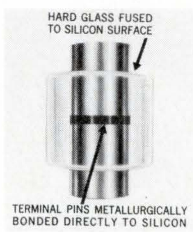

With the silicon die metallurgically bonded between terminal pins of the same thermal coefficient, the hard glass sleeve is fused to the entire outer silicon surface. Result — a voidless, monolithic structure.

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Mil-Std-220A for filters needs updating

Manufacturers and users agree that meeting the 220A's requirements for power line filters does not insure proper EMI protection

By John E. Hickey, Jr., Managing Editor

Mil-Std-220A appears to be a simple, straightforward specification dealing with the testing of power line filters for equipment. Originally issued as Mil-Std-220, June 25, 1952, and revised on December 15, 1959, it is now receiving increasing criticism and comments. Why, and what does this mean to you?

Before we answer the questions posed above, let's go back one step. Electromagnetic compatibility (EMC) has been and will always be important to users of varied electronic equipment. Thus, as we become more and more "electronified" we must be more careful about unwanted radiations.

Many design concepts and devices should be incorporated in electronic equipment. But, the prime one is a filter between the equipment and power source to block EMI (electromagnetic interference) from power lines and prevent its being passed on to other equipment operating from the same power source. Hence, the efforts and ideas behind Mil-Std-220A and other specifications for improving EMC are quite important. (It is also important that you know your equipment parameters to aid in the selection of a filter.)

While Mil-Std-220A requirements have to be met only in military equipment, let's face it, it's just as necessary for non-military equipment. And you can bet your bottom dollar that in the very near future, EMC is going to become virtually a household word, and mandatory in all equipments.

Now, here is the big hangup: The Standard covers filter insertion loss testing at only 50Ω input and output impedance. Unpublished data indicates that the impedance of 50/60 Hz power lines varies in the order of 2Ω at 2 kHz to a maximum of 100Ω in the range of 200 to 500 MHz, and falls off rapidly beyond this point. The frequency region for 50Ω is very narrow and represents only a small portion for the 2 kHz to 1000 MHz range. Impedance will vary from power line-to-power line, and outlet-to-outlet. Couple this with changing loads on the line and you have some idea of the problem.

While some power line tests have been made, more research is required in this area. With this data the filter manufacturer can and must build his filters to cover the "changing" power line impedance. Also, the equipment designer must know and supply data about his output impedance. To just assume that his impedance is 50Ω would be naive. These points are made later by two men in the filter field.

One other point that has to be considered—the placement of the filter in the equipment. If proper shielding is not part of your equipment design, or the filter is placed outside of the shielding, then you can have the added problem of leakage around the filter.

A problem occuring frequently is that the equipment designer looks at a filter catalog and picks out a unit that appears to give him the needed attenuation or suppression. He places this filter in a system, has a big smile on his face and says, "Well, that clears the problem." Unfortunately, that's not true. It is quite possible for the filter to act as a resonator. Instead of suppressing the signal, it may actually give his undesired radiations a boost, or at best, it may only offer a 10-dB suppression instead of a desired 45-dB suppression. Obviously, if a filter is to be placed in a system, it must be tested to learn if it gives the required suppression.

It is at this point that his problems can start because the chances are that he does not know how to test this filter in the equipment to determine its suppression. So, just buying a filter off-the-shelf and placing it in the equipment because it seems to meet your requirements does not solve the problem. What does this lead up to? The same thing that you have probably been hearing for years: talk to the filter manufacturer during the course of your equipment design. Even if you do not want to do this, a better filter standard will give you a better chance. . . .

Recently, some people have been in contact with the government about changing the spec. Here, then, are indications of some of the work that is being done or suggested for the needed revision of Mil-Std-220A.

Help the manufacturer

William Johnson, Task Manager of the SAE Subcommittee on Filters makes the following comments about Mil-Std-220A, and EMI filters in general.

"The source and load impedance seen by any interference filter is as significant as the inductance and capacitance of the filter. These are obviously more important than the attenuation in an ambiguous 50-Ω system.

"What is primarily needed at this point is not just another method of testing a filter, such a modification of Mil-Std-220A or any other standard test method. But most important is a method for the user of a filter to tell the filter manufacturer what he actually needs.

"This can be done in either one of two possible methods.

- User specifies source impedance, load impedance and attenuation over the entire frequency range.
- User specifies minimum values of inductance and capacitance of the filter, the filter circuit, and realistic attenuation measured in the system.
- The single most important factor, which we all lose in the day-to-day operations of meeting a filter specification or an EMI specification, is the ultimate goal of achieving an EMI-compatible system.

"To accomplish this goal it is necessary to start from the system level through the 'black box' level to the filter manufacturer by more precise spelling out of requirements.

- The system manufacturer must tell the 'black box' manufacturer what the impedance interface characteristics are.
- The 'black box' manufacturer must know what are the impedances that the 'black box' exhibits.
- The user of the filter must tell the filter manufacturer what the impedances are that the filter will see.

"If we continue to operate under the existing procurement practices, then *Caveat Emptor*. Let the buyer beware!"

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AMSEL-RD-GF
Fort Monmouth, New Jersey 07703

Dear Sir:

With reference to your present effort concerning revision of MIL-STD 220, the SAE Filter Subcommittee of the AE-4 Committee on Electromagnetic Compatibility is pleased to present the following comments.

A) Source and load impedance considerations must be included and implemented in all functional criteria. (Functional and Quality Assurance test criteria are distinguished in Item D below).

B) Impedance considerations are of such importance as to preclude the use of arbitrary impedance categories or groups. Determination of impedance values must be left to the discretion of the procuring activity.

C) Optimal filter design, based upon specified source and load impedances, does not necessitate the utilization of conjugate matching considerations. Further, the procuring activities prerogative of assigning source and load values provides adequate consideration of potential conjugate matching. The term optimum, as used above, denotes the relationship between system effectiveness and value engineering.

D) It is recommended that the revised MIL-STD 220 format consist of three parts as tabulated below.

1. General Considerations.
2. Quality Assurance Testing (maintain existing 50 ohm tests, however delete mandatory test configuration).
3. Qualification Testing (new test procedures be devised to provide the capability to measure functional filter performance under simulated operational conditions).

The aforementioned AE-4c.3 Subcommittee on filters has assumed as a task the drafting of a revision to MIL-STD 220A. Mr. W. Johnson, Task Manager of the AE-4c.3 Subcommittee, will keep you apprised of progress resulting from this effort.

Yours truly,

W. Johnson
The Potter Company

J. Fischer
Genisco Technology

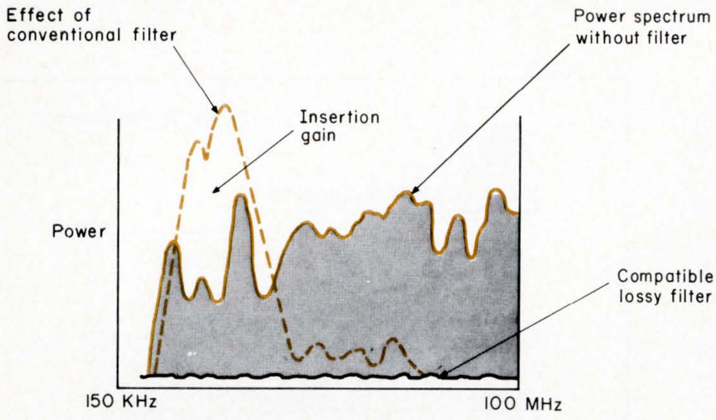
L. Jakubec
Litton Systems

Fig. 1: This is a copy of a letter sent to the military about Mil-Std-220A.

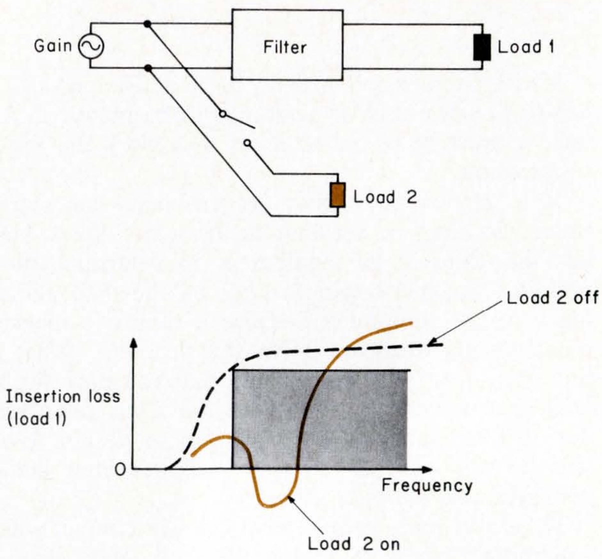
Improvements suggested

Dr. H. M. Schlicke, Allen-Bradley Company, has some strong views and suggestions concerning Mil-Std-220A. Here are some of his comments which were stated at the 1969 IEEE International EMC Symposium. Dr. Schlicke was invited to speak on this subject.

"DOD Directive 3222.3 of July 5, 1967, and Public Law PL90-379 of July 5, 1968, both spring from the recognition and growing fact that the rapidly increasing use of communications, data transmission, computers and automatic control will lead to interfering inter- and intra-systems interactions. The results of operations are not confined to the effect intended by each operation. The immunization of one operation against noise or cross talk by all the other operations, equally striving for noise-free functioning, requires detailed control plans and careful EMC design considerations to be



Above: An EMI filter can be worse than no filter when it causes insertion gain as indicated. Sweep testing filters will give a good view of a filter's "spectrum." Right: Insertion loss varies when a load is switched on and off.



made at the inception of a system. In fact, the mode of the system itself must be carefully selected.

"In EMC planning, power line filters are often overlooked as a source of trouble because of a sense of security offered by Mil-Std-220A. But since power lines infiltrate all systems, one must be sure that the filters into the power lines perform as expected.

"The originators of Mil-Std-220A were aware that their approach was, by necessity, highly simplified and hence rather imperfect. But at least Mil-Std-220A was a starting point for coming to grips with a rather perplexing problem: perplexing because a power line certainly does not represent 50Ω over the whole frequency range of interest and one does not know in advance how much the actual filter performance deviates from the idealized performance assumed by Mil-Std-220A. Hence, often excessively over-designed filters are specified to compensate for a lack of confidence in their effectiveness.

"Mil-Std-220A, with its 50-Ω reference, is based on assumptions contrary to the facts which are: one, interfacial impedances change with frequency, time, and location and can be nearly anywhere on the Smith chart; and, two, interfacial resonances in the stopband, and eigen and interactive resonances in the passband, render the conventionally predicted performance of the filter illusory.

"Hence, new, more realistic criteria for filter testing are necessary:

Compatibility: The test method must be a qualification test and must permit selection of the more insensitive filter. Insensitive meaning that in the broad area about the cutoff frequency, the filter is relatively unaffected by interface changes.

Predictability: The filter test method must permit a selection of a filter that will be effective prior to installation of the system and independent of changes in the system.

Reliability: The filter must not be destroyed by insertion gain in the so-called passband.

Practicability: Filters meeting the specs must be economical and practical.

Simplicity: The test method should be reasonably simple and brief.

"At this time, there is little agreement among the members of the EMC community about how to change Mil-Std-220A to something more meaningful.

"In the meantime some more experiments though still not quite sufficient, and extended calculations have been made. They provide a much improved understanding of how the filter performance depends on random properties of the power line. Such understanding will facilitate formulating a set of reasonable criteria upon which to base final judgments."

SAE action

The Society of Automotive Engineers (SAE) has formed subcommittee AE-4c3 to draft a revision to Mil-Std-220A. This group is headed by William F. Johnson, The Potter Company, Wesson, Miss. A copy of a subcommittee letter dated October 1, 1969 to the military is shown in Fig. 1. This letter briefly describes the subcommittee's recommendations.

The Electronic Industries Association committees G-46 and P3.3 are also struggling with the problems of the Mil Standard.

If any of you would like to contribute to the proposed changes, you can do this through one of the committees mentioned above, or directly to the military. See Fig. 1 for the address of the military contact.

INFORMATION RETRIEVAL
Components, Filters, EMI

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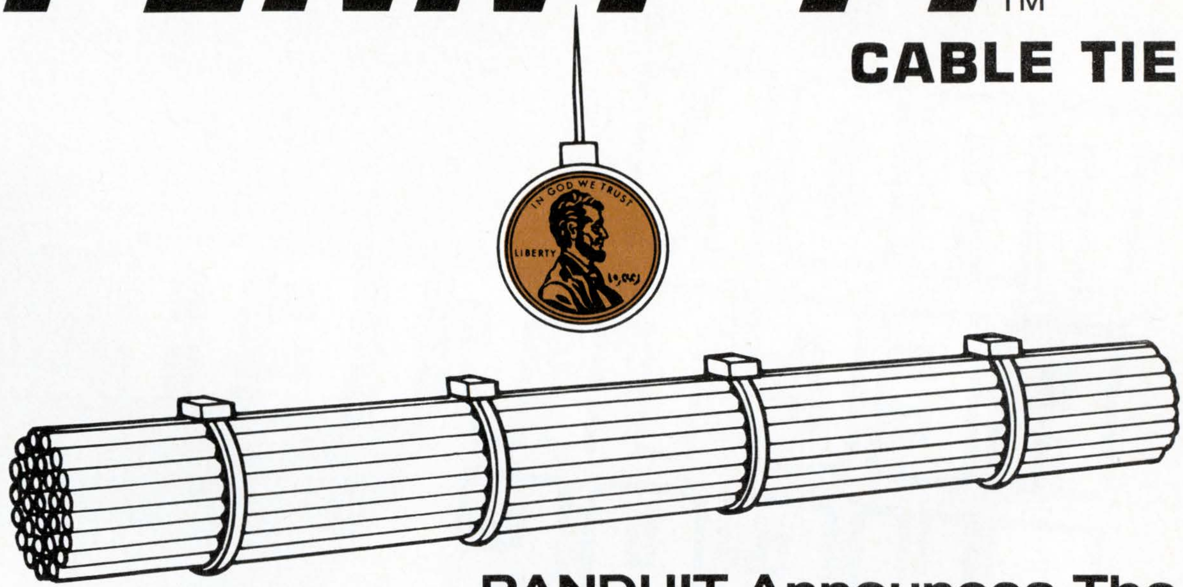

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Circle 46 on Inquiry Card

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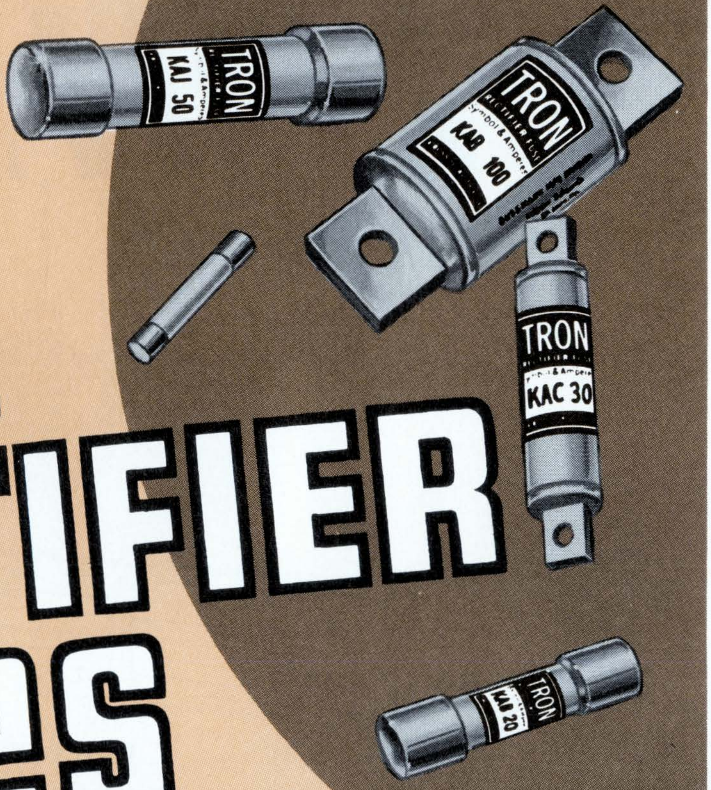

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... as used in machine tools and conveyor controls.

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NEW PRODUCTS

Motorola antes up the chips

Beam lead laminate chip offers low cost with high performance

There has been much talk about semiconductors competing with cores and plated wire for main frame memory applications, but little action. While the session "What Happened to LSI Promises?" was in progress at the Fall Joint Computer Conference, Motorola was busy announcing that it had put together all of its technology to produce its new monolithic, LSI, hybrid, 8-k Memory Module.

It has a worse-case access time of 120 ns, and a cycle time of 150 ns or three times faster than the best conventional main frame memories. Motorola's present manufacturing capacity is committed, so deliveries of new orders will not begin until mid-1970.

The large quantity price per bit is about $.10 now and expected to drop to $.05 by 1972. Motorola's price-performance predictions are presented in the chart. On the floor of the exhibit, a spot check of ten core and plated wire manufacturers yielded quotes ranging from $.01 to $.08 per bit in quantity lots. Publicly, the manufacturers are still downgrading semiconductor memories, but a couple of them are acquiring semiconductor technology "just in case."

The Memory Module is a hybrid structure and takes a lot of steam out of the MOS vs bipolar argument. P-Channel MOS chips containing 256 flip-flops each are used for high density, low power storage. Standby power for each chip is only 40 mW. Bipolar circuitry is used for high speed sensing, word driving and decoding. Forty-two monolithic LSI circuits are integrated into a six plane stack measuring about 1.6 in. on a side. The module can be used for 1-, 2-, 4-, or 8-bit words. Three voltage levels, +5, −5.2, and ground, are used to power the module. Input/output levels are ECL compatible.

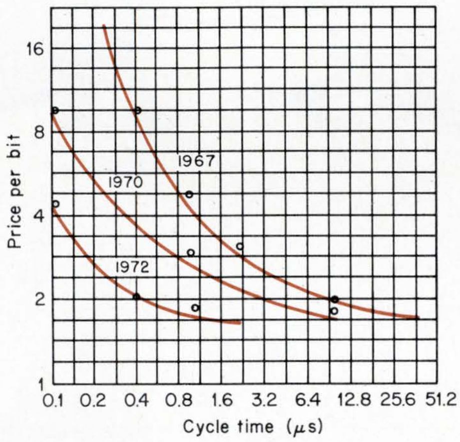
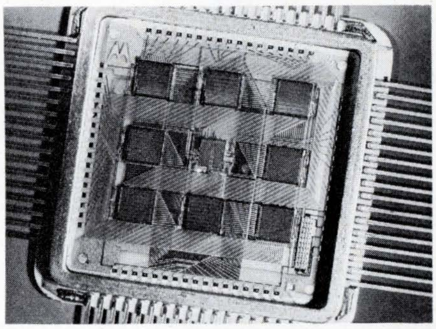


Fig. 1: Motorola's predictions for the price/bit of memories as a function of cycle time.



One of the four memory planes from Motorola's 8-k Memory Module with the package lid removed. The bipolar array-selection circuit is surrounded by 8 MOS 256-bit storage arrays. The beam lead laminate structure surrounds the chips and provides the interconnections. The upper conductors appear light and the conductors on the bottom of the laminate appear dark.

Motorola considers the solution of the interconnection problem the most important technical development in the program. A new chip interconnect method, the "beam lead laminate" system, was used after evaluation of other techniques, including Motorola's own spider bonding, showed them to be inferior.

The beam lead laminate is effectively a miniature, two-layer, flexible PC card. The dielectric is a 1-mil polymide film on which metal is deposited on each side to provide the conductor patterns. The laminate provides a beam lead device where the beams extend from the interconnection pattern to the chip bonding pads. This reversal of the conventional pattern has several advantages.

It allows you to combine MOS and bipolar chips into one assembly, yielding low cost and high performance. Bonding is done face-up, enabling visual inspection of the bonds and aiding heat rejection, because heat is dissipated into the package base, instead of out through the leads. Individual circuits can be tested before assembly and faulty chips can be replaced several times, though only one replacement per location is the Motorola policy.

The 8-k Memory Module is a basic building block for larger memories. A typical example would be a 16-k word by 17-bit word length memory package which would need 34 modules. The entire package, including fan, would fit into an 8 in. by 10 in. by 4 in. enclosure. The quarter-million bit capacity would dissipate only 200 W of power while retaining the 150 ns cycle time.

Motorola Semiconductor Products, Inc., Box 20912, Phoenix, Ariz. 85036.

Circle 314 on Inquiry Card

Are you ready for the CRT explosion?

It's coming — in information display devices. This fast-growing, highly competitive field will witness many refinements, increased technical sophistication, and upgraded readout quality in coming months. You can be ready for this explosion, if you take advantage of the CRT capabilities at Fairchild-DuMont Electron Tubes.

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750 BLOOMFIELD AVENUE, CLIFTON, N. J. 07015

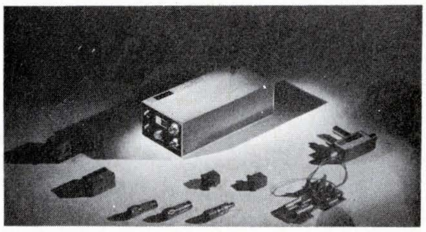
Circle 48 on Inquiry Card

Pre/post-selector rf amplifiers

With integral control circuitry and power supply.

These units give you a complete pre/post-selector amplifier for microwave receiving systems in one compact package. They are specifically designed to enhance receiver operation by improving performance in the areas of intermodulation, cross-modulation, spurious-free dynamic range and selectivity.

The amplifiers combine a dual YIG filter, TWT amplifier, power supply and YIG drive circuit in the one assembly. One section of the filter provides pre-



selection and the other, post-selection. You tune these units with a 0- to 10-V analog input or by digital tuning that comes as an option.

Two versions are being offered to provide single- or double-band frequency coverage. The table below lists some guaranteed specs for the models now available. Some notable options offer higher gain, and tracking 120 MHz away from the pre- and post-selectors by the addition of another YIG filter. Watkins-Johnson Co., 3333 Hillview Ave., Stanford Industrial Park, Palo Alto, Calif. 94304.

Circle 307 on Inquiry Card

Guaranteed Specs

	Single-band				Double-band		
	WJ-3017	WJ-3018	WJ-3019	WJ-3020	WJ-3021	WJ-3023	WJ-3024
Frequency range	2-4 GHz	4-8 GHz	8-12 GHz	12-18 GHz	0.5-2 GHz	2-8 GHz	8-18 GHz
Noise figure	11 dB	11.5 dB	11.5 dB	14 dB	14 dB	12.5 dB	14 dB
RF gain	30 dB	30 dB	30 dB	30 dB	20 dB	20 dB	20 dB
Tuner bandwidth, Min.	25 MHz	30 MHz	30 MHz	35 MHz	15 MHz	25 MHz	30 MHz
Power output	7 dBm	7 dBm	7 dBm	7 dBm	−5 dBm	−5 dBm	−5 dBm
Input VSWR	2.5:1	2.5:1	2.5:1	2.5:1	3:1	2.5:1	2.5:1

600 channel data acquisition system

The Cimron Division of Lear Siegler, Inc., San Diego, has announced its new 8000 Series of Digital Data Acquisition Systems. The entire system consists of a single compact housing containing all IC plug-in assemblies for systems components including scanner control, comparator, digital clock, programmer, serializer, source select, and program computer interface. Programmer cards give a limited control capability in place of computer control. Cimron estimates that the elimination of interfaces, troubleshooting, and crosstalk could save 50% of the amount a customer would spend assembling a comparable system.

A six-digit numerical display serves as a time shared readout for channel ID, time, and calendar. Comparator status is displayed above the data, and provision is made for up to eight flags

to be displayed below the data for indicating system conditions such as "standby," "display only," "recorder ready," "comparator error," "time error," "recorder error," and other desired status symbols. A common supply provides power for the complete DAS 8000 Series System. The scanner switch assembly is mounted in a slide drawer located at the back of the housing.

The system scans up to 600 channels of analog signals as high as 1000 Vrms. It scans randomly or sequentially, measures dc, ac, resistance, low dc, low resistance with speeds up to 23 channels per second, and records with up to 16 character words (32 optional) on magnetic tape, printed tape, punched cards, punched tape, typewriter copy, high-speed memory, or any combination of these media. Common-mode noise rejection is 120 dB @ dc and 100 dB @ 60 Hz.

The basic unit costs about $15,000. The total system cost varies, depending on the choice of scanner, measuring DVM, and recording equipment. A good system can be assembled for about $20,000, or $33/channel if all 600 are used. Delivery is 60 days.

Cimron Division/Lear Siegler, Inc., 1152 Morena Boulevard, San Diego, Calif. 92110.

Circle 308 on Inquiry Card

Function generators become more universal

Variable pulse width is latest wrinkle.

Function generators are getting better. Recently they began producing sine waves that are as good as those from RC oscillators in terms of distortion and energy content.* They can be used in almost all oscillator applications except those which demand ultra purity in the sinusoidal waveform.

Now, Interstate Electronics is introducing a line of function generators that encroaches on the domain of standard pulse generators. Previously, function generators provided only pulses with a 15% duty cycle, a somewhat arbitrary value. Interstate's new line, Series 50, adds variable pulse width to its capabilities.

During development, an attempt was made to alter pulse width by changing the slopes of the charge and discharge ramps in the voltage-to-current converter. This proved impractical, because changing the slope ratios also tended to change the period. Instead, Interstate incorporated the method illustrated in Fig. 1. Assuming negligible pot resistance, the following equations apply to that system:

*See **The Electronic Engineer,** August 1969, page 88.

The F55 is the top-of-the-line unit in Interstate Electronics Corp.'s new line of five function generators. All units have a frequency range of 0.0005 Hz to 10 MHz and variable pulse width is standard. The F55 includes phase lock and sweep in the same unit. Sweep limits are set right at the frequency dial.

$$V_1 = V_{ref} + I\ R_2$$
$$I = (V_{in} - V_{ref})/(R_1+R_2)$$

Thus:

$$V_1 = (1\text{-}k)\ V_{ref} + kV_{in}$$

where:

$$K = R_2/(R_1+R_2)$$
$$R_2 = 4R_1, \text{ so } k = 0.8 \text{ and;}$$
$$V_1 = 0.2\ V_{ref} + 0.8\ V_{in}$$

The pulse width duty cycle is specified as the time that V_{out} is high. This changes linearly from 0% at $V_{ref} = 12$ V, to 100% at $V_{ref} = -12$ V. The switching point occurs at $V_{ref} = 4\ V_{in}$, which is when $V_1 = 0$.

Other features

Other unique features of the Series 50 line vary with the model chosen. All units cover the frequencies from 0.0005 Hz to 10 MHz, with a 50% overlap on each range. Maximum output voltage is 15 V peak-to-peak into 50 ohms, and it can be calibrated in voltage and dB on the same dial. All instruments will synchronize to external signals within 1% of the frequency setting. Sweep and phase lock are available for the first time in the same instrument. The simplified frequency sweep width selector is located on the frequency selector dial. Virtually any periodical signal, not just sine waves, can be converted into pulses of any desired duty cycle.

Prices range from $595 for the model F51 to $1195 for the F55. Delivery is 6-8 weeks, beginning in March. Interstate Electronics Corp. 707 E. Vermont Ave. Box 3117, Anaheim, Calif. 92803

Circle 315 on Inquiry Card

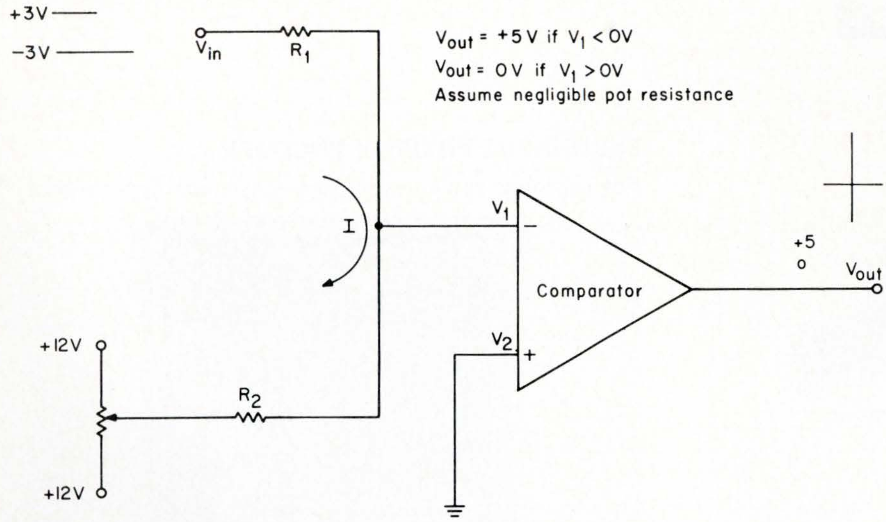


Fig. 1. Variety is the spice of life. When the variable pulse mode is selected in Fig. 2, the output of the triangle amplifier is fed into the variable pulse width shaper. It appears as V_{in} above and ranges between ± 3 V. V_{in} is connected through R_1 and R_2 to a reference voltage, V_{ref}, that can be varied between ± 12 V. One comparator input, V_1, is picked off between R_1 and R_2 and the other input, V_2, is grounded. For $V_1 > 0$, $V_{out} = 0$. For $V_1 < 0$, $V_{out} = 5$ V. When V_{ref} is changed, the relative time that V_{out} is high or low is changed, providing a variable pulse width.

Where do waves come from?

Dialing a frequency corresponds to selecting the voltage output level of the frequency control unit (see Fig. 2). The higher the voltage, the faster capacitors charge and discharge in the integrator, and the higher the frequency of the triangle wave at its output. The triangle amplifier simply boosts the signal to a more useful level.

Feedback is provided by using a voltage level sensor to sense the amplifier output and switch when predetermined ± voltage levels are reached. The resulting square wave controls ramp current direction in the voltage-to-current converter, and can also be selected as an output waveform at the front panel. The triangular waveform can be selected directly, or fed into the sine shaper to provide sine waves. These three waveforms are symmetrical, so inversion would not be useful.

Four non-symmetrical waveforms are also available. They are positive or negative pulses or ramps, and the colored waveforms correspond to their selection. When one of these is chosen by the function selector, the relative rate of charging and discharging capacitors in the voltage-to-current converter is changed so that 85% of the time is devoted to charging and 15% to discharging. The resulting skewed triangle is called a ramp and can be selected directly, or inverted to obtain a negative ramp.

The effect at the voltage level sensor is alteration of the duty cycle of the high output to 15% of the period. This is called a positive pulse and it can also be inverted. This accounts for the seven normal waveshapes of function generators.

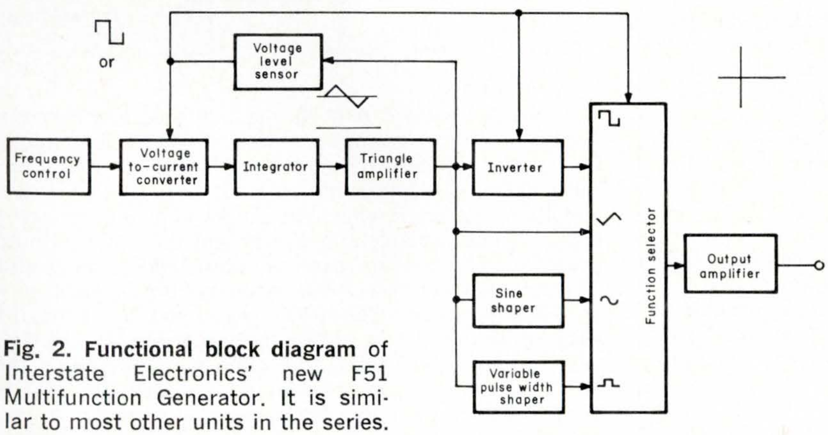
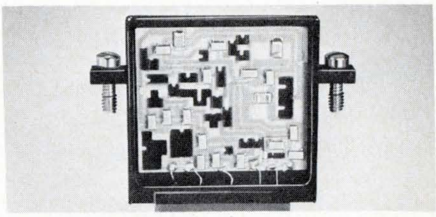


Fig. 2. Functional block diagram of Interstate Electronics' new F51 Multifunction Generator. It is similar to most other units in the series.

MICROPOWER VCO

Offers +20.0 to +36.0 V (28 ±8 V).

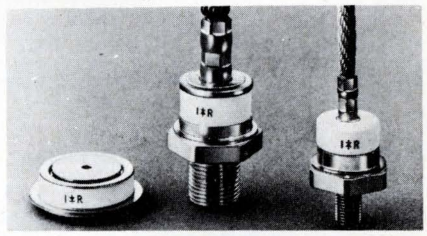


This hybrid vco comes in a variety of mechanical configurations. Subcarrier oscillator freqs for proportional BW (400 Hz to 165 kHz with deviations ±7.5% and of ±15%) and for constant BW (16 kHz to 176 kHz with deviations of ±2 kHz, ±4 kHz, ±8 kHz) are available from stock. Temperature stab. is ±1.5% dBW and distortion 1% max. from −40° to +85°C. About $185 in small quan. Lansdale Microelectronics, Inc., Advance Lane, Colmar, Pa. 18915. (215) 822-0155.

Circle 316 on Inquiry Card

100 AMP RECTIFIERS

Fast recovery featured.



Series 101KL40S20 and 101KLR-40S20 units meet the need for fast recovery diodes occupying a position between devices now available at 35 and 250 A. They are available with reverse recovery times of 1.5 μs and 2.0 μs with up to 100 A at from 400 to 1300 V. Applications include inverters, SCR assemblies and other areas requiring hf fast recovery rectification. $25 ea. (1 to 9). International Rectifier, Semiconductor Div., 233 Kansas St., El Segundo, Calif. 90245. (213) 678-6281.

Circle 317 on Inquiry Card

STRIPLINE PHASE SHIFTER

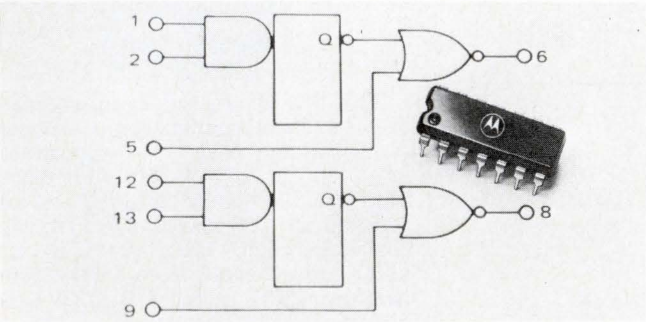
Switching time is < 100 ns.

Diode-activated 8.5 to 9.6 GHz stripline phase shifter with possible outputs of 0-, 90-, 180- and 270° phase shift (accurate to 10%), exhibits losses comparable to equivalent stripline digital ferrite phase shifters, but requires lower switching power and can switch faster. Specs include a VSWR of 1.5:1 over the operating range, 2.8 dB insertion loss and the ability to handle 25 W. It is 3 x 5 x 3/8 in. $300. Solitron/Microwave, 37-11 47th Ave., Long Island City, N. Y. 11101. (212) 937-0400.

Circle 318 on Inquiry Card

DUAL PULSE STRETCHER

Generates noise-free pulse.

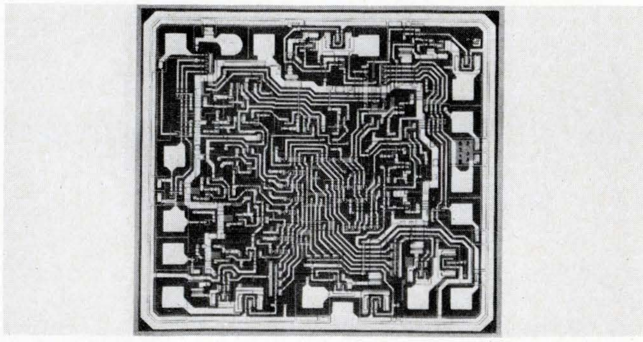


This device, Type MC675, operates on threshold levels, making input rise- and fall-times unimportant. Because the device has a two-input NOR gate at the output, you can use it either as a pulse stretcher or a pulse-shaping monostable multivibrator. When the external input to this gate is low, the device functions as a pulse stretcher. When you apply a pulse to all three input terminals simultaneously, the device acts as a pulse-shaping monostable multivibrator. Typical power dissipation is 180 mW/package and typical propagation delay is 110 ns. The device has an operating range of −40 to 75°C and sells for $4.95 ea. (1-999 pcs.). Technical Information Ctr., Motorola Semiconductor Products Inc., Box 20924, Phoenix, Ariz. 85036.

Circle 309 on Inquiry Card

EIGHT-INPUT PRIORITY ENCODER

For encoding, multiplexing and conversion applications.

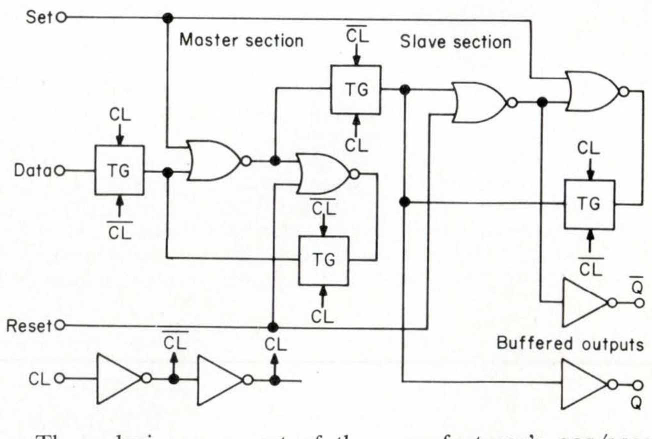


The MSI 9318 converts eight active low-level, input signals to a 3-bit binary code, and gives priority to the most significant input. It operates with a typical power dissipation of 200 mW and interfaces with current sinking logic. You can use it in priority interrupt systems, multichannel D/A converters, code conversion designs, associative memories, keyboard encoders and decimal to BCD converters. If you have more than eight inputs, you can cascade the device without additional circuitry. It's in both a DIP and a flatpack for military or industrial uses. The price (in 1-24 quantities) ranges from $15.35 to $33.80. Fairchild Semiconductor, 313 Fairchild Dr., Mountain View, Calif. 94040. (415) 962-3563.

Circle 310 on Inquiry Card

DUAL D-TYPE FLIP-FLOPS

C-MOS devices feature low power dissipation.

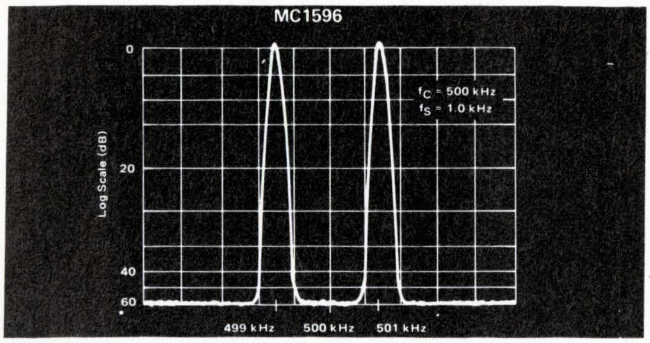


These devices are part of the manufacturer's COS/MOS (complementary - symmetry metal - oxide - semiconductor) line. Both the CD 4013 and the CD 4013D give you two independent flip-flops with buffered outputs and a set capability, on a single chip. All inputs and outputs are protected against electrostatic effects and the buffered outputs provide isolation from external noise and loading effects. Typical quiescent power dissipation is 50 nW/package with a 10 V supply. The CD 4013 is packaged in a 14-lead flatpack while the "D" version is in a ceramic and metal DIP. Both are rated over the full military temperature range. RCA Electronic Components, 415 S. 5th St., Harrison, N. J. 07029. (201) 485-3900.

Circle 311 on Inquiry Card

BALANCED MODULATOR/DEMODULATOR

Monolithic unit increases carrier suppression.

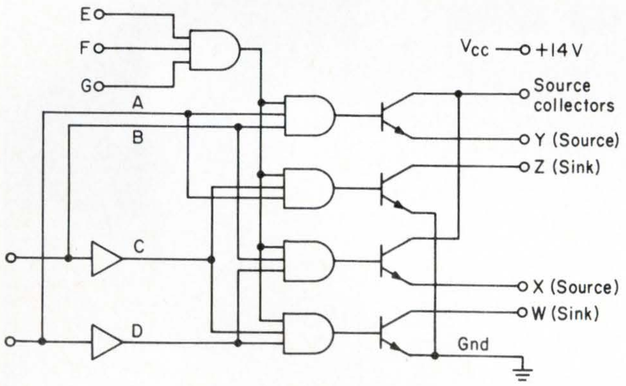


The MC1596 gives you a typical carrier suppression of 65 dB (at 0.5 MHz) in communications systems. The unit has adjustable voltage gain, balanced inputs and outputs, a typical carrier feedthrough of 90 μV rms at 0.5 MHz, and a CMRR of 85 dB typical. You can use it at carrier frequencies up to 100 MHz in modulator/demodulator applications and up to 400 MHz in other applications. The circuit is basically an input differential amplifier driving a pair of closely matched, current-mode transistor gates. It's in a hermetically sealed, long-lead version of the TO-100 metal can, and sells for $4.80 ea. in quantities of 100 and up. Technical Information Ctr., Motorola Semiconductor Products Inc., Box 20914, Phoenix, Ariz. 85036.

Circle 312 on Inquiry Card

MEMORY INTERFACE DRIVERS

Drive memory elements from logic levels.



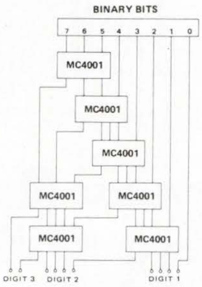
The SN75303 is a 150 mA transistor array designed for interfacing between bipolar logic levels and magnetic memory systems. The SN75308, a 500 mA transistor array, interfaces between bipolar levels and linear-select magnetic memories. A 400 mA memory driver, the SN75324, interfaces between saturated logic levels and coincident-current magnetic memories. This device replaces traditional discrete high-current transistor-transformer circuits in magnetic memory systems. Prices, in 100-999 quantities, are $5.65 for SN75303 in flat packs and $4.35 in plastic, $8.50 for SN75308 in plastic, and $6.20 for SN75324 in plastic. Texas Instruments Inc., Inquiry Answering Service, Box 5012, MS 308, Dallas, Tex. 75222. (214) 238-3741.

Circle 313 on Inquiry Card

NUMBER CONVERTER

Uses read-only memory.

BINARY-TO-BCD CONVERSION



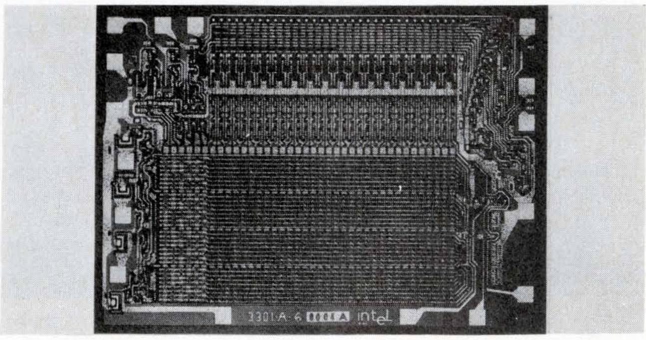
BCD DIGITS

The Type MC4001 is a binary-to-BCD or BCD-to-binary number converter that uses a 128-bit read-only memory. You can build short conversion-time systems with this device since 12 bits of binary data can be converted to BCD information in 400 ns. Conversion of any length binary or BCD words can be accomplished by interconnecting the units. Output capacitance is < 7 pF at 1.5 V and each input has pull-up resistors to eliminate the need for external resistors. It's in a 16-lead DIP and has an operating range of 0 to 75°C. $5.60 ea., (100-999 pcs.). Technical Information Ctr., Motorola Semiconductor Products Inc., Box 20924, Phoenix, Ariz. 85036. (602) 273-3466.

Circle 228 on Inquiry Card

LSI MEMORY

Stores 1024 bits on one chip.



Model 3301, a Schottky-process, bipolar ROM, stores its data in a 256 x 4 organization. The unit is fully-decoded and provides random access in a maximum of 60 ns. Two "chip select" leads permit expansion to a 1024-word memory without external decoding, and by adding two quad gates you can expand to 2048 words. Standard units will translate ASCII-8 to EBCDIC-8 and vice versa, or you can get custom units to conform to any truth table. In quantities of 1-9, the standard memories are $120. Custom units begin at $3,000 for 10 units, including masking charges. Intel Corp., 365 Middlefield Rd., Mountain View, Calif. 94040. (415) 969-1670.

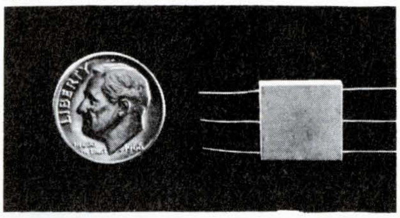
Circle 229 on Inquiry Card

Circle 52 on Inquiry Card

Circle 53 on Inquiry Card

THIN-FILM PREAMPLIFIER

With dc to 10 MHz BW.

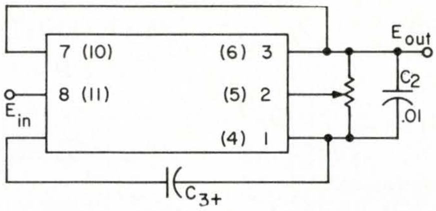


You can use this device in wide band tape reproducers and other low-level magnetic transducers. It has 40 dB gain, 2.0 dB max. noise figure at 2 kHz, input capacity of 4 pF max., and power requirements of ±12 V at 7 mA. Available in MIL-spec or commercial versions. Odetics, Inc., 1845 S. Manchester Ave., Anaheim, Calif. 92802. (714) 530-6050.

Circle 230 on Inquiry Card

PLUS/MINUS REGULATOR

In a single TO-8 package.

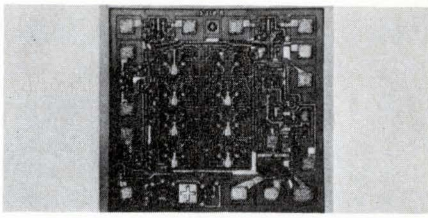


Series 873 has two thick-film voltage regulators in the same hermetically sealed package. It's preset to within 1% of ±15 V and has an output current of 100 mA. You can get adjustable output voltages from 8 V to 36 V with an external potentiometer. Price, $17.50 ea. (500-999). CTS Microelectronics, Inc., West Lafayette, Ind. 47906. (317) 463-2565.

Circle 233 on Inquiry Card

SEMICONDUCTOR IC MEMORY

Typical access time is 6.5 ns.

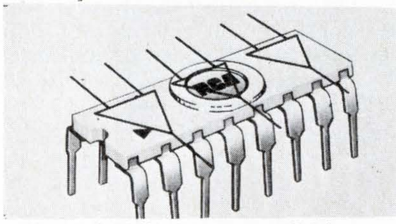


The CD 2155D is a 16-bit, read-write random access memory device. You can use this 14-pin ceramic DIP for scratch pad memories, high speed registers, buffer memories, and microprogramming applications. Price of the device is $16 ea. in 1000 lot quantities. RCA/Electronic Components, 415 S. 5th St., Harrison, N. J. 07029. (201) 485-3900.

Circle 236 on Inquiry Card

OP-AMP ARRAY

With adjustable transconductance.

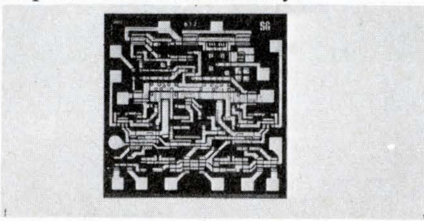


The CA3060 is a monolithic array of three independent amplifiers with a transconductance that you can vary from 10 μA to 1 mA. The device is in a 16-lead ceramic DIP and will operate over the temperature range of −55 to 125°C. Price is $5.95 ea. (1000 unit quantities). RCA/Electronic Components, 415 S. 5th St., Harrison, N. J. 07029.

Circle 231 on Inquiry Card

SENSE AMPLIFIERS

Improve threshold stability.

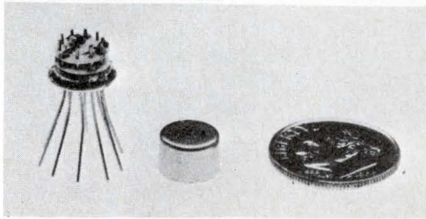


Series 7520 have a typical threshhold voltage T.C. of −15 μV/°C over the full military range. They detect differential-input signals from core arrays and provide logic-level outputs for interfacing with TTL or DTL logic. Available in a 16-lead DIP. Prices (250 pcs) vary from $5.70 to $9.05. Silicon General, Inc., 7382 Bolsa Ave., Westminster, Calif. 92683. (714) 839-6200.

Circle 234 on Inquiry Card

LOW-COST CLOCK OSCILLATOR

From 5 to 50 kHz.

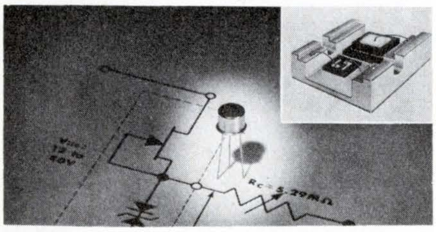


This unit, Model 622, is a thick film, hybrid oscillator housed in a standard TO-100 plastic can. You use it with an external, low-frequency crystal unit to produce a square wave output at the selected fundamental crystal frequency. About $15 in volume. Gibbs Mfg. & Research Corp., subs. of Hammond Corp., 450 N. Main St., Janesville, Wis. 53545. (608) 754-4467.

Circle 237 on Inquiry Card

REFERENCE VOLTAGE SOURCES

Miniature unit for hybrid circuits.

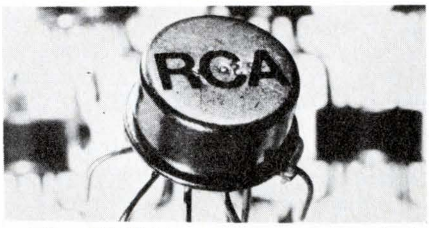


These devices have a self-contained, constant-current source and a compensated voltage reference diode. The combined coefficients give temperature compensation and stability from −55 to 100°C. Price, in 100-999 quantities, ranges from $6.50 to $23.20, with a 2 week delivery. Dickson Electronics Corp., Box 1390, Scottsdale, Ariz. 85252. (602) 947-2231.

Circle 232 on Inquiry Card

TELEVISION IC

For automatic fine tuning.

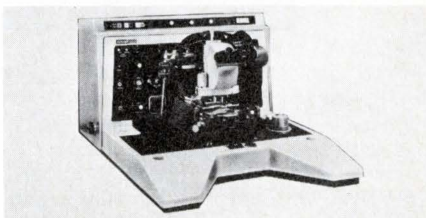


The CA3064 makes AFT practical for receivers with low-level if output. The device has a built-in input amplifier for a 20 dB improvement in sensitivity. Operating range is −40 to 85°C, and it's in a 10-lead TO-5 package. Price is $1.40 ea. in 1000 unit quantities. RCA/Electronic Components, 415 S. 5th St., Harrison, N. J. 07029. (201) 485-3900.

Circle 235 on Inquiry Card

AUTOMATIC MASK ALIGNER

For IC wafers.

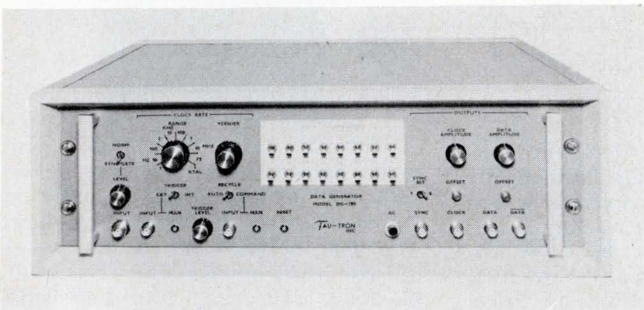


The Autolign 2686 uses an electronic system that compares the mask with the wafer pattern and recognizes when the two are aligned. Accuracy of the unit is 1 μm and the average time for complete cycling of a wafer through both alignment and exposure is 4 s. Kulicke and Soffa Industries, Inc., Ft. Washington, Pa. 19034. (215) 646-5800.

Circle 238 on Inquiry Card

PROGRAMMABLE DATA GENERATORS

Give you 16 bits in NRZ format.

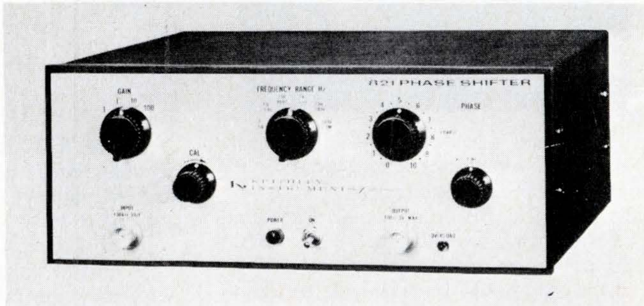


Both of these units, Models 700 and 716 operate at frequencies from a single shot to 75 MHz and the output pulse train has less than 2 ns rise and fall times. Both units provide complementary outputs plus a synchronized clock output, and both can drive RTL, DTL, TTL and ECL circuits. They also give you synchronous gating and auto/command recycle. The output voltage is 0 to 5 V with a ±2.5 V offset. The difference between the two units is that the 716 requires an external input while the 700 has its own internal oscillator. The units are priced at DG-700, $1950; DG-716, $1495. Both have a 3-4 week delivery. Tau-Tron, Inc., 685 Lawrence St., Lowell, Mass. 01852.

Circle 201 on Inquiry Card

PHASE SHIFTER

With a phase range > 210°

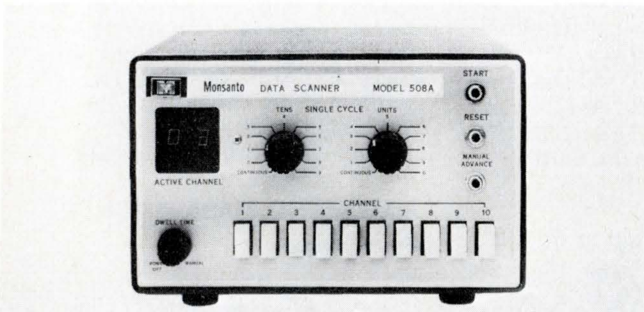


The Model 821 is a general purpose, uncalibrated sinewave phase shifter. It has a frequency range of 1 Hz to 1 MHz and a gain that is variable from −40 dB to +40dB. You can use this instrument to provide phase shifting capability in the reference channels of phase sensitive detectors and lock-in amplifier systems. It was designed to complement the manufacturer's Model 822 phase sensitive detector. The unit features a phase stability of <0.5%, an input resistance of 100 kΩ, and an output of 8 V peak to peak at up to 1 mA. Price of the instrument is $425. Keithley Instruments, Inc., 28775 Aurora Rd., Cleveland, Ohio. 44139. (216) 248-0400.

Circle 203 on Inquiry Card

AUTOMATIC REED SWITCH SCANNER

Provides continuous scanning of low-level signals.

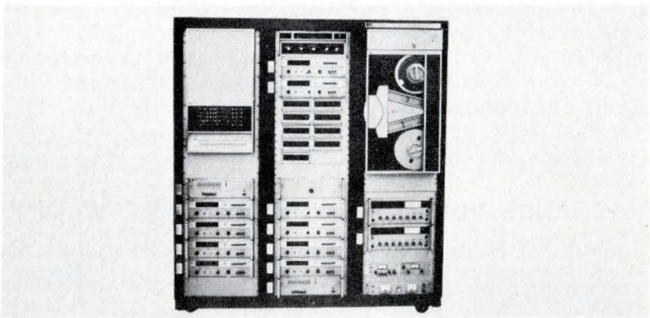


You can use this data scanner for low-level, guarded multiplexing of three or four analog signals or in 4-line/digit data transfer, commutation or steering. Model 508A has ten reed relays that connect four input terminals to a corresponding set of output terminals. Contact ratings are 100 Vdc, max.; 150 Vac, max.; and 0.5 A, max. Open circuit resistance is $10^8 \Omega$ min. and closed circuit resistance is 0.1Ω max. Solid-state, light emitting numerics indicate the active channel. You can select the operating channel manually, advance it in sequence from channel 1 to channel 10, or have the unit scan automatically. Dwell time/channel is adjustable from 20 ms to 10 s. $595. Monsanto Electronic Instruments, 620 Passaic Ave., W. Caldwell, N. J. 07006. (201) 228-3800.

Circle 202 on Inquiry Card

DATA RECORDING SYSTEM

Gives you formatted mag. tape for off-line analysis.

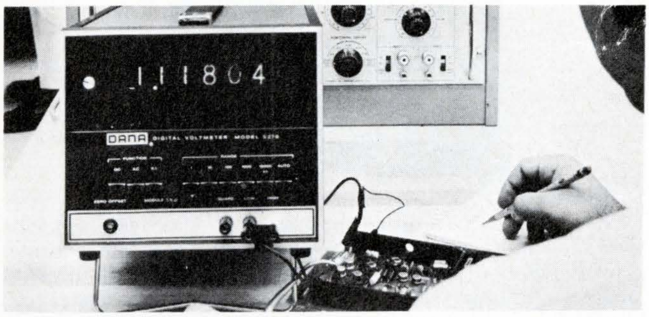


The Model 7401B system comprises standard instruments and the HP 2116B computer. The system scans 10 channels of analog data and 18 on/off events every 0.1 s. After measuring and digitizing the analog data and converting to engineering units, the system records all of the data on magnetic tape along with timing and identification information. It also displays the data on its front-panel digital readouts. The system digitizes inputs as high as 100 Vdc within ±0.006%. It comes with a software library including all standard 2116B software and costs about $150,000. The exact cost depends on the specific configuration and the software supplied. Delivery time is 20 to 26 weeks. Inquiries Manager, Hewlett-Packard, 1501 Page Mill Rd., Palo Alto. Calif. 94304. (415) 326-7000.

Circle 204 on Inquiry Card

FIVE-DIGIT MULTIMETER

For rack mounting or bench use.

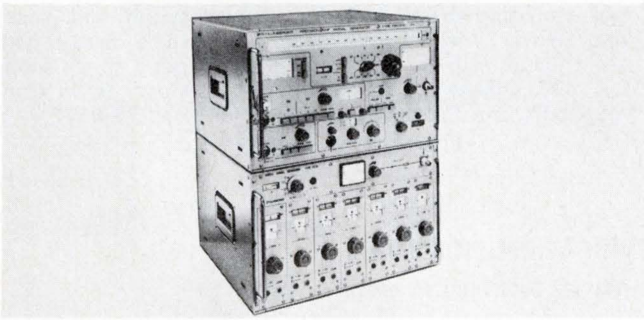


The Series 5200/550 has a dc accuracy of ±0.005% of the measured reading and ±0.002% of full scale. A dual-slope integrator and three-pole active filter give you a normal-mode noise rejection of 100 dB at 60 Hz. Common-mode noise rejection is 120 dB and the ac capability goes to 100 kHz. This instrument has 4 dc ranges, 4 ac ranges, and 5 Ω ranges and all have a sixth digit 20% overrange. Dc/dc ratio and BCD output are options as is an analog output for driving recorders. You also get autoranging from 1 to 1000 V as a standard feature. Measurements Div., Dana Laboratories, Inc., 2401 Campus Dr., Irvine, Calif. 92664. (714) 833-1234.

Circle 205 on Inquiry Card

SYNTHESIZER SIGNAL GENERATORS

With a carrier range of 300 Hz to 470 MHz.



These units, designated series FSM 530, have fine incremental tuning and precision modulation facilities for am, fm, phase-modulation, pulse-modulation and sweep applications. You can extend the frequency range to 1550 MHz with optional accessories. Crystal locked frequency increments are provided every 10 kHz (for type FSM 533), 1 kHz (FSM 534), and 100 Hz (FSM 535), and a fine tuning stage gives you 100 calibration points by interpolating the respective crystal locked increment. All the units have spurious phase noise of <0.05°, non-harmonic sidebands better than 80 dB, and a built-in precision attenuator which provides 1 dB steps from 0-140 dB with 0.2 dB accuracy. EMR-Hatboro, East County Line Rd., Hatboro, Pa. 19040. (215) 672-1240.

Circle 206 on Inquiry Card

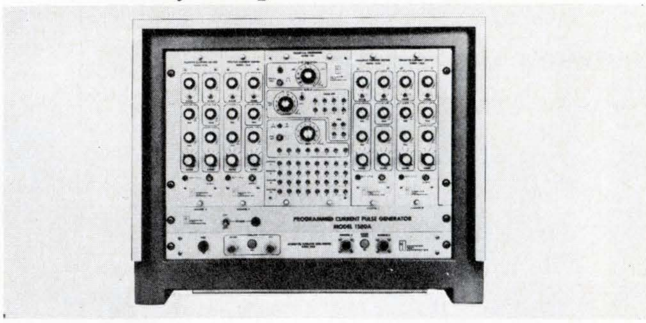
Circle 54 on Inquiry Card

Circle 55 on Inquiry Card

NEW LAB INSTRUMENTS

PROGRAMMED CURRENT PULSE GENERATORS

For core memory testing.



Available in two models, these units give you a 15 ns risetime and a narrow pulse width into the load. Model 1580A has two positive and two negative current drivers, one core jig unidriver and the required power supplies and ventilating equipment in a bench top unit. Its program generator operates at 5 MHz and has an 8-step programming capability which lets you repeat selected steps or step pairs. Model 1780A has a 6-channel, 16-step, 5 MHz program generator, three positive and three negative current generators plus a core jig unidriver. Computer Test Corp., 3 Computer Dr., Cherry Hill, N. J. 08034.

Circle 207 on Inquiry Card

MONITOR OSCILLOSCOPE

With a bandwidth of 10 MHz.

You can fit seven of these units in a single 3½ in. high by 19 in. wide rack mounting chassis. The series MS200 scope has an input sensitivity of 0.1 to 10 V rms/in. and a sweep rate of 10 Hz to 1 MHz. Both the vertical accuracy and the sweep accuracy and linearity are $<\pm3\%$ of full scale. The CRT is 1 x 3 in. and has a ¼ in. graticule. The rack mounting chassis includes a power supply and comes with chassis slides for rear panel access. The chassis with seven scopes sells for $2995 or you can get a single scope for $825. Delivery is 30 days. Vu-Data Corp., 7595 Convoy Court, San Diego, Calif. 92111. (714) 279-6572.

Circle 208 on Inquiry Card

VIBRATION MONITOR

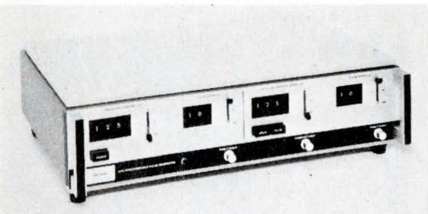
Accepts four inputs simultaneously.

The Type 1-147 accepts both velocity and piezoelectric transducers, and it gives you a choice of displacement, average velocity, or peak acceleration outputs. You can install up to three high-pass or band-pass plug-in filters/channel in the monitor to eliminate unwanted portions of the frequency spectrum or you can use variable filters for selecting any desired frequency from 8 Hz to 2500 Hz. The unit includes an oscilloscope output, internal calibration and a 0.5 to 500 range switch for each channel. Frequency response is $\pm4\%$ from 5 Hz to 10,000 Hz in the linear mode and $\pm5\%$ from 5 to 1000 Hz in the integrating mode. Prices start at $3050. CEC/Transducer Div., Bell & Howell, 360 Sierra Madre Villa, Pasadena, Calif. 91009. (213) 796-9381.

Circle 209 on Inquiry Card

PULSE GENERATOR

With programmable outputs.



The Model 1210 has two independent pulse generating units in the same chassis. Both generators are programmable in PRI (or delay) from 200 ns to 9.99 ms. (100 Hz to 5 MHz), and pulse widths from 100 ns to 0.99 ms. All inputs and outputs are TTL compatible. Price: $995 with 60 day delivery. Antekna, Inc., 4015 Fabian Way, Palo Alto, Calif. 94303.

Circle 210 on Inquiry Card

ACCELEROMETER

Radiation resistance.

The AQB 4981 withstands gamma rates of 3.2 x 10^8 rads (c)/hr. and neutron fluences of 9.6 x 10^{16} n/cm^2 without degradation. Its operational temperature range is −452 to 1150°F with a charge sensitivity of 5 pC/g. Frequency response is 2 Hz to 3.5 kHz. Gulton Industries, Instrumentation Div.-West, 1644 Whittier Ave., Costa Mesa, Calif. 92627.

Circle 211 on Inquiry Card

WIDEBAND FILTER

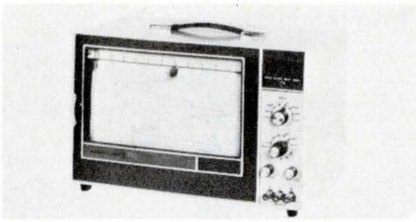
Attenuation rate is 72 dB/octave.

You can use the Model 262 in one of five modes: high-pass, low-pass, bypass, band-pass and band-stop. It has a cutoff frequency that is adjustable from 10 Hz to 10 MHz and pass-band adjustable from 5 Hz to 15 MHz. $3,450; delivery within 90 days. Systems Research Laboratories, Inc., 7001 Indian Ripple Rd., Dayton, Ohio (513) 426-6000.

Circle 212 on Inquiry Card

STRIP CHART

For transmittance and absorbance.

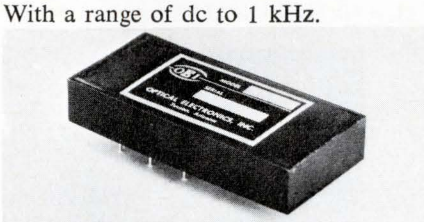


This 10 in. strip chart records the output from spectrophotometers directly in percent transmittance or absorbance units. The Model 11 has five chart speeds (from 0.05 to 20 in./min.) and a built-in event and speed mark pen. Price is $1,245. Graphics Div. of Bausch & Lomb, Inc., 4950 Terminal Ave., Bellaire, Tex. 77401. (713) 667-7403.

Circle 213 on Inquiry Card

WATT METER MODULE

With a range of dc to 1 kHz.

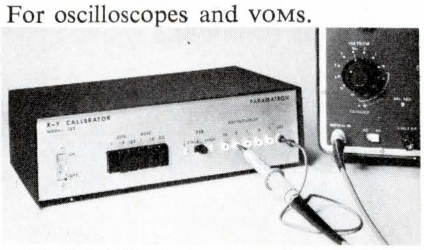


The Model 5636 gives you an output voltage equal to the instantaneous product of load voltage and load current. Sensitivity is ±10 V full scale output for 10 mW of load power and it has a typical accuracy of ±0.3%. Price is $125 ea (1-9), $102 (10-29), with immediate delivery. Optical Electronics, Inc., Box 11140, Tucson, Ariz. 85706. (602) 624-8358.

Circle 214 on Inquiry Card

X-Y CALIBRATOR

For oscilloscopes and VOMS.

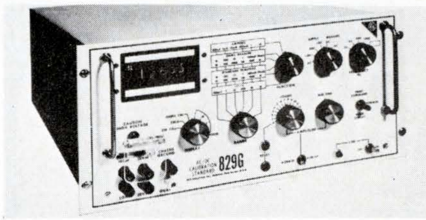


Model 132 gives you a dc or square wave output up to 1.0 MHz from 0.10 to 10.0 V. A crystal oscillator and IC dividers provide time base calibration with ±0.005% accuracy. Rise and fall times are < 40 ns when 10X scope probe is used. Price, $99.50 in kit form or $198.50 assembled. Delivery, 30 days. Paramatron Corp., Box 9207, Rochester, N. Y. 14625.

Circle 215 on Inquiry Card

CALIBRATION STANDARD

And measuring unit.

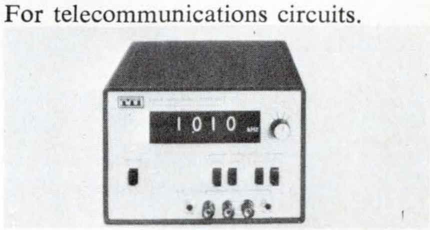


The 829G can supply or measure ac or dc voltages and currents to 1400 V and 14 A. Standard frequencies of 50, 60, 400, and 1000 Hz are internally generated and the instrument also has provisions for an external oscillator. A built-in ohmmeter measures up to 100 M Ω. Price, $3,100. RFL Industries, Inc., Boonton, N. J. 07005. (201) 334-3100.

Circle 216 on Inquiry Card

DBM/KHZ TEST SET

For telecommunications circuits.



The TTI 1101A makes both frequency and transmission level measurements. Automatic ranging circuitry provides a direct digital readout for signals between −50 dBm and +10 dBm. A rechargeable battery supply is optional. Price, $1,185. Delivery: 60 days. Telecommunications Technology, Inc., 920 Commercial St., Palo Alto, Calif. 94303.

Circle 217 on Inquiry Card

WAVEFORM GENERATOR

Has 0.01 Hz to 3 MHz bandwidth.

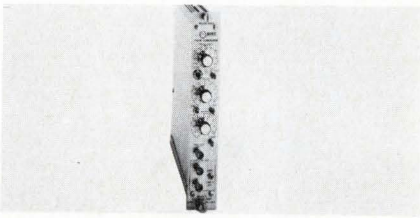
This unit has voltage controlled frequency over a 1000:1 ratio. The Model 123 gives you sine, square and triangle waveforms, and a sync pulse. Frequency is ±2% accurate and the external voltage control can either be dc programming or ac frequency modulation. $345. Delivery, stock to 30 days. Exact Electronics Inc., Box 160, Hillsboro, Ore. 97123. (503) 648-6661.

Circle 218 on Inquiry Card

NEW LAB INSTRUMENTS

PULSE GENERATOR

With 125 MHz output.

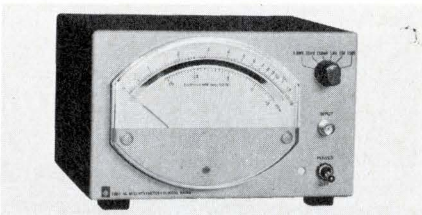


The Model 8020 provides 1 ns rise time and gives you continuous adjustment of frequency, delay and width. Other features include single pulse and 1 to 10 Hz operation, a synchronous external gate input, and single or double pulse operation. Berkeley Nucleonics Corp., 1198 Tenth St., Berkeley, Calif. 94710.

Circle 219 on Inquiry Card

AC MILLIVOLTMETER

Has 10 Hz to 10 MHz BW.



This instrument, the TR 1808 has a 20 dB dynamic range in each of six ranges (1.5 mV to 150 V full scale). Other features are: 10 MΩ input impedance, 1% accuracy, and a floating dc output. The bench model is $295; rack model, $315; and a probe adaptor is $10. General Radio Co., 300 Baker Ave., West Concord, Mass. 01781. (617) 369-4400.

Circle 220 on Inquiry Card

DIGITAL PANEL METER

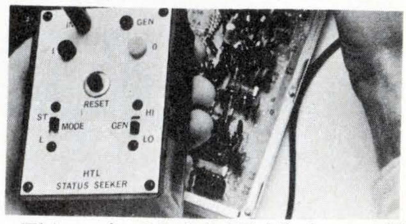
With MTOS circuitry.

The manufacturer uses LSI circuitry in this full 3-digit meter with 0.5% accuracy. The instrument has an automatic zero, internal calibration voltage, and 100 μV resolution. You can operate it on either 117 Vac or 12 Vdc. The VT 500 costs $139 and is available from stock. Dixson Inc., Box 1449, Grand Junction, Colo. 81501. (303) 242-8863.

Circle 221 on Inquiry Card

LOGIC TEST SET

For HTL systems.

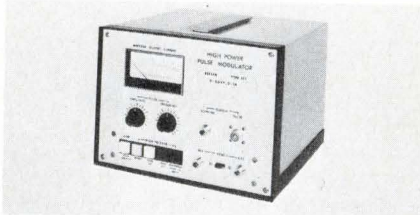


This unit, Model ST-15, is specifically for testing high threshold logic systems. It shows logic levels and also displays pulses as short as 40 ns graphically. The unit can also generate and detect pulses simultaneously. Price is $95 with delivery from stock. Dataprobe, Inc., 290 Huyler St., S. Hackensack. N. J. 07606. (201) 489-5588.

Circle 222 on Inquiry Card

PULSE MODULATORS

Up to 10 kW power output.



This series includes standard units with peak outputs of 3.5 kV at 3 A, 5 kV at 2 A, and 100 V at 100 A. Pulse regulation is held to ±1.0% for ±10% line variation and zero to maximum duty cycle variations. Pulse-to-pulse amplitude jitter is 0.05% max. $985. Bertan Associates, Inc., 15 Newtown Rd., Plainview, N. Y. 11803. (516) 293-5340.

Circle 223 on Inquiry Card

PARTICLE MASS MONITOR

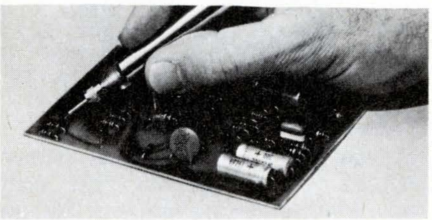
Provides quick measurements.

The Model 3200 monitors the airborne particle mass concentration directly. Instead of the hours required by filter type samplers, the instrument gives you the aerosol mass concentration in minutes. Concentration range is 1-100,000 micrograms/meter^3. Thermo-Systems Inc., 2500 Cleveland Ave. North, St. Paul, Minn. 55113. (612) 633-0550.

Circle 224 on Inquiry Card

SIGNAL SOURCE

For IC testing.

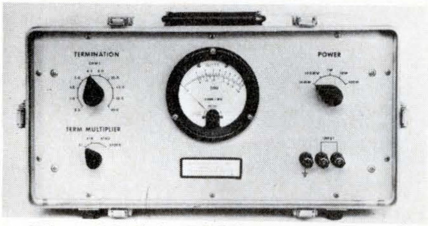


You can use the "Mosquito" as a trigger signal for DTL, RTL, and TTL circuits. The unit generates and injects pulses covering the audio, i-f and rf spectrum. It operates on a single AAA size, 1.5 V battery and weighs 1 oz. Don Bosco Electronics, Inc., 525 Broad St., Bridgeport, Conn. 06604. (203) 335-4179.

Circle 225 on Inquiry Crad

OUTPUT POWER METER

From 1 mW to 100 W.

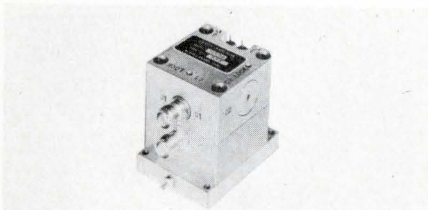


The Model PM-2 measures the power output of audio-frequency generators, transducers, amplifiers and transmission lines while terminated with a known impedance. The impedance range is 2.5 to 20,000 Ω and the unit has a frequency range of 10 to 20,000 Hz. AUL Instruments, Inc., 139-30 34th Rd., Flushing, N. Y. 11354. (212) 886-0600.

Circle 226 on Inquiry Card

CAVITY AMPLIFIERS

For vhf, uhf, telemetry uses.



This line covers the range of 200 MHz to 2300 MHz. Power outputs range from 15 to 100 W cw. Load variations from open circuit to short circuit have no effect on these amplifiers and you can get all of them with filters, power supplies and associated devices. Resdel Engineering Corp., 300 E. Live Oak Ave., Arcadia, Calif. 91006. (213) 684-2600.

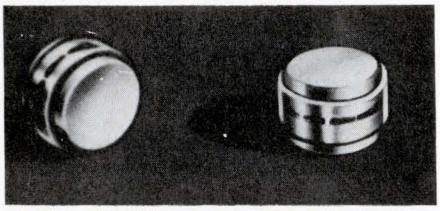
Circle 227 on Inquiry Card

Circle 59 on Inquiry Card

NEW PRODUCTS

PIN DIODE

For stripline and microstrip.

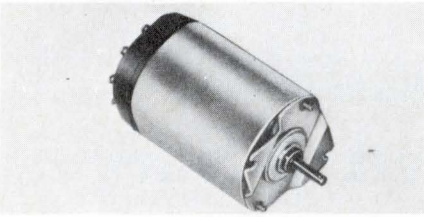


UM7000P series "Micro-Pill" PIN diode uses a fused-in-glass, whiskerless, metallurgically-bonded voidless construction for best reliability under severe rf stress conditions. Though only 0.040 in. high x 0.060 in. in dia., it can dissipate 40 W of average pwr. and 75 kW of pk pwr. with a 1 μs pulse. From $13 (1000 pieces). Unitrode Corp., 580 Pleasant St., Watertown, Mass. 02172. (617) 926-0404.

Circle 239 on Inquiry Card

STEPPER MOTOR

And logic drive.

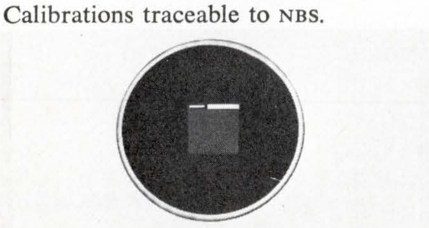


The 1D06 is a 4-phase, 5 Vdc motor that meets a variety of industrial incremental and variable speed drive requirements. Applications include data plotters, computer peripherals, tape and film transports and chart drives. Features are low power consumption (4 W), low temp. rise, high pull-in rate (200 pps), drive torques to 6.95 oz.-in., and a 7½° step angle. The A. W. Haydon Co., 232 N. Elm St., Waterbury, Conn. 06720.

Circle 240 on Inquiry Card

IRRADIANCE DETECTORS

Calibrations traceable to NBS.

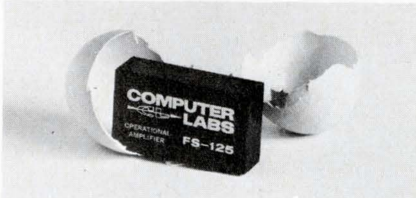


Detectors CSC-11 through CSC-14 are for measuring visible and near infrared radiant energy. Applications include measurement of ss light emitting diodes and lasers, and visible and near IR gas lasers. Spectral range is 350 to 1150 nanometers. Centralab Semiconductor, 4501 N. Arden Dr., El Monte, Calif. 91734.

Circle 241 on Inquiry Card

FAST-SETTLING OP AMP

Has many applications.

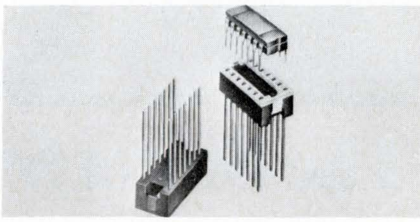


Model FS-125 is designed for fast settling on step function input signals. With a closed-loop gain of 1, it will settle to within 0.1% of full scale < 80 ns after the input is applied. It can be accurately calibrated with dc and remain within 0.1% of its dc accuracy at rates to 12 MHz. $97.00 (small lot). Computer Labs, 1109 S. Chapman St., Greensboro, N. C. 27403. (919) 292-6427.

Circle 242 on Inquiry Card

MOUNTING SOCKETS

For dual in-line devices.



Series 121-2002 production mounting sockets are for all std. 14-lead DIL devices. They have double wiping action type replaceable contacts that accept round or flat leads interchangeably. Terminals come in two styles: round solder type 0.018 x 0.020 x 9/64 in. long, or square solderless-wrap type 0.025 x 0.025 x 11/16 in. long. Barnes Corp., 24 N. Lansdowne Ave., Lansdowne, Pa. 19050. (215) 622-1525.

Circle 243 on Inquiry Card

DIP LOADER

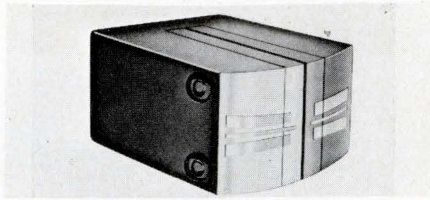
At rates to 3600 pieces/h.

Model SM-2000 insertion machine accepts DIP's from "sticks," loads them into carriers, and stacks the loaded carriers into magazines for further automated processing. Except for manual loading of the carriers and DIP circuits, it is fully automatic. Weltek Div., Wells Electronics, Inc., 1701 S. Main St., South Bend, Ind. 46623.

Circle 244 on Inquiry Card

MAGNETIC HEADS

For use with computers.

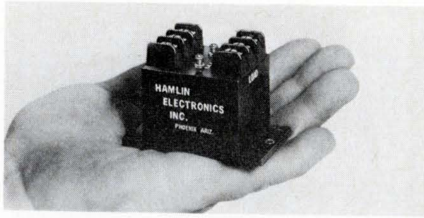


New Redundant K-Set head, (KRW-3) lets you use complex write methods with transports designed for use with the std. Phillips cassette. It provides write track widths of 0.041 in. on 0.070 in. centers, and read track widths of 0.029 in. on 0.070 in. centers. Read-to-write gaps are 0.150 in. apart. Central Services, 1442 Griswold, Detroit, Mich. 48226. (313) 962-4638.

Circle 245 on Inquiry Card

AC CONTROLLER

For fractional hp motors.

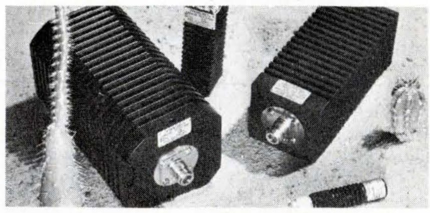


Control-Pak provides arcless "make" and zero current "break," reducing rfi and emi to levels where drive motors can be operated adjacent to low level logic circuits. It operates from 208-440 Vac 3 phase with a max. load rating of 1 hp. Maximum phase current is 2.5 A with control voltages of 5, 12, 24, 48 Vdc, 24 Vac or line voltage. Hamlin Electronics, Inc., 3879 N. 28th Ave., Phoenix, Ariz. 85017.

Circle 246 on Inquiry Card

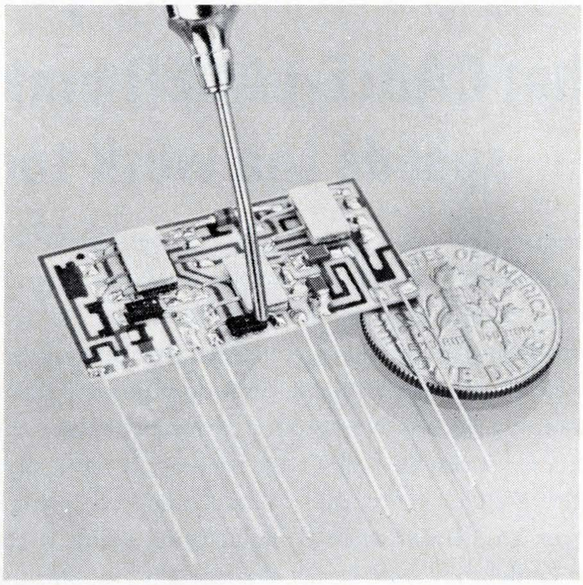
DRY RF LOAD RESISTORS

For termination of 50 Ω systems.



New Models 8166 (150 W) and 8164 (100) Termaline® resistors are air-cooled line terminations designed for use in any position. The 150 W and 100 W dry loads both have a low vswr of 1.1 from dc to 1 GHz and 1.2 to 2.5 GHz. Bird Electronic Corp., 30303 Aurora Rd., Cleveland (Solon) Ohio 44139. (216) 248-1200.

Circle 247 on Inquiry Card



MINITAN is the first choice in size and reliability for Spacetac heart pacer modules.

NOW ...more microfarads per millimeter with MINITAN®!

MINITAN . . . THE WORLD'S SMALLEST, PROVEN MICROMINIATURE SOLID ELECTROLYTE CAPACITOR GIVES YOU THE CAPACITANCE-TO-VOLUME RATIOS YOU'VE BEEN SEARCHING FOR.

75% Smaller than equivalent CS13 Sizes! With Minitan you solve high density hybrid or thick film packaging problems without sacrificing performance. Polar and non-polar types from .001 to 220 ufd . . . working voltages to 35 volts . . . yet packaged in a case about the size of a pinhead — as small as .100 X .050 X .040.

Flexibility To Fit! 11 resin-sealed mylar case sizes . . . rectangular and tubular shapes . . . axial or radial leads. Easy-soldered nickel leads, as well as gold-plated kovar ribbon leads for maximum IC compatibility. Standard tolerances to ±5%.

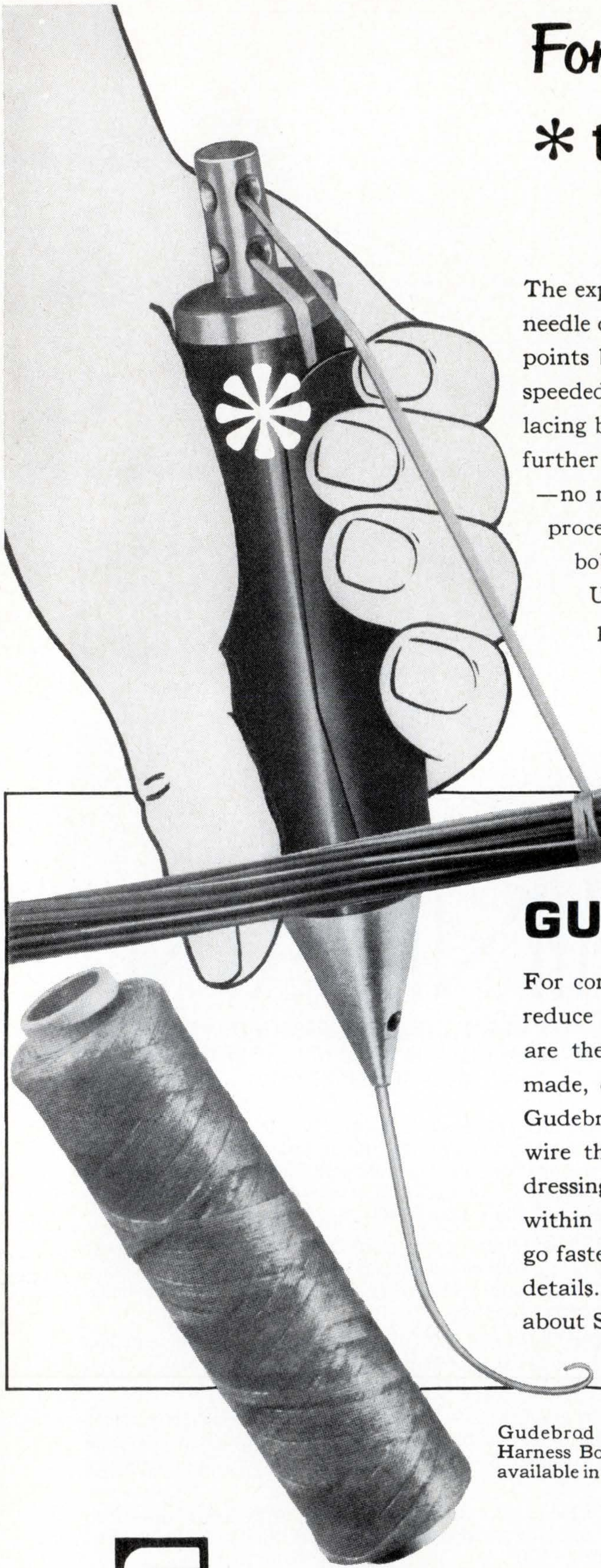
Proven Reliability! 1,679,000 Life Test Hours @ 85°C with only one failure. 130% surge voltage rating. Operating temp. range from −55°C to 125°C. DC leakage typically less than .01 uA per ufd — volt.

Specified for manned space flights—where reliability and performance count! Specified for micropackaged commercial computers, portable communications, thick film hybrids—where reliability and performance count.

Specify Minitan to solve your space problems. Write today—we'll rush data sheets, samples and documented proof of Minitan reliability. See EEM file system 1500.

COMPONENTS INCORPORATED CI

BIDDEFORD, MAINE 04005



For continuous lacing...

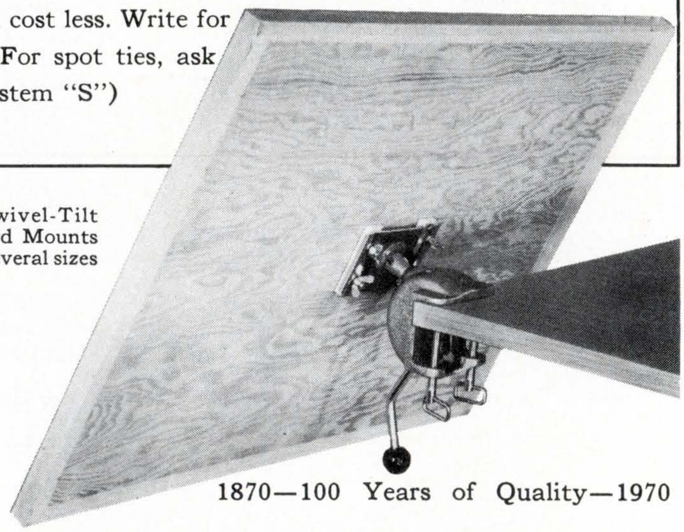
* that CABLE-LACER brake speeds the work too!

The experienced harness worker can quickly guide the hooked needle of the Gudebrod Cable-Lacer* across narrow break-out points between pins to grasp the loop. This is where work is speeded first. But then, the pressure of four fingers on the lacing break allows a swift, single pull for firm knot setting—further speeding the job. No need for wrapping around the fist—no need for a second pull. It all becomes a naturally fast procedure. What's more, the special Gudebrod lacing tape bobbins are helpful when all-hand tying seems required! Use Gudebrod Cable-Lacer, Gudebrod's Bobbins for improved accuracy and time saving.

*T.M. Union Special Machine Co.

Save money & time with
GUDEBROD SYSTEM "C"

For continuous lacing Gudebrod offers a four part system to reduce your harnessing costs. The Cable-Lacer and Bobbins are the first two parts. Add to them Gudebrod's specially made, case hardened, extra long, wire holding pins and the Gudebrod Swivel-Tilt Harness Board Mount. The pins make wire threading easier and sharply reduce the need for redressing. The Gudebrod Mount brings any part of the harness within easy reach. Gudebrod System "C" makes harnessing go faster, cost less. Write for details. (For spot ties, ask about System "S")



Gudebrod Swivel-Tilt Harness Board Mounts available in several sizes

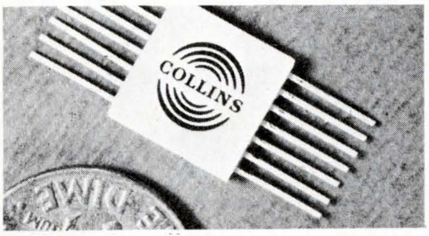
GUDEBROD
Electronics Division

1870—100 Years of Quality—1970

GUDEBROD BROS. SILK CO., INC. Founded 1870, 12 South 12th Street, Philadelphia, Pa. 19107

HYBRID OSCILLATOR

Thin film circuit.

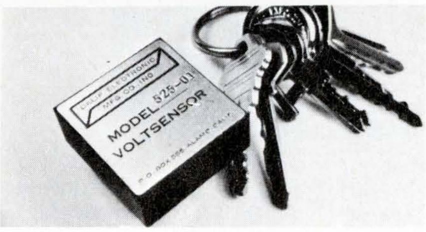


This 3/8 in.² package contains a Pierce oscillator circuit and a two-stage buffer amplifier. Circuit is designed to be combined with an external crystal to form a complete oscillator in the 10 to 30 MHz region. It can also be used at freqs as low as 1 MHz by adding two small ext. capacitors. Collins Radio Co., 19700 Jamboree Blvd., Newport Beach, Calif. 92663.

Circle 248 on Inquiry Card

VOLTAGE COMPARATORS

Precision ss devices.

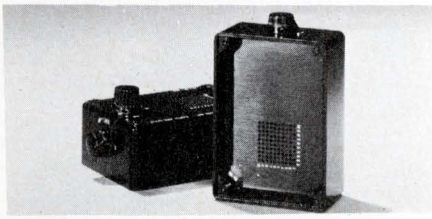


The "−01" series Voltsensors have a max. drift of < 0.1 mV/°C (typ. 0.05 mV/°C), hysteresis specified < 1 mV (typ. 0.5 mV) and an output rise and fall time of < 1 μs. The "−01" Voltsensors come in single set point, dual set point and dual set-dual out. California Electronic Mfg. Co., Box 555, Alamo, Calif. 94507. (415) 932-3911.

Circle 249 on Inquiry Card

TEST CONNECTOR

Eliminates soldering and test leads.



This unit connects component or circuit and test unit. Three sizes are available. Model A-2 has 100 pinholes on top (to receive pins of component being tested) and 100 pin-holes in the bottom (to receive pins of test unit). Models A-4 and A-6 can receive 100 or 200 pins and 100, 200, 300, or 400 pins respectively. Reynolds & Taylor, Inc., 2109 C S. Wright, Santa Ana, Calif. 92705.

Circle 250 on Inquiry Card

CONDUCTIVE EPOXY INK

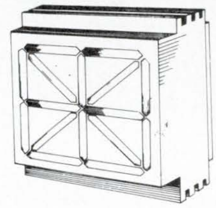
Single-component, silver-filled.

SS-570 ink can be silk screened directly onto matrix boards and ceramic wafers to provide conductive paths. It can also be sprayed or brushed on for shielding and grounding applications. Advantages include low-temp. cure cycles (94°C-160°C), thermal and environmental stability, ease of application, and low resistivity (< 0.01 Ω-cm). Rogers Corp., Rogers, Conn. 06263.

Circle 251 on Inquiry Card

ALPHA/NUMERIC READOUT

Wide viewing angle.

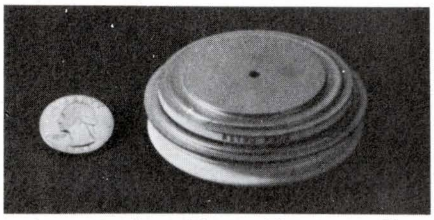


New 16-segment alpha/numeric readout has large, easy-to-read segments. Each segment has its own lamp, each of which has a min. life of 50,000 hours. Lamps can be easily and economically replaced. Available with a character height of 1 or 5/8 in. Systems Technology, Inc., Rte 29 N., Box 5387, Charlottesville, Va. 22903. (703) 973-5379.

Circle 252 on Inquiry Card

SCR

Supplies up to 1500 A.

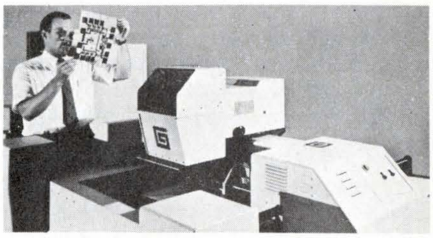


Astro-Pack, with a 48 mm pellet dia. can supply up to 1500 A and up to 1200 V. It offers I^2T up to 1 million. Astro-Pack supplies up to 2000 A rms in an ac switch in a water cooled setup. Its large size eliminates the need to parallel devices. It can be purchased as a component or a heat sink sub-assembly. Power Semiconductors, Inc., 90 Munson St., Devon, Conn. 06460.

Circle 253 on Inquiry Card

DRAFTING MACHINE TABLE

For precision artwork.

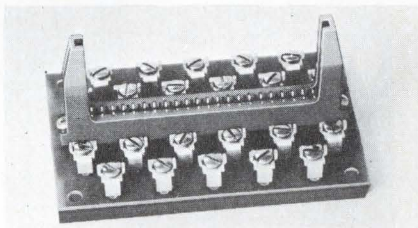


Model 33 is for making precision IC photo masks and complex multilayer PC artwork. Table guarantees accuracies to ±0.0005 in. over its 24 x 24 in. active work area. Accuracies up to 0.0001 are guaranteed over a 3 x 3 in. working area. These features are offered at a plotting speed of 60 in./min. The Gerber Scientific Instrument Co., 83 Gerber Rd., So. Windsor, Conn. 06087. (203) 844-1551.

Circle 254 on Inquiry Card

CONNECTOR INTERFACE

Between PCB's and buss wiring.

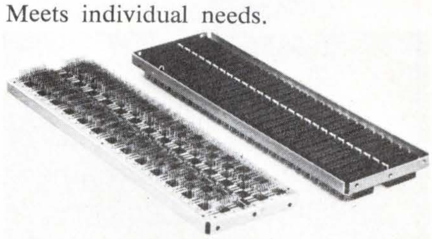


Model 22 edge connector interface socket bridges the gap between PC technology and factory control panel installation. It lets you insert a PCB into a panel-mounted connector with screw terminals, eliminating soldering. solderless wrap connections and PC mounting panels. Farmer Electric Products Co., Inc., Natick, Mass. 01760. (617) 653-8850.

Circle 255 on Inquiry Card

PLATE CONNECTOR SYSTEM

Meets individual needs.



New solderless wrap modular system of edge type connectors is for 0.056 to 0.068 in. thick double sided PC boards. Card receptacles are made up of four and six position contact modules, polarization modules and keys, card guides and grounding clips installed on an aluminum plate up to 24 x 24 in. Wrap posts are 0.025 in.³ Burndy Corp., Norwalk, Conn. 06852. (203) 838-4444.

Circle 256 on Inquiry Card

INDUSTRIAL SCRs

Hermetically sealed.

These SCRS are for industrial/consumer uses and are priced (from 45¢/1000) to compete with conventional plastic devices. The ID100 series is for 1 V, low-current-sensing applications. Voltage ratings are from 30 to 200 V with a continuous dc forward current rating of 500 mA at 100°C case and a gate sens. of 200 mA max. gate current. Unitrode Corp., 580 Pleasant St., Watertown, Mass. 02172.

Circle 257 on Inquiry Card

SILVER SUBSTITUTE

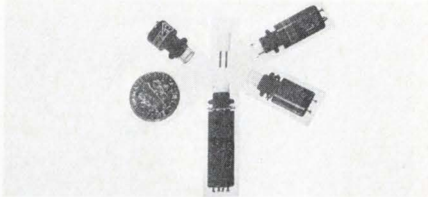
Silver coated ceramic powder.

Silclad G-100 may be substituted for pure silver in conductive gaskets, coatings, plastics, and so forth. Typical resistance of G-100 is 0.008 Ω at room temp. and < 0.040 Ω after 1000 hrs at 500°F. Particle size is < 44 μm and density is one-third that of pure silver. Cost is about 25% that of pure silver. Sigmatronics, Box 105, Moorestown, N. J. 08057. (609) 235-9429.

Circle 258 on Inquiry Card

L.E.D. INDICATORS

Virtually infinite life.

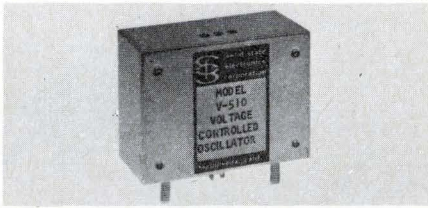


New indicators and switch indicator devices use light emitting diodes as the light source instead of normal incandescent or neon lamps. All of these "SS" series devices use gallium arsenide phosphide light sources. Body dia. is 0.360 in., and ⅜ in. mounting center in a ¼ in. panel hole is std. TEC, Inc., 6700 S. Washington Ave., Eden Prairie, Minn. 55343. (612) 941-1100.

Circle 259 on Inquiry Card

SUBCARRIER OSCILLATOR

Provides data accuracies within 1%.

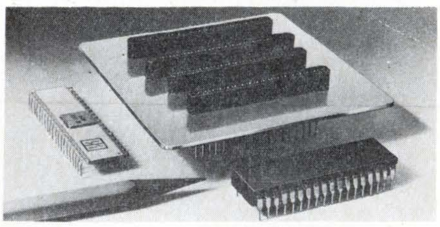


Model V-510 voltage controlled oscillator converts or varies analog dc voltage to a linearly proportional sine wave freq. Special consideration has been given to its use with FM-FM telemetering systems and as an A/D converter. Standard units operate from 400 Hz to 70 kHz within IRIG bands 1 to 18 (±7.5% freq. deviation) and A to E (±15% freq. deviation). Solid State Electronics Co., 15321 Rayen St., Sepulveda, Calif. 91342. (213) 894-2271.

Circle 260 on Inquiry Card

DIL SOCKETS

For modular direct entry packaging.

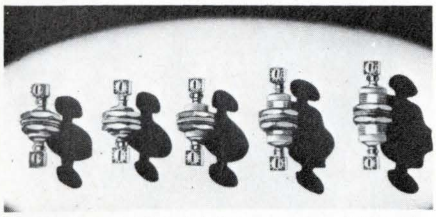


New 36-pin and 40-pin sockets accept any width center (0.5, 0.6 or 0.8 in.). They take any combination of ICs and discrete components using modular direct entry packaging methods. The Modu-Wrap power and ground distribution planes offer up to 25 pF of distributed capacitance/in.² Interdyne, 2217 Purdue Ave., Los Angeles, Calif. 90064. (213) 477-6051.

Circle 261 on Inquiry Card

FEEDTHRU CAPACITORS

Reduce EMI interference.

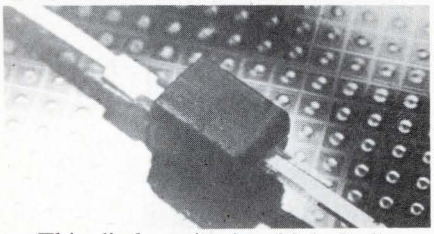


Series 112P high-current (50 A), heavy-duty Thru-Pass® capacitors are for use in military and industrial electrical and electronic equipment and all types of atmospheric conditions to 85°C. There is always a noise-leak-proof closed path around the conductor. Ratings range from 0.01 μF to 0.22 μF at 250 Vac. Sprague Electric Co., Marshall St., North Adams, Maine (413) 664-4411.

Circle 262 on Inquiry Card

VARACTOR DIODE

Low series inductance.

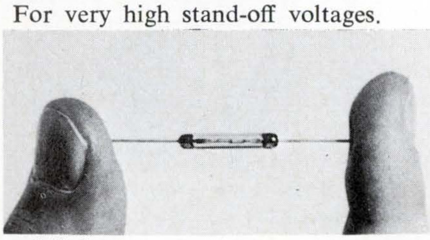


This diode series has high Q, linear response and a spread of five to one at 3 to 30 V. They are for use in solid-state TV tuners, instrumentation, remote freq. controls and microwave circuits. The junction in these varators provides linear capacitance-voltage characteristics, eliminating the need for matching diodes in some applications. Kollstan Semiconductors, Standard Kollsman Industries, 111 New York Ave., Westbury, N. Y. 11590. (516) 997-8300.

Circle 263 on Inquiry Card

MINIATURE SWITCH

For very high stand-off voltages.

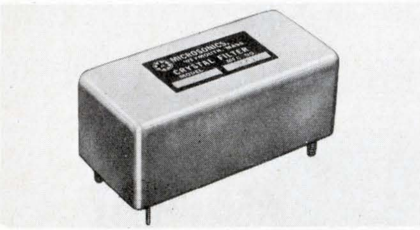


Miniature rhodium HV drireed switch is for use where up to 600 Vdc transient voltages can be expected. It is for contact rating of 1.0 A max., 5 W max., ins. res. of 10^{10} Ω min. Dielectric strength is 600 Vdc min., and initial contact resistance is 0.200 Ω max. Hathaway Instruments Inc., 5250 E. Evans Ave., Denver, Colo. 80222.

Circle 264 on Inquiry Card

SSB CRYSTAL FILTER

With 5 MHz carrier freq.



Model SB56A filter has a carrier freq. of 5.0 MHz with 3 dB high and low bandwidth of +3.5 kHz and +300 Hz respectively. Carrier rejection is 20 dB min. Temperature range is -20°C to -71°C and a ripple of 2 dB max. Filter dimensions are 2.38 x 1.03 x 1 in. Microsonics, 60 Winter St., Weymouth, Mass. 02188.

Circle 265 on Inquiry Card

DIGITAL PANEL METER

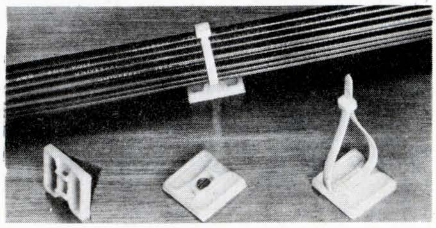
Takes only 2 1/16 x 4½ in. of panel.

All SS Model 275 has 0.05% accuracy and 100 μV resolution. It has an input imp. of 100 M Ω and features drift cancelling, ramp voltage comparator and crystal-controlled digitizing oscillator. The meter displays a full scale reading of 999.9 mVdc. $295. United Systems Corp., 918 Woodley Rd., Dayton, Ohio 45403.

Circle 268 on Inquiry Card

ADHESIVE BACKED MOUNT

Secures wiring to smooth surfaces.

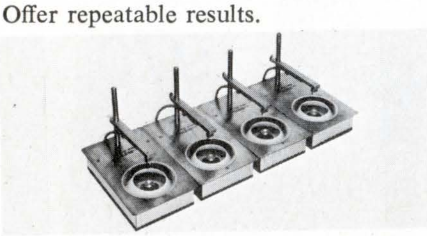


ABMS-A mount has a countersunk hole which permits it to be used with a #6 flat-head screw or a ⅛ in. flat-head rivet. Result is a one-hole mount which will not rotate. It can support ¼ lb. max. when used without a screw or rivet. Panduit Corp., 17301 Ridgeland Ave., Tinley Park, Ill. 60477. (312) 532-1800.

Circle 271 on Inquiry Card

PHOTO RESIST SPINNERS

Offer repeatable results.

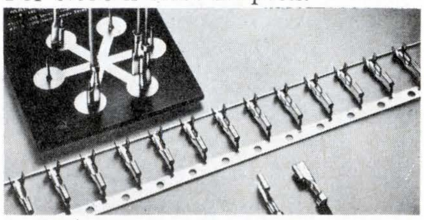


EC101 series spinners have high acceleration (about 500 ms to 9,500 rpm), electronic speed regulation, automatic cycle control, and automatic dynamic braking. Uniform minimum stressed films result from the high acceleration and the precise speed regulation. Marketing Dept., Headway Research, Inc., 3713 Forest Lane, Garland, Tex. 75040. (214) 272-1567.

Circle 266 on Inquiry Card

PIGGYBACK RECEPTACLE

For 0.030 x 0.060 in. posts.

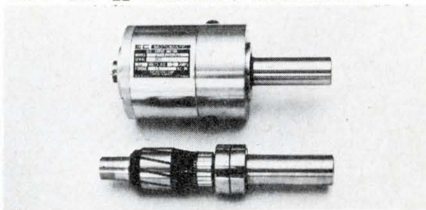


New receptacle for connect/disconnect applications of stranded or solid wires provide a wide tol. range with ½ lb. min. retention force. Receptacle stacks 2 levels piggyback and covers 16 through 24 gauge wire sizes. It come in phosphor bronze with several different finishes. Malco Mfg. Co., Inc., 5150 W. Roosevelt Rd., Chicago, Ill. 60650.

Circle 269 on Inquiry Card

PRECISION SERVOMOTOR

Low 1.5 Ω armature resistance.

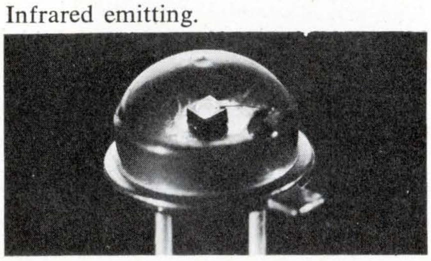


New precision capstan dc servomotor is for use in high quality analog instrumentation and video recorder/reproducer systems. Model ET-425 is designed for a continuous torque output of 16 oz-in. at speeds to 3,300 rpm. Rated input is 24 V at 4 A. Advanced Products, Electro-Craft Corp., 1600 S. Second St., Hopkins, Minn. 55343. (612) 935-8226.

Circle 272 on Inquiry Card

GALLIUM ARSENIDE DIODE

Infrared emitting.

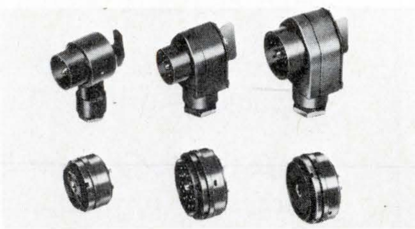


These narrow band ss lamps (FLD 100) are well suited for use with Si photo sensors since their spectral peaks are closely matched. Typical specs are: forward voltage, 1.35 V; reverse voltage, 8.3 V; reverse current, 5 nA and 9000 A wavelength at peak. Angle between half intensity points and peak axis is 65°. $5.00 (1-99), $1.50 (10,000+). Fairchild Microwave & Optoelectronics, 2513 Charleston Rd., Mountain View, Calif. 94040. (415) 961-1391.

Circle 267 on Inquiry Card

POWER CONNECTORS

Conform to Mil-C-12520.

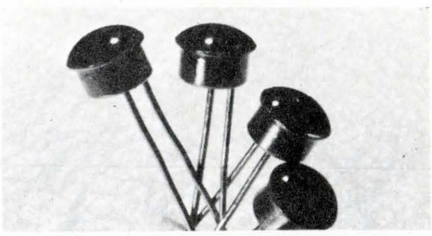


Series UW waterproof connectors are now available with 4, 9, 14, 19, or 30 contacts whose current ratings range from 11 to 41 A. They are for power and control circuit uses in mobile radar, radio, teletype, and related communications equipment. Both plugs and receptacles, which are polarized to prevent mismating, can be fitted with either pin or socket contacts with solder turret terminations. Elco Corp., Willow Grove, Pa. 19090. (215) 659-7000.

Circle 270 on Inquiry Card

PHOTOTRANSISTORS

Easily mount into PC boards.

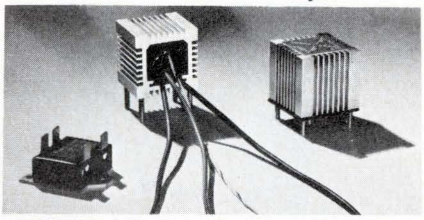


A new line of npn planar Si phototransistors (TIL-63, 64, 65, 66 and 67) are for applications such as: Character recognition, tape and card reading, velocity indication and decoding. Light current sens. ranges for the five devices are 0.4 mA min., 0.4 to 1.6 mA, 1.0 to 4.0 mA, 2.5 to 10.0 mA, and 6.0 mA min., respectively. Price (for 100-999 quan.) ranges from $0.67 to $1.00. Texas Instruments Incorporated, Box 5012, M/S 308, Dallas, Tex. 75222. (214) 238-3741.

Circle 273 on Inquiry Card

SOLID STATE DRIVERS

Function as dc control relays.

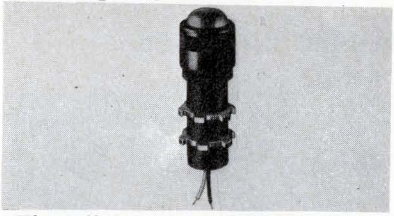


Their ability to handle coil currents of contactors, relays and solenoid valves from low level control sources make them applicable as an interface in transistor logic systems. SX6 series drivers are rated at 6, 12, 24 and 36 Vdc to 8 A. Specialty Products Div., Cutler-Hammer, Inc., 4201 N. 27th St., Milwaukee, Wisc. 53216. (414) 442-7800.

Circle 274 on Inquiry Card

PILOT LIGHTS

Explosion-proof.

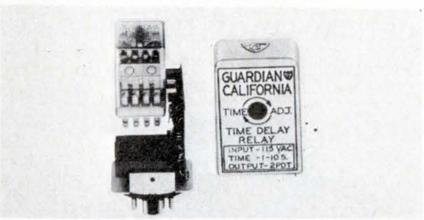


These lights are suitable for Class I, Groups C and D; Class II, Groups E, F, and G, NEMA 7 and 9 hazardous locations. They come with 3, 6 or 10 W lamps in 30- to 250-V sizes. Overall length is 4¼ in., including a 2⅝ x ¾ in. NPSM threaded stem. Adalet Mfg. Co., div. of The Scott & Fetzer Co., 4801 W. 150th St., Cleveland, Ohio 44135. (216) 267-9000.

Circle 275 on Inquiry Card

TIME DELAY

Operates on high or low line.



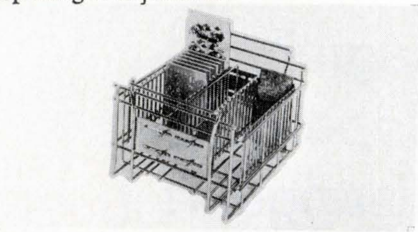
BDT series time delays use all silicon transistor circuits that operate over an input range of 75 - 125 Vac, 50-60 Hz and draw only 5 mA prior to time out. Enclosed in a std. relay housing terminated with an octal plug, they are available with time delays from 1-10 to 10-60s. Screw driver adjustable, they have a replaceable electro-mechanical relay. Guardian Electric Mfg. Co. of Calif., Inc., 5755 Camille Ave., Culver City, Calif. 90232. (213) UP 0-4642.

Circle 276 on Inquiry Card

NEW PRODUCTS

CIRCUIT BOARD BASKET

Spacing is adjustable.

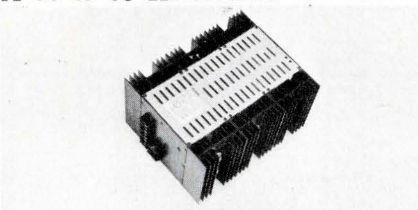


Vertical slots hold circuit boards firmly in position in these baskets. A set of slotted divider-panels can be adjusted and locked in position to provide wider or narrower compartments. They are for transporting, storing, washing and general production line use. Advantages include free circulation of air, full visibility of contents and avoidance of dust accumulation. Metropolitan Goods Corp., Wilkes-Barre, Pa.

Circle 277 on Inquiry Card

POWER MODULE

A dc to 60 Hz inverter

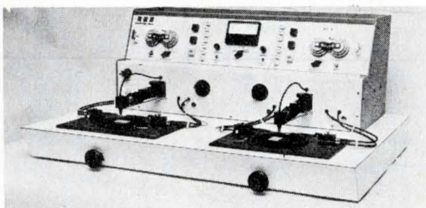


K12 series units convert 11-13 Vdc to 115, 220, or 440 Vac, 60 Hz at 120 VA. Regulation is within ±0.2% for input variations of 11 to 13 Vdc, and within 1% limits for load changes of ½ to full load. Output voltage is adj. over a range of ±10% from nom. Abbott Transistor Laboratories, Inc., 5200 W. Jefferson Blvd., Los Angeles, Calif. 90016. (213) 936-8185.

Circle 278 on Inquiry Card

RESISTOR TRIMMER

Semi-automatic unit.



Model DT-5 dual station abrasive thick film resistor trimmer has typical production rates of 1500 resistors/h. It can trim to accuracies of 0.1%. Range is 10 Ω to 1 M Ω. Each station is independent so resistors of different value and desired accuracy can be trimmed simultaneously. Modern Printing Methods Corp., 9 Harvey St., Cambridge, Mass. 02140.

Circle 279 on Inquiry Card

NEON LAMP

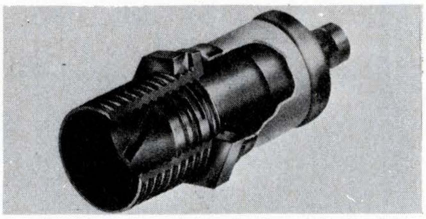
Has built-in limiting resistor.

The MSC 115 Vac lamp operates at 105-125 Vac or 150 Vdc, providing high intensity brightness adequate for most applications of midget lamps. Lamps with built-in current limiting resistors are available in three types featuring average life of 1500, 10,000 and 25,000 hrs. They meet all applicable requirements of Mil-E-5272. Master Specialties Co., 1640 Monrovia, Costa Mesa, Calif. 92627. (714) 642-2427.

Circle 280 on Inquiry Card

HIGH Q CAPACITORS

Self resonant freq. above 6 GHz.

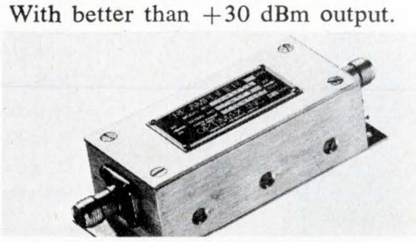


An improved and simplified drive mechanism has increased the Q of these air trimmer capacitors over other std. air units. Typical readings are 5000 at 10 pF and 10,000 at 3.5 pF. This series includes self resonant freq. above 6 GHz and low dynamic noise during adjustment. Johanson Mfg. Corp., 400 Rockaway Valley Rd., Boonton, N. J. 07005.

Circle 281 on Inquiry Card

SS AMPLIFIER

With better than +30 dBm output.

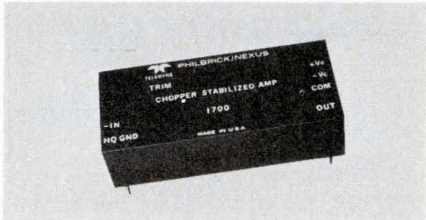


Model A51DIO-M2 Class "A" amplifier has a 1 W linear output capability from 10-500 MHz. Operating from 28 Vdc, the amplifier measures 2 x 4 x 6 in. Intermodulation products are down a min. of 20 dB over the freq. range of 100-500 MHz. Gain is 22 dB, with gain ripple < 1 dB across the passband. Optimax, Inc., 258 Main St., Ambler, Pa. 19002.

Circle 282 on Inquiry Card

STABILIZED AMPLIFIER

Totally encapsulated, high-speed.

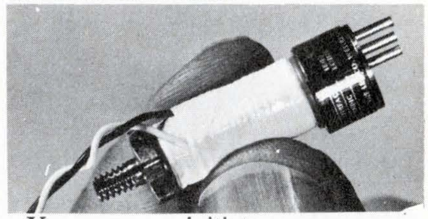


Model 1700 stays within its required specs over its entire op. temp. range of −25° to +85°C. A stable high gain of 10^8 and an offset voltage TC of 0.2 μV/°C (Model 170002) assure high accuracy. Model 1700 provides a typical gain-bandwidth product of 20 MHz, a full output freq. response to 1 MHz, and a typical slew rate of 200 V/μs. Philbrick/Nexus Research, Allied Dr. at Rte. 128, Dedham, Mass. 02026. (617) 329-1600.

Circle 283 on Inquiry Card

FLUIDIC INTERFACE

Electrical and fluidic.

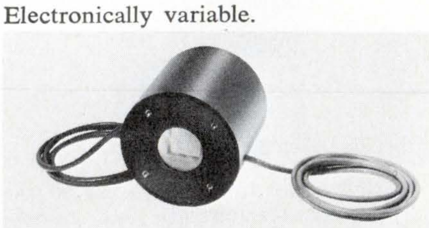


You can now initiate a sequence or override a fluidic control system from an electric ext. signal source with "Interface." Designed for 12 Vdc, its low power requirements make it useful in control circuits. It eliminates time lags previously associated with fluidic controls installed far from a signal source. The Lee Co., 2 Pettipaug Rd., Westbrook, Conn. 06498. (203) 399-6281.

Circle 284 on Inquiry Card

OPTICAL COLOR FILTER

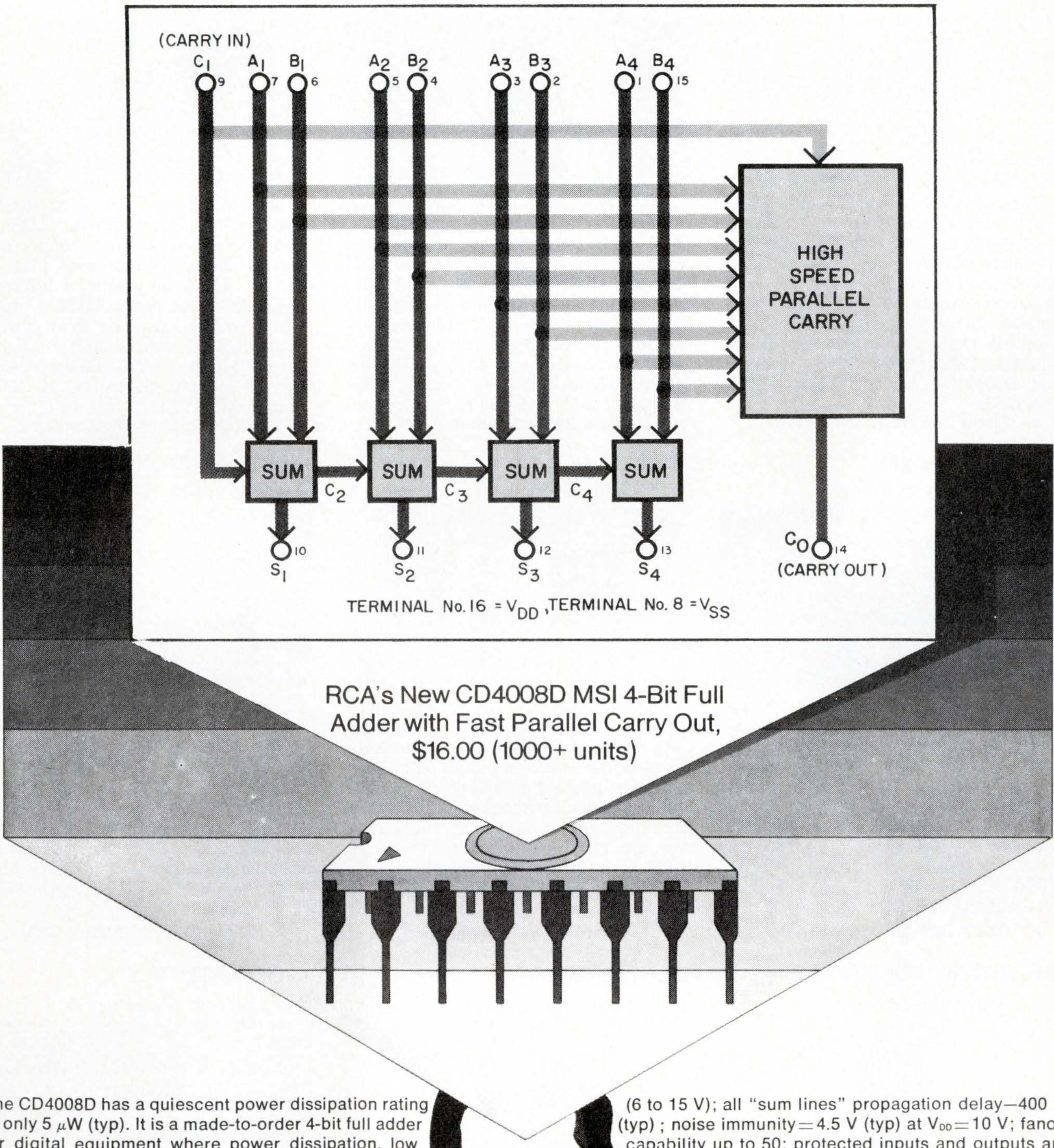
Electronically variable.



Optichron filter is useful with lasers, TV, optical data processing, graphic arts and display systems. Voltage tuneable over the visible spectrum, it can be modulated from dc to > 8 MHz. Model 24 passes cyan from 0 to 2kV magenta from 5 to 7 kV and yellow from 9 to 10 kV. $450. Electrochrome Corp., 11 Commercial St., Plainview, N.Y. 11803. (516) 433-0808.

Circle 285 on Inquiry Card

COS/MOS makes other low-powered IC logic circuits look power-hungry



RCA's New CD4008D MSI 4-Bit Full Adder with Fast Parallel Carry Out, $16.00 (1000+ units)

The CD4008D has a quiescent power dissipation rating of only 5 μW (typ). It is a made-to-order 4-bit full adder for digital equipment where power dissipation, low package count or high noise immunity are primary design prerequisites.

You don't have to wait for summing before the carry signal is available with the CD4008D. The new adder includes a high speed parallel carry circuit that provides a fast carry output signal [t_{pd} (C_i-C_o) = 50 ns (typ) at C_L = 15 pF] to permit high speed operation in arithmetic sections that may require several CD4008D's. Add to that: operation from a single power supply (6 to 15 V); all "sum lines" propagation delay—400 ns (typ); noise immunity = 4.5 V (typ) at V_{DD} = 10 V; fanout capability up to 50; protected inputs and outputs and operation over the full military temperature range. Here you have a 4-bit full adder that will fulfill many circuit applications.

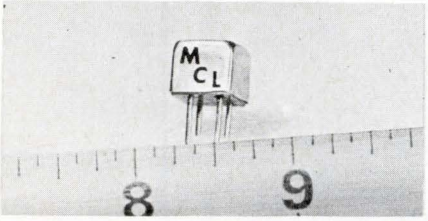
For further details, see your local RCA Representative or your local RCA Distributor. Or write to RCA Electronic Components, Commercial Engineering, Section ICJ-2 CD20, Harrison, N. J. 07029. In Europe: RCA International Marketing S.A., 2-4 rue du Lièvre, 1227 Geneva, Switzerland.

THINK ABOUT IT.

RCA Integrated Circuits

DOUBLE BALANCED MIXERS

Only 0.05 cubic inches.

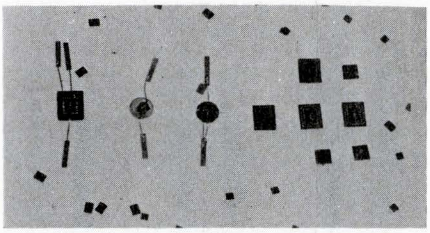


The ASK-2 is a 25 kHz to 500 MHz mixer with a bandwidth of > 14 octaves, from audio to uhf. Standard performance includes good conversion efficiency and noise figure typ. < 6 dB throughout most of the freq. range. Isolation between ports ranges as high as 40 dB. Under $45 in quantity. Mini-Circuits Laboratory, 2913 Quentin Rd., Brooklyn, N. Y. 11229. (212) 252-5252.

Circle 286 on Inquiry Card

POWER TRANSISTOR CHIPS

Also on moly-tab or moly pedestals.

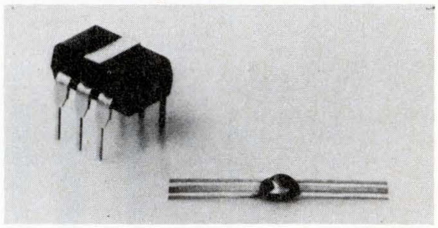


This line of silicon planar transistor chips includes the company's 2, 5, 10 and 20 A families in npn, pnp, and npn high voltage. The npn and pnp chips are offered as complementary pairs with sustaining voltages to 100 V. The npn high voltage chips come with sustaining voltages to 300 V. Solitron Devices, Inc., 1177 Blue Heron Blvd., Riviera Beach, Fla. 33404. (305) 848-4311.

Circle 289 on Inquiry Card

TRANSISTOR

Measures magnetic fields.

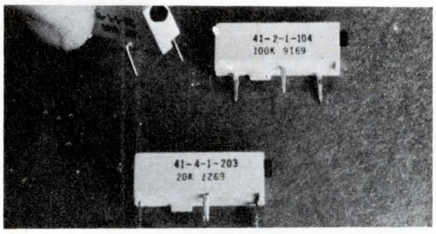


The Magnistor™ is a magnetically sensitive transistor with two collectors and one emitter. When connected to biasing circuitry similar to that used for differential amplifiers, a differential signal from the two collectors proportional to the magnetic field intensity is available. Output sens. of 0.5 mV/gauss. $3.50 (1-24) Hudson Corp., Box 867, Manchester, N. H. 03105. (603) 669-8570.

Circle 292 on Inquiry Card

CERMET TRIMMER

Three pin styles available.

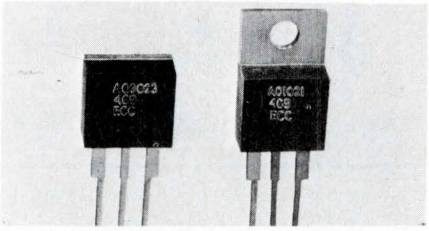


A narrow 0.16 in.-wide sealed housing and a low-profile, featured in the Model 41, allows tighter side-by-side installation and closer board stacking. The unit comes in std resistance ranges from 10 Ω to 1 M Ω with 10% and 20% tol. Temperature coefficients available to 100 ppm/°C. $1.85 ea. (1-9) Spectrol Electronics Corp., 17070 E. Gale Ave., City of Industry, Calif. 91745. (213) 964-6565.

Circle 287 on Inquiry Card

TRIACS

Electrically isolated.

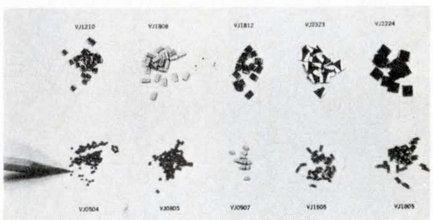


This new line of Triacs comes in a "Thermotab" package. Mylar, mica or ceramic discs or washers are not needed to isolate package or tab from heat sink. The package allows direct mounting to heat sink without loss of thermal efficiency. Triac devices in this package are rated from 1.6 to 16 A at 80°C case (tab) temp. Electronic Control Corp., 1010 Pamela Dr., Euless, Tex. 76039. (817) 267-2601.

Circle 290 on Inquiry Card

CHIP CAPACITORS

Range of 10 to 470,000 pF.

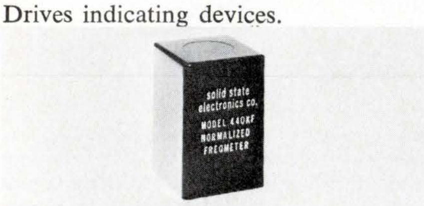


"Vee-Jem" chip capacitors come in 10 sizes (0.050 x 0.040 in. through 0.220 x 0.240 in.), for thick- and thin-film applications. Temperature range: −55°C to +125°C. Voltage ratings: 50 Vdc @ 125°C and 100 Vdc @ 85°C. Capacitance tol.: ±5%, ±10%, ±20%. Noble metals are std. termination materials. Vitramon, Inc., Box 544, Bridgeport, Conn. 06601. (203) 268-6261.

Circle 293 on Inquiry Card

FREQ.-TO-DC CONVERTER

Drives indicating devices.

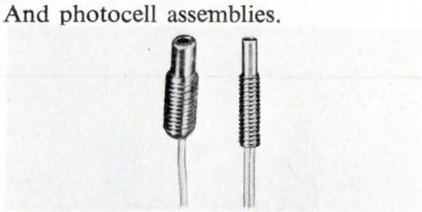


Normalized Freqmeter will linearly convert freq. or rep. rate of signals to a proportional dc voltage. This is done with four models over an input freq. range extending from 0 to 100 kHz—Model 410KF, 0 to 100 kHz; Model 420KF, 0 to 1 kHz; Model 430KF, 0 to 10 kHz; Model 440KF, 0 to 100 kHz. Solid State Electronics Corp., 15321 Rayen St., Sepulveda, Calif. 91343. (213) 894-2271.

Circle 288 on Inquiry Card

LIGHT SOURCE

And photocell assemblies.

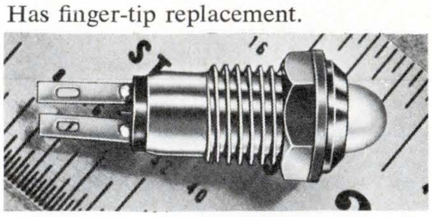


Model L-1 light source, ½ in. long x ¼ in. in dia., has a focused lens producing a parallel beam with a spot of light. Bulb is rated at over 40,000 h at 5 V. Model P-1 photocell assembly, smaller than L-1 is only 1/10 in. in dia. and ½ in. long. It uses a high sensitivity photo duo diode with a 2 μs response time. Scanning Devices Co., 179 Fifth St., Cambridge, Mass. 02141.

Circle 291 on Inquiry Card

LAMP ASSEMBLY

Has finger-tip replacement.

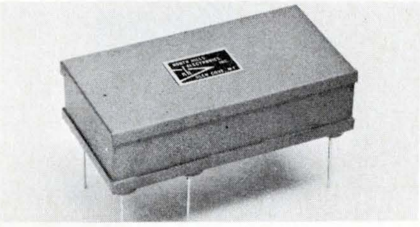


Brite Glo lamp assembly can easily be serviced from the front after it has been installed in a panel. Removable round dome lens unscrews and the T-1 lamp is exposed for removal. A std. #680 incand. lamp rated 5 V at 60 mA is supplied installed. It is only 0.500 in. behind the panel; 0.315 in. dia. $1.29 ea. Alco Electronic Products, Inc., Box 1348, Lawrence, Mass. 01842. (617) 686-3887.

Circle 294 on Inquiry Card

PHASE SEQUENCE ALARM

For PC board mounting.

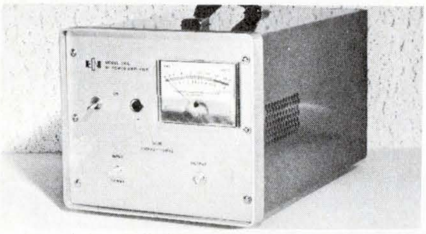


Model PK-1 alarm monitors the sequence and quadrature relationship between voltages of a two-phase system. Should the sequence be reversed, or the phase difference vary from 90°, an output signal is generated for energizing an ext. alarm and/or control circuit. It is 3.5 in. long, 1.8 in. wide and 1 in. high. $124. North Hills Electronics, Inc., Glen Cove, L. I., N. Y. 11542. (516) 671-5700.

Circle 295 on Inquiry Card

BROADBAND AMPLIFER

With over 10 W of rf power out.

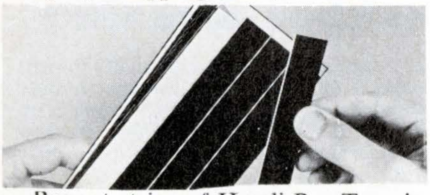


Model 310L is an untuned, ss power amplifier that can provide over 10 W of rf power output from 250 kHz to 110 MHz. Its flat 50 dB gain permits it to be driven to its full power output by all signal and sweep generators. Useful power output is available up to 150 MHz at reduced gain. Electronic Navigation Industries Inc., 1337 Main St. E., Rochester, N. Y. 14609. (716) 288-2420.

Circle 296 on Inquiry Card

PRE-CUT TAPES

Simplify wrapping wires, cables.



Pre-cut strips of Handi-Pac Tape in pocket size dispenser books provide an easy way to splice, insulate, tie or code wires and cables. Because only the length of tape itself is involved in wrapping the wire, your hands are free to complete the application firmly, with ease and speed. No tools are needed for cutting. W. H. Brady Co., 726 W. Glendale Ave., Milwaukee, Wis. 53201. (414) 332-8100.

Circle 297 on Inquiry Card

NEW PRODUCTS

HE-NE LASERS

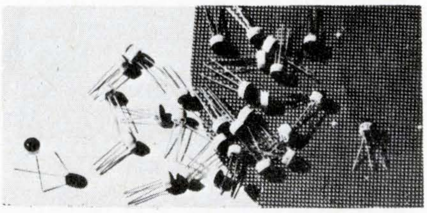
For airborne applications.

New 3 mW TEM_{00} laser designated 3079H, meets Mil-E-5400 environmental specs. It operates from $-65°$ to $+80°C$ and at altitudes from 0 to 55,000 ft. Intensity variation is $<$ 20% when subjected to temps from 0° to 55°C and when operated from sea level to 50,000 ft. Warm-up time is $<$ 10 minutes from 0°C; beam intensity modulation is $<$ 1% rms under static conditions; and $<$ 2% rms when the laser is subjected to 2.5 g vib. from 70 to 2000 Hz. Hughes Electron Dynamics Div., 3100 W. Lomita Blvd., Torrance, Calif. 90509.

Circle 298 on Inquiry Card

JUNCTION FET's

2N equivalent devices.

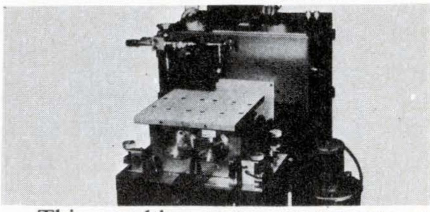


These new N-channel FETS come in TO-18 type epoxy package (TO-106) Types being introduced are: ITE3066-68—low level, low noise chopper uses; ITE4117-19 — applications requiring low leakage; ITE4338-41—multiplexer uses; ITE4391-93 — low R_{DS} (on) switch applications; ITE4416 — vhf/uhf front ends; ITE4867-69 — audio applications requiring ultra low noise devices; and the 2N5163, a low noise, general purpose amplifier and switch. Intersil Inc., 10900 N. Tantau Ave., Cupertino, Calif. 95014. (408) 257-5450.

Circle 299 on Inquiry Card

VIBRATION MACHINE

Tests ICs and semiconductors.



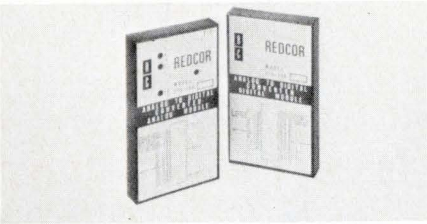
This machine tests components at acceleration levels to 70 g. The RV-16-50 has a mechanical vibration generator which operates in the freq. range of 10 to 1000 Hz. It tests ICs for Mil-STD-883, Method 2005. Features are heavy duty hydrodynamic sleeve bearings with forced oil lubrication, no gears in the vibration table, cooling water circulating through the table and bearings housings, a low inertia torsion bar suspension system and cooling water control. L.A.B. Corp., 500 Onondaga St., Skaneateles, N. Y. 13152.

Circle 300 on Inquiry Card

SYSTEMS EQUIPMENT

MODULAR A/D CONVERTER

Conversion time is 50 μs ±4 μs.

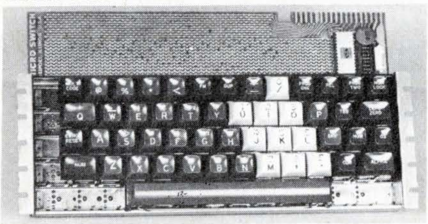


Model 770-754 is a 13 bit converter contained in two 5.2 in.^{3} modules. One contains the digital portion and the other the analog portion of the converter. Five different output codes are available: Straight binary, one's complement, two's complement, offset binary, and BCD. Accuracy is ±0.015% of F.S., ±½ LSB. $725.00. Redcor Corp., 7800 Deering Ave., Box 1031, Canoga Park, Calif. 91304. (213) 348-5892.

Circle 301 on Inquiry Card

TERMINAL KEYBOARD

MOS-encoded.

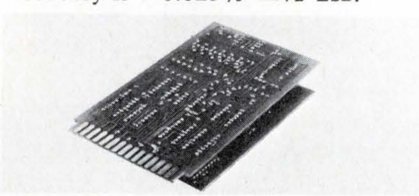


This keyboard uses a large scale IC to handle all of its electronic signal-coding tasks for remote communications terminals and data-preparation devices. It generates up to four levels of code from the same key. It is compatible with any terminal system logic: high- and low-level MOS, DTL, TTL, and RTL. Micro Switch, div. of Honeywell Inc., Chicago & Spring Sts., Freeport, Ill. 61032.

Circle 302 on Inquiry Card

A/D CONVERTERS

Accuracy is ±0.025% ±½ LSB.



AD300 Series includes 14 std. models. They provide binary or BCD output code with 8, 10 or 12-bit binary or 12-bit BCD resolution. They digitize at a rate of about 10,000 conversions/s. Models are available that operate at rates to 20,000 conversions/s with slightly reduced accuracy. Computer Products, 2709 N. Dixie Hwy, Box 23849, Ft. Lauderdale, Fla. 33307. (305) 565-9565.

Circle 303 on Inquiry Card

DATA TERMINALS

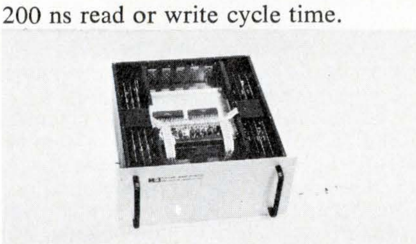
Has a solid state printhead.

Series 720 terminals are compatible with KSR (keyboard send-receive) 33 to 35 teletypewriters. They are offered in USASCII and BCD codes and in keyboard and receive-only models. The new data terminal models (15, 20, 21, 22, 30 and 31) are almost silent at speeds up to 40 char./s. All models use a 5 x 7 matrix pattern. Texas Instruments Incorporated, Box 66027, Houston, Tex. 77006. (713) 526-1411.

Circle 304 on Inquiry Card

PLATED WIRE MEMORY

200 ns read or write cycle time.

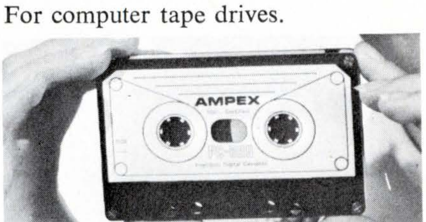


System/200's basic module is 1024 words by 36 bits and is expandable upward or downward. It is a two cross-over/bit system with single turn word straps, using a one transistor/word line matrix and gated preamplifiers in the sense-digit loop. High speed TTL logic is used throughout. Memory Systems, Inc., 3341 W. El Segundo Blvd., Hawthorne, Calif. 90250. (213) 772-4220.

Circle 305 on Inquiry Card

DIGITAL CASSETTE

For computer tape drives.



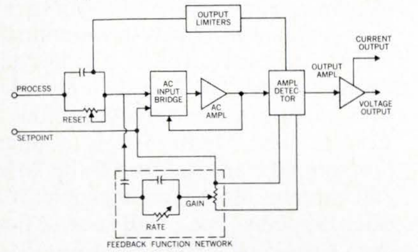
Series PC-800 precision cassette was designed specifically for cassette tape drives used as computer peripheral devices. It uses a precision metal plate, steelbearing mounted fixed hubs, and a four-point tape path system. Other features: self-aligning precision rollers, new pressure pads and a new hub construction principle. Ampex Corp., 401 Broadway, Redwood City, Calif. 94063. (415) 367-4151.

Circle 306 on Inquiry Card

LITERATURE

Control systems

Featuring solid state circuitry, the Veritrak® system encompasses a comprehensive line of transmitters, receivers, controllers, recorders, computer control stations, preassembled packages for specific analog computing applications and related accessories for analog and direct digital control systems. Details are provided for you in a 20-page bulletin which introduces,



among other instruments, two major units — the Veritrak® performance optimizing controller, operating directly on analog signals to achieve the efficiencies of computer control, and the computer control station, a compact solid state process control instrument for computer/process interface in DDC and supervisory systems. Motorola Instrumentation and Control Inc., Box 5409, Phoenix, Ariz. 85010.

Circle 370 on Inquiry Card

Power semiconductors

Pirgo NPN and PNP silicon planar power transistors, which exhibit low saturation voltage at maximum collector current, are listed in a 26-page brochure. Ratings range from 2 to 90 as the transistors are packaged in a variety of cases. Operating characteristics are listed in chart form and graphs are included by Pirgo, an affiliate of Sprague. Sprague Products Co., North Adams, Mass. 01247.

Circle 371 on Inquiry Card

Instrumentation

Electronic test and measuring instruments are shown in a 24-page publication. Among those products and systems described are oscillographs, X-Y and magnetic tape recorders, signal—conditioning equipment, digital multimeters, transducers and RFI/EMI surveillance and analysis equipment. A picture accompanies the write-up of each instrument available, and the capabilities of each instrument are discussed. Honeywell Test Instruments Div., Box 5227, Denver, Colo. 80217.

Circle 372 on Inquiry Card

Insulating materials

For the designer of transformers here is a 12-page guide to insulating materials and systems. Electrical insulating materials are the subject of the brochure, and it describes the latest in materials for use from the initial structural frame to the final life-lengthening encapsulation. It tells you where to specify each material, what to use for various temperature ranges and what to specify for special environmental conditions. 3M Co., Dielectric Materials and Systems Div., 3M Center, St. Paul, Minn. 55101.

Circle 373 on Inquiry Card

Diffractometer

In this 14-page bulletin you will find a complete description of the Model ADG-301 X-ray diffractometer system. To help you better understand the working features of the instrument, detailed specs are given for its compo-

nent parts — X-ray generator, timer, X-ray tubes and tube housings, goniometer and recorder. Typical readout charts are reproduced and block diagrams illustrate its construction. Beckman Instruments Inc., 2500 Harbor Blvd., Fullerton, Calif. 92634.

Circle 374 on Inquiry Card

Transistors and ICs

Two catalogs are offered to you on these subjects. A condensed catalog provides pertinent information on small signal and power transistors. All devices are indexed by type number allowing easy access to information. ICs and discrete devices are the subjects of a second catalog. Electrical characteristics are given in chart form and outline drawings are provided for several models. Comprehensive data sheets, application notes, detailed catalogs and reliability data are available. Solitron Devices Inc., 1177 Blue Heron Blvd., Riviera Beach, Fla. 33403.

Circle 375 on Inquiry Card

Cable control systems

"Why Use Cable Tension Regulators" supplies data enabling the control systems engineer to calculate the effect on cable control systems of thermal deflections, structural deflections and aircraft pressurization. The 15-page bulletin illustrates many available design variations including designs for the new jumbo jets. Pacific Scientific Co., 1346 South State College Blvd., Anaheim, Calif. 92803.

Circle 376 on Inquiry Card

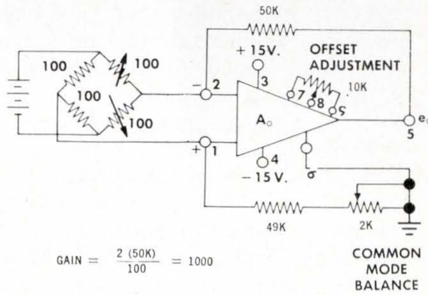
Mini beam lamp

A miniature beam lamp, designated PAR-16, was developed to meet the need for a small, high performance, low voltage lamp that could function in extreme climatic conditions. Suggested applications are provided in the 4-page foldout brochure that discusses the lamp, as are specs. Tung Sol, Div. Wagner Electric Corp., 1 Summer Ave., Newark, N. J. 07104.

Circle 377 on Inquiry Card

Solid state modules

For each product promoted in this 32-page catalog you will find a general description of the product's physical characteristics, its capabilities and applications. A photograph and/or schematic accompany each description. All units are of completely solid state design and miniature modular construction, assuring stable operation through shock, vibration and accelera-



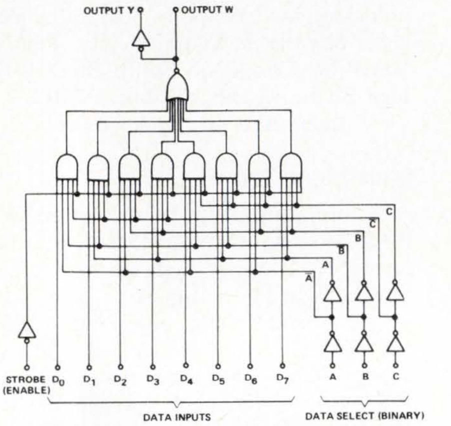
Bridge amplifier built using a differential operational dc amplifier.

tion. Included are such items as the model 3002 dc operational amplifier which features an active internal low-power temperature regulator, isolated within a high thermal resistance package, to maintain a constant substrate temperature above the highest ambient up to 125°C. Solid State Electronics Corp., 15321 Rayen St., Sepulveda, Calif. 91343.

Circle 378 on Inquiry Card

TTL data selectors

In digital systems, where information from multiple sources must be processed, stored, transferred or handled in some other way, it is necessary to have circuits that provide selective access to information sources. This 18-page report discusses applications of these circuits being used for random



Data Selectors SN54/74151— Functional Block Diagram

and sequential data selection, parallel-to-serial conversion, multiplexing to multiple lines, binary word comparison, character generation and implementation of logic functions. Texas Instruments Inc., Box 5012—M/S 308, Dallas, Texas 75222.

Circle 379 on Inquiry Card

Signal processor

A digital signal processing system, designated CompuSignal System-3 (CSS-3), is the subject of an 8-page brochure. Applications for the device which have already been investigated lie in the areas of geophysics, shock vibration, acoustics, marine sonics, biomedicine, radio astronomy and communications/intelligence. Typical performance spectra are provided. Computer Signal Processors, Inc., 209 Middlesex Trpk., Burlington, Mass. 01803

Circle 380 on Inquiry Card

Chemical product index

An index of industrial, specialty and fine chemicals is contained in a 12-page booklet. Properties for the various chemicals, which are listed by product group, are included in the listing. Cellulose products with applications are described. Eastman Chemical Products, Inc., 1133 Ave. of the Americas, New York, N.Y. 10036.

Circle 381 on Inquiry Card

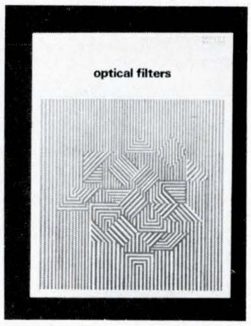
Audio recorders

Product descriptions are not just product descriptions as this company presents two case histories of the use of their recording equipment. One of the two 2-page bulletins tells of the introduction of multichannel audio recorders to a creative recording studio in New York City. The other describes the use of multichannel recorders by a studio in Calif., as both industry and studio meet the growing demand for electronic products used for creative effects. Ampex Corp., 401 Broadway, Redwood City, Calif. 94063.

Circle 382 on Inquiry Card

Optical filters

A comprehensive discussion of optical interference filters is contained in a 24-page reference book. Detailed in the handbook are narrow band UV filters, wavelength IR filters, neutral density filters, and multilayer dielectric filters. Suggested as a reference for



those involved in research, industry, aerospace, the military and medicine, the guide includes photos, diagrams and specs for the entire filter line. System Components Div., Baird-Atomic, Inc., 125 Middlesex Turnpike, Bedford, Mass. 01730.

Circle 383 on Inquiry Card

Solid state choppers

The solid state chopper (or modulator) is a rigidly encapsulated unit designed to alternately connect and disconnect a load from a signal source. It may also be used as a demodulator to convert an ac signal to dc. It is capable of linearly switching or chopping voltages over a wide dynamic range which extends down to a fraction of a millivolt and up to 150 volts or more. This and more information on a complete line of choppers (30 types) is available in a 62-page catalog from Solid State Electronics Corp., 15321 Rayen St., Sepulveda, Calif. 91343.

Circle 384 on Inquiry Card

Micro 800 computers

All your questions concerning the Micro 800 and 810 computers will be answered in this 16-page brochure. Simply organized, but thoroughly informative, the brochure first presents a "mini-seminar," a two-page discussion on the basic characteristics of each computer. It then takes each model and gives its general description, specs, a block diagram, and its functional organization. To start you off, we'll tell you that the Micro 800 is a high-speed, micro-programmable digital computer which executes programs located in a read-only store with a command execution time of 220 ns. The Micro 810 is a microprogrammed adaptation of the Micro 800 system. Both are available from MicroSystems Inc., Sub. of Microdata Corp., 644 E. Young St., Santa Ana, Calif. 92705.

Circle 385 on Inquiry Card

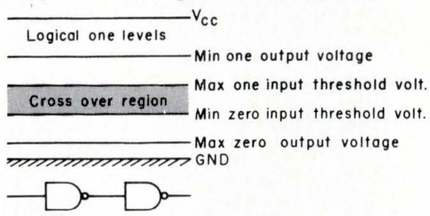
Crystals concept

A 76-page source covers data on single crystals. Information on each crystal includes growth method, crystal structure and purity, as well as a breakout of each element from a periodic table. An introduction to the growth of single crystal materials is provided. Alfa Crystals, Bradford. Pa. 16701.

Circle 386 on Inquiry Card

Application memos

This interesting book (416 pages) does justice to its name—its full of applications, with very few commercials. Most of the applications are, of course, for circuits Signetics makes, but they are written to help you solve a problem, rather than select a product. The applications start from the very basic background of digital ICs—



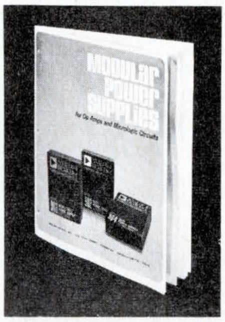
DC noise margin representation

there is even an excellent "glossary" of logic terms—and work their way up to more specialized applications for both linear and digital ICs, such as oscillators, log amplifiers, TV waveform generators and arithmetic circuits. Signetics Corp., 811 East Arques Ave., Sunnyvale, Calif. 94086.

Circle 387 on Inquiry Card

Modular power supplies

Modular dc sources for use in power and reference applications are discussed in a 12-page catalog. The power supplies described have been designed for power op amps and related analog



circuitry that require dual ±15 Vdc. Operating characteristics, schematics and a power supply directory are included in the reference. Analog Devices, Inc., 221 5th St., Cambridge, Mass. 02142.

Circle 388 on Inquiry Card

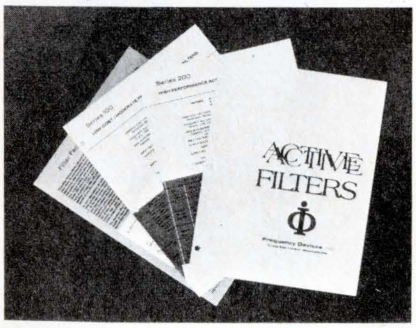
VHF tuner requirements

A 15-page application report discusses the VHF input stage with FET or bipolar transistors. Using the FET, it is possible to substantially improve large signal characteristics of the input stage. Schematics are included in the note, as are charts and graphs. Telefunken, South St., Roosevelt Field, Garden City, N. Y. 11530.

Circle 389 on Inquiry Card

Filter facts

A 6-page active filter report provides the systems engineer with data needed for selection of proper filter characteristics. Tables of transfer functions and plots of frequency response,



step response, and time delay are provided for 2-6 poles. High pass, low pass, bandpass, and band reject filters are described. Frequency Devices, Inc., 25 Locust St., Haverhill, Mass. 01830.

Circle 390 on Inquiry Card

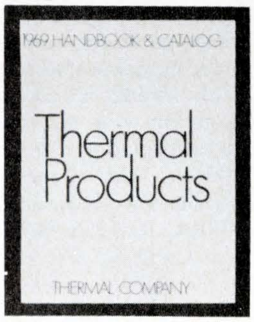
IC wideband amp

Principal features of RCA's CA3040 IC wideband amplifier are discussed in application note ICAN-5977. Operation of the IC is covered as are electrical characteristics, ratings and its primary appplication as a wideband amplifier. Schematics are provided throughout the note. RCA, Electronic Components, Harrison, N. J. 07029.

Circle 391 on Inquiry Card

Thermal products

Information about the availability and uses of thermal products for the measurement or exchange of thermal energy is offered to you in this 206-page catalog. More than 40 pages are devoted to engineering data, such as thermal properties of materials, ther-



moelectric tables and calculation aids —handbook data. Section II lists its products by temperature measurement, heat measurement, heat application, heat removal, and tools and supplies. This versatile catalog is yours from Thermal Corp., Box 5327, Huntsville, Ala. 35805.

Circle 392 on Inquiry Card

Signal conditioners

Before this 20-page bulletin describes and illustrates the individual models available in the 9800 series of input signal-conditioning couplers, it devotes two pages to a coupler application guide and two pages to a physiological measurement guide. The couplers are compatible with all high-sensitivity Dynograph® recorder systems using the Type 481B or Type 461B preamplifier, including the Biomedical Standard R, Types R, RP, RS, R-2005 and S-II. The guides help you to choose the proper model according to the function to be recorded and the type of transducer. Beckman Instruments, Inc., Electronic Instruments Div., 3900 River Rd., Schiller Park, Ill. 60176.

Circle 393 on Inquiry Card

LITERATURE

Digital processor

Designed for economical high-speed time-series analysis and synthesis under computer control, the Time/Data 90 is the subject of a 7-page catalog. The system, which is an all digital processor offering fast Fourier transforms and power spectrums, can be used independently or coupled with most computers. Standard system configurations are included in the brochure. Time/Data Corp., 490 San Antonio Rd., Palo Alto, Calif. 94306.

Circle 394 on Inquiry Card

Semiconductor products

"The zener specialists" will send you a 24-page catalog covering their standard product line and introducing a complete line of semiconductor chips now being used in thick- and thin-film hybrid microcircuits. If you are a zener user you will find the line has expanded to cover requirements up to 5 W in micro-packages, and to include temperature-compensated reference devices. Each product is accompanied by a chart giving you all the essential technical information for your selection. Address your request on company letterhead to Centralab Semiconductor, Dept. A, 4501 N. Arden Dr., El Monte, Calif. 91734.

Coaxial-package transistors

Application note 4025, titled "The use of coaxial-package transistors in microstripline circuits" describes the design, construction and performance of microstripline circuits using 2N5470 coaxial transistors. The two circuits discussed are a 1.5 GHz amplifier which provides 1.5 watts of output power with 8.0-dB power gain and 50% collector efficiency, and a 2-GHz amplifier which provides 1.2 watts of output power with 6-dB power gain and 40% collector efficiency. Schematics and Smith chart diagrams are included. RCA, Electronic Components, Harrison, N. J. 07029.

Circle 395 on Inquiry Card

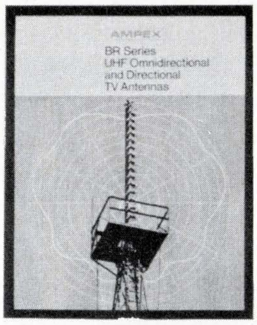
Photomultiplier tubes

Catalog PIT-700A is an expanded and updated version which includes preliminary selection information on photomultiplier tubes, image converter tubes, photodiodes and electro-multipliers. Physical characteristics for the devices are provided in the 57-pager, as are schematics.

Available for 80¢ from RCA, Electronic Components, Harrison, N. J. 07029.

TV antennas

Omnidirectional and directional UHF antennas for commercial and educational broadcasters are described for you in this 6-page brochure. To help you with your selection, vertical and



horizontal plane patterns are explained and illustrated, and a 2-page chart gives gives you the complete specs for each model. Ampex Corp., M.S. 7-13, 401 Broadway, Redwood City, Calif. 94063.

Circle 396 on Inquiry Card

Neon glow lamps

Applications for neon glow lamps, as circuit components and voltage regulators, are outlined in a 12-page brochure. Twenty-two circuit applications are listed for the lamps, as in vidicons, photomultipliers, power supplies and remote controls, among others. Signalite Inc., 1933 Heck Ave., Neptune, N. J. 07753.

Circle 397 on Inquiry Card

Vacuum/coater systems

Suggested for those using vacuum deposition equipment, a 20-page brochure describes and provides a working knowledge of vacuum/coater systems. Included in the catalog are vacuum performance graphs, space and

utility requirements, and descriptions of the various available systems. Modular options for the equipment are discussed and include pumping modules, power supplies and feed-throughs. Norton Co., 160 Charlemont St., Newton, Mass. 02161.

Circle 398 on Inquiry Card

Seminar and Workshop

APPLICATIONS OF INTEGRATED CIRCUITS TO COMMUNICATIONS

sponsored by
THE ELECTRONIC ENGINEER
magazine

When:

Tuesday, February 17, 1970
8:00 A.M. to 5:00 P.M.
(the day before the International Solid State Circuits Conference in Philadelphia)

Where:

Pennsylvania East Room
Sheraton Hotel
Philadelphia, Pa.

THE SEMINAR: (8:00 A.M. to 12:30 P.M.)

A series of papers devoted to practical applications of the new families of ICs to communications and consumer products.

Moderator: J. Lightsey Wallace, Atlantic Research Corp.

Phase-lock loops in communications systems

Arthur Fury
Signetics Corp.

How and where to use phase-locked loops. Applications in telemetry and fm stereo include decoders, demodulators, i-f strips and limiters, etc.

AGC—the old dynamic range with good signal-to-noise trick

Jack MacIntosh and Tom Mills
Fairchild Semiconductor

Automatic gain control and how to apply it to high gain, wideband and wide dynamic range i-f amplifiers. Ssb generators, i-f product detectors, and two-tone intermodulation distortion will be demonstrated.

Complex communications functions with ICs

Ted Hanna
National Semiconductor

How to combine a few ICs to obtain a multitude of communications functions, such as ssb and video amplifiers.

Modulation, rf/i-f amplification, and multiplexing

Roy Hejhall
Motorola Semiconductor Products Div.

Integrated circuits are changing rf design concepts. Here's how to use them for balanced modulators, vhf i-f's, ssb receivers, etc.

A-m/fm receivers with ICs

Ronald W. Lutz
Sprague Electric Co.

ICs for limiter/detector circuits a-m/fm i-f strips as used in both TV and fm receivers.

Large scale integration of TV circuits

Dan Gertzis
Amperex Electronic Corp.

A complex circuit, whose functions include video preamplification, agc detection and amplification, noise gating, sync separation, etc., serves as central processor and distribution circuit in TV receivers.

Luncheon

THE WORKSHOP: (2:00 P.M. to 5:00 P.M.)

Here's an opportunity to get your hands on the circuits described in the morning session. There will be test equipment and breadboards available to test the circuits.

ADVANCED REGISTRATION FORM

Tear off and mail to:

Communication ICs Seminar
THE ELECTRONIC ENGINEER
Chilton Publishing Co.
One Decker Square
Bala Cynwyd, Pa. 19004

*Make check or money order payable to Communications ICs Seminar; all payments will be acknowledged.

Enclosed is my check (money order) in the amount of $45.00* ($55.00 after February 6) to enroll me in the Seminar and Workshop on the "Applications of Integrated Circuits to Communications" to be held Tuesday, February 17, 1970 at the Sheraton Hotel in Philadelphia, Pa. This fee covers attendance, one issue of the Proceedings, and luncheon and coffee break.

NAME ____________________ TITLE ____________

COMPANY ____________________ DIVISION ____________

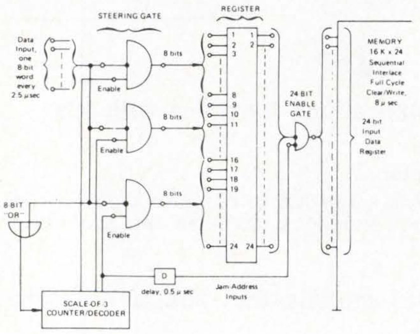
STREET ________________________________

CITY ____________ STATE ____________ ZIP ________

LITERATURE

Digital memories

A rather comprehensive 28-page applications manual titled "How to use digital magnetic core memories" contains 172 practical applications including interface. The handbook provides a review of how a coincident-current magnetic core memory system works, and includes a section on the func-



tional capabilities of such a system. Applications covered are digital data links, instrumentation systems, business data machines, process control and monitoring, telemetry and communications, and data processing and organization. Ferroxcube Corp., Saugerties, N. Y.

Circle 399 on Inquiry Card

Wire systems

Featured in this 16-page catalog is the "P/2/P" wire terminating system, a semi-automatic type capable of terminating wires in electronic production applications by wire wrapping, clip-on, or taper pin insertion. Other sections tell you about applications, programming the numerical control unit, comparing incremental and absolute controllers, software and accessories. The final section compares in detail three wire terminating methods—manual, semi-automatic and fully automatic—giving you a basis for evaluating the correct method for your company's wire wrapping operations. Synergistic Products Inc., 150 E. Stevens Ave., Santa Ana, Calif. 92707.

Circle 400 on Inquiry Card

Crimping tools

Catalog T103 covers crimping tools for a variety of applications and includes class I and II specs of MIL-T-22520. Included in the booklet are crimp tool phraseology and suggested crimping techniques. A description of available tools is provided, with illustrations and specs for each. Buchanan Electrical Products Corp., 1065 Floral Ave., Union, N. J. 07083.

Circle 401 on Inquiry Card

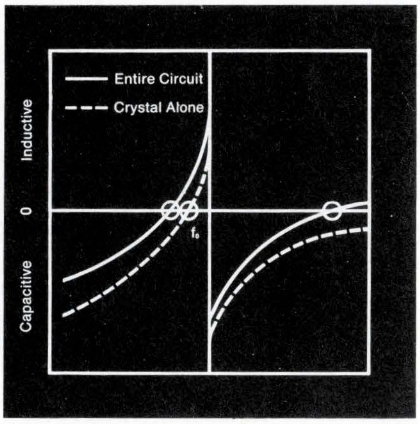
Heat sinks for SCRs

A series of heat sinks, designed for use with high power, flat pack type rectifiers termed "hockey-pucks," are described in a 6-page catalog. Permitting a variety of solutions to such problems as heat dissipation, packaging, bussing and stacking, the high current dissipated heat sinks can be used effectively with either natural or forced convection cooling. Performance curves as well as outline dimensions are provided. Astrodyne Inc., 207 Cambridge St., Burlington, Mass. 01803.

Circle 402 on Inquiry Card

Crystal oscillators

Damon VCXOs are crystal oscillators with voltage-controlled reactive components that provide variations in output frequency without materially affecting the crystal frequency stability. With this 10-page catalog you will



learn of product applications; you will receive background information on stability and spectral purity; and you will be informed of essential VCXO characteristics. Damon/Electronics Div., 115 Fourth Ave., Needham Heights, Mass. 02194.

Circle 403 on Inquiry Card

Switches

Lighted matrix displays and switches are described in a 46-page catalog giving complete descriptions for matrix display/switching systems, four-lamp and single-lamp pushbutton switches for individual mounting power rotary switches and miniature indicator lights. Product series features, performance and environmental specs, dimensioned views, schematic diagrams, legend availability and arrangements and outline drawings are included. Stacoswitch, 1139 Baker St., Costa Mesa, Calif. 92626.

Circle 404 on Inquiry Card

Permanent magnets

The "do's" and "dont's" of magnet design are illustrated for you in a 4-page paper titled "Mechanical Design of Permanent Magnets." Although short, the article is very comprehensive and covers such topics as magnet material selection and mounting methods. It compares the characteristics and usability of the three material types and gives the benefits of the various protective coatings. A chart gives you the properties of permanent magnets according to their material composition. Indiana General Corp., 405 Elm St., Valparaiso, Ind.

Circle 405 on Inquiry Card

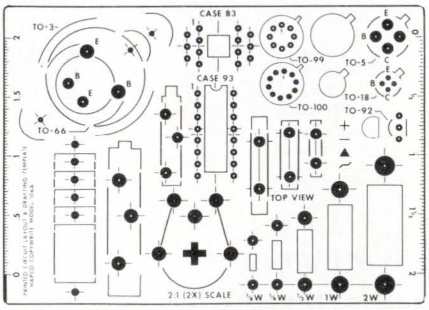
Laser guide

Various aspects of laser measurement are the subject of a 2-page data sheet. Different measurement situations are discussed with specific reference to applicable units, transducers and measurement devices. A reference chart of available measurement systems is included in the guide. International Light, Dexter Industrial Green, Newburyport, Mass. 01950.

Circle 406 on Inquiry Card

PC design

"Printed Circuit Design and Documentation: A Straight Forward System" is a 16-page short course on PC design. In PC manufacturing, communication is initially the responsibility of the designer. This presentation describes a system with which the designer can adequately communicate the requirements of each circuit to the fabricator, component purchasers

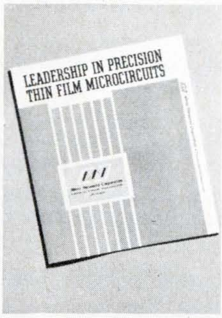


and assemblers, technical writers and customers. In addition to saving up to 70% of the normal drafting time, this system can essentially eliminate errors caused by poor communication. Typical layout and taping sequences are illustrated and described for you, and a layout and spec guide recommends various components according to their usage. HAPCO, Box 1205, Boulder, Colo. 80302.

Circle 407 on Inquiry Card

Manufacturing thin-film microcircuits

The processing philosophy and materials characteristics involved in producing thin-film microcircuits are discussed in a 6-page brochure. Such



topics as electrical circuit design, thin-film evaporation, photoresist, resistor trimming testing and quality assurance are dealt with. Micro Networks Corp., 5 Barbara Lane, Worcester, Mass. 01604.

Circle 408 on Inquiry Card

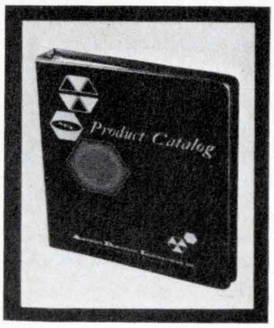
Stepping motor

A 16-page application note discusses the principles upon which an electronic stepping motor is based. Designated model 110, the motor offers 1/3 hp at speeds up to 8000 steps per second. The theory of the motor is described in non-technical terms as are its construction and application, including electronic driving techniques. Comparisons with other electronic steppers are provided, demonstrating how model 110's substantial performance differential over other motors is achieved. Icon Corp., 156 6th St., Cambridge, Mass. 02142.

Circle 409 on Inquiry Card

Microwave products

A 100-page technical catalog covers a line of microwave products. Information on antennas, microwave components, semiconductor diodes, fil-



ters, solid state sources, multipliers, testers, and instruments is provided. American Electronic Labs., Inc., Box 552, Lansdale, Pa. 19446.

Circle 410 on Inquiry Card

Beam lead bonder

Not only does this 4-page brochure give you the essential characteristics of the product it is meant to sell, but it goes into a description of how the bonding machine works. In narrative form you learn both the features of the product and how it works. "One of the major innovations of this machine is the unique optical system that makes possible direct alignment of tool and die as well as die and workpiece." Pictures and diagrams illustrate the step-by-step description. Kulicke and Soffa Industries Inc., 135 Commerce Dr., Industrial Park, Fort Washington, Pa.

Circle 411 on Inquiry Card

Digital data system

The H4200 digital data system monitors and measures temperature, pressure, load, thrust, voltage and resistance directly in engineering units. You will find all information clearly outlined in this 24-page brochure. The two digital indicators are pictured, diagrammed and described with specs and a chart providing information on ranges and accuracies. Comparable information is given for the scanners, scan extenders, the digital limit comparator and the output converter. Howell Instruments Inc., 3479 W. Vickery Blvd., Fort Worth, Texas 76107.

Circle 412 on Inquiry Card

Solid state relays

In this 4-page bulletin you will become familiar with the applications and features of a solid state DPDT relay incorporating conventional semiconductor devices in a hybrid, microelectronic assembly. Three models are diagrammed for you—the NSW 2001, NSW 3001, and NSW 4001. Application notes are given and a diagram shows how the relay is connected in the circuit. Nanotron Inc., 8720 Woodley Ave., Sepulveda, Calif. 91343.

Circle 413 on Inquiry Card

Aerospace instruments

A line of instruments for the aviation and aerospace industries are listed in a 14-page brochure. Design data for each of the devices are included in the catalog as are operating characteristics and physical dimensions. Products discussed range from standard illumination devices for aviation use to instruments for space applications, including trim and event indicators. Weston Instruments Inc., 614 Frelinghuysen Ave., Newark, N. J. 07114.

Circle 414 on Inquiry Card

LITERATURE

Bite indicators, an internal drum-type for front panel mount where legend or character displays are required, and a Braille type for back panel mount—bulletins M-14 and M-15 respectively. Minelco, 600 S. Street, Holbrook, Mass. 02343.
Circle 415 on Inquiry Card

Reed relay scanners are high-speed switching instruments capable of connecting in a controlled manner one input to one output, bulletin 012-68. Analog Digital Data Systems Inc., 830 Linden Ave., Rochester, N. Y. 14625.
Circle 416 on Inquiry Card

Digital electrometer for research, industrial or clinical use provides five-digit direct readout measurement of ionic activity—bulletin SI-101 (4-69). Corning Scientific Instruments, Corning Glass Works, Medfield, Mass. 02052.
Circle 417 on Inquiry Card

Airbrasive® resistor trimmer automatically adjusts microresistor elements in hybrid, thick-film micro/electronic circuits—bulletin 6705-RT. S. S. White Industrial, 201 E. 42nd St., N.Y.C. 10017.
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High-speed test system for low-cost production checkout and maintenance of electronic equipment — 12-pages. TeleSciences Inc., 351 New Albany Rd., Moorestown, N. J. 08057.
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Spectrophotometric measurements without expanded scale slidewires, including proper sample handling techniques—application report 16-1. Cary Instruments, 2724 S. Peck Rd.. Monrovia, Calif. 91016.
Circle 420 on Inquiry Card

Keyboard data entry system which permits direct data entry from keyboard to magnetic tape, eliminating handling of punched cards and multiple reels or tape—publication 316-000004-000. Systems Engineering Labs., 6901 W. Sunrise Blvd., Ft. Lauderdale, Fla. 33313.
Circle 421 on Inquiry Card

EMI and pressure sealing gasketing, designed for low-frequency magnetic fields, has high internal conductivity and high contact conductivity with mating surfaces — 4 page booklet. Metex Corp., 970 New Durham Rd., Edison, N.J. 08817.
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Transducers designed for measurement problems in industrial and biomedical applications—catalog D-23960 (20-pages). Honeywell Test Instruments Div., Box 5227, Denver, Colo. 80217.
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Concealed head studs, designed with a hex head for permanent installation in blind holes, are made of corrosion resistant stainless steel (1 page data sheet). Precision Metal Products Co., 41 Elm St., Stoneham, Mass. 02180.
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Multi element resistor networks feature 1 ppm temperature coefficients and ½ ppm tracking with tolerance matching to ±0.005%—technical bulletin N-100. Vishay Resistor Products, 63 Lincoln Highway, Malvern, Pa.
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Mini motor switch for sequencing, scanning, testing, counting and cross-point switching, 1 page, data sheet 10. Ansley E. Corp., Old Easton Rd., Doylestown, Pa. 18901.
Circle 426 on Inquiry Card

Byte generator for simulation and testing of digital equipment at an 8-MHz byte rate (8-bits)—data sheet EC-22 (2-pages). Adar Associates, Inc., 85 Bolton St., Cambridge, Mass. 02140
Circle 427 on Inquiry Card

DIP sockets for dual in-line IC devices, functional for 10,000 insertions, aging and burn-in applications — bulletin 539. Barnes Corp., 24 N. Lansdowne Ave., Lansdowne, Pa. 19050.
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Hybrid dividers feature discrete performance, small size (occupy ½ in.^{3}), and require no external amplifiers or adjustments. GPS Instrument Co., Inc., 14 Burr St., Framingham, Mass. 01701.
Circle 429 on Inquiry Card

Storage tubes for data processing and special-purpose microwave devices (4-page short form catalog). Warnecke Electron Tubes, Inc., 175 W. Oakton St., Des Plaines, Ill. 60018.
Circle 430 on Inquiry Card

Plated-wire element testers developed to satisfy on- and off-line production and lab test requirements—8 pages. Computer Test Corp., 3 Computer Dr., Cherry Hill, N.J. 08034.
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Transmitter/printer terminal, designed to operate with computer-controlled voice response systems and to provide a printed record of the desired information—bulletin 180. Technitrend Inc., 7300 N. Crescent Blvd., Pennsauken, N.J. 08110.
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IC core memory (ICM-160) includes specs, salient features, applications and options—6 page bulletin. Honeywell Computer Control Div., Old Connecticut Path, Framingham, Mass. 01701.
Circle 433 on Inquiry Card

Hybrid microelectronic circuits, which combine monolithic chips, active devices and passive components, perform one of several circuit functions at frequencies from dc to microwave —2-pages. American Electronic Labs., Inc., P.O. Box 552, Lansdale, Pa. 19446.
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Solid state switches, integrated and silicon-controlled in ac and dc models, for low power control switching of high wattage loads—bulletin 73-869A (4-pages). Gems Co., Inc., Farmington, Conn. 06032.
Circle 435 on Inquiry Card

Shaker systems, one with solid state "lifetime guarantee" transistor power amp and the other with 8 kVa air-cooled power amp, systems TA 16400-150 and 8208AMA respectively (4-pages). Unholtz-Dickie Corp., 3000 Whitney Ave., Hamden, Conn. 06518.
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Chip capacitor covering sizes 0.050 by 0.040 through 0.220 by 0.240 with values ranging from 10 to 470,000 pF, for thin- and thick-film applications, data sheet C25 Vitramon, Inc., P. O. Box 544, Bridgeport, Conn. 06601.
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OEM power modules feature extra design margin, in an offering of 26 models from 3 to 48 V, from 0.7 to 9.0 A—bulletin 113A. Deltron, Inc., Wissahickon Ave., North Wales, Pa. 19454.
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Microwave antennas and advanced components, including an X-band planar array and an L-band electronically scanned cylindrical slot array (20-pages). ITT Gilfillan Inc., Box 7713, Van Nuys, Calif. 91409.
Circle 439 on Inquiry Card

Plasmacoating, a sputtering process developed for industrial decorative coating. Varian, Vacuum Div., 611 Hansen Way, Palo Alto, Calif. 94303.
Circle 440 on Inquiry Card

Broadband mini amp with low noise gain over the frequency range from 1 to 2 GHz, bulletin A-12 (1-page data sheet). Electro/Data Inc., 1621 Jupiter Rd., Garland, Tex. 75040.
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Plug for cables, incorporates an internal shoulder to prevent the cable jacket from protruding past the machined mating surface of the plug body — bulletin CX-132. Sealectro Corp., RF Components Div., 225 Hoyt St., Mamaroneck, N.Y. 10543.
Circle 442 on Inquiry Card

Function module consists of a pair of non-circular gears and a linear potentiometer or other transducer mounted in a compact unit—4-page article reprint. Cunningham Industries Inc., 56 Hubbard Ave., Stamford, Conn.
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Mini-rectangular connectors, for solderless-wraps, feature a 0.045-in. sq. termination for wrapping up to three #20 AWG wires—brochure W869. Continental Connector Corp., 34-63 56th St., Woodside, N.Y. 11377.
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Digital angle conversion chart compares N, 2^N bits, degrees per bit, minutes per bit, and seconds per bit. Astrosystems Inc., 6 Nevada Dr., Lake Success, N.Y. 11040.
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Transient waveform reproducer for use in computer analysis eliminates the need for manual digitizing and the possibility of human error—bulletin 691. PhysiTech Inc., 645 Davisville Rd., Willow Grove, Pa. 19090.
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Communications grade, variable inductors for PC board mounting, 500 to 50,000 Hz — Bulletin 5104 (16 pages). Sangamo Electric Co., Box 359, Springfield, Ill. 62705.
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Optical incremental encoder used for display, data-logging and control applications, combines low price with solid state techniques — engineering bulletin 67-16A. Theta Instrument Corp., Fairfield, N.J. 07006.
Circle 448 on Inquiry Card

Cable termination systems for terminating solid dielectric shielded power cables: easily adapt to tape shielded/jacket cables with an optional adapter assembly—bulletin 1MF-126 (8-pager). General Electric, Insulating Materials Dept., 1 Campbell Rd., Schenectady, N. Y. 12306.
Circle 449 on Inquiry Card

Griplet^{tm} connectors, available in brass or phosphor bronze, suggested for applications where circuit boards require high reliability in soldering—bulletin 301. Berg Electronics Inc., New Cumberland, Pa. 17070.
Circle 450 on Inquiry Card

Rotary pulse generators that provide digital measurement of shaft position and speed in industrial equipment (6-pages). Available on company letterhead from Trump Ross Industrial Controls, Inc., 265 Boston Rd., N. Billerica, Mass. 01862.
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Diffusion furnace profiler, useful in determining stability and flatness of chamber temperatures to 0.2°C using platinum rhodium thermocouples without the need of peripheral equipment —4-page bulletin. Conklin Instrument Corp., Pleasant Valley, N. Y. 12569.
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RF generators, in effect, combine the functional resources of two instruments in one: an rf signal generator and a high-speed digital frequency meter. LogiMetrics Inc., Sub. Slant/Fin Corp., 100 Forest Dr., Greenvale, N.Y. 11548.
Circle 453 on Inquiry Card

Laser optical components including precision substrates and laser coatings (26 pages). Oriel Optics Corp., 1 Market St., Stanford, Conn. 06902.
Circle 454 on Inquiry Card

Digital integrators provide continuous display during and after integration and can be used with a spectrum analyzer to improve signal-to-noise conditions (4-pages). Signal Analysis Industries Corp., 595 Old Willets Path, Hauppauge, N.Y. 11787.
Circle 455 on Inquiry Card

Power instruments, all-silicon, convection-cooled, for lab and test instrument use (16-page catalog). Lambda Electronics Corp., Route 110, Melville, N.Y. 11746.
Circle 456 on Inquiry Card

READ THESE BOOKS

Radar Design Principles

Signal Processing and the Environment

By Fred E. Nathanson. Published 1969 by McGraw-Hill Book Company, 330 West 42 St., New York, N. Y. 10036. Price $22.50. 626 pages.

One of the classic problems of radar system design and evaluation has been the problem involved in attaining so-called "all weather capability." The "total radar environment" offers such problem areas as, unwanted reflections from the sea, land, precipitation and chaff, as well as thermal and jamming noise.

Nathanson, in a comprehensive survey of current techniques, delves into the relationship between radar signals and environment and suggests optimum types of processing for specific radar environments. Assessing the current state-of-the-art, he states "multiple modes of transmission may be the best solution if the radar can somehow sense the environment and adapt to it."

The book is divided into three sections. The first is an introduction to signal processing; the second analyzes reflectivity of both material and man-made targets; and the third describes various signal processing techniques for future radar systems.

A Guide to Superconductivity

Edited by David Fishlock. Published 1970 by American Elsevier Publishing Company. Inc., 52 Vanderbilt Ave., New York, N. Y. 10017. Price $7.00. 150 pages.

Since the Dutch scientist Kamerlingh Onnes first discovered the phenomenon of superconductivity nearly sixty years ago, the idea of electrical conductors that flaunt Ohm's law by conducting without losses has frustrated engineers. Because of the cost and difficulty, superconduction has been more attractive to physicists but in the last decade powerful electromagnets, large dc motors and dc generators have been designed that show a definite economic advantage.

This book, an English one, takes a realistic view at the potential for superconductivity in such fields as magnets, rotation machines, transmission equipment, computers and electronic engineering.

Basic Nuclear Electronics

By Hai Hung Chiang. Published 1969 by Wiley-Interscience, a Division of John Wiley & Sons, 605 Third Avenue, New York, N. Y. 10016. Price $14.95. 342 pages.

Pulse Radiolysis

By Max S. Matheson and Leon M. Dorfman. Published 1969 by The MIT Press, 50 Ames St., Cambridge, Mass. 02142. Price $11.75. 202 pages.

Manufacture of Semiconductor Compounds 1969

By Marshall Sittig. Published by Noyes Development Corp., Noyes Building, Park Ridge, N.J. 07656. 326 pages. Price $35.00.

Transient Performance of Electric Power Systems

By Rhine Holt Rudenberg. Published 1969 by the MIT Press, 50 Ames St., Cambridge, Mass. 02142. Price $20.00. 832 pages.

Design of Resonant Piezoelectric Devices

By Richard Holland in EerNise. Published 1969 by the MIT Press, 50 Ames St., Cambridge, Mass. 02142. Price $12.50. 258 pages.

Discrete and Integrated Semiconductor Circuitry

By Al J. Herbst. Published 1969 by Chatman and Hall. Distributed by Barnes and Noble Inc. 105 Fifth Ave., N.Y., N.Y. 10003. Price $6.00. 197 pages.

Communication Systems Engineering Theory

By E. D. Sunde. Published 1969 by John Wiley & Sons, Inc., 605 Third Ave., N.Y., N.Y. 10016. Price $19.95. 512 pages.

The 1969 NEREM Record

A digest of papers presented at the IEEE Northeast Electronics Research and Engineering Meeting, November, 1969. Published by the Boston Section of the Institute of Electrical and Electronics Engineers, Inc., 31 Channing St., Newton, Mass. 02158. Price $8.00 for paperback in the U. S. and Canada; $9.00 elsewhere. 240 pages.

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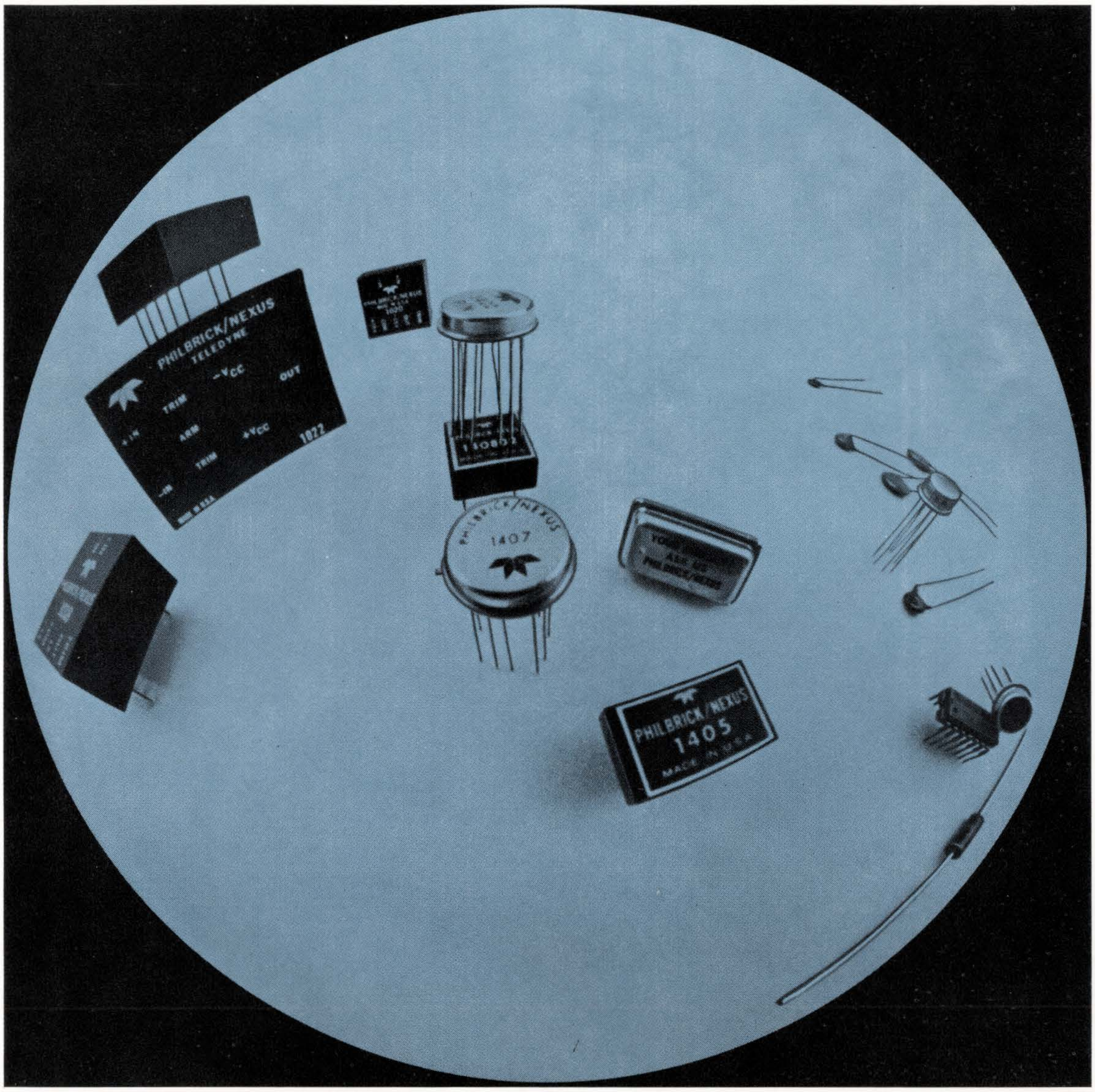
Index to Product Information

Listed below are all products and new literature that appear in this issue, along with the page number they appear on and their Reader Service Numbers (RSN). For more information, see the appropriate page and circle the corresponding number on the reader service card.



THE NOW GENERATION OF OP AMPS

MINI-PRICED WITH MAXI-PERFORMANCE

Teledyne Philbrick Nexus Operational Amplifiers combine existing monolithic and discrete module technologies while adding advantages of their own.

Teledyne Philbrick Nexus offers the widest variety of hybrids as well as a complete line of monolithics and discrete op amps.

Teledyne Philbrick Nexus Hybrids are microminiature available in standard or custom packages.

It's another example of Teledyne Philbrick Nexus' ability to innovate, design, and manufacture hybrid op amps with the highest performance specifications and the lowest prices.

1402—High performance FET amplifier for battery applications in a TO—8 case. 500μA quiescent drain, $\pm$4V to $\pm$24V supply range, 30pA bias current, 70kHz fp, 10μV/^{o}C. $44 in hundred quantity.

1404—Low power drain (60μA) in a dual-in-line configuration. $\pm$2V to $\pm$18V supply range,50k: 1 CMRR, 10μV/^{o}C. $40 in hundred quantity.

1405—This differential FET input, high speed, hybrid op amp comes in a dual-in-line size package with no external stabilization required. Salient specifications include 1 MHz full output frequency, A_o=500k, slew rate of 50V/μsec and output current of $\pm$20ma.

1406—Fast, general purpose amplifier in a TO—8 case. 100kHz fp, 5V/μs slew rate, 100k: 1 CMRR. $21.50 in hundred quantity.

1407—Low cost, fast, high performance FET amplifier in a TO—8 package. 30MHz GBW, 200kHz fp, 10k: 1 CMRR. $52 in hundred quantity.

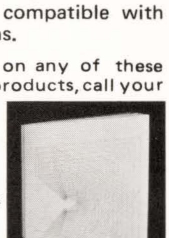
1408—High performance, lowest cost FET amplifier in a "mini-cube" package (0.6 x 0.6 x 0.2"). 5pA bias current, 70kHz fp, 250k open loop gain, 10k: 1 CMRR. $25 in hundred quantity.

OTHER MICROCIRCUITS

1300—Dual amplifier monolithic chip in a dual-in-line size package. Two general purpose amplifiers in one package for the price of one. $5.20 in hundred quantity.

1301/1303—Single general purpose amplifiers in a dual-in-line size package (1303) and a TO-99 package (1301) compatible with μA709 size configurations.

For further information on any of these Teledyne Philbrick Nexus products, call your local Teledyne Philbrick Nexus field representative, or write today for your free copy of the new 1970 Teledyne Philbrick Nexus Catalog. Teledyne Philbrick Nexus, 67 Allied Drive at Route 128, Dedham, Massachusetts 02026 U.S.A. Telephone: (617) 329-1600. Prices F.O.B. Factory U.S.A.



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