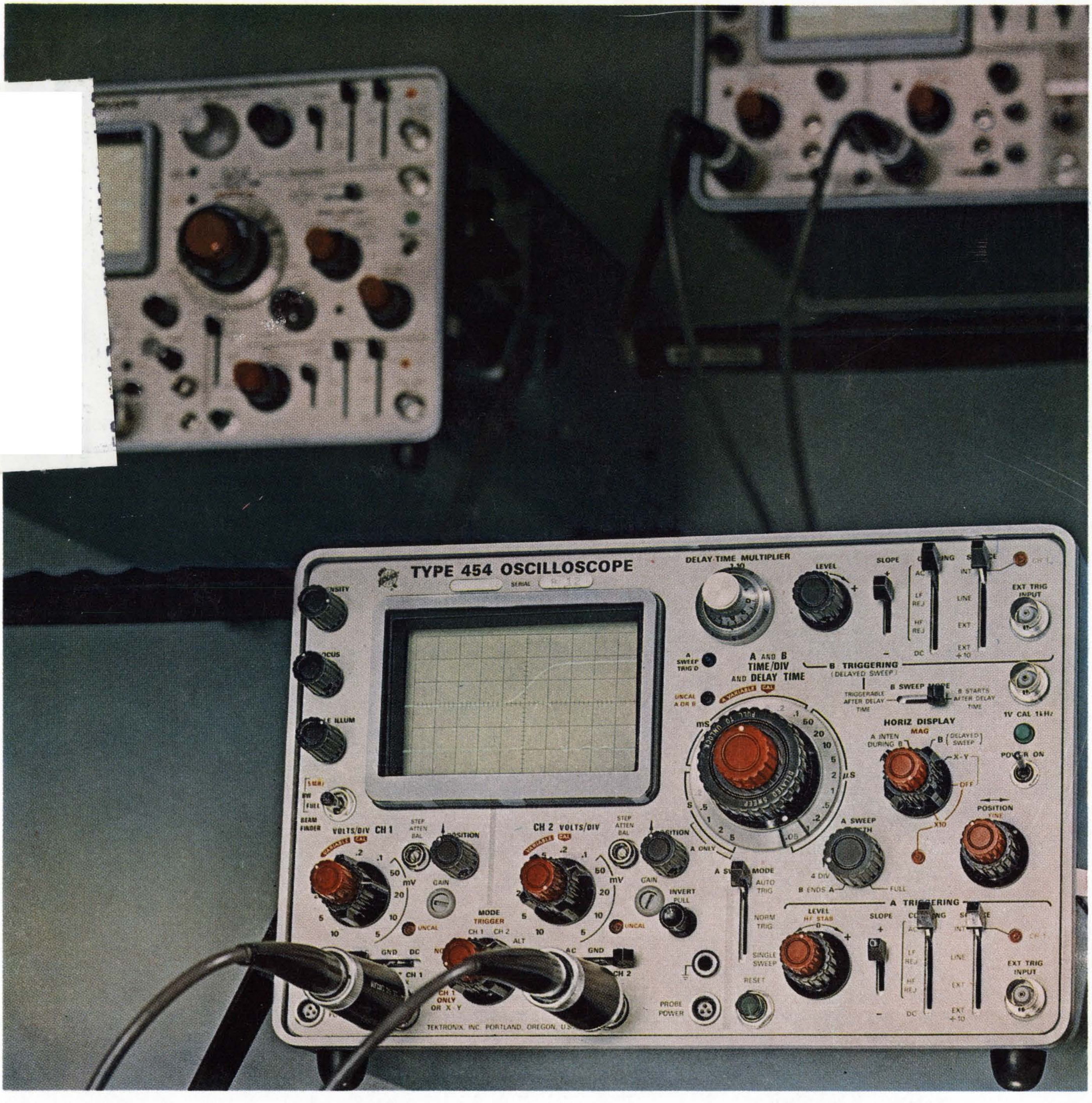
Electronic Design

VOL. 15 NO. 7

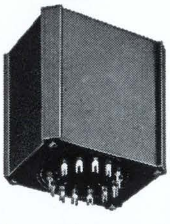
THE MAGAZINE OF ESSENTIAL NEWS, PRODUCTS AND TECHNOLOGY

APRIL 1, 1967

Scope bandwidth tops 150 MHz with a rise time of 2.4 ns – both specs taken from the probe tip. Now you can look at nanosecond logic and radar pulses and the 150-MHz modulated carriers in FM systems. The lossless FET probe gives tip-to-scope accuracy. Here's a real-time scope right in sampling territory. Page 106.

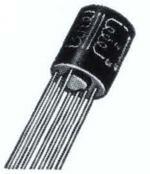


HI-FI



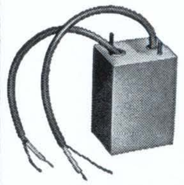
Transistor output; matches any PP transistor to 4, 8, 16 Ω speaker. Primary 48, 36, 12 Ω C.T.; 20 ∽ to 20 KC; 40 watts.

MINIATURE MIL TYPE



Metal case hermetically sealed to MIL-T-27B. Gold Dumet leads spaced on 0.1 radius, for printed circuit application.

CHOPPER



Magnetic shielded plus electrostatic shield for voltage isolation of $2x10^6$. Primary 200K C.T. to within 0.1%. Secondary 50K.

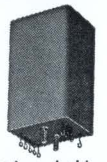
HIGH POWERED AUDIO

Low distortion 2.5 KW output transformer, PP 450 TH's 18,500 ohms C.T. to 24/6 ohms, 20 KV hipot. 520 lbs.

CATHODE FOLLOWER OUTPUT

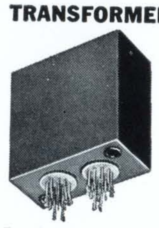
Provides equal voltages to 5 loads. Primary inductance maintained to 5% with 20% change in DC unbalance and 30% change in AC voltages.

HI-FREQUENCY CARRIER TO MIL-T-27B



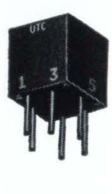
Electrostatically shielded, humbucking, +30 dbm level. Within .5 db 250 cycles to 110 KC. 600/135: 600 centertapped to .1% tolerance.

HYBRID TRANSFORMER



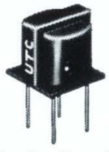
Two transformers each 600 Ω primary. 40K Ω C.T. secondary 250 cycles to 5 KC within ¼ db. 40 db isolation over band.

MICROMODULE



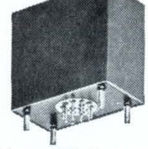
Life tested per micromodule specs.: no failures. 10K Ω C.T. to 10K Ω, 100 mw from 400 ∽ to 20KC.

SUBMINIATURE MOLDED TRANSFORMER



Grade 3 with printed circuit leads for transistor application. 150 Ω to 150 Ω at 10 dbm level. Size ½ x ½ x ½"; weight 5 grams.

BOLOMETER TRANSFORMER



Primary 10 ohms, secondary 530K ohms, 230:1 ratio, response from ½ cycle to 25 cycles. 120 db magnetic shielding, plus full electrostatic shielding.

ULTRA-MINIATURE

Electrostatically & magnetically shielded output transformer $\frac{5}{16}$ D. x ¼" H. Pri. 15K CT, Sec. 8K CT; max. level 50 mw; audio range response. To MIL-T-27B, grade 4.

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"SPECIAL" CUSTOM BUILT AUDIO TRANSFORMERS TO YOUR SPECIFICATIONS

Exceptional quality and reliability is provided in all UTC designs. Over 30 years of engineering knowledge and experience substantiated by extensive field performance assure the highest quality and most reliable components in the industry. Complete environmental testing facilities are incorporated to prove out new designs. Full analysis and evaluation of materials are conducted in UTC's Material and Chemical Laboratories. Rigid quality control measures coordinated with exhaustive statistical findings and latest production procedures results in the industry's highest degree of reliability. Range covered in Audio Transformers is from 0.1 cycles to 400 MC . . . microwatts to 50 KW.

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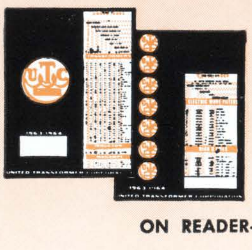
Write for catalog of over 1,300 UTC TOP QUALITY STOCK ITEMS IMMEDIATELY AVAILABLE from your local distributor.



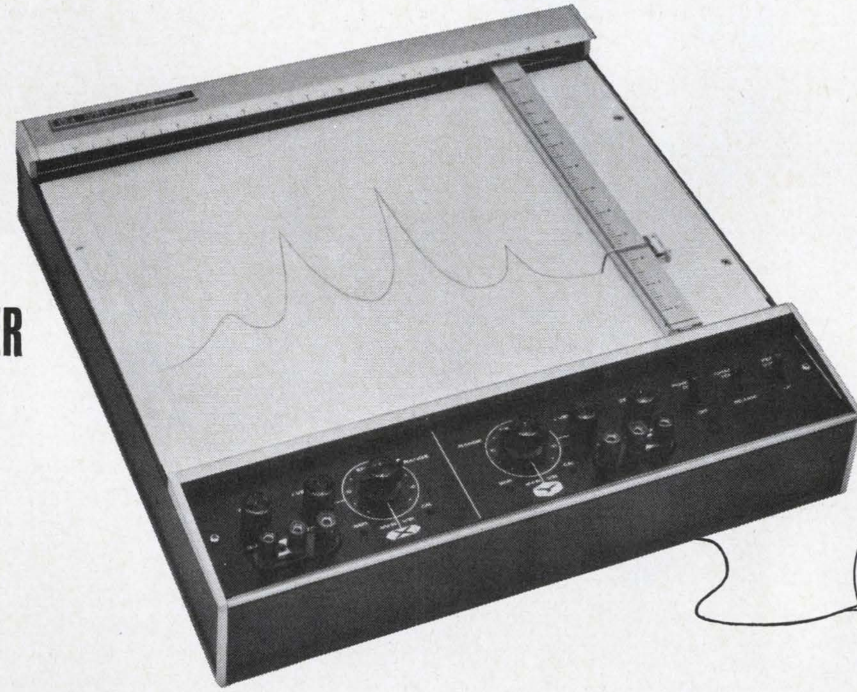
UNITED® TRANSFORMER CO.

DIVISION OF TRW INC. • 150 VARICK STREET, NEW YORK, N. Y. 10013

ON READER-SERVICE CARD CIRCLE 102

VALUE

BIG: 11"x 17" X-Y RECORDER



SMALL: $1195

Now in a bigger chart size—a value-priced Moseley X-Y recorder offering solid-state reliability and the same performance you get from the Model 7035A 8½"x11" X-Y Recorder ($895).

The Moseley 7005A lets you record on an 11"x17" chart for increased resolution. Five calibrated ranges each axis, 1 m V/in. to 10 V/in. High input impedance, floating and guarded input, 0.2% accuracy at full scale. Adjustable zero set each axis. Autogrip care-free electric paper holddown. Electric pen lift. Bench and rack mount model in one. Metric Model 7005AM is also available.

You get all these features for your recording applications for just $1195. For complete information just call your Hewlett-Packard field engineer or write Hewlett-Packard, Palo Alto, California 94304, Tel. (415) 326-7000; Europe: 54 Route des Acacias, Geneva.

BRIEF SPECIFICATIONS

Input Ranges: 7005A 1, 10, 100 mV/in.; 1, 10 V/in.
7005AM 0.4, 4, 40, 400 mV/cm; 4 V/cm

Input Resistance: Potentiometric—1 mV/in. range; 100K—10 mV/in.; 1 Megohm—0.1, 1, 10 V/in.

Accuracy: ± 0.2% at full scale; linearity: ± 0.1% of full scale; dead band: ± 0.1% of full scale.

Model 17108A External Time Base provides 5 sweep speeds either axis 0.5 to 50 sec/in. ($175).

HEWLETT PACKARD hp MOSELEY DIVISION

2358

ON READER-SERVICE CARD CIRCLE 2

Unit Citation

We're honored! Not that we've won our crusade yet...just another battle ribbon. A while back we scored a military victory with our Model 880, the *first* solid state Mil Spec counter. This time it's a fully-militarized 5MHz all-silicon solid state universal counter-timer. Call it USN/AN-245, sir.

There's a good reason you should be interested. You see, the military model had its basic reliability well proved by our original commercial version, Model 607A. Now *there's* the one for *you!* It offers more features and capabilities than even the Admirals asked for. And it's available on-the-double.

Now hear this: Our lowest-bidder-type price is only $1,575. (Check *that* saving against our competitor!) Then check these features: Model 607A is ideal for wide-range frequency measurements, frequency ratio determination, period and multiple period or time interval measurements, and pulse count totalizing. Time base is a 1 MHz crystal oscillator (for 1 microsec resolution). Display is six decade inline with display storage. BCD output transfers directly to CMC Model 410 tape printer, computer systems, etc. Automatically positioned illuminated decimal. Either ac or dc coupling of input signal. Front and rear A and B channel inputs. Rugged, compact (approx. 3½" high). Available for bench or rack.

THANKS

With all our pride and excitement over our USN/AN-245 award, and other new products, we haven't forgotten our fellow Crusaders who've made this success possible...YOU. A FREE Crusading Engineers medal is our fun-loving way of saying thanks. Get yours by writing for data so you can "Check the Specs" of our 607A. Your "chief" will be so proud of you at mail call!

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Phone (213) 367-2161 / TWX 910-496-1487

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Computer Measurements Company is a Leading Designer and Manufacturer of Electronic Instrumentation to Count, Measure, and Control.

ON READER-SERVICE CARD CIRCLE 3

Electronic Design

VOL. 15 NO. 7

THE MAGAZINE OF ESSENTIAL NEWS, PRODUCTS AND TECHNOLOGY

APRIL 1, 1967

NEWS

TECHNOLOGY

PRODUCTS

Departments

ELECTRONIC DESIGN is published biweekly by Hayden Publishing Company, Inc., 850 Third Avenue, New York, N. Y. 10022. James S. Mulholland, Jr., President. Printed at Poole Bros., Inc., Chicago, Ill. Controlled-circulation postage paid at Chicago, Ill., Cleveland, Ohio, and New York, N. Y. Application to mail at controlled postage rates pending at St. Louis, Mo. 61,732 copies this issue.

New! 100 MHz in a ruggedized oscilloscope with 3.5-ns risetime at the probe tip

DC-to-100-MHz bandwidth at 10 mV/cm
is NOW AVAILABLE
in a plug-in oscilloscope
with solid-state design . . .
the Tektronix Type 647A and R647A.

New Type 10A2A Dual Trace Amplifier. The risetime and bandwidth are specified where you use it — at the probe tip. The vertical system performance with or without the new miniature P6047 10X Attenuator Probe is DC-to-100 MHz bandwidth with 3.5-ns risetime at ambient temperatures of 0° C to +40° C (+32° F to +104° F). Bandwidth is DC-to-90 MHz with 4.1-ns risetime over its entire operating range, —30° C to +65° C. The calibrated vertical deflection range (without probe) is from 10 mV/cm to 20 V/cm.

Bright Displays. The Tektronix CRT provides bright displays with its advanced design and 14-kV accelerating potential. It has a 6-by-10 cm viewing area and a no-parallax, illuminated, internal graticule.

New Type 11B2A Delayed Sweep Time Base. The Type 11B2A triggers to above 100 MHz internally and provides a calibrated delayed sweep. Calibrated sweep range is from 100 ns/cm to 5 s/cm, extending to 10 ns/cm on both normal and delayed sweeps with X10 magnification. Calibrated sweep delay is from 1 μs to 50 s and the plug-in also provides single sweep operation.

Rugged Environmental Capabilities. These instruments are capable of accurate measurements in severe environments and offer an extra margin of dependability and even greater accuracy in normal environments. Temperature: Operating —30° C to +65° C. Non-Operating —55° C to + 75° C. Shock: Non-Operating 20 G's max, 2 shocks, each direction, along each of the 3 major axes. Vibration: Operating or Non-Operating 0.025" p-to-p, 10-55-10 Hz, (4 G's) 1 min cycles, 15 min each major axis. Humidity: Non-Operating meets MIL-STD-202B, Method 106A, except freezing and vibration, through 5 cycles (120 hours). Altitude: Operating 15,000 ft. Non-Operating 50,000 ft.

New Type R647A Rack Mount. The same DC-to-100 MHz performance also is available in a 7-inch-high rack mount oscilloscope, the Type R647A. Additional plug-ins include the Type 10A1 Differential Amplifier and the Type 11B1 Time Base.

Type 647A Oscilloscope (includes 2-P6047 Probes)	$1500
Type R647A Oscilloscope (includes 2-P6047 Probes)	$1625
Type 11B2A Time Base	$ 850
Type 10A2A Dual Trace Amplifier	$ 775

U. S. Sales Prices FOB Beaverton, Oregon

For complete information, contact your nearby Tektronix Field Engineer or write: Tektronix, Inc., P. O. Box 500, Beaverton, Ore. 97005.

Environmental testing

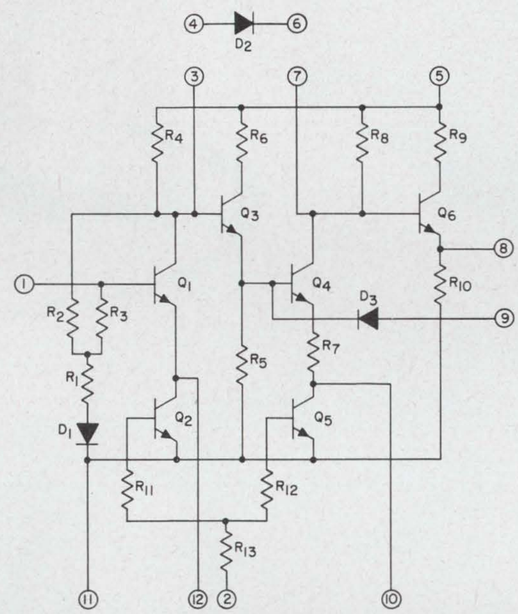
. . . part of the Tektronix commitment to technical excellence

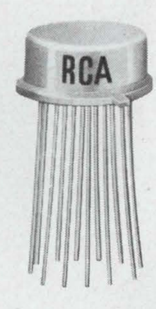
ON READER-SERVICE CARD CIRCLE 4

RCA integrated circuits

Low-Cost Wideband Amplifiers Deliver High gain @ 1 MHz – 5 MHz – 10 MHz

(4 mW) (12.5 mW) (35 mW)





- **Low Power Consumption**
- **Good AGC capabilities**
- **Single supply voltage**
- **Versatility**–FM, AM video amplification, oscillator, mixer stages

TYPICAL SPECIFICATIONS	CA3021	CA3022	CA3023
Power drain @ V_{cc}=6V	4 mW	12.5 mW	35 mW
–3 dB bandwidth	2.4 MHz	7.5 MHz	16 MHz
Voltage Gain	56 dB @ 0.5 MHz	57 dB @ 2.5 MHz	53 dB @ 5 MHz
PRICE (1000+)	**$2.25**	**$1.95**	**$1.85**
Power Supply Operating Range . . . 4½ V to 12 V			

Evaluate new RCA-CA3021, CA3022, CA3023 linear integrated circuits for your newest designs. Ask for complete data and application notes from RCA Electronic Components & Devices, Commercial Engineering, Dpt ICG3-4 Harrison, N. J. 07029.

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RCA ELECTRONIC COMPONENTS AND DEVICES

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Here's Amphenol's new square version of the low cost 2600 trimmer

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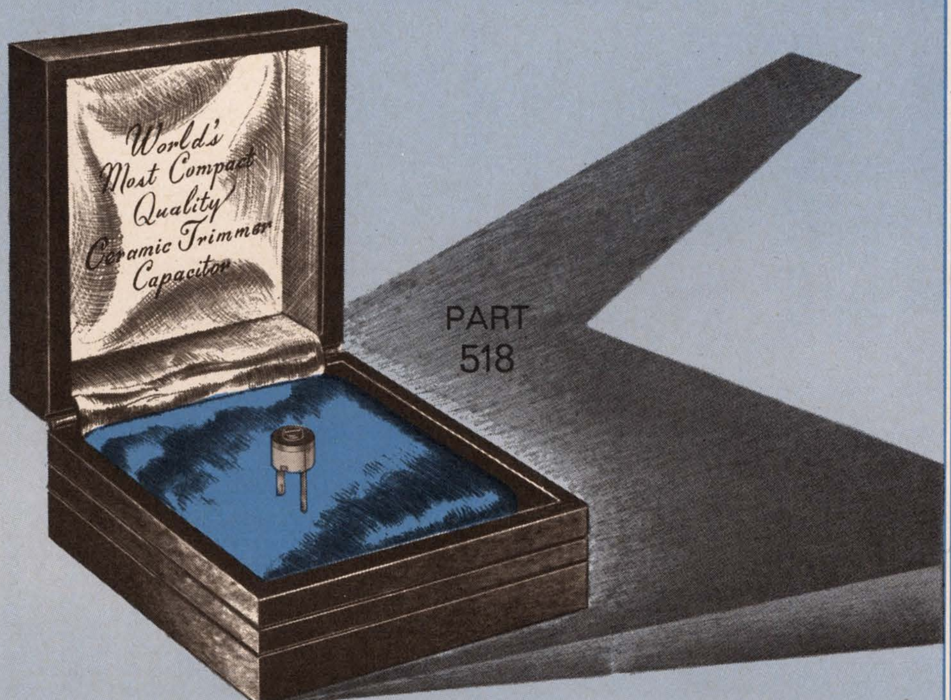
CERAMIC TRIMMER CAPACITOR



AMAZING 5 to 25 pF. CAPACITANCE RANGE IN LESS THAN .007 CUBIC INCH

A precious jewel? Not at all . . . This is a new subminiature Ceramic Trimmer Capacitor. It represents the most significant development in variable capacitors in more than a decade . . . and again Erie leads the State of the Art. The tiny 518 occupies only .007 cubic in. . . . and has an incredible capacitance range of 5 to 25 pF. Operating temperature range: -55°C to 125°C. — Working voltage 100 WVdc to 85°C; 50WVdc to 125°C. The unit exhibits remarkable ruggedness, being a development from Erie's exclusive Monobloc Process®. The Monobloc rotor with its sealed electrode provides stability under extreme environmental conditions. The 518 permits rigid mounting in both printed circuit and point to point wiring applications. Tuning linearity is assured by precision lapped bearing surfaces.

This compact little trimmer is the ultimate in volumetric efficiency . . . after all, it's only .218″ in diameter — almost the size of a precious jewel.

ERIE OFFERS THE MOST COMPLETE SUBMINIATURE TRIMMER CAPACITOR LINE IN THE INDUSTRY . . .

CERAMIC AIR GLASS AND QUARTZ PLASTIC

Another Series of Components in Erie's Project "ACTIVE"
Advanced Components Through Increased Volumetric Efficiency

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TECHNOLOGICAL
PRODUCTS, INC.

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Erie, Pennsylvania

ON READER-SERVICE CARD CIRCLE 8

Did You Know Sprague Makes 51 Types of Foil and Wet Tantalum Capacitors?

125 C FOIL-TYPE TUBULAR TANTALEX® CAPACITORS

Type 120D polarized plain-foil
Type 121D non-polarized plain-foil
Type 122D polarized etched-foil
Type 123D non-polarized etched-foil

ASK FOR BULLETIN 3602C

ON READER-SERVICE CIRCLE 161

FOIL-TYPE RECTANGULAR TANTALEX® CAPACITORS

Type 300D polarized plain-foil
Type 301D non-polarized plain-foil
Type 302D polarized etched-foil
Type 303D non-polarized etched-foil

ASK FOR BULLETIN 3650

ON READER-SERVICE CIRCLE 162

FOIL-TYPE TANTALUM CAPACITORS TO MIL-C-3965C

CL20, CL21 tubular 125 C polarized etched-foil
CL22, CL23 tubular 125 C non-polar etched-foil
CL24, CL25 tubular 85 C polarized etched-foil
CL26, CL27 tubular 85 C non-polar etched-foil
CL30, CL31 tubular 125 C polarized plain-foil
CL32, CL33 tubular 125 C non-polar plain-foil
CL34, CL35 tubular 85 C polarized plain-foil
CL36, CL37 tubular 85 C non-polar plain-foil
CL51 rectangular 85 C polarized plain-foil
CL52 rectangular 85 C non-polar plain-foil
CL53 rectangular 85 C polarized etched-foil
CL54 rectangular 85 C non-polar etched-foil

ON READER-SERVICE CIRCLE 163

85 C FOIL-TYPE TUBULAR TANTALEX® CAPACITORS

Type 110D polarized plain-foil
Type 111D non-polarized plain-foil
Type 112D polarized etched-foil
Type 113D non-polarized etched-foil

ASK FOR BULLETIN 3601C

ON READER-SERVICE CIRCLE 164

SINTERED-ANODE TUBULAR TANTALEX® CAPACITORS

Type 109D elastomer seal 85 C
Type 130D elastomer seal 125 C
Type 137D hermetic seal 125 C

ASK FOR BULLETINS 3700F, 3701B, 3703

ON READER-SERVICE CIRCLE 165

SINTERED-ANODE CUP STYLE TANTALEX® CAPACITORS

Type 131D 85 C industrial-type
Type 132D 85 C vibration-proof
Type 133D 125 C vibration-proof

ASK FOR BULLETINS 3710B, 3711

ON READER-SERVICE CIRCLE 166

SINTERED-ANODE CYLINDRICAL TANTALEX® CAPACITORS

Type 140D up to 175 C operation, ⅞″ diam.

Type 141D up to 175 C operation, 1⅛″ diam.

ASK FOR BULLETIN 3800

ON READER-SERVICE CIRCLE 167

SINTERED-ANODE RECTANGULAR TANTALEX® CAPACITORS

Type 200D negative terminal grounded

Type 202D both terminals insulated

ASK FOR BULLETIN 3705A

ON READER-SERVICE CIRCLE 168

SINTERED-ANODE TANTALUM CAPACITORS TO MIL-C-3965C

CL14 cylindrical, ⅞″ diam.
CL16 cylindrical, ⅞″ diam., threaded neck
CL17 cylindrical, 1⅛″ diam.
CL18 cylindrical, 1⅛″ diam., threaded neck
CL44 cup style, uninsulated
CL45 cup style, insulated
CL55 rectangular, both terminals insulated
CL64 tubular, uninsulated
CL65 tubular, insulated

ON READER-SERVICE CIRCLE 169

For comprehensive engineering bulletins on the capacitor types in which you are interested, write to:
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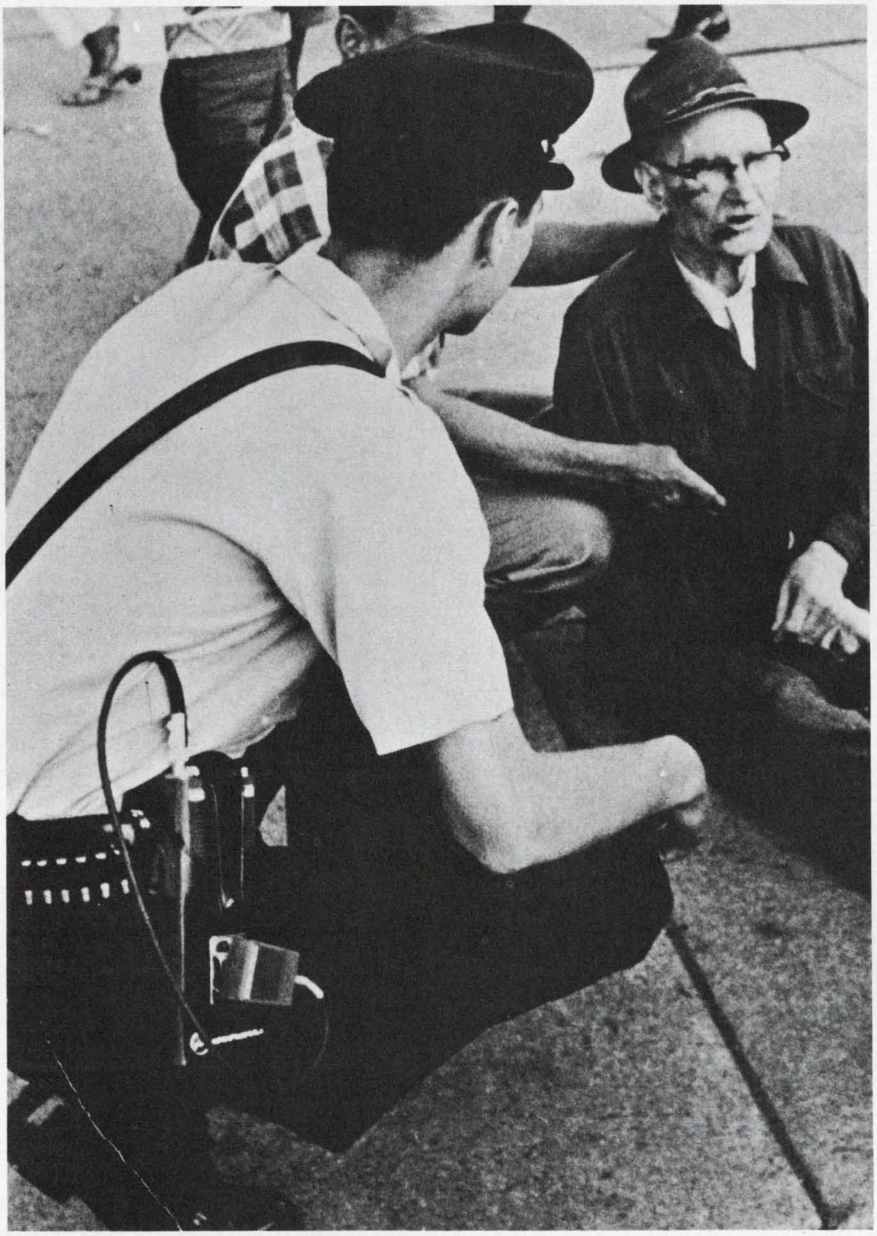
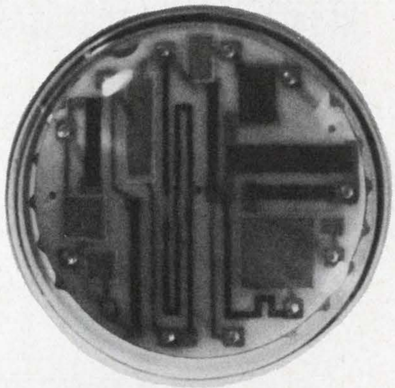
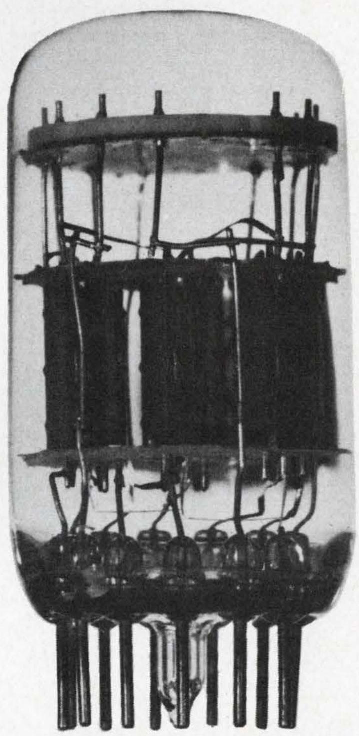
News



Innovations in equipment to help detect and prevent crime are urged at law enforcement symposium in Chicago. Page 17





Thick-film module package may cut TV-set cost. Page 24

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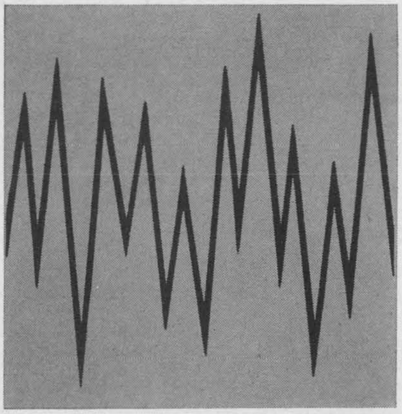


News Scope

National data bank to store statistics, not dossiers

A proposed national data bank into which Government records on income tax returns, Social Security information and business surveys would be deposited has been assailed by critics inside and outside the Government as a menace to individual and business privacy.

The data bank was proposed last fall by a Presidential task force headed by Carl Kaysen, chairman of the Institute for Advanced Studies, Princeton. While no specifications have been worked out, it is assumed that the center will consist of five or six master computers and will be operational in three to five years.

Arthur R. Miller, Professor of Law at the University of Michigan Law School, testifying before a Senate subcommittee conducting hearings on the "Big Brother" implications of computers, made a gloomy forecast.

"The computer, with its insatiable appetite for information, its image of infallibility, its inability to forget anything that has been put into it, may become the heart of a surveillance system that will turn society into a transparent world in which our home, our finances, our associations, our mental and physical condition are laid bare to the most casual observer," he warned.

The legislator who heads the subcommittee, Sen. Edward V. Long (D-Mo.), well-known for his opposition to electronic eavesdropping, agreed.

"Our privacy today depends on decentralization of information on individuals" he said. The senator and other critics of the proposed national data bank feel that consolidation of the records of divers agencies would present an uncomfortably full picture of an individual's life and habits. Bernard Fensterwald, chief counsel to the Long subcommittee, acknowledges that computer timesharing may jeopardize the security of business confidences, which depend on proper handling by Government agencies. "The day is approaching when business secrets will be stolen by computer," he predicted.

Carl Kaysen said in rebuttal to Prof. Miller that only statistical data useful to economic planners would be fed into the computers. "We wouldn't dream of feeding in any information such as how many drinks a man takes, what his wife says about him, or anything that might be found in personnel files," Mr. Kaysen affirmed.

While controversy over the potential abuses will rage for some time, an analysis of how the collected data would aid the economic analyst while still being properly protected against abuses is offered by Paul F. Krueger, Assistant Chief of the Office of Statistics, U. S. Bureau of the Budget:

- Much of the material will consist of such general data as national income by industrial classification and production and price indices. It would be useful to have this in more detailed form so that economists could better relate profit margins to such factors as capital investment.
- Where original source materials are used, only samples would be transferred into the center's computers—not the entire body of data.
- Dossiers on individuals and businesses would not be stored. There would be no place for personnel records, results of checks and investigations, Treasury audits, revoked drivers' licenses and the like.

The Government agencies concur with Sen. Long that technical safeguards must be embodied in legislation to provide for the punishment of those who make unauthorized disclosures about individuals and company proprietary material. It is expected that the subcommittee will recommend much additional study of the technical safeguards.

One technique suggested to the subcommittee is the use of keys or scramblers that are different for each contributing agency, so that no one person can gain access easily to secrets on production and shipments. Also, Government employees with access to the data bank would have to be carefully screened.

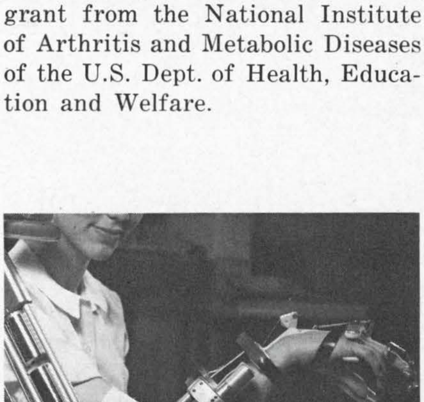
Electronic brace to aid paralytics' mobility

The University of Denver is to undertake three years' research on an electronically controlled orthopedic brace that will aid paralytics to regain the use of their arms.

The brace in its present stage of development is mechanically more advanced than its control system. Research will aim to improve the control devices of the brace, which has seven joints that simulate shoulder, elbow, wrist and hand movements. The joints are powered by electric motors controlled by switches operated by the patient's tongue.

Work will concentrate on a control device that will provide smooth, coordinated motion under the patient's complete control. At present the patient can activate each joint only separately. The use of an eye motion to facilitate coordination is under consideration.

The research, to be directed by Prof. C. A. Hedberg, head of the university's Electronics Div., has been made possible by a three-year grant from the National Institute of Arthritis and Metabolic Diseases of the U.S. Dept. of Health, Education and Welfare.



Electronic brace moves paralyzed arm.

Beanbag balances radio on any kind of surface

An ashtray? No. It's an AM radio with a Black Watch-tartan beanbag bottom from RCA.

Ever tried to prop up a transistor radio on your car's dashboard? Or had to grab for it as your boat took a lurch?

Designers at RCA have come up with a clever solution to problems like these with the Beanbag battery-powered radio, selling for less than $15.

Portability is the key design feature in this radio as in dozens more of the home-entertainment products in the company's spring line. Among them is a portable 14-inch color television set that sells for under $330. Consumers are increasingly on the go—to the beach, picnic, summer cottage, boat or just plain traveling—and consumer design is keeping pace. RCA is backing up its design engineers this season with a $3.5 million promotion campaign, compared with about $1 million last spring.

'Automatic' drive used for large electric vehicles

Electric drive systems for small electric vehicles, such as golf carts and industrial fork-lift trucks, have been available for some time.

Hitherto it has been difficult, however, to scale up such a system to the massive power requirements of a truck.

General Electric's Research and Development Center in Schenectady, N. Y., has developed an all-solid-state "automatic transmission" system for use in electrically powered trucks. It was recently demonstrated in an 8000-lb M-37 military truck that had been converted to operate off a fuel-cell-powered, 40-horsepower traction motor.

The transmission system, which includes SCRs and diodes, is packaged under the driver's seat. The only driver controls are an accelerator, a brake, an on-off switch and a forward-neutral-reverse switch on the dashboard. The input to the system can be either 112 volts or 224 volts dc, while the output is continually adjustable from zero to 375 volts dc. ■ ■

RCA dedicates computer education facility

"Wrong, try again" appeared on Johnny's desk-top display console. He carefully typed out another answer on his electronic keyboard. This time the words on the screen registered approval: "Correct, now answer question No. 2."

Such a computerized education system may not be far off, following the recent dedication of Radio Corp. of America's new electronics technology facility in Palo Alto, Calif. The facility is known as RCA Instructional Systems.

RCA is working on a teaching system that envisions elementary-school or college students spending up to 20 minutes a day each before a terminal with a display screen and keyboard.

Textbook authors in the various curricula would supply questions and answers to be entered in a disk-storage unit containing as many as 7.25 million characters.

A student would sign in with his name and grade, and questions transmitted from a nearby equipment room would appear before him on the screen. In the student-machine dialogue, the machine automatically paces the student's learning process according to the answers he types into the system.

Palo Alto was chosen as the site for the system's development because of its proximity to Stanford University, which, RCA president Robert Sarnoff said, "has become the seed-bed of the industrial revolution of American education. ■ ■

Terminal packs away for computer commuter

An on-line computer terminal packed for travel in two carrying cases gives its possessor access to distant computers. All he needs is a telephone and an ac power outlet.

The portable 60-pound input-output station is a modified teletypewriter with an electronic power converter and phone coupler. It was developed at the Carnegie Institute of Technology, Pittsburgh, to facilitate remote, conversational use of a computer.

The designer, Jesse Quatse, engineering development manager of the institute's computation center, says that prototype models have enabled students to solve problems and gain information from CIT's central computer, even though they were miles away from its Pittsburgh location.

Dr. Quatse expects the equipment to be especially useful to traveling engineers, accountants and even salesmen who need a computer to solve problems or furnish current financial or business data.

Production versions of the experimental models are being made by Vernitron Corp., Farmingdale, N. Y. The teletypewriter is able to receive even while messages are being typed in. The system has automatic answer-back ability and may be substituted for any conventional computer console.

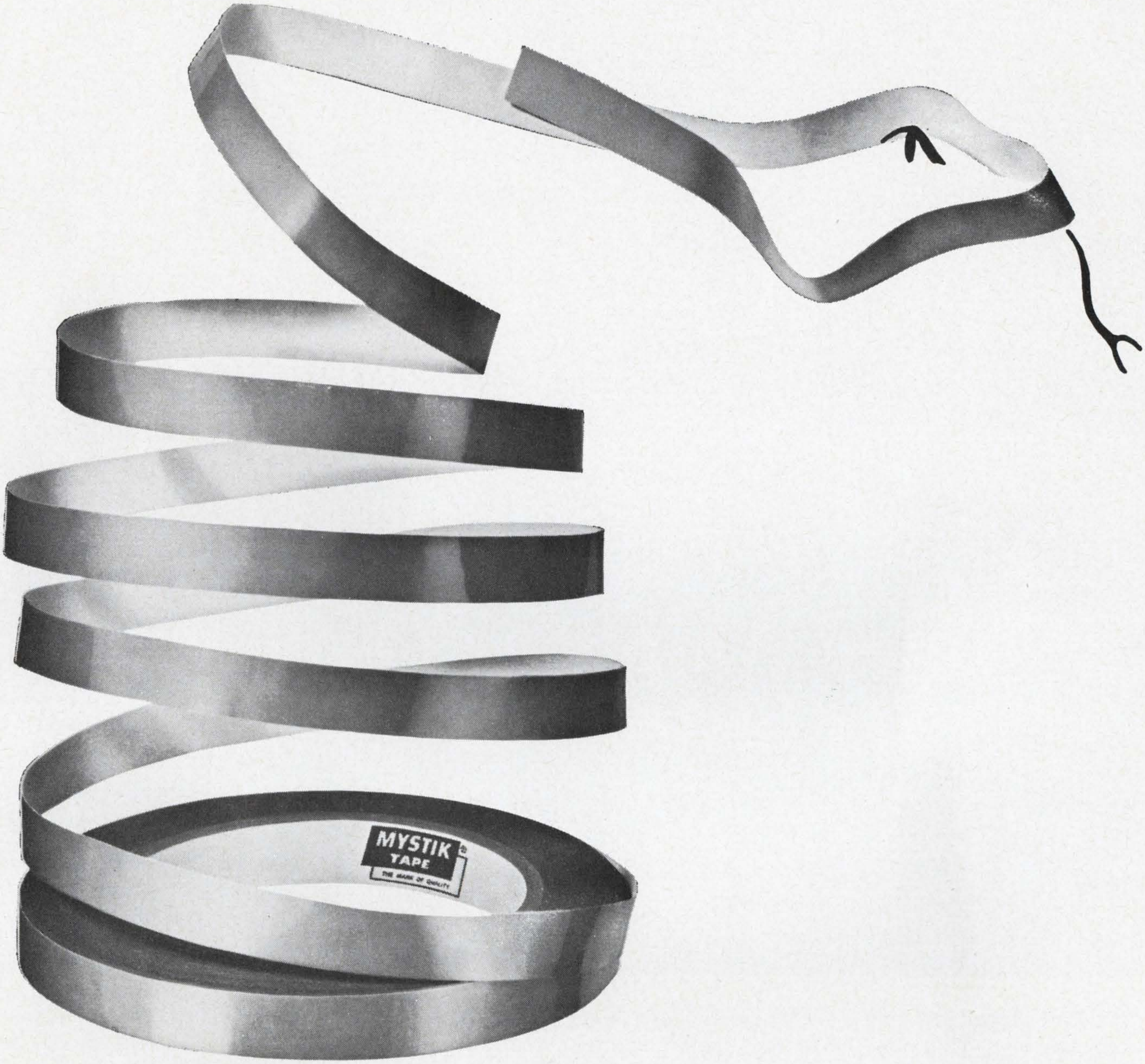
"Once you are plugged in, all you need is the password to any computer with a phone adapter and you are ready to go to work" says Dr. Quatse.

Kodak to stop making magnetic tape in U.S.

Eastman Kodak has announced that it plans to phase out its manufacturing and marketing in the U.S. of magnetic tape, including audio and instrumentation tapes. Magnetic striping of film will not be affected.

The volume of tape sales is relatively small, a Kodak official said, and the phase-out will not have any significant effect on the company's over-all business.

Kodak Pathé, an associate company in France, will continue to manufacture and sell magnetic tapes overseas.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ON READER-SERVICE CARD CIRCLE 11

Electronic aids sought to outwit criminals

Symposium calls for innovations in mobile radios and fingerprint checking at economical costs

Neil Sclater
East Coast Editor

In the police department of the future, the radio-car patrolman, cruising his sector, will spot what appears to be a stolen car—only he isn't sure it is. With the suspect in custody, the patrolman will type out on a two-way teleprinter in his car a request to headquarters: Has the car been reported stolen? A central computer will feed back the answer.

In the well-guarded industrial plant, a burglar may slip past an electric wire fence and a patrolling watchman. But once inside the plant, he will unwittingly enter an area saturated with sound waves, transmitted at 19 kHz. His interruption of the ultrasonic pattern will alert a monitor at a display panel. From that point on, his progress through the plant will be tracked by further interruptions of both sound and infrared energy. It will be only a question of time before he is cornered and captured.

These ideas for electronic law enforcement—the first still in the development stage and the second already available on a limited basis—were among several novel ones discussed last month at the First National Symposium on Law Enforcement Science and Technology. Speakers at the symposium, held at the Illinois Institute of Technology Research Institute in Chicago, stressed the urgent need for applying the resources of science, electronics and other technology to stem increasing crime in the nation.

Among the advances sought at the meeting:

- More diverse mobile radio receiver-transmitters for foot and radio-car patrolmen.
- Automatic data processing to speed the cumbersome process of fingerprint checking.
- Better burglar-alarm systems that rely on miniaturization for unobtrusive surveillance.

Among the obstacles cited:

- A limited radio-frequency spectrum.
- A fingerprint pattern-recognition problem described as "one of the most complex" for electronic equipment.
- Demands to deliver increasingly sophisticated anticrime systems at prices that the average police department and commercial user can afford.

Communications are critical

In a day when criminals are becoming more mobile and when crimes involve persons in many different geographical areas, the need for improved communications is becoming critical, the Associated Public Safety Communication Officers of Pittsburgh, represented by Robert E. Brooking, told the symposium. But police authorities are faced with a radio-frequency spectrum whose available channels are becoming overloaded.

Among the projects being investigated is the use of "handie-talkies" for direct communication between foot patrolmen and police headquarters. The hand-held transceivers can also be carried by radio-car patrolmen. If a car patrolman must leave his vehicle, he can still keep in touch with headquarters with his handie-talkie; the radio in the patrol car acts as a relay in transmitting messages.

Elmer W. Soldan, director of communications in the Detroit Police Dept., reported that his department was finding Motorola handie-talkies that operate at 450 MHz highly useful in combatting crime.

"Detroit is the first major city in the United States with a system which equips the majority of its officers with personal two-way radio," Soldan asserted. He added:

"We conservatively estimate that because of time saved in scout car runs and various other routine duties, we have gained the equivalent of 150 extra police officers on duty round the clock every day—or the

"Handie-talkie" transceivers keep patrolmen in touch with headquarters, even during absence from cars.

(**police,** *continued)*

equivalent of over one million dollars a year saved."

The problem of spectrum crowding is leading to serious consideration of mobile teleprinters in patrol cars, Brooking said. Sharing frequency bands with the car's voice equipment, the teleprinters can tap out and receive printed messages while the cars are moving or halted.

Several companies are offering these mobile units, and although all installation and system problems have not been solved, the practicality of the current equipment has been demonstrated, according to industry spokesmen.

One unit, built by the Codamite Div. of the Pacific Ordnance and Electronics Co., Anaheim, Calif. was described by the company's president, R. W. Johnson. It uses an impact type of electromechanical printer that types out up to 120 words a minute on standard adding machine paper. Designed and built under a Navy-Marine Corps contract, the shoe-box-sized teleprinter has been adapted for police work, Johnson said.

Ferranti, Ltd. of Edinburgh, Scotland, reported development of a competing teleprinter. It uses electronic means to convert digitally coded messages to serial text on thin, sensitized paper ribbon. Somewhat smaller than the Codamite unit, it is said to be able to print at 40 characters a second. Both the Codamite and Ferranti units operate from a car's power supply.

Neither company has announced exact unit prices, because the equipment has not yet been mass-produced. An estimate by Codamite is that the car units will sell for about $1500 each.

In their sales literature, both companies point out that in addition to conserving the RF spectrum, their units offer these extras: unattended printout to patrolmen while they are away from their patrol cars; improved security for police communications, and a reduction in the interference that sometimes plagues voice transmission.

Neither system envisions the elimination of voice communications from the patrol car. Both assume, however, that it will be used less often, preferably in emergency situations.

The General Electric Co.'s Communications Products Dept. in Lynchburg, Va., has gone a step farther. It is developing a two-way teleprinter that will permit patrolmen to maintain contact with headquarters and also with a central computer for law-enforcement information.

Requests are typed on a keyboard, mounted in the vehicle. Although still in the developmental stage, the system could be operational in a few months, GE's spokesman, Richard L. Larson and Archie V. Miller, told the symposium.

Fingerprinting problem noted

Another problem was pinpointed by Carl Voelker of the Federal Bureau of Investigation.

"Law enforcement today," he said, "has a need for a really fast method of retrieving fingerprint data of offenders. If this can be done at computer speed, law enforcement will gain a tremendous advantage."

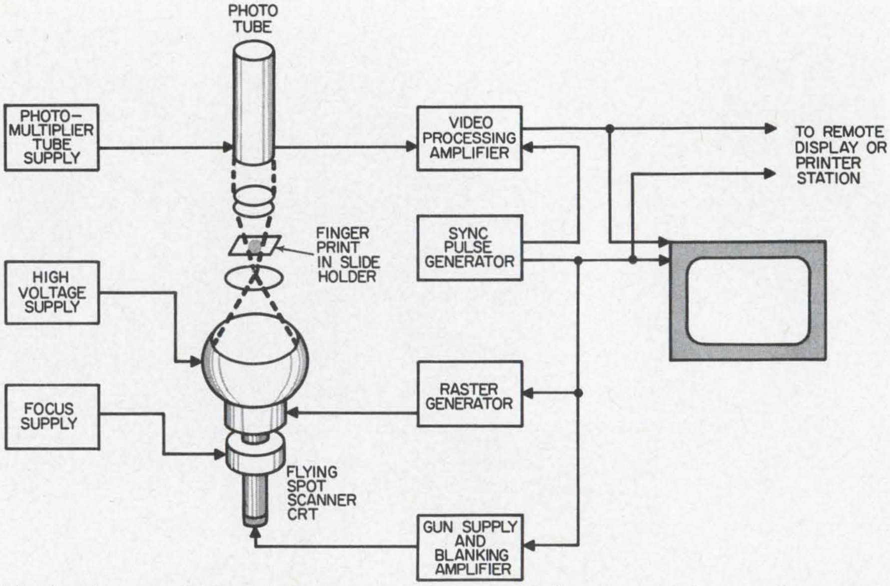
Voelker said that the FBI processed about 27,500 fingerprints a day and that, of these, only some 700 were transmitted by facsimile back to the inquiring agency over phone lines; the rest are sent back by mail, a slow process.

The FBI has approximately 177 million fingerprint records on file, Voelker said, an indication of the magnitude of the task in retrieving identification information on one individual.

California has a file of 5.5 million records and receives 3000 inquiries a day, Voelker continued, while New York State has 1.3 million records and receives 700 requests. And the files are growing each day.

Representatives of Bendix, GE, the Argonne National Laboratories and Litton Industries described experimental work in data processing to meet the problem. But no system has yet been produced that can match the human expert in analyz-

Miniature teleprinter in police vehicle translates digital data into a printed record at up to 120 words a minute.



Electronic scanning methods are used to convert fingerprints for use in a computer. This diagram of a Litton experimental system shows how prints on transparent film are converted to digital data.

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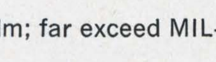

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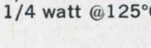

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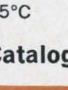

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ON READER-SERVICE CARD CIRCLE 12

(**police,** *continued*)

ing fingerprints, the symposium was told.

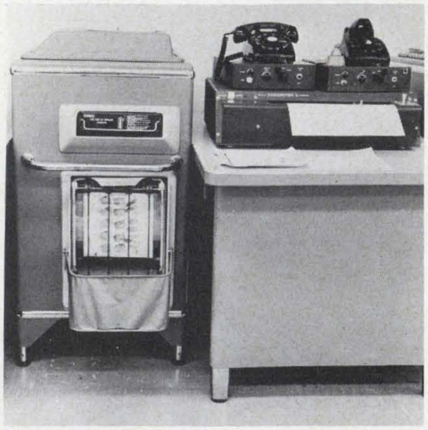
"Fingerprint recognition is one of the most complex forms of pattern recognition," said Bernard Van Emden, program manager at Litton's Advanced Data Systems Div. in Beverly Hills, Calif. The reason? No two prints are exactly alike.

Noting that present fingerprint classification systems—the FBI and the so-called "All American"—were based on 60-year-old work by the English scientist Henry, the Litton program manager said they could identify only about 20 categories of differences in prints. Three basic patterns are used for identification: loops, whorls and arches.

Van Emden said that Litton was experimenting with converting fingerprint patterns directly, by electronic scanning, to digital information for computer storage. Litton hopes ultimately that its system will be able to scan, first, the finger itself and then within 30 seconds, the files to produce identification of the individual—provided, of course, that a file of the print exists. Van Emden said that an individual fingerprint could be segregated for scanning purposes into 10^{12} classifications.

Intrusion detection improving

Electronic intrusion sensors are being used to supplement guards at



Fingerprint transmission and receiving equipment, made by Litton's Litcom Div., sends and receives printed records over phone lines by means of a photographic process. Checking time is reduced.

Central control station monitors strategic points in a plant. In this Honeywell system, television scans an outside gate and sensitive sonic detectors guard the interior. The console includes fire detection and alarm equipmnt.

stores, factories and other sites that are vulnerable to thieves or saboteurs, said Eugene L. Fuss, an applications engineer of Honeywell, Inc., Minneapolis. The newer systems employ sonic, radio-frequency or photoelectric energy to set up energy fields or light beams at strategic points in a building. When an intruder interrupts the pattern of energy, the sensor pinpoints the interruption on the central console.

Other anti-intruder systems that have been developed, Fuss said, include one that senses vibration—when holes are chipped in walls or ceilings, for example.

"Reliability is the key word in security alarm systems," Fuss cautioned.

He described one system that uses an infrared modulated beam. The light source, a narrow beam passed through an infrared filter and lens system, is modulated by a motor-driven disc or by changing the frequency on a power oscillator. The varying output of the photocell is coupled to a high-gain amplifier, tuned to the frequency of modulation.

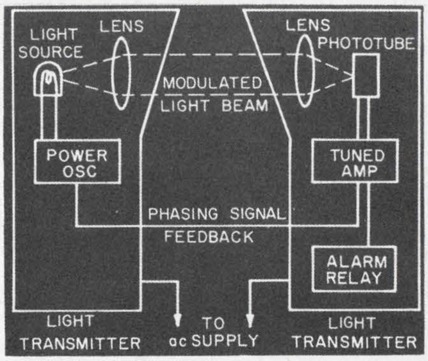
Fuss said that the modulation technique eliminated false tripping by a variety of conventional light sources. He added that a careful layout and the prudent use of mirrors helped hold down the cost of the system.

Lasers, Fuss said, have no overall advantages over infrared systems, especially if the detection system is set up outdoors. The wider beams projected by infrared units are less subject to accidental interception by birds, leaves or other harmless objects, he noted. It would take a portable laser to trick the system into remaining off under harmless conditions, Fuss said, and even that would be difficult, because of the critical acceptance angle of the laser receiver.

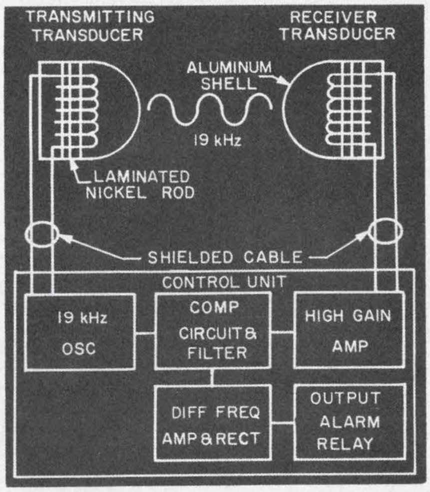
Photoelectric devices are called "line detectors"—they alert guards when intruders cross the invisible lines of energy that are set up between a transmitter and a receiver.

"Motion detectors," on the other hand, give their alarms when a moving object disturbs an energy field set up inside an entire area—a room, for example. Sonic and radio-frequency sensors are used as motion detectors. The sonic sensors can be either audible (in the range of 460 Hz) or inaudible (operating at about 19 kHz).

Fuss said the audible sonic motion system consisted basically of an electronic control unit with two oscillators, which feed one or two loops of transceivers. The two oscillators are at essentially the same frequency. The phase relationship



(a)



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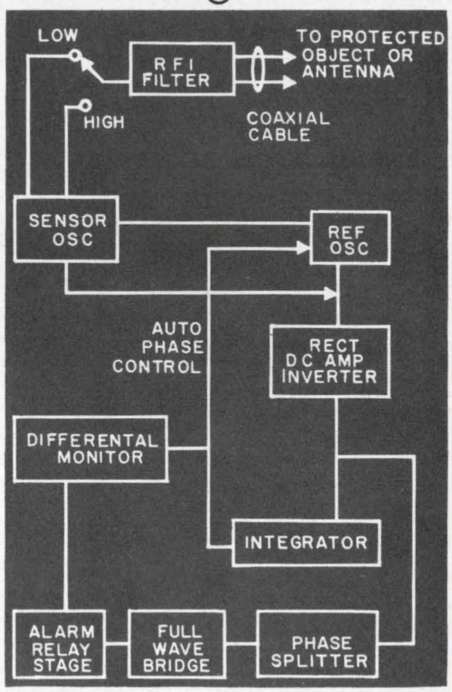


(c)

Two kinds of intrusion-detection systems are recognized: "line detectors" and "motion detectors". The electronic modulated infrared system (a) is an example of the line system—the intruder sets off an alarm by intercepting a beam. Modern motion detectors include the ultrasonic (b) and capacitance (c) systems—the intruder's motion interrupts a broad energy pattern in a volume.

(**police,** *continued*)

can be adjusted by a capacitor decade network so the two waveforms are 45 to 60 degrees out of phase.

The signal from one of the oscillators is fed to the transceiver loop, which consists of as many as 12 horn speakers matched to the control unit. While the speaker is acting as a transmitter of sonic energy, it is also acting as a receiver. Motion in the protected area will cause sound reflections that impinge on the voice coils of the speakers. The reflections generate low-frequency, low-amplitude voltages, Fuss said.

A portion of the signal from both oscillators is fed into a discriminator circuit. Diodes rectify these signals, which are then filtered to produce a steady negative dc voltage. Motion occurring in the protected area will cause this normally steady dc voltage to be modulated when an object in motion generates the low-frequency signal.

The typical ultrasonic motion detector, Fuss said, has an oscillator in the control unit that generates the frequency. After being amplified, the signal is fed to a magnetostrictive sound projector, a laminated nickel rod wound with wire.

The receiving transducer is of a configuration very similar to the projector. Sound waves impinging on the shell drive the nickel rod. The expansion and contraction of this rod generates a low-amplitude signal in the coil that is of the same frequency as the airborne energy. This small signal is passed over shielded cable to the electronic control unit.

Thus, Fuss said, the projector can be compared to a speaker, and the receiver to a microphone.

The projector saturates the protected area with sound waves, which upon hitting any hard surface, are reflected in a random pattern. However, the energy is contained within the area by its boundaries. A portion of this airborne energy is sensed by the receiver and passed on to the control unit. After being amplified, it is compared, or beat, with the frequency of the oscillator or projected signal.

If no motion exists in the area, the sound frequency is equal to the frequency of reception—in effect, a zero beat condition exists. Should motion occur in the area, a doppler shift in frequency occurs on the received energy, Fuss said. The extent of shift depends upon the speed of the moving body.

The Honeywell engineer said that a variety of motion detectors used radio-frequency energy. Since they depend upon a doppler, or antenna radiation-resistance, principle, they are not subject to the effects of noises or air motion in the protected area.

Vibration-detection systems, Fuss said, often use the same amplifier as the audio system. The sensors in this case are piezo-electric contact microphones. Prudent placing of these microphones in walls, ceilings and floors can detect forcible entry through these surfaces, the Honeywell engineer said.

There are probably more capacitance detection systems on the market today than any other electronic detection system, Fuss said. Most modern systems operate at frequencies under 50 kHz, he observed. All systems measure the capacitance of the antenna to ground. Each has an oscillator or oscillators operating at a fixed frequency. When an intruder approaches, he displaces the air dielectric that ordinarily insulates the antenna from ground.

Cost reduction needed

High cost is a major deterrent to wider use of electronics to combat crime, James Vorenberg, executive director of the President's Commission on Law Enforcement, warned the symposium. Quoting from the commission's report of an 18-month study, he noted the need for "computer-aided command-and-control systems for large police departments."

"To insure the maximum use of such a system," he said, "headquarters must have a direct link with every on-duty police officer. Because large-scale production would result in a substantial reduction of the cost of miniature two-way radios, the commission recommends that the Federal Government assume leadership in initiating a development program for such equipment and that it consider guaranteeing the sale of the first production lot of perhaps 20,000 units." ■ ■

New packaging concept

Thick-film substrate in a vacuum tube

General Electric is developing a tube that promises simpler circuit design and lower costs in color TV

Though solid-state technology has helped reduce the size of color television sets since they first hit the market, they still contain roughly three times as much circuitry as black and white sets. The large number of passive components, multiple connections and complex manufacturing operations has made it difficult for manufacturers to bring down the cost of color television as fast as consumers would like.

Designers at General Electric Co.'s Tube Div., Owensboro, Ky., are developing a new packaging concept in which a thick-film substrate, containing 20 to 23 passive circuit elements, is incorporated inside a standard GE Compactron vacuum tube. The thick-film module together with the tube's active elements would perform most major circuit functions without use of some external discrete components. The thick-film module is simply a mix of commercially available thick-film resistors, capacitors and conductors. The tube is not enlarged nor are the active elements of the tube (cathode, grid, etc.) functionally changed.

Significant advantages of the thick-film modules, according to a company spokesman, are:

- Circuit designers will in most cases not have to change their existing circuit designs in order to use the module.
- Cost savings will result from simpler printed-circuit boards, fewer connections, fewer manufacturing operations.

Dan Wilson, product planning manager, anticipates that the greatest demand for the thick-film module will be in television receivers, color as well as monochrome. He emphasized that applications are also envisioned in scopes and other equipment.

Nearly all circuits in television receivers can use the module. Three exceptions are the high-voltage circuits—the horizontal output, damper and rectifier. These cannot benefit from the thick-film techniques because of their high-voltage requirements.

Except for the high-voltage devices, nearly 75% of all passive elements in a television receiver can be included within a tube envelope, Wilson said.

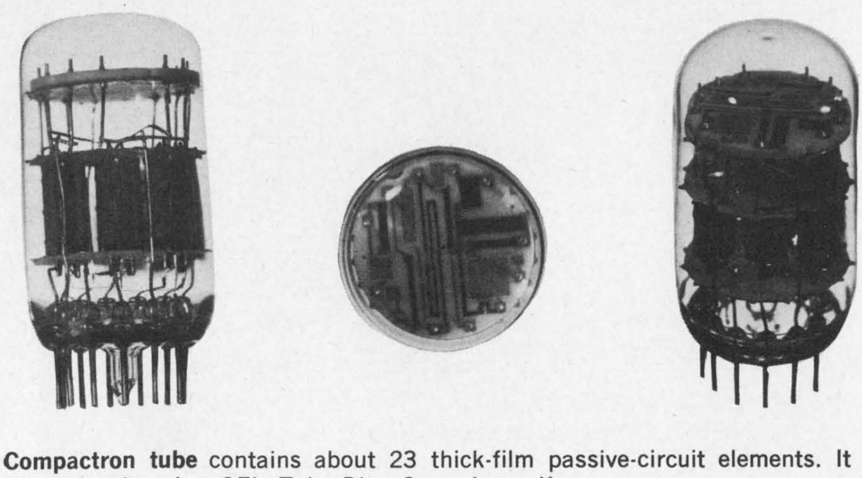
At present, two major applications are being developed for thick-film modules in television receivers. Both are triple triodes—one a horizontal oscillator for phase control and the other a color demodulator. Under consideration are vertical oscillators, IF amplifiers and audio amplifiers. In all, seven types of tube are being investigated.

Thick-film passive elements could also be placed inside a vacuum tube for protection without including the tube's active elements, according to Wilson. The module could then be used in conjunction with external conventional tubes or three-terminal devices, he said. In fact, three-terminal devices themselves, such as SCRs or transistors, could be put inside the tube, Wilson noted.

Few specifications given

For obvious reasons, GE is very reticent about releasing design details or specifications of the new devices. All the company will say is that the same GE tubes now in use in TV sets will be used for thick-film modules; only the thick films are added. The tube is not enlarged nor are the active elements functionally changed. All the Tube Dept. will add about the thick film is that it uses several capacitor, resistor and conductor mixes. The resistor material, which is about one mil thick, is made from a mix rated at 1 to 20 kΩ/square/mil. Nothing about the conductor and capacitor mixes is being revealed.

By using thick-film passive elements in their circuits, original equipment manufacturers, the company said, could realize a 50% saving in costs over equivalent discrete components. For example, if it costs a hypothetical 50 cents to install a conventional tube and discrete components on a printed-circuit board, including the cost of all these components, it will cost only 25 cents to place the same function on a PC board when using the TFM, exclusive of the cost of the tube itself. ■ ■



Compactron tube contains about 23 thick-film passive-circuit elements. It is being developed at GE's Tube Div., Owensboro, Ky.

ON READER-SERVICE CARD CIRCLE 16 ➤

Stripe contact simplifies laser diode's light pattern

A semiconductor injection laser with a stripe contact is reported to produce radiation patterns that are simpler and easier to control than those from the typical semiconductor laser.

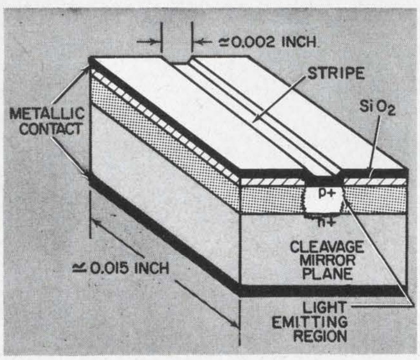
The new laser structure, developed by Dr. John C. Dyment of Bell Telephone Laboratories, Murray Hill, N. J., can produce a less complex pattern with a smaller number of vertical bands of radiation than that produced by earlier devices.

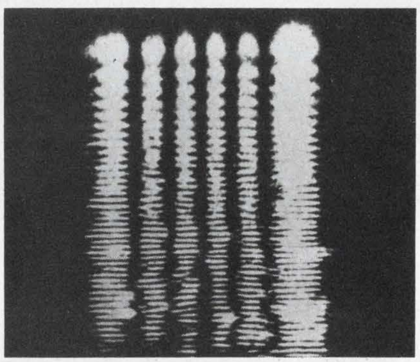
These simple patterns, according to Dr. Dyment, will make it easier to couple the laser to other optical devices and will be helpful in transmitting laser beams over long distances.

The performance of the new laser hinges on the strip contact, or narrow strip of metal, which touches the p+ layer along the length of the semiconductor. The stripe helps to concentrate and focus the laser illumination from small regions at both cleaved end surfaces.

The construction of the new laser is similar to that of the other gallium-arsenide devices, except that a layer of silicon oxide is deposited on the p+ layer. A narrow channel is etched in the oxide layer, and a metallic contact is formed adjacent to the p+ region.

The stripe that is formed concentrates the applied electrical field and limits the illumination region to the end zones, generally bounded by the strip width and the depth of the two-micron-thick p+ layer. Earlier lasers produced illumination patterns across the whole width of the chip, but these were irregular and usually not coherent across the entire emitting surface.





Junction laser diode with a thin metallic stripe contact forms simple symmetrical light patterns. The mode pattern at right is similar to that from a gas laser with external focusing mirrors. The patterns depend on the diode geometry.

"Using this special geometry, we can observe radiation patterns which are considerably simpler than those from conventional lasers," Dr. Dyment says. He reports that patterns from the device are similar to those obtained from gas lasers with external mirrors for focusing the radiation.

He says that the internal focusing action occurs between the diode's cleaved plane ends, which act as mirrors. But he adds that the exact mechanism by which the symmetrical pattern is formed is not fully understood. The strip contact, he believes, confines the gain to the narrow region under the strip contact and eliminates some pattern complexities that were formed in the earlier diodes.

The Bell scientist says that this phenomenon has been observed in two structures—in the conventional p+n+ and in a p+nn+ with a lightly doped n layer between the p+ and n+ layers. The additional n layer, Dr. Dyment says, affects only the pattern obtained but not the action of the metallic stripe.

He also reports that he has obtained the simple, controllable patterns in pulsed and cw operation.

The symmetrical pattern of illumination bands can be changed by varying the impressed dc current through the diode. The pattern becomes more complicated as the current is raised above the normal operating limits. ■ ■

Computerized probe measures 3-D parts

A computer-controlled measuring system automatically gauges two-dimensional or three-dimensional parts in a fraction of a second to an accuracy of ±0.0003 inch. Either optical or mechanical measuring methods can be used.

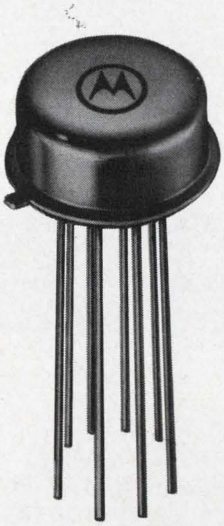
The developer, International Business Machines Corp., at Kingston, N. Y., is using the system to check the quality of its manufactured parts and printed circuitry.

With an optical probe, the system has measured a printed-circuit memory plane with 1248 dimensions, processed the data and printed a report—all in eight minutes, or at a rate of approximately two measurements a second.

A probe in the assembly, positioned over the work, "feels" or "sees" the dimensions to be measured. The associated computer, guided by a simple program, processes the measurement data against specifications while the measurements are being taken. The computer then records the data and analyzes and summarizes the results.

The system is able to compensate for a part's movement and misalignment. It contains 14 sensors that measure these unwanted errors, and the computer removes these effects. This scheme eliminates the need for precise, vibration-free part-mounting during measurement.

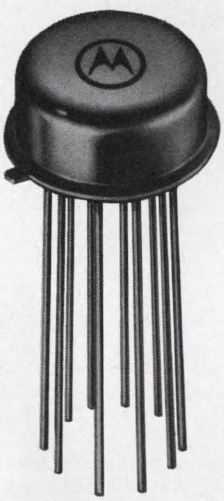
Calibration information is stored in the computer's memory and is used to correct all subsequent measurements. Because of this feature, the probe assembly can be off center by as much as 1/16 inch without affecting accuracy. ■ ■



THIS IS THE MC1709 (Some Call It The μA 709)

INTEGRATED CIRCUIT OP AMP

- It has gain of 25,000 (min)
- It has a drift-rate, with temperature, of 6 μV/°C (typ)
- It has input offset voltage of 5 mV (max)



THIS IS THE MC1533

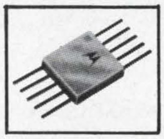
INTEGRATED CIRCUIT OP AMP

- It has gain of 40,000 (min)
- It has a drift-rate, with temperature, of 5 μV/°C (typ)
- It has input offset voltage of 5 mV (max) (Adjustable to 0)

They're Both Available from Motorola . . . Right Now!

Now, Motorola lets you choose either of these two state-of-the-art integrated circuit operational amplifiers. Either one will provide top performance in a wide range of applications such as summing amplifiers, source-followers, twin tee filters and oscillators, for military or industrial equipments. Choose the one that best fits your particular application requirements.

Both the MC1709 (μA709) and the MC1533 are available in the 10-pin ceramic flat pack. In addition, they are also available in the 8-pin TO-5 and the 10-pin TO-5, respectively. Complete data on both circuits is yours for the asking — including three new application notes on op amp uses. We'll also send you a data sheet on our MC1433 Op Amp (economy counterpart of the MC1533 — priced at just $15.00 in 100 quantities).



Then, when you're ready for evaluation quantities, call your nearby Motorola franchised semiconductor distributor. Ask for either the MC1709 or MC1533. He has both types available for immediate delivery. To order flat pack, designate suffix "F"; for TO-5, use suffix "G."

where the priceless ingredient is care!

MOTOROLA Semiconductors

MOTOROLA SEMICONDUCTOR PRODUCTS INC. / P.O. BOX 955 / PHOENIX, ARIZONA 85001 / (602) 273-6900 / TWX 910-951-1334

ON READER-SERVICE CARD CIRCLE 17

Semiconductors

NEW IDEAS IN APPLICATION AND DESIGN

NEW 2-TRANSISTOR DARLINGTON AMPLIFIER COSTS AS LOW AS 35¢

Use GE's new D16P NPN device to simplify your audio amplifier circuits in pre-amps, phonographs and tape recorders. The D16P comes in monolithic structure and actually costs less than its discrete counterpart—two 2N3394's. GE D16P transistors provide single stage impedance over two megohms with a 6-to-1 voltage gain at negligible distortion (less than 0.1%). For more information circle magazine inquiry card **Number 811.**

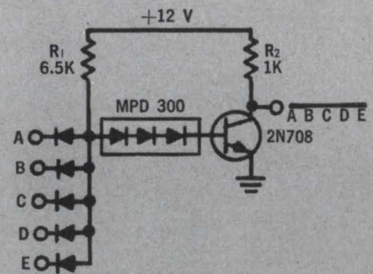
GE MULTI-PELLET DIODES GIVE CONTROLLED CONDUCTANCE THRU 5 DECADES OF CURRENT

I_F	V_F (MPD200)	V_F (MPD300)	V_F (MPD400)
0.01 mA	0.90—1.00 V	1.40—1.54 V	1.82—2.01 V
0.1 mA	1.05—1.16 V	1.62—1.78 V	2.14—2.36 V
1.0 mA	1.22—1.34 V	1.84—2.03 V	2.47—2.71 V
10 mA	1.39—1.54 V	2.10—2.33 V	2.80—3.07 V
100 mA	1.60—1.76 V	2.40—2.65 V	3.16—3.49 V

. . . and you can specify them in 2-, 3-, or 4-pellet units. Each MPD features tightly controlled conductance, controlled stored charge and low leakage. MPD's are excellent as:

- low voltage regulator diodes.
- amplifier non-linear bias elements.
- signal limiters or level shifting diodes in transistor logic circuits.
- d-c coupling devices in d-c amplifiers and digital circuits such as multi-vibrators.

Typical applications include computers, business machines, power supplies, calculators, instruments, and radios and TV's. Ask for copies of our latest application notes on GE MPD's. Circle **Number 813.**



MPD FOR LEVEL-SHIFTING IN DTL CIRCUITS: Multi-pellet diode (MPD300) in this circuit permits level shifting from a single power supply. The high stored charge and resulting long recovery time of the MPD speeds up the transistor's turn-off time by providing it with enough reverse current to draw the stored charge from its base.

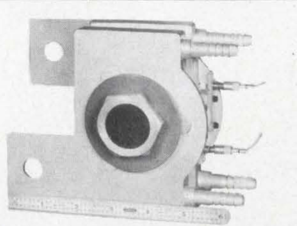
PROVEN PERFORMER FOR HIGH POWER SWITCHING: GE C500X1 WATER-COOLED SWITCH

Even welding locomotives doesn't tax the high power capability of these SCR's.

For seven months one GE C500X1 water-cooled switch has been in use at a large locomotive plant. It operates at 900 amperes RMS and 480 volts, with an on-time of 1.5 seconds and a 25% duty cycle for resistance welding.

The same plant has been using a second C500X1 for five months and expects to install more of them in the future.

C500X1's are also now in use for automotive welding. Other possible applications include particle accelerator power supplies, primary transformer control, static switching, and control of large lighting loads. (Three C500X1's could theoretically control all the lighting in a 60,000-seat stadium.) The C500X1 is rated at 1200 amps RMS with peak blocking capability to 1800 volts in both directions. Surge ratings are 4000 amperes peak for ten cycles and 7000 amperes for one cycle. The device can be used directly in 440 or 550 volt a-c service. Circle **Number 812.**

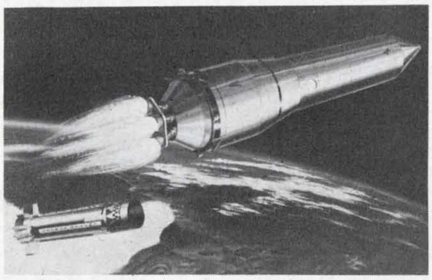


You'll get 1800 volt peak blocking capability from this 1200 amp GE C500X1 water-cooled switch.

These are just a few examples of General Electric's total electronic capability. For more information on all GE semiconductor products, call your GE engineer/salesman or distributor. Or write to Section 220-54, General Electric Company, Schenectady, New York. In Canada: Canadian General Electric, 189 Dufferin St., Toronto, Ont. Export: Electronic Components Sales, IGE Export Division, 159 Madison Ave., New York, N.Y., USA.

GENERAL ELECTRIC

New materials to increase Apollo weight



Washington Report

S. DAVID PURSGLOVE,
WASHINGTON EDITOR

Apollo electronics to be redesigned

Electronics designers should have their hands full as a result of the fatal fire in the crewmen capsule of the Apollo 204. The Review Board's interim reports indicate clearly to many NASA officials that much on-board equipment in future craft will have to be fabricated with materials of far greater fire-resistance than are presently used. As a rule, the more fireproof materials are made, the heavier they become. The question now is where the weight sacrifices will be made.

An aide to deputy NASA administrator Robert C. Seamans, Jr., said: "Electronics constitutes a major portion of the weight of a capsule. Certainly, after you have rejected some things, such as the craft's shell, where you can't do much to cut the weight without changing the whole concept, electronics makes up the largest 'variable' weight load."

He added that as long as a system can be varied, it may have to be varied in the direction of reducing weight. He hinted that some experiments may therefore have to be sacrificed because of the weight of the equipment that they use.

Solid-state flight displays on their way

An entire family of completely electronic solid-state displays capable of presenting all the information needed for aircraft flight control may soon be in existence, according to the Air Force Flight Dynamics Laboratory. A laboratory report says that this is not only feasible but is also "foreseeable in the near future."

The Air Force says that what has made this development possible is a recent breakthrough in display filtering techniques. The report's author, C. J. Peterson, says that this has permitted the fabrication of displays that reflect 2% of all incident light and transmit 35% of all emitted light. The laboratory has now combined this feature with high-intensity sulfoselenide electroluminescent phosphors. The advantages of such displays, built and successfully tested at the laboratory, over other display techniques include greater reliability, automatic-scale-factor variability, minimized weight, lower cost and amenability to digital control.

Navy goes all out on ASW

The Navy is moving full speed ahead on development of a new form of ASW—anti-swimmer warfare. When the anti-swimmer warfare program was first announced two years ago, many observers mocked it as a boondoggle to provide safe jobs for R&D men who thought "too far out." The success, however, of swimmer teams in astronaut recovery programs and in Vietnam operations has silenced the scoffers and made it clear that potential enemies may have similar capabilities and that there is therefore a need to take precautions against them. Some part of the Sealab tests and the Man-In-Sea program have now been oriented toward anti-swimmer warfare.

The Navy is now looking for instrumentation specifically designed for defense against swimmer attack. The Navy Mine Defense Laboratory, through the Naval Training Device Center in Orlando, Fla., has asked the electronics industry for development proposals for a mobile underwater acoustic instrumentation package. The package would sense acoustic transmission loss, ambient noise, reverberation and similar factors that might help to detect a swimmer in water. The package, to be a study and training device, would also simulate swimmers and then treat this simulated information analytically. It would have to be able to record the oceanographic and climatic data that have to be taken into account to make a meaningful analysis of the other data collected. The data that it gathers would have to be in a form that could be handled by computers in the field without needing to be returned to the laboratory.

During the development and evaluation phase, the successful contractor would have to make allowance for both equipment and test team to have great mobility "for operation in the inshore environment, under secure conditions, anywhere in the world." The Navy envisions the instrumentation permanently installed in a small boat that could be transported on the deck of a ship. It also expects the test team to include at least an acoustic research engineer, an oceanographer and a sonar engineer. A Mine Defense Laboratory officer commented: "This anti-swimmer warfare probably will never be as big as the 'other' ASW, but it will be just as important to limited warfare like Vietnam as anti-submarine warfare is to strategic, global warfare."

Commerce Dept. playing down science?

Commerce Dept. scientists are concerned lest the department's science and technical activities should be pushed into a back seat. Much technological capability was transferred out to the new Dept. of Transportation. Now nonscientific interests seem to be gaining the upper hand: witness the Executive proposal to merge the Commerce and Labor Depts.

Employees of the Bureau of Standards, Patent Office and Environmental Science Services Administration express their fears in these terms. But their greatest worry seems to be that their chief is being hamstrung by political and nonscientific matters. The Assistant Secretary of Commerce for Science and Technology was last year given the task of overseeing the Office of State Technical Services, often likened to "a county agent's organization for technology." Now he has been assigned another duty to take up more of his time and budget. He will be responsible for implementing the decisions of the Fair Packaging and Labeling Act of 1966. This, the scientists say, is too great a dilution of his proper concerns.

DOD to computerize guerrilla war

The Defense Communications Agency is trying to set up a computerized war game in guerilla warfare. The computer, furthermore, has to play at insurgency, which is usually considered a further step down into the informal arena of sabotage and subversion.

Officers wonder whether the agency has not bitten off a little more than it can chew. Even such well-planned war games as STAG (the Army's Strategy and Tactics Analysis Group) often require months to simulate a single day's operations. When taken down to the regimental level and played on a theater-wide basis, a game involves thousands of actions that have to be analyzed for each simulated hour. And each evaluation of an action may lead to alternatives, each of which, too, requires analysis. On a less integrated level where guerrilla bands and civilians operate independently of each other, it may prove utterly impracticable to elaborate any war game.

"But we have one hope," a Defense Communications officer said. "We are just gaming the command and control operations of our own forces in counterinsurgency operations."

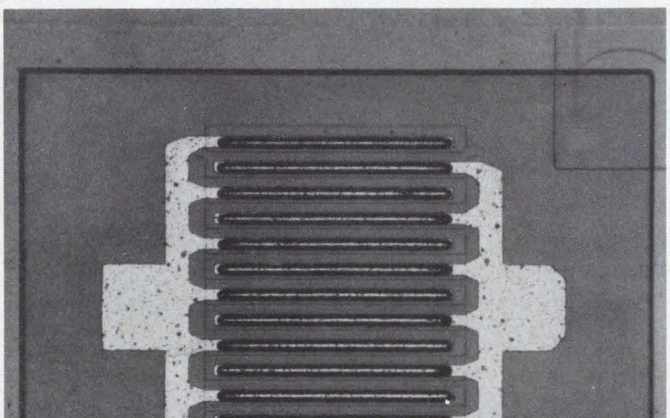
Component shipments set record

In the third quarter of 1966, electronic components did far better in the plant shipping department than on the Stock Exchange. Final figures now released show that the dollar volume of shipments reached a new high of $1.1 billion, an increase of 33% over July-September, 1965. The entire first nine months of last year were 34% better than the same 1965 period, according to the Commerce Dept.'s Business and Defense Services Administration.

Traditionally the third quarter shows a decline over the second, but the agency said that last year the over-all drop was a bare 4%. A few areas actually registered gains over the second quarter: power and special-purpose tubes, connectors and transistors. Color and monochrome TV tubes were also slightly up, but over 1965's third quarter showed a whopping 81% increase.

FOR THE FINEST FET FIGURES OF MERIT

Your Engineering Data Sheet
Tear Out and Keep



Photomicrograph of the geometry of the 2N4391 series.

Compare these two figures of merit. For amplifier performance the formula is $^{I}D^{(off)/I}DSS$. For switching performance, use r_{DS}(on) x$C_{iss.}$ Sample the 2N4391 series for yourself. You'll discover the finest combination of figures of merit among any field effect transistors now available.

Use these devices as switches or amplifiers. We specify the 2N4391, 2, 3 primarily for switching applications, because of their low on-resistance and low capacitance. But, in any class lot of these devices you can select low frequency through UHF amplifier devices, with transconductance from 10 to 30,000 μMHOS. Therefore, the Union Carbide 2N4391 is useful in the following applications—shunt switch, series switch, chopper, A/D converter, multiplier, linear ramp generator, or even a 200 MHz amplifier.

UNION CARBIDE

ELECTRONICS

Semiconductor Department / 365 Middlefield Road, Mountain View, California 94040 / Telephone: (415) 961-3300 / TWX: 910-379-6942

ON READER-SERVICE CARD CIRCLE 20

UNION CARBIDE

ELECTRONICS

2N4391 • 2N4392 • 2N4393

N-CHANNEL FIELD EFFECT TRANSISTORS FOR CHOPPER AND SWITCHING APPLICATIONS

Silicon planar epitaxial construction • high input impedance • fast switching • low r_{ON}/C_{iss} ratio

MAXIMUM RATINGS

@ 25°C (UNLESS OTHERWISE NOTED)[1]

	SYM.	2N4391	2N4392	2N4393	Units
Drain to Gate Voltage	V_{DG}	40	40	40	V
Drain to Source Voltage	V_{DS}	40	40	40	V
Source to Gate Voltage	V_{SG}	40	40	40	V
Gate Current	I_G	50	50	50	mA
Device Dissipation 25° C Ambient Temp.	P_D (amb)	0.5	0.5	0.5	W
Linear Derating Factor		3.0	3.0	3.0	mW/°C
Device Dissipation, 25° C Case Temp.	P_D (case)	1.8	1.8	1.8	W
Linear Derating Factor		10.0	10.0	10.0	mW/°C
Storage Temperature	T_s	−65 to +200	−65 to +200	−65 to +200	°C
Lead Temperature for 10 seconds		300	300	300	°C

ELECTRICAL CHARACTERISTICS

@ 25°C (UNLESS OTHERWISE NOTED)

	SYM.	2N4391 Min.	2N4391 Max.	2N4392 Min.	2N4392 Max.	2N4393 Min.	2N4393 Max.	Units	CONDITIONS
Gate to Source Breakdown Voltage	$V_{(BR)\ GSS}$	−40		−40		−40		V	$V_{DS} = 0$ V, $I_G = -1.0\ \mu A$
Pinch-Off Voltage	$V_{GS\ (OFF)}$	−4.0	−10	−2.0	−5.0	−0.5	−3.0	V	$V_{DS} = 20$ V, $I_D = 1$ nA
Total Gate Leakage Current[2]	I_{GSS}		−100		−100		−100	pA	$V_{GS} = -20$ V, $V_{DS} = 0$
Total Gate Leakage Current (150°C)[2]	I_{GSS}		−200		−200		−200	nA	$V_{GS} = -20$ V, $V_{DS} = 0$
Gate-Source Forward Voltage	V_{GS} (f)		1.0		1.0		1.0	V	$V_{DS} = 0$ V, $I_G = 1$ mA
Drain Cutoff Current	I_D (off)		100					pA	$V_{DS} = 20$ V, $V_{GS} = -12$ V
					100			pA	$V_{DS} = 20$ V, $V_{GS} = -7$ V
							100	pA	$V_{DS} = 20$ V, $V_{GS} = -5$ V
Drain Cutoff Current (150°C)	I_D (off)		200					nA	$V_{DS} = 20$ V, $V_{GS} = -12$ V
					200			nA	$V_{DS} = 20$ V, $V_{GS} = -7$ V
							200	nA	$V_{DS} = 20$ V, $V_{GS} = -5$ V
Saturation Current, Drain to Source[3]	I_{DSS}	50	150	25	75	5.0	30	mA	$V_{DS} = 20$ V, $V_{GS} = 0$
Drain-Source "On" Voltage	V_{DS} (on)		0.4					V	$V_{GS} = 0$ V, $I_D = 12$ mA
					0.4			V	$V_{GS} = 0$ V, $I_D = 6$ mA
							0.4	V	$V_{GS} = 0$ V, $I_D = 3$ mA
Static Drain-Source "On" Resistance	r_{DS} (on)		30		60		100	Ohms	$V_{GS} = 0$, $I_D = 1$ mA
Small-Signal Drain-Source "On" Resistance	r_{ds} (on)		30		60		100	Ohms	$V_{GS} = 0$ V, $V_{DS} = 0$, f = 1 kHz
Small-Signal, Common Source, Short Circuit Input Capacitance[4]	C_{iss}		14		14		14	pF	$V_{DS} = 20$ V, $V_{GS} = 0$ V, f = 1 MHz

NOTE 1. Maximum ratings are limiting values above which the transistor may be damaged.

NOTE 2. I_{GSS} is the total gate leakage current. "I_{DGO}" and "I_{SGO}" will be less than "I_{GSS}."

NOTE 3. Pulse test required. Pulse width 100 μsec duty cycle $\leq 1\%$.

NOTE 4. Care must be taken in performing this test as power dissipation may exceed maximum dissipation of the unit.

March 1967

ELECTRICAL CHARACTERISTICS

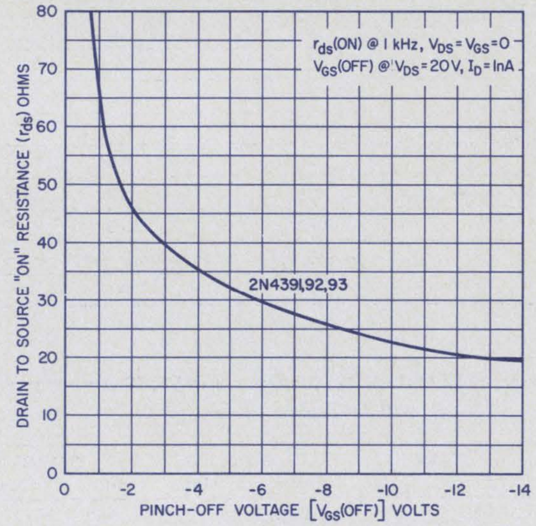
@ 25°C (UNLESS OTHERWISE NOTED)

		2N4391	2N4392	2N4393		
Small-Signal, Common Source, Short Circuit Reverse Transfer Capacitance	C_{rss}	3.5			pF	$V_{DS} = 0$ V, $V_{GS} = -12$ V, f = 1 MHz
			3.5		pF	$V_{DS} = 0$ V, $V_{GS} = -7$ V, f = 1 MHz
				3.5	pF	$V_{DS} = 0$ V, $V_{GS} = -5$ V, f = 1 MHz

TYPICAL PERFORMANCE CURVES

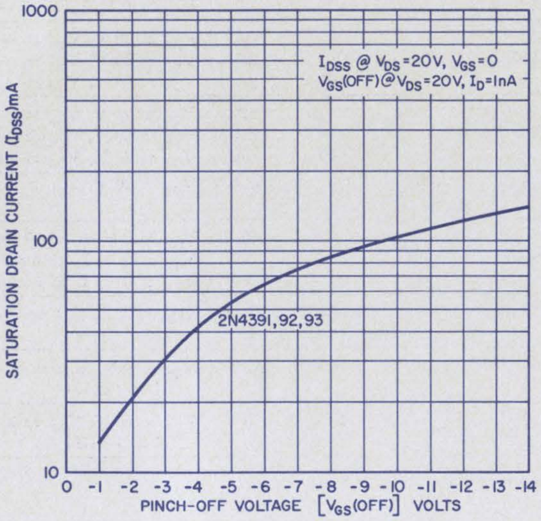
@ 25°C (UNLESS OTHERWISE NOTED)

PARAMETER INTERRELATIONSHIP



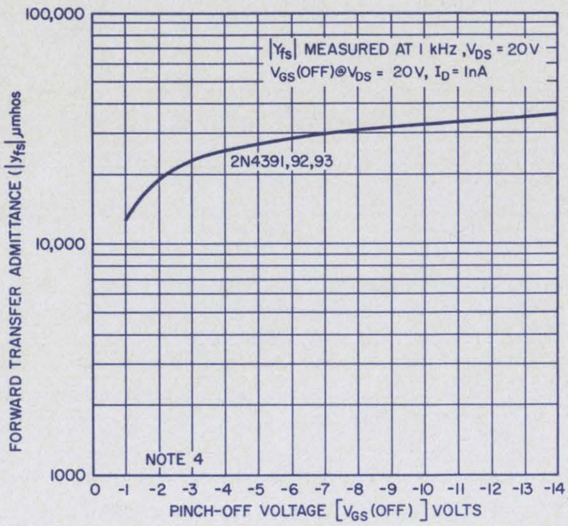
DRAIN TO SOURCE "ON" RESISTANCE VS. PINCH-OFF VOLTAGE

FIGURE 1



SATURATION DRAIN CURRENT VS. PINCH-OFF VOLTAGE

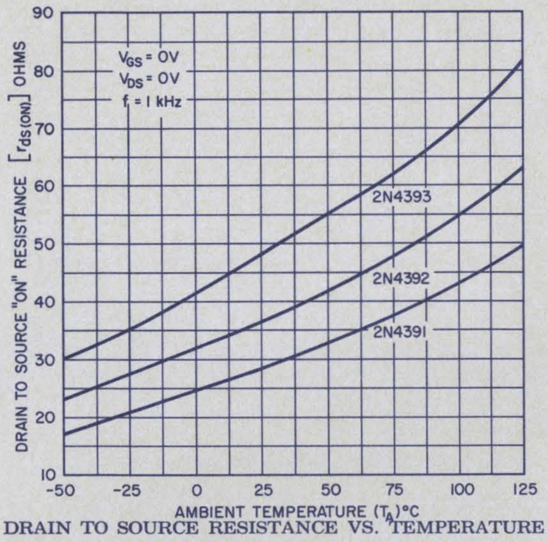
FIGURE 2



FORWARD TRANSADMITTANCE VS. PINCH-OFF VOLTAGE

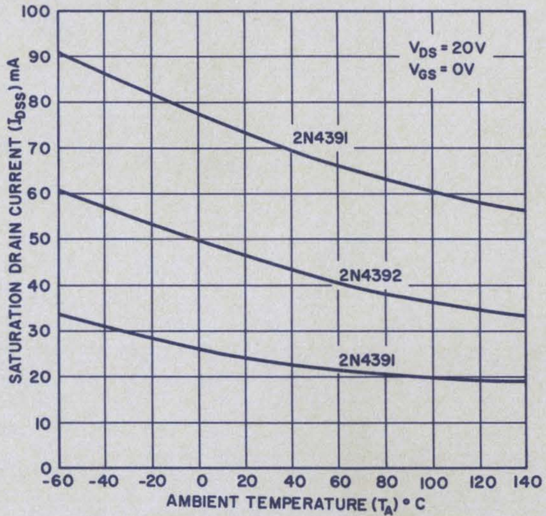
FIGURE 3

TEMPERATURE AND LEAKAGE CHARACTERISTICS



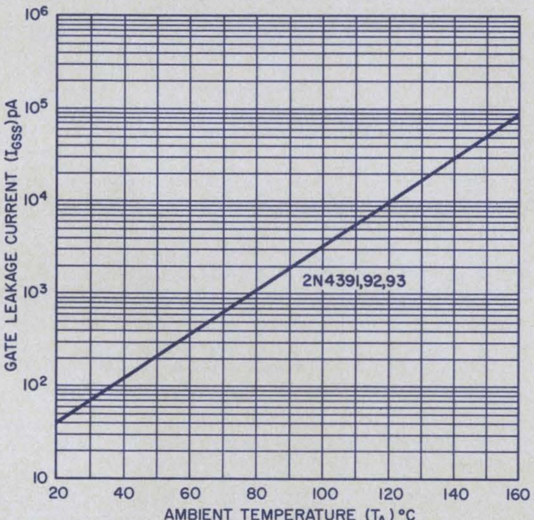
DRAIN TO SOURCE RESISTANCE VS. TEMPERATURE

FIGURE 14



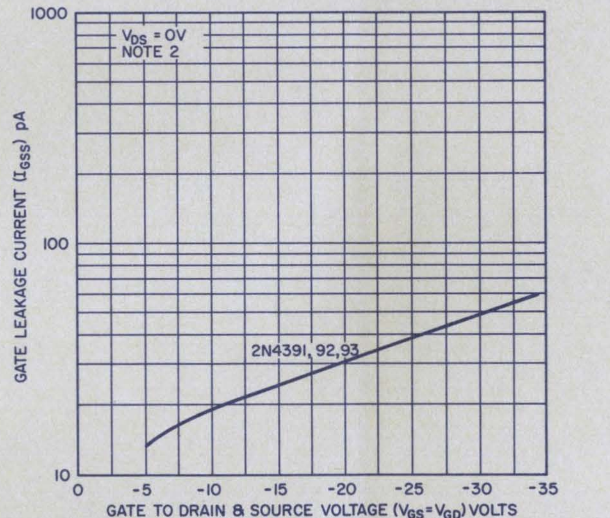
SATURATION DRAIN CURRENT VS. TEMPERATURE

FIGURE 15



GATE LEAKAGE CURRENT VS. TEMPERATURE

FIGURE 16



GATE LEAKAGE CURRENT VS. GATE TO DRAIN VOLTAGE

FIGURE 17

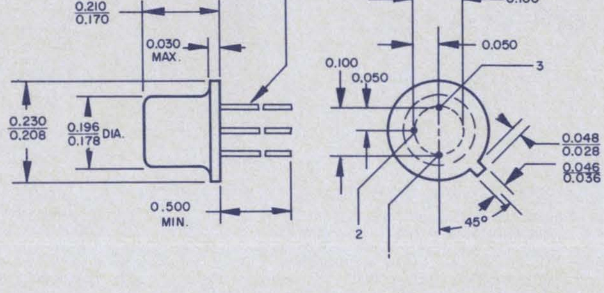
MECHANICAL DATA

Case: JEDEC TO-18

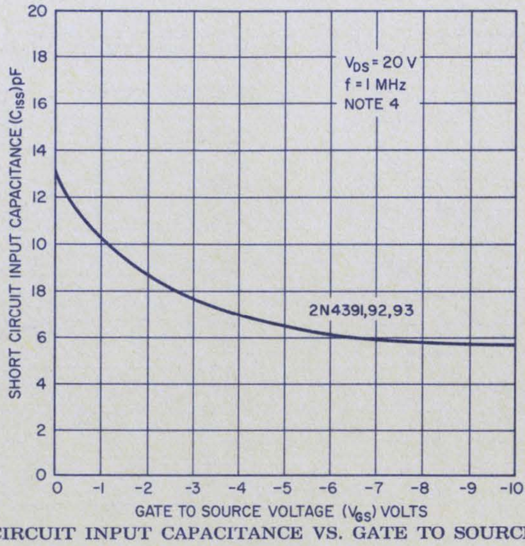
TERMINAL CONNECTIONS

Lead 1 Source　　Lead 3 Gate

Lead 2 Drain

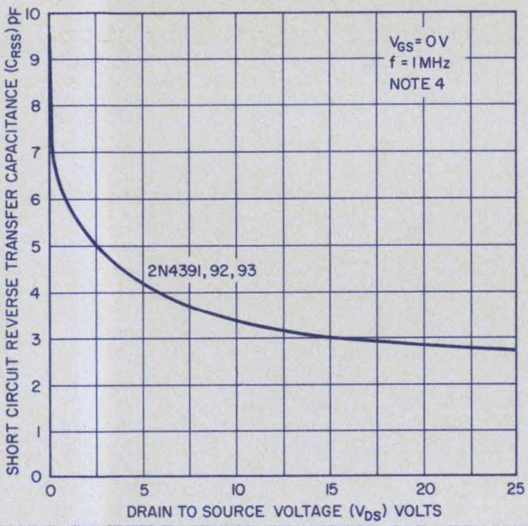


CAPACITANCE VOLTAGE CHARACTERISTICS



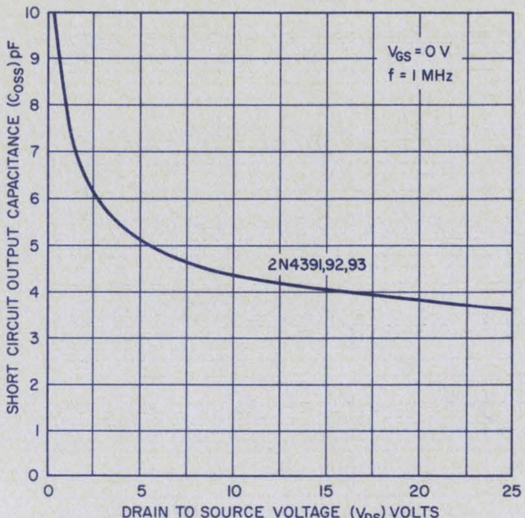
SHORT CIRCUIT INPUT CAPACITANCE VS. GATE TO SOURCE VOLTAGE

FIGURE 9



SHORT CIRCUIT REVERSE TRANSFER CAPACITANCE VS. DRAIN TO SOURCE VOLTAGE

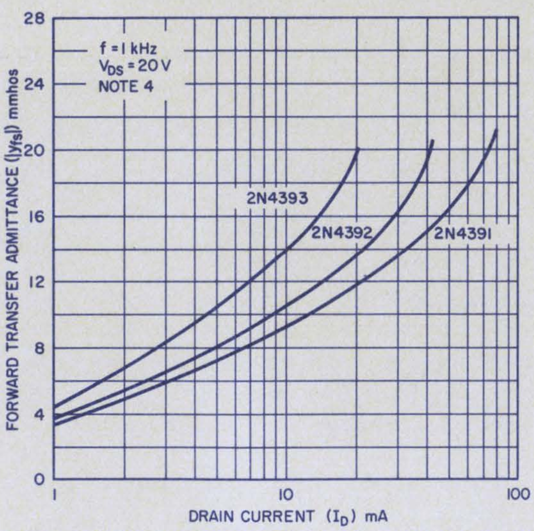
FIGURE 10



SHORT CIRCUIT OUTPUT CAPACITANCE VS. DRAIN TO SOURCE VOLTAGE

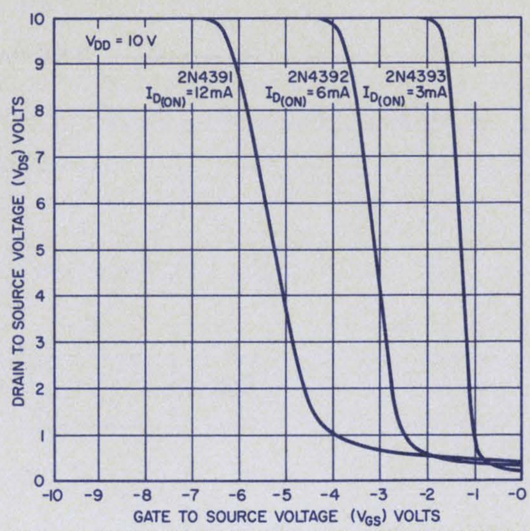
FIGURE 11

TRANSFER CHARACTERISTICS



FORWARD TRANSADMITTANCE VS. DRAIN CURRENT

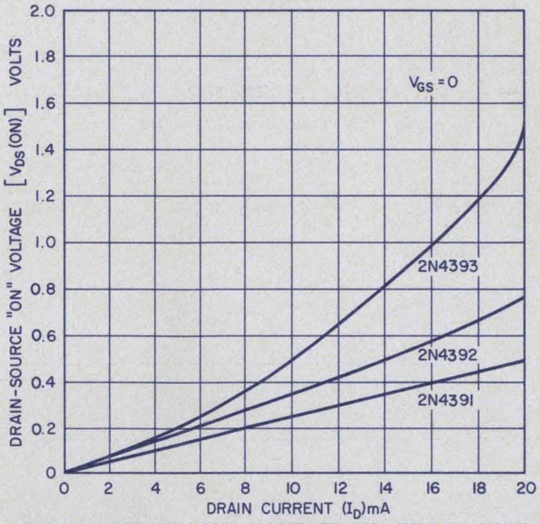
FIGURE 12



DRAIN TO SOURCE VOLTAGE VS. GATE TO SOURCE VOLTAGE

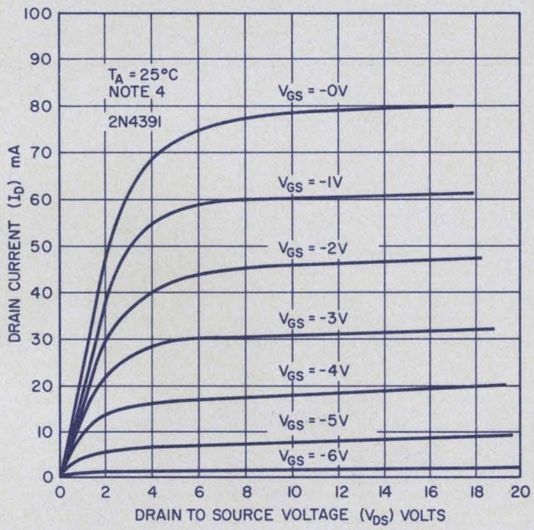
FIGURE 13

DRAIN CHARACTERISTICS



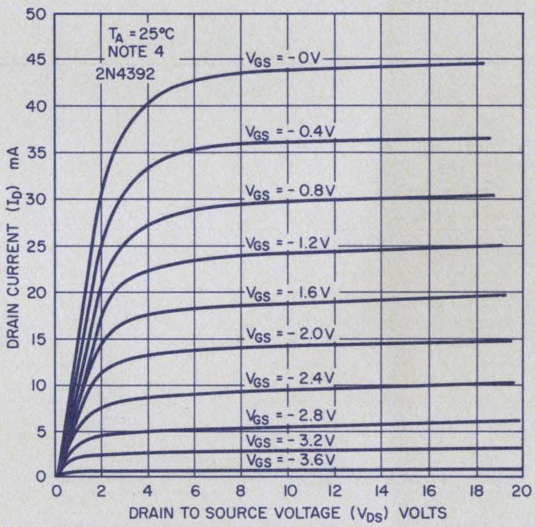
DRAIN SOURCE "ON" VOLTAGE VS. DRAIN CURRENT

FIGURE 4



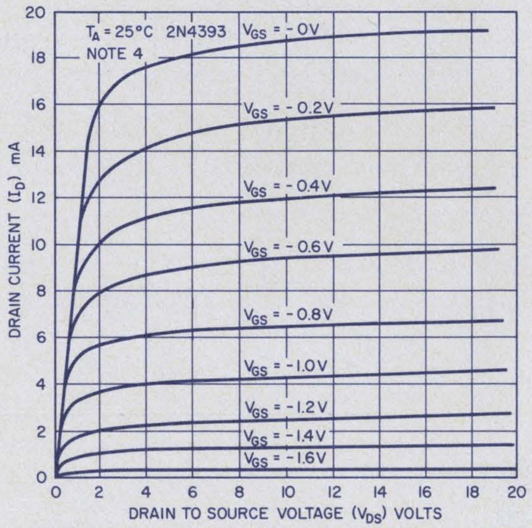
DRAIN CURRENT VS. DRAIN TO SOURCE VOLTAGE

FIGURE 5



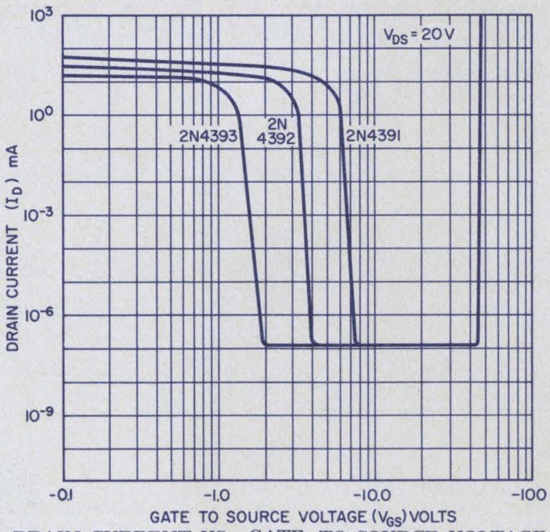
DRAIN CURRENT VS. DRAIN TO SOURCE VOLTAGE

FIGURE 6



DRAIN CURRENT VS. DRAIN TO SOURCE VOLTAGE

FIGURE 7



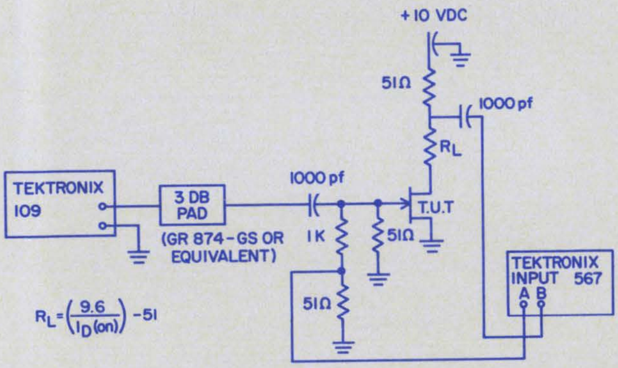
DRAIN CURRENT VS. GATE TO SOURCE VOLTAGE

FIGURE 8

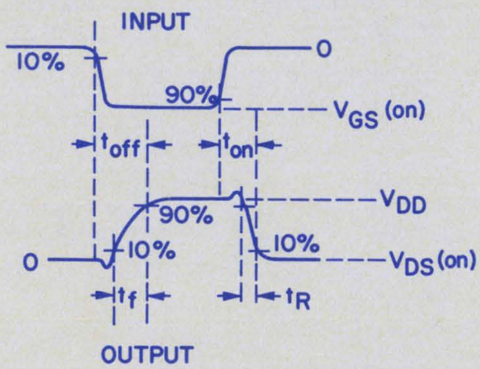
SWITCHING CHARACTERISTICS

@ 25°C (UNLESS OTHERWISE NOTED)

Type No.	Turn On Time t_{on} nsec. Max.	Rise Time t_r nsec. Max.	Turn Off Time t_{off} nsec. Max.	Fall Time t_f nsec. Max.	CONDITIONS
2N4391	15	5	20	15	$V_{DD} = 10$ V, $V_{GS} = 0$ I_D (on) $= 12$ mA V_{GS} (off) $= -12$ V
2N4392	15	5	35	20	$V_{DD} = 10$ V, $V_{GS} = 0$ I_D (on) $= 6$ mA V_{GS} (off) $= -7$ V
2N4393	15	5	50	30	$V_{DD} = 10$ V, $V_{GS} = 0$ I_D (on) $= 3$ mA V_{GS} (off) $= -5$ V



SWITCHING TEST CIRCUIT



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ELECTRONICS

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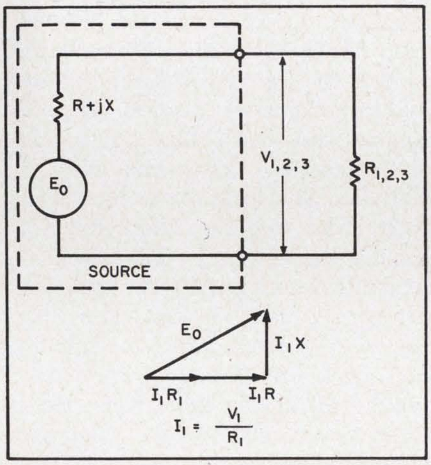
Letters

Impedance measuring method applied to Z_s

Sir:

The method that A. T. Snyder used [Letters, ED 2, Jan. 18, 1967, p. 44] to calculate the R and X components of an impedance with limited measuring equipment can also be applied to finding the components of a source impedance. The required equations can be derived as follows:



Since three unknowns are involved, R, X and E_o, three equations are needed. Load the source with some R_1 and note the corresponding V_1 (see Figure). Then find an R_2 and R_3 such that V_2 across $R_2 = V_1/2$, and V_3 across $R_3 = V_1/4$. The vector diagram shows the case for R_1 and V_1. Then from the vector diagram, on the assumption that E_o is constant:

$$E_o^2 = [(V_1/R_1)(R_1+R)]^2 + [(V_1/R_1)X]^2.$$

Similarly for V_2 and V_3:

$$E_o^2 = [(V_2/R_2)(R_2+R)]^2 + [(V_2/R_2)X]^2;$$
$$E_o^2 = [(V_3/R_3)(R_3+R)]^2 + [(V_3/R_3)X]^2.$$

Eliminating E_o^2, setting $V_2 = V_1/2$ and $V_3 = V_1/4$, and canceling V_1s give the following equations:

$$[(R_1+R)/R_1]^2 + (X/R_1)^2 = [(R_2+R)/2R_2]^2 + (X/2R_2)^2; \quad (1)$$
$$[(R_1+R)/R_1]^2 + (X/R_1)^2 = [(R_3+R)/4R_3]^2 + (X/4R_3)^2. \quad (2)$$

Simplifying Eqs. 1 and 2 and putting them into standard form give:

$$X^2 + (R-a)^2 = b^2, \quad (3)$$
$$X^2 + (R-c)^2 = d^2, \quad (4)$$

where:

$$a = [R_1R_2(R_1-4R_2)]/(4R_2^2-R_1^2);$$
$$b^2 = \{[2R_1R_2(R_1-R_2)]/(4R_2^2-R_1^2)\}^2;$$
$$c = [R_1R_3(R_1-16R_3)]/(16R_3^2-R_1^2);$$
$$d^2 = \{[4R_1R_3(R_1-R_3)]/(16R_3^2-R_1^2)\}^2.$$

Solving Eqs. 3 and 4 gives:

$$R = [(d^2-b^2)/2(a-c)] + [(a+c)/2];$$
$$X = [d^2-(R-c)^2]^{1/2}.$$

Should the measuring instrument not load down the source significantly, then E_o can, of course, be found directly and only two equations are required. Analogously to the previous case, find an R_1 such that V_1 across $R_1 = E_o/2$, and an R_2 such that V_2 across $R_2 = E_o/4$. Then:

$$E_o^2 = [(V_1/R_1)(R_1+R)]^2 + [(V_1/R_1)X]^2;$$
$$E_o^2 = [(V_2/R_2)(R_2+R)]^2 + [(V_2/R_2)X]^2.$$

Setting $V_1 = E_o/2$ and $V_2 = E_o/4$, eliminating E_o^2s, and simplifying give:

$$X^2 + (R+R_1)^2 = 4R_1^2, \quad (5)$$
$$X^2 + (R+R_2)^2 = 16R_2^2. \quad (6)$$

Solving Eqs. 5 and 6 gives:

$$R = (3/2)[(R_1^2-5R_2^2)/(R_1-R_2)];$$
$$X = [(3R_1+R)(R_1-R)]^{1/2}.$$

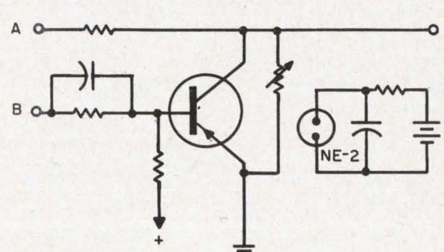
S. Barilovits
AFC Group,
Lockheed-Georgia Co.
Marietta, Ga.

FORSURE mode boosts MAYBE gate operation

Sir:

The performance of the MAYBE gate described in Electronic Design [Letters, ED 4, Feb. 15, 1967, p. 49] can be improved by operation in the FORSURE mode with an increase in reliability and decrease in initial cost and maintenance.

To ensure reliable operation, the only requirement is to increase the



MAYBE gate gives random accuracy.

positive base potential on the pnp transistor to guarantee that no current will ever flow through the device. In this fashion, the MAYBE gate (see Figure) will ignore all information at the input junction, regardless of its veracity. Since the output will never contain any misinformation, the device is said to operate in the FORSURE mode. It is interesting to note that the neon flasher is no longer necessary, so that the initial cost may be cut. Careful consideration of the circuit by the astute designer may result in further cost savings by elimination of other components.

H. F. Clark
T. K. Denton
J. F. Kenney
J. E. Miller

Staff Members
Geo-Astrophysics Laboratory
Boeing Co.
Seattle, Wash.

'Gypsy engineers' elicit sympathetic response

Sir:

The editorial by Peter Budzilovich, "Needed: A Way to tame the gypsy in us," in the February 15, 1967, issue of ELECTRONIC DESIGN [p. 75] ends with the question, "What do you think?"

I think that ED is to be commended for its frequent and varied coverage of the dilemma of the engineer in the defense effort. This is a problem on which it is hard to print too much. I have a collection of editorials and letters to ED, all touching on the sticky problem of the gypsy engineer. I also clipped and saved a copy of Maria Dekany's excellent article on EE societies ["EE Societies . . . are they doing enough?" ED 6, March 15, 1966, pp. U86-U91]. Whenever the opportunity arises, I take out these articles and show them to my coworkers. The majority of them dedicate a few minutes to bewailing the engineer's lack of professional status. Then they lapse into professional somnolence. When will they learn?

ELECTRONIC DESIGN with its generous coverage of this problem is helping to awaken the engineering fraternity to the need for careful thought and constructive action. When and if engineering becomes a true profession, its members should look back to the efforts of ED and give a loud thank you.

Robert Bruce

Senior Engineer
Sperry Gyroscope
Great Neck, N. Y.

Sir:

Let us consider the problem you raised in your recent editorial from the point of view of the older person who has attained his or her degree at an advanced age (after 35). Two such people graduated in 1963 from Arizona State University's College of Electrical Engineering. Guess who got the highest offer on campus that year? The 38-year-old male graduate who had worked part-time at a local electronics firm. Guess who got the first offer on campus that year? The woman, graduating at age 37 with less than a B average because she had a full-time outside job, a half-time outside job, and a full 18-hour engineering course—all at the same time. Both graduates received more than six job offers apiece.

Four years later, both are still getting job offers, although they are well satisfied with their present jobs. Evidently it isn't the age of the engineer, but the age of the degree or postgraduate work that counts. We may be forced to spoon-feed a majority of citizens as a result of complaints of prejudice, disadvantaged childhoods, sex bias, and other feeble excuses, but engineers should be able to think for themselves, act for themselves, not expecting other people to pay any part of their upkeep.

(Mrs.) Faith Lee

Project Engineer
Phoenix, Ariz.

Sir:

Offering an opinion on the suggestion in your good editorial in the Feb. 15, 1967, issue of ED, I would like to propose that the prejudice against older engineers is not entirely due to their lack of recent formal education. In part it may be due to the demands of government agencies on their contractors for products having the ultimate in performance without regard to cost or reliability—"hot rod" engineering. This requires intensive training in highly specialized disciplines, such as heat transfer, the economic demand for which is fickle.

The rest of the cause, I would like to suggest, is that the over-45 engineers have just been around too long, and understand Personnel Dept. gimmicks. Competent but politely skeptical, they make the managers subtly uncomfortable. The managers' reaction, perhaps, might be like that of the late W. C. Fields when he was faced by a panhandler: "Throw the bum out! He's breaking my heart."

Possibly technical expertise is not enough to save the over-45 engineer, no matter how many courses he has taken. An engineer of my acquaintence has the following qualifications: BS (MIT); Fellow of a Member Society of the American Institute of Physics; listed in *American Men of Science;* author of over 40 published technical papers (right up to 1966); 14 patents; developer of several successful commercial products in the electronic instrument field. This guy has been quietly looking for another job. He is getting nowhere. He is 51 years old. Agencies and personnel men don't even understand his résumé. It bothers them; it doesn't fit into the categories they have been taught. Wasted talent? Does anybody want talent? Who will pay for success?

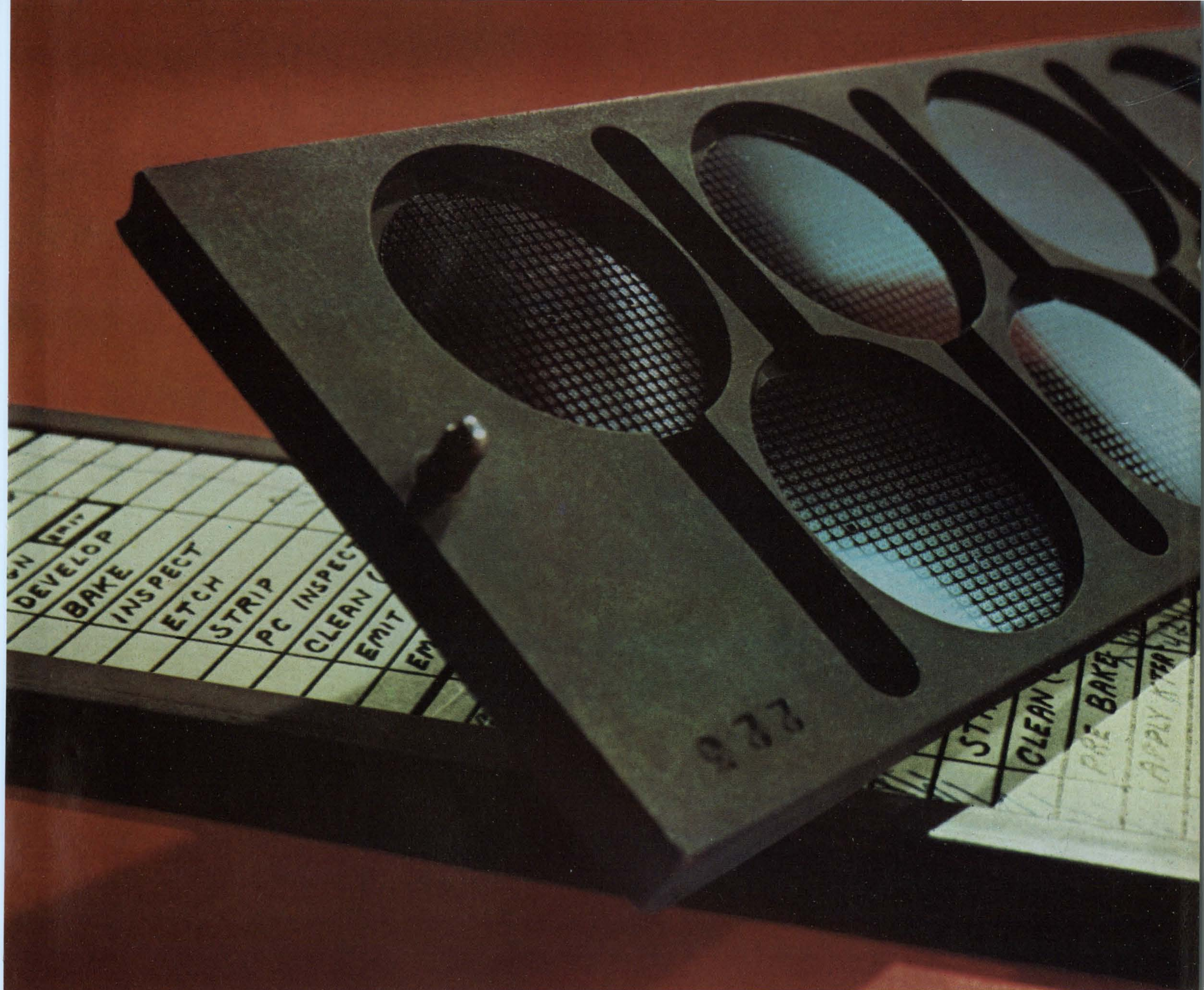
Name withheld

Company Vice President
Costa Mesa, Calif.

Sir:

In regard to your editorial in the February 15 issue, I feel some comments are necessary. The idea of an industry-wide pension plan has a definite appeal, but care needs to be taken when comparing the "gypsy" engineer's plight to that of the baseball player.

Once the player is signed by a club, he has essentially no place to go unless the club trades him, and therefore loyalty is not a consideration in the usual sense. The engineer, on the other hand, can quit to accept a better offer without the



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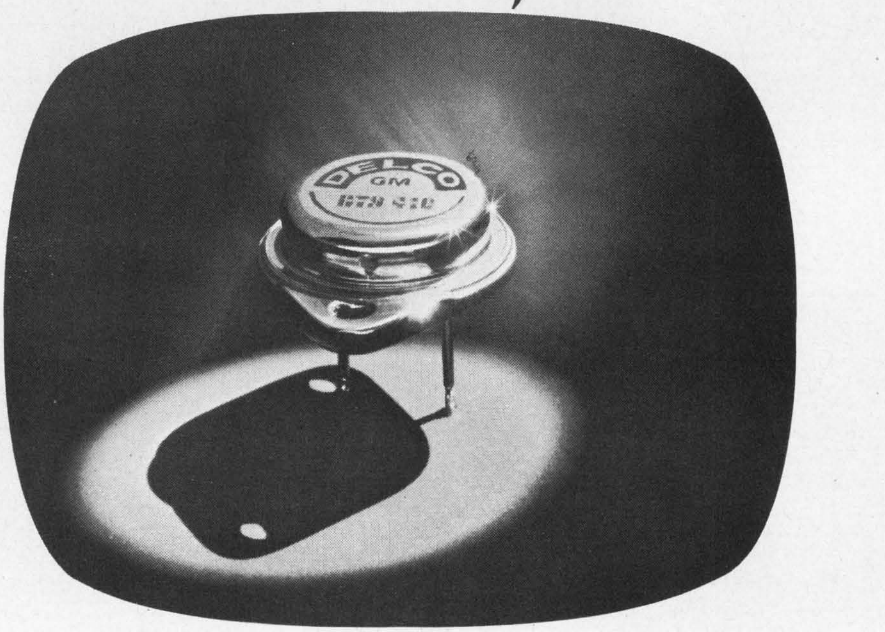

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consent of his present employer. Therefore, the engineer's vested interest in his present company is one of the incentives many companies use to hold on to their engineers. This is needed by those companies that are heavily engaged in government contract work. Regardless of how it started, the present situation is hard on noncontract companies, particularly those in the same area as the contract companies. When a contract company gets a new contract, the rest shiver in the knowledge of the impending talent raid. The salaries offered under these conditions completely abort any attempt at an industry-wide salary schedule, or even an individual company's attempt at an equitable salary schedule.

It seems that there is a requirement for both types of environment and that these two environments will generate disjointed salary conditions. What the engineer really needs is to be aware of the two environments and what their effect can be. The engineer must realize that tremendous adjustments are necessary if he is going to leave one environment to enter the other, whichever direction he goes. Probably the most difficult direction is from the contract company to the noncontract company; the average engineer will probably find the salary levels lower but the other benefits more meaningful in the long haul. I am not suggesting that one environment is better than the other, I am stating that the engineer needs to analyze the situation in the same cold light he would use on any engineering problem.

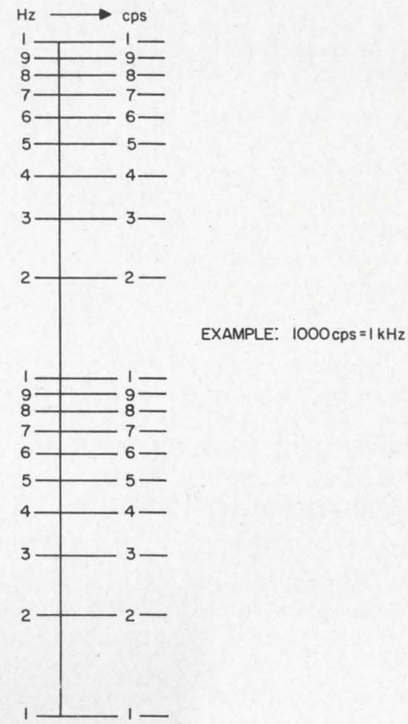
Marvin McClay

Chief Engineer
Helipot Division
Beckman Instruments, Inc.
Fullerton, Calif.

Nomograph accurately converts Hz into cps

Sir:

The accompanying nomograph was designed to facilitate conversion from hertz into cycles per sec-



ond. Although as shown it spans only two decades, it can be extended to higher and lower frequencies by making use of the well-known relationships, $10^{-x}\ 10^{x} = 1$ and slipping the decimal point.

Another nomograph is now in the process of validation by extensive computer runs. It will mechanize the conversion from cycles per second into hertz.

Guy Fawkes

Fleagle Design, Inc.
Boston

Accuracy is our policy

In "Check design program availability," ED 23, Oct. 11, 1966, pp. 76-80, Prof. Alan B. Macnee of the University of Michigan draws attention to an error in the last four programs in the list, FACTOR, TCHDEL, RATTCH and LAPLAC (p. 80). Dr. Macnee says that he can provide only program listings, not tapes, decks or instruction manuals as indicated. The university is expressly forbidden to rent its computer for commercial use. The four programs are written in MAD; IBM-7090 users can obtain MAD compiler system tapes from SHARE. MAD can also be transcribed into FORTRAN IV and into ALGOL languages.

Semiconductor Report

ON HIGH Q, LOW pF TUNING DIODES FROM MOTOROLA

SHARPER SELECTIVITY POSSIBLE WITH NEW TUNING DIODE TYPES

It has long been possible to get tuning diodes with high Figures of Merit (Q) — and, one could usually find a device with a good tuning ratio . . . But, Motorola's two new series of EPICAP© tuning diodes now offer *both* of these important features — together — in one device!

This excellent combination of high Q and tuning ratio is illustrated here by the specifications for the lowest to the highest capacitance devices in the MV1720-50 and MV1858D-70D series:

DEVICE	C_T Diode Capacitance V_R = 4 Vdc f = 1 MHz	T_R Tuning Ratio C_2/C_{30} f = 1 MHz		Q Figure of Merit V_R = 4 Vdc f = 50 MHz
	pF Nom	Min	Max	Min
*MV1720	6.8	2.80	3.80	500
MV1722	8.2	2.80	3.80	500
MV1724	10.0	2.80	3.80	500
MV1726	12.0	3.00	4.00	450
MV1728	15.0	3.00	4.00	450
MV1730	18.0	3.00	4.00	450
MV1732	20.0	3.20	4.20	400
MV1734	22.0	3.20	4.20	400
MV1736	27.0	3.20	4.20	400
MV1738	33.0	3.20	4.20	350
MV1740	39.0	3.20	4.20	350
MV1742	47.0	3.20	4.20	300
MV1744	56.0	3.20	4.20	300
MV1746	68.0	3.20	4.20	250
MV1748	82.0	3.20	4.20	250
MV1750	100.0	3.20	4.20	250
**MV1858D	1.0	2.40†	3.20	350††
MV1860D	2.2	2.50	3.30	350
MV1862D	3.3	2.60	3.40	300
MV1863D	4.7	2.60	3.40	300
MV1864D	6.8	2.70	3.50	300
MV1865D	8.2	2.70	3.50	250
MV1866D	10.0	2.80	3.60	250
MV1868D	12.0	2.80	3.60	200
MV1870D	15.0	2.80	3.60	200

*BV_R = 30V **BV_R = 60V
†T_R @ C_4/C_{60} ††@ f = 100 MHz

The high Q of these devices makes possible the design of tuning circuits that have sharp selectivity; and, is the result of an optimized resistivity profile. Tuning ratio — directly related to the tuning range capability of a voltage-variable capacitor — is obtained in these two series by careful doping control.

The MV1720-50 series will match the high performance requirements of equipment operating up to 1 GHz, while the MV1858D-70D series will perform well in the 3 to 4 GHz range. Applications include aircraft radio, guidance and control systems; preselected filters in ECM equipment and high frequency spectrum analyzers.

MAXIMUM RELIABILITY & STABILITY

The MV1720-50 series diodes are in a DO-7 glass package that features Motorola's RamRod* (straight-through) construction:

- To prevent "S-bend" mismatches and shorts to substrate.
- For continuous device operation, even when subjected to shock or vibration.
- To provide closely matched thermal expansion coefficients.

The MV1858D-70D devices are available in the versatile and rugged, low inductance microwave pill with prong package.

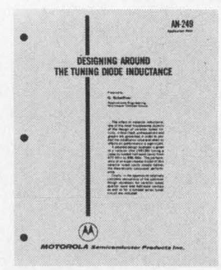
The MV1720-50 series is priced at $4.90 each and the MV1858D-70D series is $8.00, both in 100-up quantities.

CUSTOM SELECTED DIODES

Motorola can also "custom select" high-quality tuning diodes to meet a wide variety of application requirements. In many cases, where you do not require the high performance specified for the types above, these "specials" may be able to lower your unit costs.

If you need applications assistance in applying Motorola EPICAP diodes in your circuit design, take advantage of our Applications Assistance Program — for device analysis, engineering aid, circuit design assistance, or technical literature. For complete details on the MV1720-50 and MV1858D-70D series, circle the reader service number below.

On Reader Service Card Circle 74



HOW TO AVOID TUNING DIODE INDUCTANCE COVERED IN NOTE

One of the most troublesome aspects of the design of varactor-tuned circuits is the effect of varactor inductance. Motorola Application Note 249 provides a comprehensive explanation of how to predict the inductance value; and also, when its effects on performance will be significant. In addition, a detailed design example is given of a varactor tuning a capacity-loaded half-wave cavity from 470 MHz to 890 MHz. The performance of an experimental model closely follows the theoretically calculated performance.

If you're concerned with varactor-tuned circuit design, this well-written note will be a valuable addition to your semiconductor library. Send for it today!

On Reader Service Card Circle 75

MOTOROLA Semiconductors
—where the priceless ingredient is care!

ELECTRONIC DESIGN announces the 'Top Ten' winners

On the following pages you will see the ten outstanding advertisements among the 150 that appeared in our January 4 issue. Our "Top Ten" contest attracted over 4000 readers who attempted to match their ratings of the 10 most memorable advertisements with the "recall-seen" scores from Electronic Design's regular Reader-Recall survey.

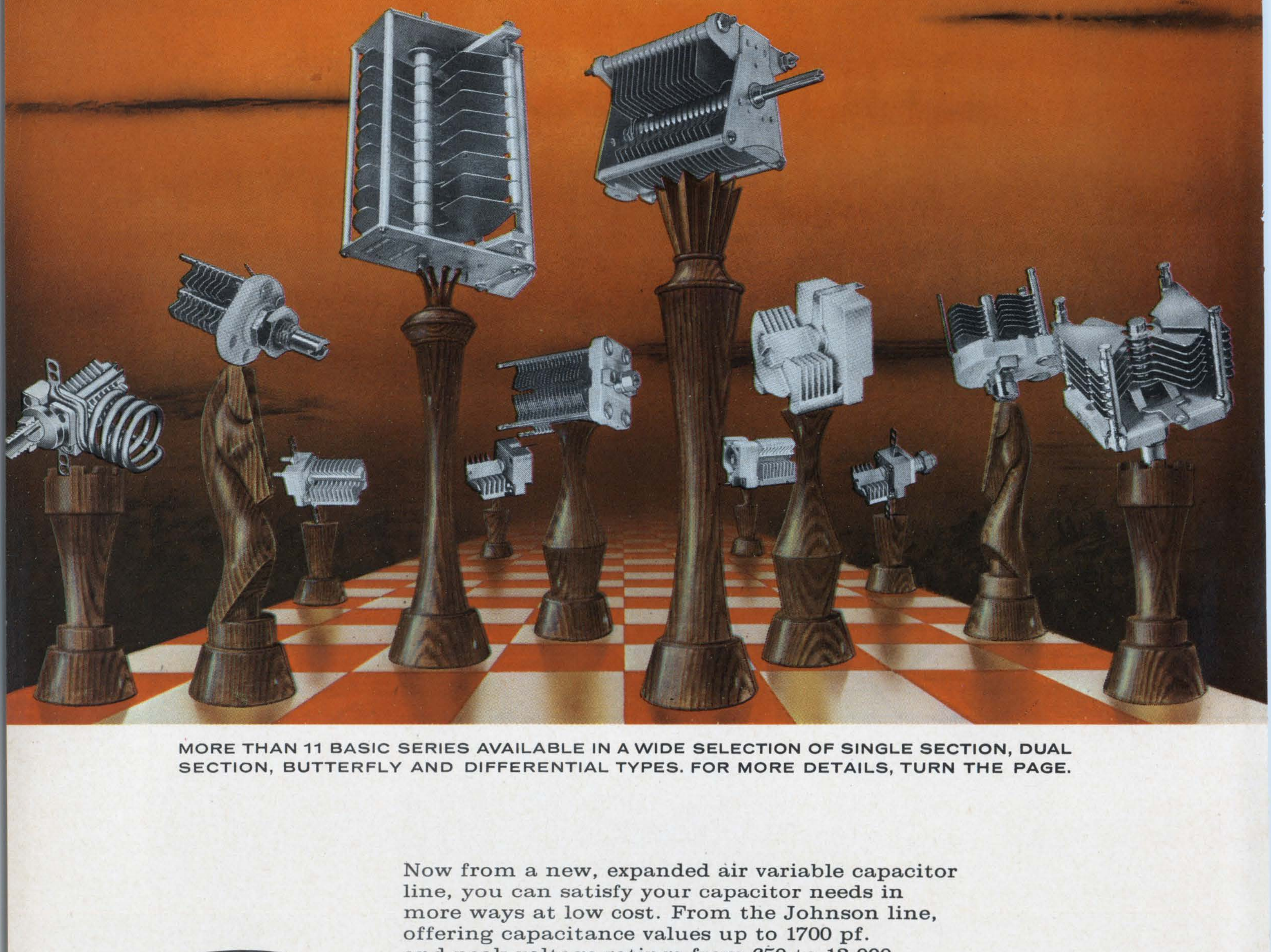
The winning advertisements combine attractive colors, tasteful design, and well-written copy–result: impact.

In order of highest Reader-Recall score, the winners are these:

1. Charles Bruning Co.
2. Sylvania, Electronic Components Group
3. The Thomas & Betts Co., Inc.
4. Monsanto Electronic Instruments
5. Dow Corning Corp.
6. E. F. Johnson Co.
7. Oak Manufacturing Co.
8. Guardian Electric Manufacturing Co.
9. Cutler-Hammer
10. Allen-Bradley Co.

The April 15 issue will contain the names of the readers who won the two Air France tickets to Paris, the Hoffman color TV set, the Bulova Accutron watches and copies of *Microelectronic Design.*

Johnson gives you the most moves in capacitor selection



MORE THAN 11 BASIC SERIES AVAILABLE IN A WIDE SELECTION OF SINGLE SECTION, DUAL SECTION, BUTTERFLY AND DIFFERENTIAL TYPES. FOR MORE DETAILS, TURN THE PAGE.

Now from a new, expanded air variable capacitor line, you can satisfy your capacitor needs in more ways at low cost. From the Johnson line, offering capacitance values up to 1700 pf. and peak voltage ratings from 650 to 13,000 volts, you can specify air variables and be assured your design will yield a product that's competitively priced. Johnson air variable capacitors range from sub-miniature types to large units suitable for heavy duty applications. Whatever the use, they provide excellent stability, high Q, uniform capacitance, and exhibit low "hook" in applications involving a square wave form.

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MACHINED PLATE TRIMMER AND TUNER TYPES – U, UA, UB, U-LC, V, AND W – Available in both printed circuit and chassis mounting types. U types available in differential and butterfly printed circuit mounting types in addition to single section types. V and W capacitors available in single section type only. Maximum capacities of up to 54 pf. Tuners consist of a machined plate trimmer and high Q air wound silver plated inductor, in resonant frequencies of 100 to 750 Mc.

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Type S: Capacity values to 100 pf. Voltage ratings to 3000 volts peak. Available in single section, differential and butterfly types.

Type K: Capacity values to 150 pf. Voltage ratings to 3800 volts peak. Available only in single section types. May be furnished in production quantities in full compliance to MIL-C-92A.

Type R: Capacity values to 340 pf. Voltage ratings to 4400 volts peak. Available only in single section type.

Type L: Capacity values to 200 pf. Voltage ratings to 3500 volts peak. Available in single section differential, butterfly and dual section types.

SPACER TYPES – Type C: Capacity values to 1500 pf. Voltage ratings to 13,000 volts peak. Available in single section and dual section types.

Type D: Capacity values to 1700 pf. Voltage ratings to 9000 volts peak. Available in single section and dual section types.

STAKED PLATE TYPES – Type E: Capacity values to 1000 pf. Voltage ratings to 4500 volts peak. Available in single section and dual section types.

Type F: Capacity values to 400 pf. Voltage ratings to 3000 volts peak. Available in single section and dual section types.

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STANDARD INSULATED CONNECTORS – A complete line of connectors molded of tough, low-loss, shock-proof polyamide in 10 colors meeting Fed. Std. 595. Tip, Banana and Dual Banana Plugs; Tip and Banana Jacks; Metal-Clad Tip Jack, Military; Jack and Sleeve; Binding Posts.

RIB-LOC TERMINALS – A new line of miniature, one-piece, insulated terminals with a unique serrated conical design, which resists loosening and turning. Provides an inexpensive approach to convenient press-in type terminals. Six colors conforming to Federal Color Standard No. 595. Terminal styles include single and double turret feed-thrus and stand-offs, .040" dia. tip plug and mating jack for .040 plug.

Tube Sockets, Insulators, Pilot Lights, and Hardware

ULTRA HIGH FREQUENCY SOCKETS – Continuous heat resistance to 500°F. with low loss, glass filled silicone base and heat treated beryllium copper contacts. Low inductance screen bypass capacitor available for VHF and UHF operation.

KEL-F SERIES – Molded of low dielectric loss-factor Kel-F plastic – designed for use with a wide selection of high power transmitting tubes.

STEATITE WAFER TYPES – Available in 4, 5, 6, 7, and 8-pin standard socket types, as well as Super Jumbo 4-pin types. Also giant 5 pin, and 7 pin Septar and VHF Septar Sockets.

SPECIAL PURPOSE TYPES – Includes sockets for special purpose tubes.

Note: For detailed specifications, request Socket Standardization Booklet 536 on your company letterhead.

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PANEL BEARINGS – For use on ¼" shafts and panels up to ⅜" thick. CRYSTAL SOCKETS – For low capacity, high voltage and high temperature operation. Glazed steatite, Grade L-423 or better. DC-200 impregnated. RF CHOKES – High quality construction. For 1.7 to 30 Mc range.

CHECK Johnson for all your component requirements

Johnson also offers a complete line of heavy-duty RF components for broadcast transmitting, RF heating, antenna phasing and other commercial applications.

Equipment in this line includes fixed and variable inductors, antenna phase sampling loops, isolation filter inductors, feed-thru bowl insulators, static drain chokes, RF contactors and heavy-duty make-before-break switches.

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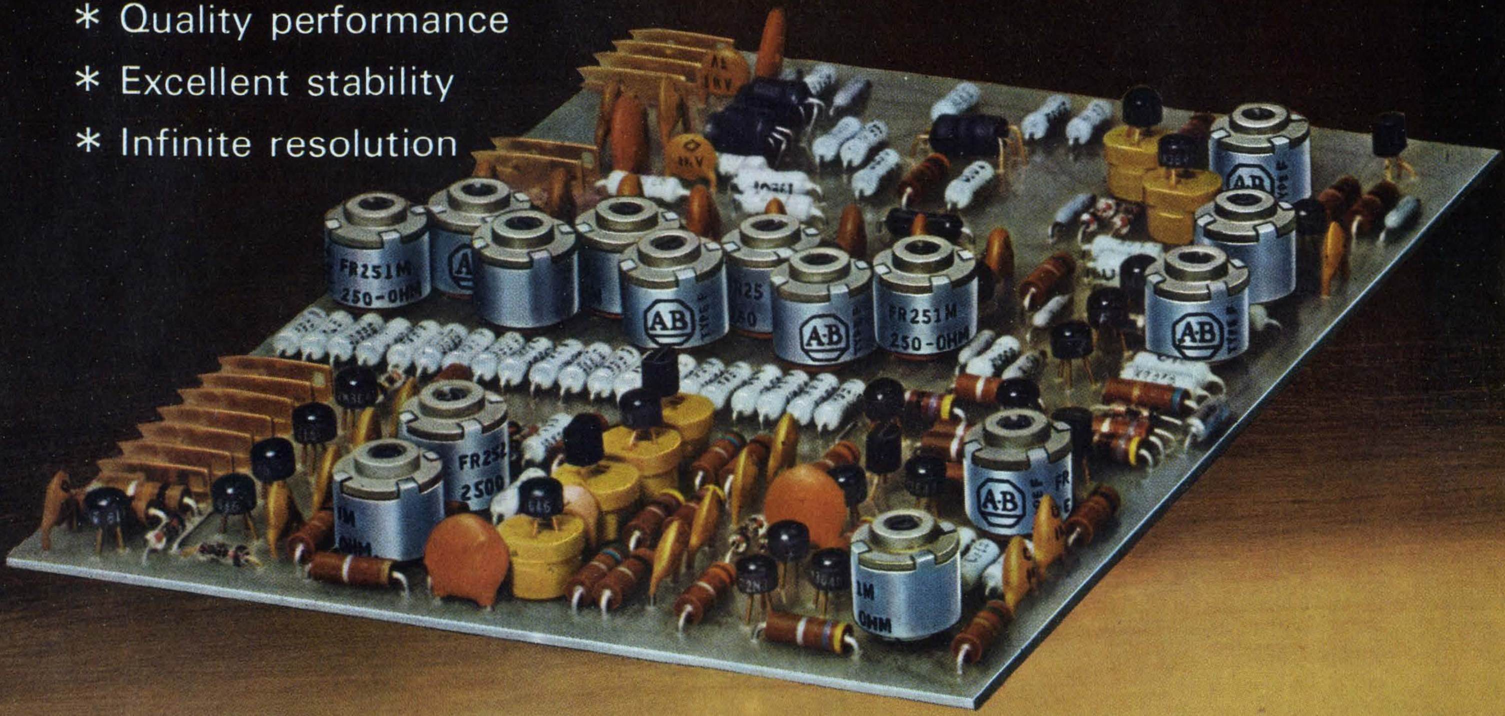
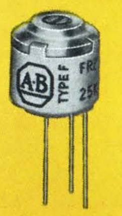
* Excellent stability
* Infinite resolution



One of the 5-inch by 6½-inch Wavetek printed circuit cards, showing 15 of the 25 Allen-Bradley Type F hot molded variable resistors and numerous hot molded fixed resistors used in the Model 111 VCG function generator.

Type F variable resistor with pin type terminals for mounting directly on printed wiring boards. Rated ¼ watt at 70°C. Total resistance values from 100 ohms to 5 megohms.



Actual Size

Wavetek Model 111 VCG generates sine, square, triangle, and ramp waves from 0.0015 Hz to 1 MHz, and offers precision control of the frequency of the waveforms by external voltage.

■ The precision waveforms generated by Wavetek's Model 111 VCG place exacting demands on the large number of variable resistors used to set amplitudes to very precise values and assure symmetry of all functions. They must provide velvet smooth control, and quiet operation. And since this is a Wavetek adjustment, it is essential that the variable resistors, once adjusted, will stay "put".

Allen-Bradley Type F variable resistors satisfy all of these requirements, because they have the same solid hot molded resistance track as the famous Type J and Type G variable resistors. There's velvet smooth control at all times—never the problem of discrete steps common to all wire-wound units. And since Type F variable resistors are essentially noninductive and have low distributed capacitance, they can be used at high frequencies where wire-wound controls are useless.

When a manufacturer like Wavetek has standardized on the quality of A-B electronic components, you can be sure of the superior performance of such equipment.

For more details on the complete line of Allen-Bradley quality electronic components, please write for Publication 6024. Allen-Bradley Co., 222 W. Greenfield Avenue, Milwaukee, Wis. 53204. In Canada: Allen-Bradley Canada Limited. Export Office: 630 Third Avenue, New York, N.Y., U.S.A. 10017.

ALLEN-BRADLEY

QUALITY ELECTRONIC COMPONENTS

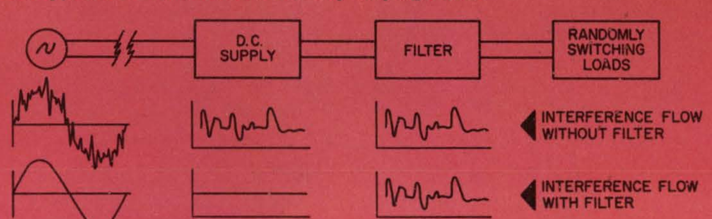
9-12-6E **ON READER-SERVICE CARD CIRCLE 26**

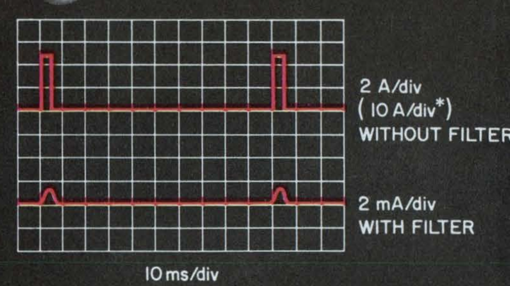
announcing...

Allen-Bradley Active Filters, which offer a 60 db attenuation over the range of 10Hz (3Hz*) to 100KHz

Allen-Bradley active filters can provide as much as a 50 to 1 reduction in size and a corresponding reduction in weight over conventional passive elements.

The diagram below and performance curve at right illustrate how Allen-Bradley *active* filters prevent current fluctuations in the power distribution system above 10Hz (3Hz*), developed by pulse modulated communications equipment, such as teletypewriters and other randomly varying loads.





Typical example of A-B Active Filter performance

Directly as the result of some new ideas applied to the field of ElectroMagnetic Compatibility, Allen-Bradley has been able to produce a new *active* low pass filter that provides an attenuation of greater than 60 db over the range of 10Hz (3Hz*) to 100KHz. The maximum dc component of the load current is 5 amperes.

The primary purpose of this filter in the above application is to prevent impulses generated by rapid load fluctuations, which may be carrying information of a confidential nature, from being reflected back through the power supply and into the power distribution system.

These new filters are designed to satisfy specific requirements. For instance, power line filters are under development for 60Hz and 400Hz power frequencies. Here, a sharp pass band is afforded the power frequency while greatly attenuating all other frequencies.

Allen-Bradley active filters produce a far greater attenuation of unwanted signals than is possible with a filter composed of conventional passive elements, occupying the same volume. By using the A-B *active* filter, a size reduction of 50 to 1 is attained, together with corresponding savings in weight. These filters employ solid-state circuitry. No external power source is required other than that supplying the power to the load. In addition, complete inrush and short circuit protection is provided.

Allen-Bradley specialists in filter engineering are available to discuss with you such problems for which these new active filters might offer the best solution. Please write: Allen-Bradley Co., 222 West Greenfield Avenue, Milwaukee, Wis. 53204. In Canada: Allen-Bradley Canada Limited. Export Office: 630 Third Ave., New York, N. Y., U. S. A. 10017.

* WITH EXTERNAL CAPACITOR

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QUALITY ELECTRONIC COMPONENTS

We dropped "Chemical" from our


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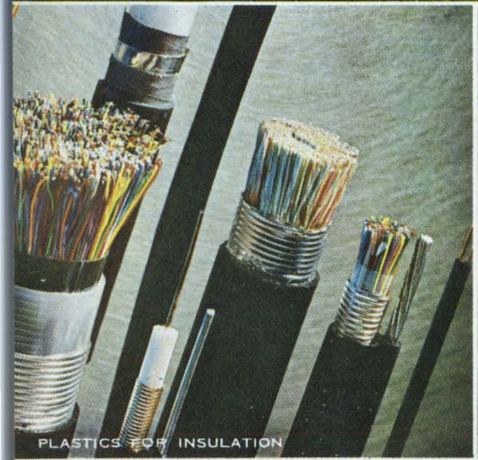
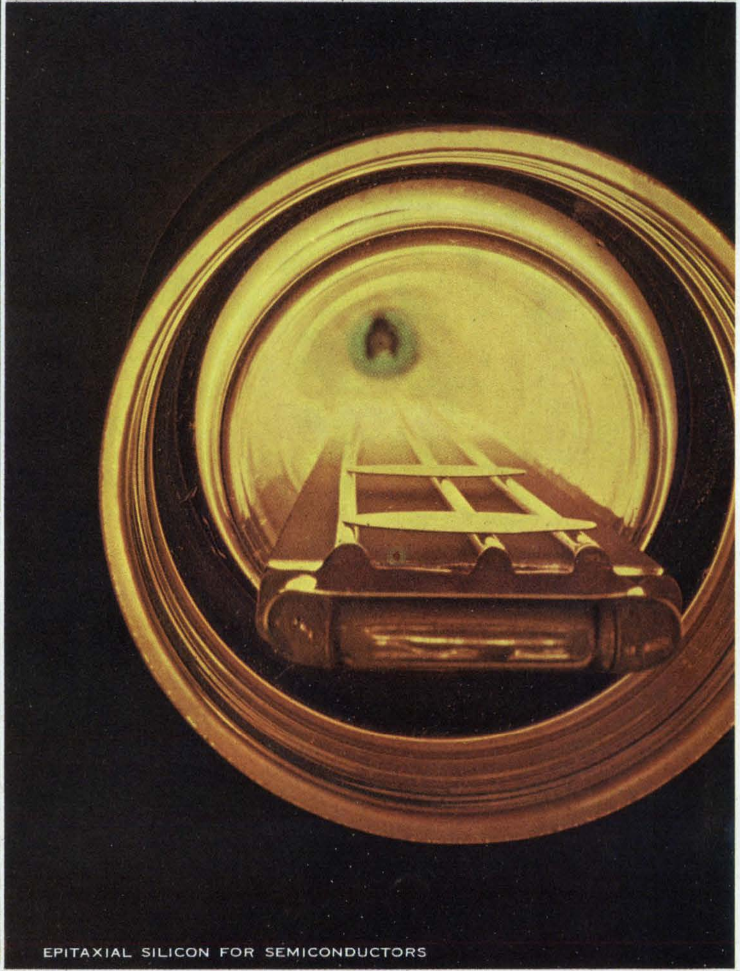
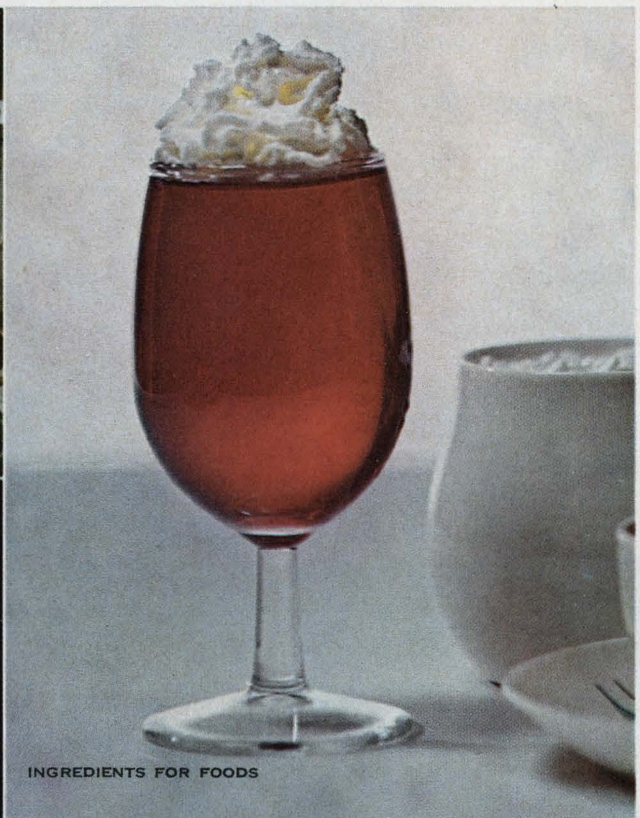

PLASTICS FOR INSULATION


ACRILAN® ACRYLIC FIBERS FOR CLOTHING


EPITAXIAL SILICON FOR SEMICONDUCTORS


HYDRAULIC FLUIDS FOR JET AIRCRAFT

name because it pinched!



INGREDIENTS FOR FOODS

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ON READER-SERVICE CARD CIRCLE 27


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CONTROL

ON READER-SERVICE CARD CIRCLE 28

Component and Circuit Design IDEAS

from SYLVANIA Electronic Components Group

READOUTS

Breakthrough in EL panel design permits greater display flexibility

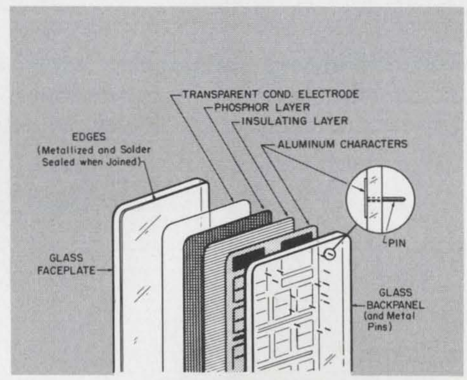
The newest advancement in electroluminescent readouts is a panel design of all-glass construction. Display designers and users now have a solid-state readout with higher reliability than ever before which lends itself to even greater design flexibility than previously possible with EL.

Completely engineered by Sylvania, this new concept actually allows both a decrease in readout character size (to ⅜-inch) as well as increased panel size. This means more characters per panel are possible than before in hermetically sealed EL designs.

Designers still get all the inherent advantages associated with Sylvania EL readouts: solid-state reliability, low-power consumption, wide viewing angle, light weight, low reflection, variety of characters, stable performance, no catastrophic failure, clear readability and rapid information display. Performance of the all-glass units is judged by the same standards as the metal-glass devices: brightness, spectral emission, contrast, life, etc.

What does "all-glass" really mean in this sense? While metal-glass EL panels use metal contact pins and metal sealing frames, this new design concept is completely of glass construction, with the only metal present being the connector pins. Eliminated also are conductive rubber contacts.

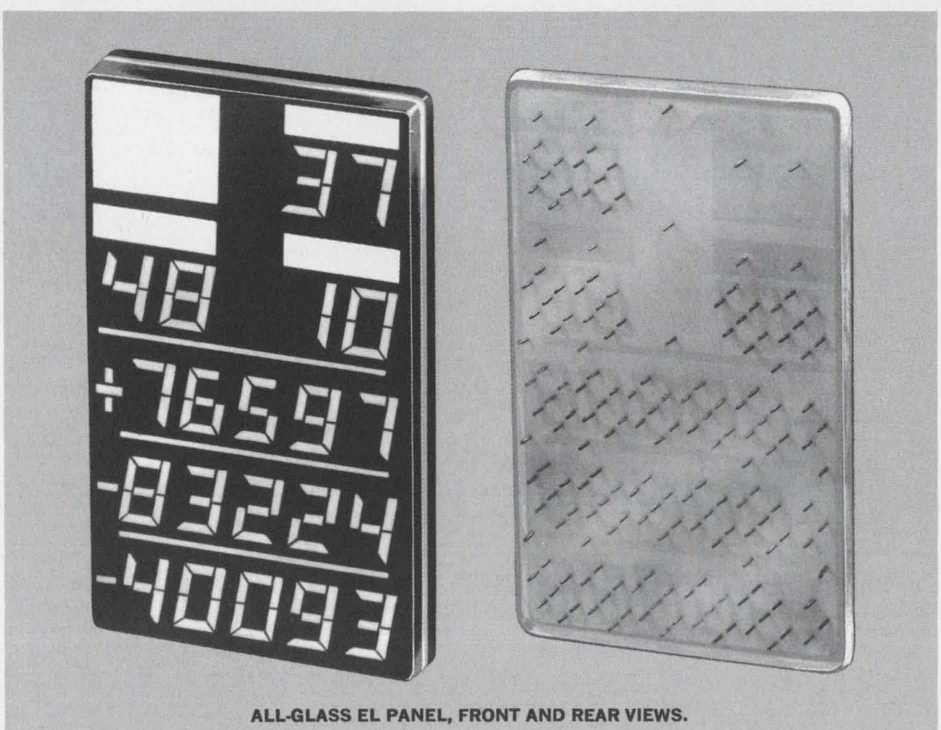
The user-benefit of this new construction is a higher degree of lamp



reliability for the demanding environmental and operational conditions encountered in severe aerospace applications.

The panels are designed to rigid specifications. The glass contact panel is molded as a single piece with the connector pins in place as integral parts of the panel. Combined with

(continued)



ALL-GLASS EL PANEL, FRONT AND REAR VIEWS.

This issue in capsule

READOUTS *(continued from page 1)*

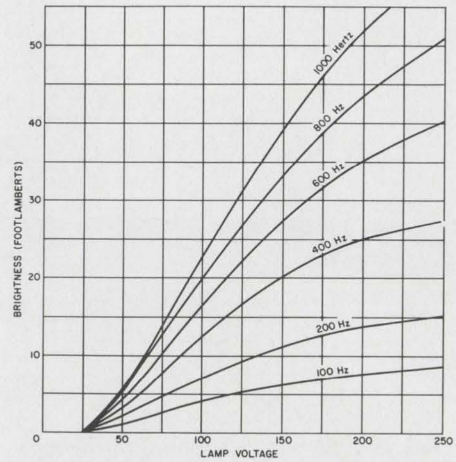
true hermeticity, the result is panels which perform reliably at extreme changes in altitude, temperature and humidity. They are also highly resistant to shocks and vibrations.

In the new construction, the glass contact panel containing sealed connector pins is ground flat on one side. The patterned back metallic electrode is applied to this glass surface. Thus, each active area becomes an integral part of its own connector pin, eliminating any possibility of registration problems. An electrical insulating layer is then applied over the back electrode and covered by a phosphor. A transparent conducting electrode put over the entire phosphor surface is the last electrical layer.

To protect the whole assembly, a glass front panel is placed on the transparent conductor and sealed to the contact panel, using a metal-solder technique. For less critical applications, an epoxy sealant may be used.

This simple construction process makes it easy to mass produce reliable and reproducible devices. The excellent match of expansion characteristics of faceplate and contact plate assemblies minimizes stress on the hermetic seal during temperature variations. Elimination of conductive rubber contacts provides a significant improvement in lamp reliability.

Standard all-glass units are available in 115 V and 250 V versions. The lower operating level is achieved by appropriate reductions in thickness of the EL and dielectric strata. Initial brightness is on the order of 25-30 FL at room temperature and 250 volts, 400 Hz. Spectral emission, contrast, life and half life are comparable to that of conventional EL panel design.



CIRCLE NUMBER 300

INTEGRATED CIRCUITS

How 4-bit array registers reduce IC package count, speed storage and transfer

Each of Sylvania's integrated four-bit binary register arrays contains the equivalent of at least 87 discrete components and the equivalent of 25 IC gates used in conventional integrated circuits. These monolithic digital functional arrays implement parallel storage or transfer of four binary bits every 15 nanoseconds. Here's how they work and how they can be used to build a temporary storage memory using only five IC packages.

Series SM-60 and SM-70 four-bit storage registers are for use as high-speed storage elements in control and arithmetic sections of digital computers. The SM-60 series has clocked inputs and clocked outputs. Further, the SM-60 output has wired OR capability which means outputs can be tied together to provide the logic OR function. The SM-70 series is operationally identical to the SM-60 except that it has a SUHL type output network and is not clocked with an enable signal. This means information set in the device is available at the output after a propagation delay of 20 nanoseconds.

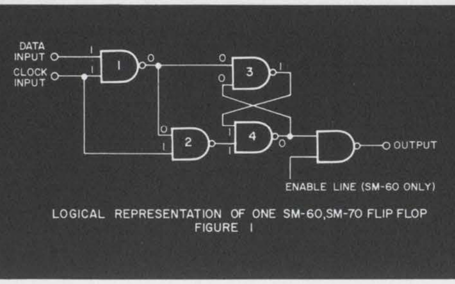
Figure 1 shows the logical operation of one of the four flip-flops in a storage register. With the data and clock inputs both at high (Logic "1"), the output of gate 1 is low (Logic "0"). This low condition appears at the input to gate 3 and forces the output of gate 3 to go high. The low output of gate 1 also appears at the input of gate 2, forcing the output of gate 2 to go high. Thus, both inputs to gate 4 are in the high condition. This means output of gate 4 is low. This low output appears at the input of gate 3, forcing the output of gate 3 high. The circuit is now latched with the output high. Once the circuit is latched, the clock input can be removed without disturbing the flip-flop.

Where data input is low (Logic "0") and clock input is high (Logic "1"), the circuit latches the flip-flop with its output in the low condition. If the clock input is low, no data is accepted.

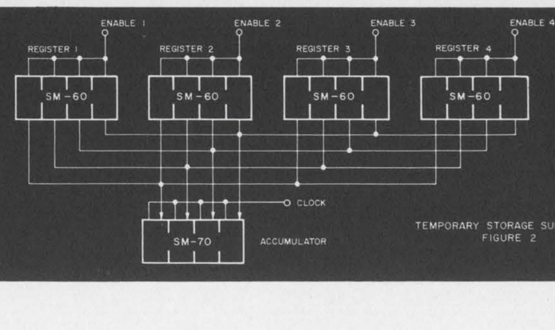
Figure 2 illustrates how to form a temporary storage register subsystem with common accumulator. Here, registers 1 through 4 can be enabled either separately or jointly. In the latter case, a logical OR is performed allowing masking techniques to be used. The SM-70 gives the accumulator a high fan-out. Only five packages are required and the number of external connections are cut to ⅛ of those required when conventional integrated circuits are used.

The SM-60 and SM-70 series operate over a temperature range of −55° to +125°C. Both these monolithic digital functional arrays are available in Sylvania's standard 14-lead dual in-line plug-in package and the TO-85 flat pack. They are completely compatible with the SUHL line of integrated circuits.

CIRCLE NUMBER 301

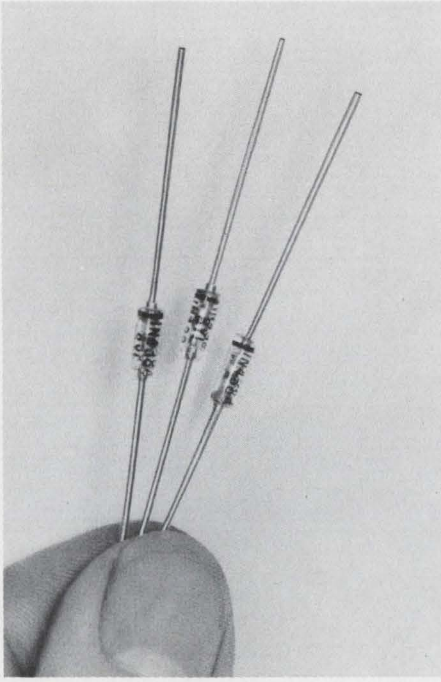


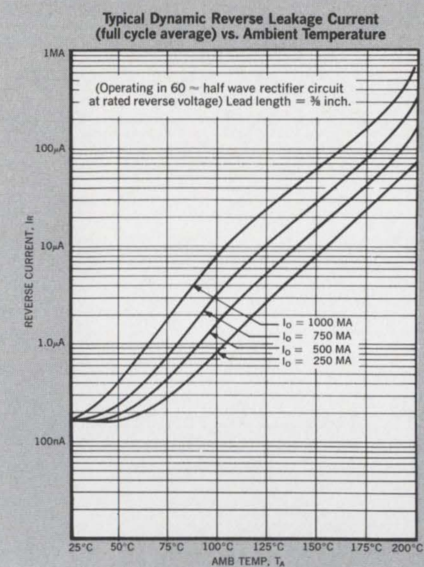
LOGICAL REPRESENTATION OF ONE SM-60, SM-70 FLIP FLOP
FIGURE 1

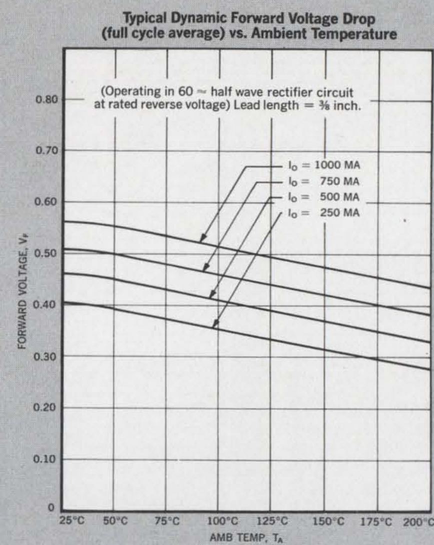


TEMPORARY STORAGE SUBSYSTEM
FIGURE 2

Absorb 1000-watt reverse transients with Sylvania's glass devices







Circuit designers are finding that Sylvania's glass rectifiers are better than other glass rectifiers. In this instance, the improved characteristics result in enhanced circuit performance and increased device reliability. Sylvania has coupled the inherent advantages of glass encapsulation with superior device design to make these glass diodes rugged enough for military applications. This designed-in dependability also makes this line of glass units an excellent choice for many other uses in computer, industrial and communications equipment. It is the improvements in device design that make Sylvania's glass silicon rectifier line stand out from other glass units.

In the improved devices, a large double diffused junction allows handling of 1000-watt reverse power transients while still maintaining the standard 50-amp forward surge capability. Sylvania's first glass rectifiers, can take outputs of up to 1 amp at reverse working voltage of 1000 volts without damage.

Heat dissipation is aided by welding a solid high conduction power lead to an oversized heat conduction stud. This enhances power handling capability while extending device life by keeping the unit cooler. The glass package is electrically neutral and smaller than many metal rectifiers, thus permitting greater stacking and card densities. With Sylvania's sealing techniques, the designer gets the benefits of improved device design without sacrificing any of the advantages of glass encapsulation. Use of a glass package means not only improved insulating characteristics but units that can be hermetically sealed. Radiflo leakage rate for these devices is less than 1×10^{-10} cc/sec. Low leak rates extend life and increase reliability. The glass body also enhances the thoroughness of in-process quality control by allowing visual inspection during production.

In addition to the ability to handle high reverse pulses, these rectifiers have low reverse leakage current. Typical rating is 10 na at 25°C ambient and rated reverse voltage. The high voltage rating and wide temperature operating range (−65°C to 175°C) capability of these units can't be matched by ordinary non-hermetically sealed devices.

All units in the Sylvania series are packaged in the conventional DO-29 outline. They are replacing existing glass, epoxy or top hat types in applications which demand higher reliability levels. These devices meet or exceed all the standard life and design requirements of MIL-S-19500.

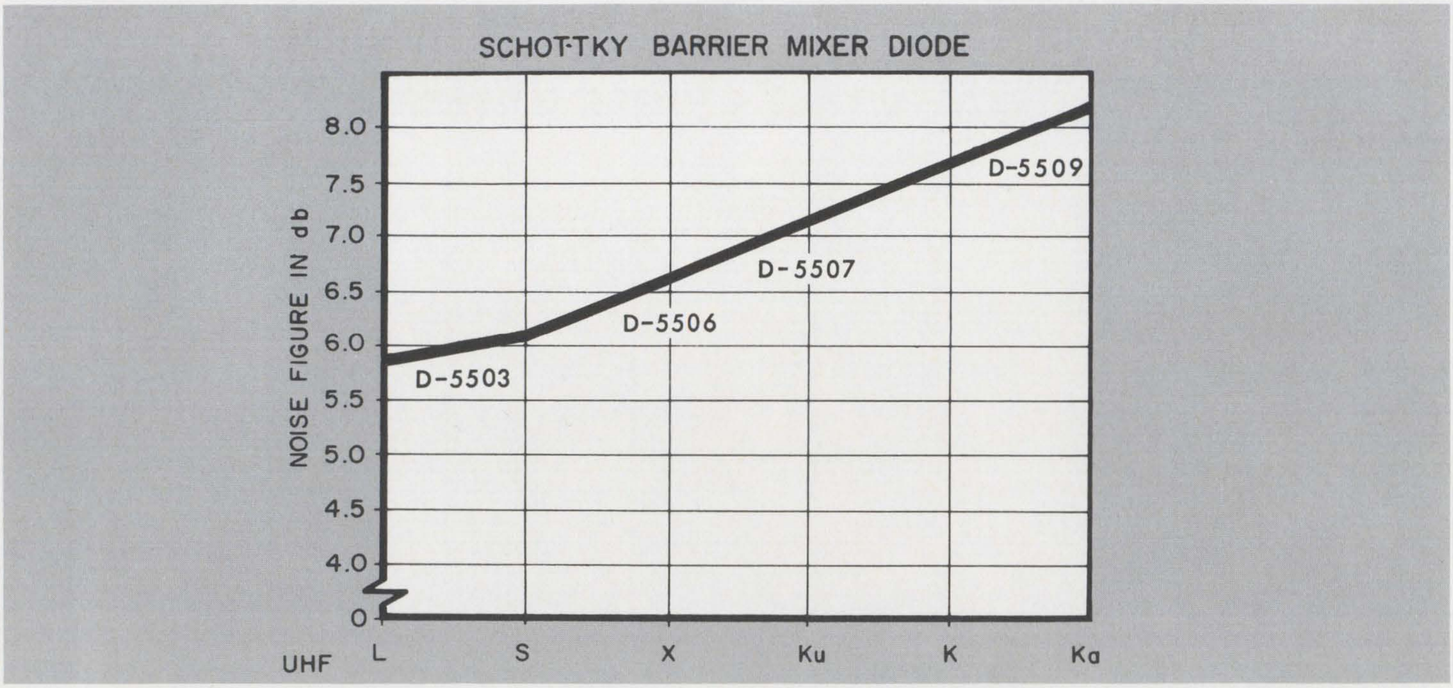
CIRCLE NUMBER 302

ABSOLUTE MAXIMUM RATINGS:
−65°C to +175°C — Resistive and Inductive Loads — Single Phase, half wave at 60 cps.

	Units	1N4383	1N4384	1N4385	1N4585	1N4586
Continuous Reverse Working Voltage, V_R	volts	200	400	600	800	1000
RMS Input Voltage, V_{rms}	volts	140	280	420	560	710
Average Forward Current, I_o	amps					
@ 50°C		1.0	1.0	1.0	1.0	1.0
@ 100°C		1.0	1.0	1.0	0.6	0.6
@ 150°C		0.3	0.3	0.3	0.2	0.2
Forward Surge Current, 1 cycle — $I_{F\ sur}$	amps	50	50	50	50	50
Forward Surge Current, Recurrent, $I_{F\ sur}$	amps	6	6	6	6	6

ELECTRICAL CHARACTERISTICS:

	Units	1N4383	1N4384	1N4385	1N4585	1N4586
Typ. Dynamic Forward Voltage Drop, V_F @ 1.0 amp	volts					
@ 50°C					.56	.56
@ 100°C		.52	.52	.52		
Typ. Dynamic Reverse Current, I_R @ V_R	μa @ 1.0 amps					
@ 50°C					.55	.55
@ 100°C		8	8	8		
Typ. Reverse Current, I_R @ V_R and +25°C	na	10	10	10	10	10
Typical Junction Capacitance — All Types — @ 0 V 80 picofarads; @ 10 V 21 picofarads						



Sylvania's Schottkys can take your designs through Ka-band...reliably

In last November's IDEAS, we announced MQM-packaged Schottky Barrier diodes that operate at frequencies through X-band. We have now extended the operating range of available Schottky Barrier diodes to include Ku-, K-, and even Ka-band. These newest diodes are also in the MQM package, and feature an even lower junction capacitance than their L-, S-, and X-band counterparts.

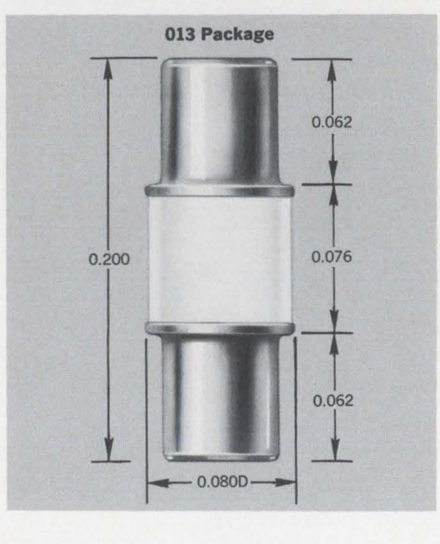
Effective coverage through the Ka-band (26.5 to 40.0 GHz) is only one of the outstanding features of Sylvania's Series D-5509 Schottky Barrier mixer diodes. To fully describe these new devices, one must combine the operating frequency performance with the extreme broadband capability having good burnout characteristics, and with an inherently low 1/F noise characteristic.

To get all this improved performance in one device means there must be not only an optimized semiconductor, but also an optimized package. The performance level of the D-5509 units shows they have both.

Sylvania's MQM package is the key to the broadband capability of these new units. Measuring only 0.08″ x 0.20″ overall, this package utilizes a low dielectric glass body hermetically sealed to precision mounting pins. The result is a package capacitance of only 0.08 pf allowing operation of a wide frequency spectrum.

In addition to its low capacitance, the MQM package features precise axial alignment of the mounting pins allowing precision design of miniature holders. Easy insertion and positive RF contact in holders are assured by a package design which has over 50% of its length devoted to circuit contact area.

Low junction capacitance of the diode permits operation in the Ka region. This low junction capacitance is the result of the superior alignment methods used in new Schottky Barrier diode processing techniques. The process employs epitaxial silicon to make devices with precisely controlled impurity distribution. In this improved method, a thin insulating layer and a relatively thick metallic contact layer over the barrier are used. The insulating layer and the superior mask alignment methods combine to produce the precise etching needed to make barrier regions of low capacitance. The metallic contact and pinpoint mask alignment maintain tight registration during metallization to give a reliable contact without increasing barrier region capacitance.



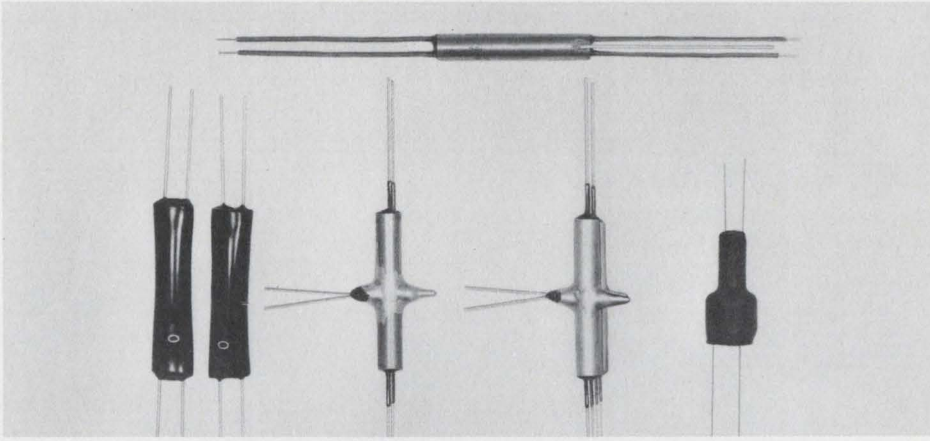
The low noise figures exhibited by the units in the D-5509 series (D-5509 = 10.0 db, D-5509A = 9.0 db, D-5509C = 8.0 db) result from the low series resistance of the diode. This low series resistance is obtained by keeping the epitaxial layer extremely thin, on the order of 1 micron. Because of the low 1/F noise characteristics of these units, they are ideal for doppler applications including police radar, proximity fusing, and traffic monitoring systems.

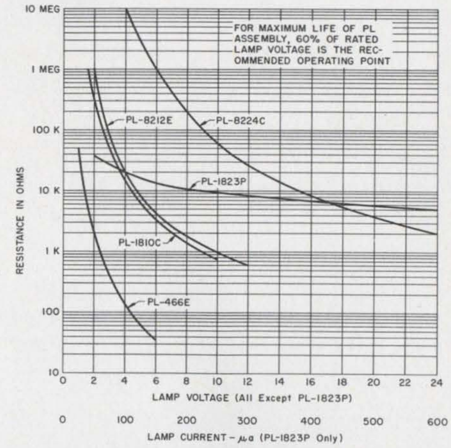
SYLVANIA'S SCHOTTKY BARRIER MIXER DIODES IN MQM PACKAGE

Frequency Band	S & C	X	Ku	K	Ka
Sylvania Series	D-5503 C	D-5506 C	D-5507 C	D-5508 B	D-5509 B
Minimum ONF	6.0 db	6.5 db	7.0 db	7.5 db	8.0 db

CIRCLE NUMBER 303

Combine lamps and photoconductors to get the function you need





Perhaps none of Sylvania's standard photoconductor-lamp (PL) assemblies fills your specific circuit requirement. Perhaps the new units that are coming don't include one that's just the right device. What do you do? Look for Sylvania's custom PL capability to get what you need, whether it be a simple detector unit or a combination of PL devices in one package.

Custom PL assemblies from Sylvania now allow circuit designers to implement many additional potential applications of photoconductor-lamp assemblies. A wide variety of possible photoconductor and lamp combinations means special assemblies can be designed to meet the most exacting requirements.

These custom assemblies take designers beyond the standard single-throw single-pole or double-pole types. Typical of one such custom design is an assembly containing two NE23 neon lamps optically coupled to three cadmium sulfide photoconductors. The photoconductors are enclosed in a lightproof metal cylinder and mounted perpendicular to the neon lamps.

Because Sylvania custom-designs, the company can offer PL combinations which more closely match the impedance level of the circuit they will be used in. For instance, with many entertainment manufacturers now becoming interested in all solid-state construction, Sylvania can deliver PL units that match impedance levels of solid-state circuits.

Availability of a wide variety of standard (shown in the table) and custom units erases limitations on the applications of PL assemblies. Because they have the characteristics of both a switch and a potentiometer and a response time in the millisecond range, they are unrivaled in many areas of remote control, low-level switching or potentiometry.

For example, for minimum hum pickup, the photoconductor can be soldered directly into an audio circuit to be controlled. Control can be achieved by varying PL lamp voltage from a remote location. PLs can directly replace switches and relays in any application within their power handling capabilities. Indirectly they can be used as triggering devices for higher power components.

Because of their time delay, PL assemblies are used extensively in the entertainment field to produce special musical effects such as tremolo and vibrato. Also, they may be used to regulate high voltage in color television receivers and for remote volume control in broadcast studio consoles. Industrial applications include performing AND and OR logic functions and the voltage control of time delay and frequency in monostable and astable multivibrators. Used with silicon controlled rectifiers, they can provide low-voltage isolated control for high-voltage loads.

CIRCLE NUMBER 304

	PHOTOCONDUCTOR								LAMP	
	Voltage (Volts)1,2	Dissipation at 25°C (MW)1	Light Resistance (Ohms)3	Dark Resistance (Megohms)4	Ascent Time (MS)3,5	Descent Time (MS)4,6	Shunt Capacitance (pf)7	Coupling Capacitance (pf)8	Rated Voltage (Volts)	Rated Current (MA)
PL-466E	400	300	35	0.3	55	17	4.944	0.433	6	35–45
PL-1810C	300	75	800	10.0	75	20	0.550	0.264	10	15–20
PL-8212E	300	75	700	10.0	55	17	0.960	0.229	12	35–45
PL-8224C	300	75	1500	10.0	55	17	0.740 (case grounded) 1.141 (case not grounded)	0.017 (case grounded) 1.070 (case not grounded)	24	15–20
PL-1823P	300	75	2750	10.0	50	12	0.700 (case grounded) 1.030 (case not grounded)	0.025 (case grounded) 0.905 (case not grounded)	90 (Breakdown), 59 (Operating)	0.3

AMBIENT OPERATING TEMPERATURE RANGE: —40° to +70°C

NOTES:
1. Absolute maximum rating system.
2. Measured with photoconductor in complete darkness at a pulse rate of 120 pps, 50 μs duration. Voltage in excess of rated may damage the photoconductor. Maximum DC voltage is limited by maximum dissipation and minimum dark resistance rating.
3. Measured at rated lamp voltage.
4. Measured 10 seconds after removal of rated lamp voltage.
5. Time to reach 63.2% of illuminated photoconductor current after application of rated lamp voltage.
6. Time to reach 36.8% of illuminated photoconductor current after removal of rated lamp voltage.
7. Measured across photoconductor leads (leads parallel to major axis) at frequency of 456 kc.
8. Measured between photoconductor and lamp leads (photoconductor leads tied together—lamp leads tied together) at frequency of 456 kc.

How a philosophy breeds IC reliability

As an engineering manager on the production side of integrated circuits, I'm necessarily involved in every facet of IC manufacturing and quality control. Occasionally, though, I'm asked to squeeze extra time into the day's occupation for, what is to me, an enjoyable diversion—showing and explaining our Woburn, Massachusetts, facilities to people who have a professional interest in ICs.

I'd like to comment on a couple of points that frequently come up in our discussions. The first is on reliability through hermeticity, especially as it relates to the dual in-line plug-in package. The second point deals with what we at Sylvania feel is a unique IC manufacturing philosophy.

The Sylvania dual in-line plug-in package was designed and constructed with the same reliability criteria in mind as the Sylvania flat pack. It is understood, then, that the cross-sectional appearance of the dual in-line package is very similar (except in size) to the flat pack.

The dual in-line (DIP) features a kovar bottom sealed to an alumina-filled glass construction in which the kovar leads have also been sealed. All of these seals take advantage of the technology gained from the kovar-to-glass seal originally developed for transistors. This is the classic kovar-oxide-glass combination. The package integrity that is achievable with this technology has been an established fact for many years.

The high degree of hermeticity that has become standard in the industry for such older packages as the TO-18 and TO-5, is now being achieved with the Sylvania DIP construction. The one significant difference between the older transistor metal packages and the DIP is the fact that the seal length (a possible leak path) is much longer than that encountered in the metal package. If anything, this would seem to lead to an even greater hermeticity capability.

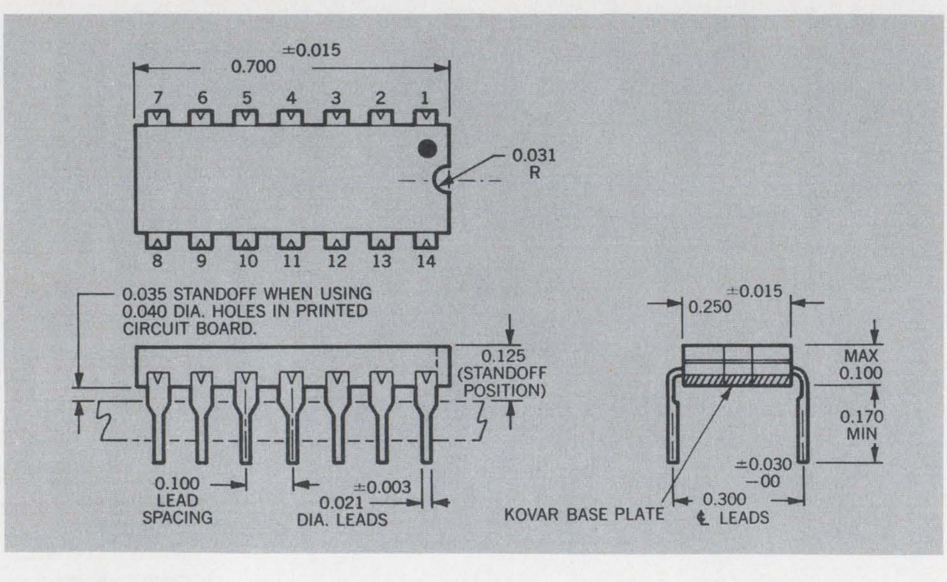
The cover of the DIP is made out of the same material as the body with the seal being a pyroceram frit. As a result of the use of these materials, the Sylvania dual in-line package is composed of thermally matched seals throughout its construction.

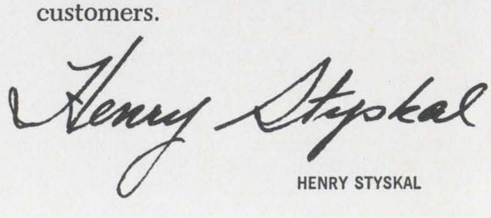
The integrated circuits manufacturing philosophy at Sylvania has always been to manufacture all circuits with identical care and a high degree of workmanship. Therefore, in the final analysis, Sylvania circuits need only be graded by their industrial or military capabilities as determined in the 100% final test. All Sylvania integrated circuits go through a sequence of reliability tests during their manufacture. These tests are applied after sealing the package in the following order.

First, each IC package is subjected to five cycles of –65°C to +200°C thermal cycling with fifteen-minute soak times at each of the temperature extremes. This test is assurance to both Sylvania and its customers that the package will withstand demanding stresses after sealing. Second, all packages are subjected to a 20,000 G centrifuge test while they are in the Y_1 plane. This test insures that the wire bonds have also been subjected to a mechanical stress test. Third, all packages are bubble-tested in 150°C glycerine for any leaks that might have come about as a result of deficient sealing or due to the package stress tests discussed above. Fourth, all integrated circuits are stabilization-baked at 300°C for 48 to 60 hours. Fifth, all Sylvania circuits are subjected to the worst-case DC tests at the temperature extremes guaranteed and also for all parameters which are called for on the Sylvania data sheet or in the customer's specifications. The ultimate electrical capability of each and every integrated circuit is tested at 75°C, 125°C, –55°C and 0°C for DC parameters. Following that, every unit is tested for all dynamic characteristics at switching. This is done in Sylvania's fully automatic test equipment at the rate of one circuit every two seconds. This equipment has been dubbed "Mr. Atomic" Multiple Rapid Automatic Test Of Monolithic Integrated Circuits). It is only as a result of the test performance in "Mr. Atomic" that any differentiation between military and industrial capability is made.

Each lot of integrated circuits is then held in quarantine for quality audit of the capability of the lot. During this audit, random samples are drawn for electrical parameter check and also for a hermeticity check. The latter is performed with Sylvania's radiflo equipment. This equipment uses radioactive krypton for a tracer gas and is the most efficient means available today for determining the fine leak rate of hermetically sealed packages with sensitivity to at least 1×10^{-12} cc/sec/standard atmosphere.

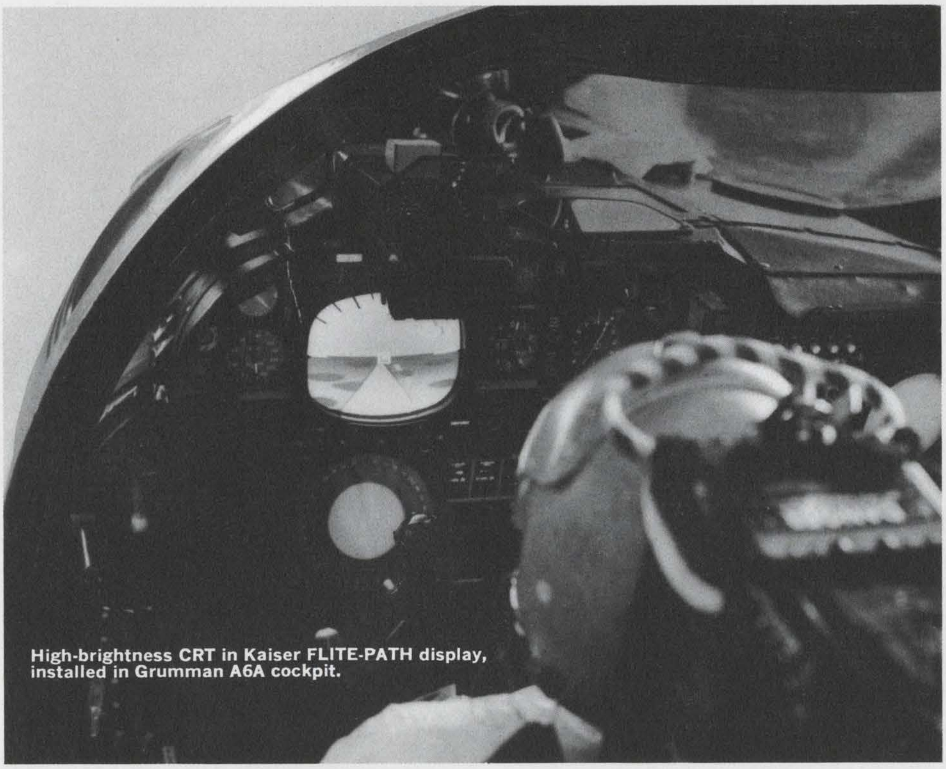
It is only after the complete circuit tests and package mechanical and hermeticity tests described above have been performed that Sylvania integrated circuits are shipped to our customers.





HENRY STYSKAL

New high-brightness, high-resolution tubes customed to your needs



High-brightness CRT in Kaiser FLITE-PATH display, installed in Grumman A6A cockpit.

What size high-brightness, high-resolution CRTs do you require for your aerospace equipment? Now, chances are you can get precisely the right devices to fulfill this need. You can, that is, if you consider Sylvania's new family of customized high-brightness, high-resolution CRTs. We've already made many variations of the basic unit. Each still retains the superior performance characteristics of the basic design. We'll use this same custom capability to build you a CRT tailored to meet your specific needs.

Sylvania's new family of custom high-resolution, high-brightness CRTs makes possible displays which are clearly visible even in ambients of high light levels. Combine this high-brightness, high-resolution capability with the ability to stand high altitudes and you get an ideal aerospace display device.

Other high-brightness tubes in this line can enhance quality of displays used in shipboard command systems, battlefield surveillance equipment, tv monitors or just about anywhere conventional CRT displays are washed out by high reflected or direct ambient light.

One important use of this new type tube has been in fighter aircraft for Vietnam. In the aircraft, a high-brightness cockpit display uses an 8" version of the tube to get an electronic photograph of the horizon. The picture the pilot sees is computer-generated by radar to give him a fix on the terrain.

Other customized versions of this tube may be the answer to your display problems. While usual applications for this family range from 3" to 8" screens, Sylvania will design and build tubes to your specific requirement.

Typical of these new tubes is type SC-4649A, with a rectangular screen having useful dimensions of 4⅜ x 5¾ inches. Key features of this unit include a high voltage gun of improved design and a neck diameter of 0.870 inches. Encapsulated leads insure reliable operation at high altitudes. Typical operating conditions show a brightness of 1.000 foot-lamberts minimum at 225 μa of anode current.

The SC-4649 series uses high voltage electrostatic focus and magnetic deflection with deflection angles of 70 degrees. An aluminized P31 phosphor gives a green fluorescence with a medium short persistence.

In addition to the SC-4649A, other versions of this series (SC-4649B through F) are available with various combinations of faceplates and bonded shield cover panel.

CIRCLE NUMBER 305

SEE OUR SPECIFICATIONS IN VSMF MICROFILM CATALOG FILE

Use Sylvania's "Hot Line" inquiry service, especially if you require full particulars on any item in a hurry. It's easy and it's free. Circle the reader service number(s) you're most interested in; then fill in your name, title, company and address. We'll do the rest and see you get further information almost by return mail.

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COLOR TELEVISION

Now available for '67 sets, rectangular 22" color bright 85® tube

Even though most other color tube manufacturers now use rare earth phosphors, color bright 85 *picture tubes by Sylvania are still brighter. This has been true since we first coupled Sylvania-developed rare earth phosphors with exclusive phosphor dusting and glass panel stabilizing techniques. It's still true with the latest addition to our color picture tube line.*

Availability of production quantities of Sylvania's 22" *color bright* 85 tube gives TV set manufacturers five different extra bright tubes from which to choose. Other tubes in the *color bright* 85 line include 19" and 25" rectangular types. Sylvania uses an exclusive dusting process with each of these types to make them as much as 15 percent brighter than units from other manufacturers.

The new 22" tube has minimum useful screen dimensions of 17.446" by 13.640", producing a minimum projected area of 227 square inches. Because of new FTC labeling requirements, this tube will be used in sets marketed as 20" units.

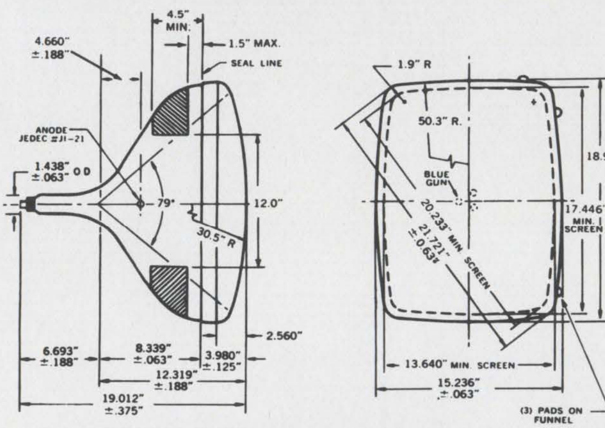
Three versions of the tube are available. The RE-22KP22 is the non-bonded configuration. Both the RE-22JP22 and RE-22LP22 have an integral protective window sealed to the faceplate. They require no separate safety glass window. Surface of the protective window of the RE-22JP22 is treated to minimize specular reflection.

All versions are manufactured to the same high standards which characterize the *color bright* 85 line. Prestabilization of the tube's glass face panel permits near-perfect alignment between phosphor dots and shadow mask holes. Cross hair indexed electron guns provide positive alignment of the electron beam and the phosphor dots. And the mask and the face panel are aligned automatically by a computerized process which precisely establishes optimized relationship.

CIRCLE NUMBER 306

FEATURES

Minimum useful screen dimension	17.446 × 13.640"
Minimum useful screen area	227 sq. in.
Overall length (non-bonded tube)	19.012 ± .375"
Neck length	6.693 ± .188"
Weight (approximate) (non-bonded tube)	28 pounds
Deflection angle (diagonal)	90 degrees
Maximum anode voltage	20,000V to 27,500V
Construction	Bonded-etched and unetched, unbonded
Phosphor	Sylvania rare-earth Europium



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TECHNIQUES FOR FABRICATING WIRE HARNESSES

With The Thomas & Betts TY-RAP® System

A number of distinct advantages over other techniques are gained by using the *T&B TY-RAP* System. This method, first developed by Thomas & Betts 8 years ago, is based on the concept of providing maximum integrity for each individual tie. Today, it has expanded into a broad practical system covering all phases of tying, clamping, mounting, identification and prefabrication of harnesses and bundles...even to the point of mechanizing harness boards.

The main advantages of the TY-RAP System are:

RELIABILITY

Operators, after minimal training time, can produce ties that are superior to other methods in uniformity of tightness, in appearance, in strength and in over-all quality. Easy-to-use automatic tension tools give you the same quality and tightness in each tie.

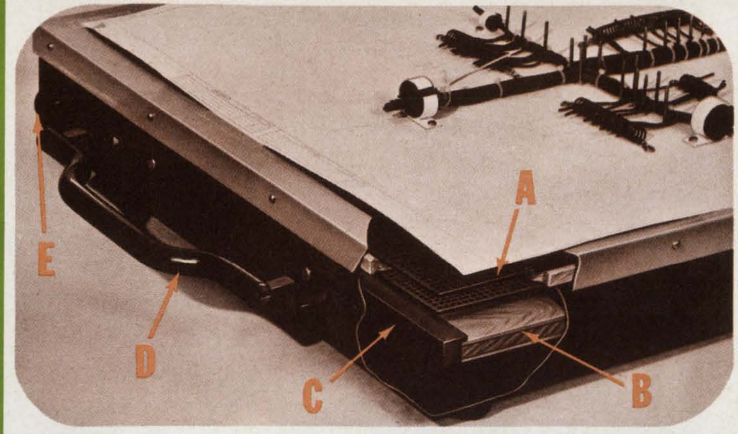
COST SAVINGS

T&B TY-RAP cable ties can be applied in half the time required for string. Because of wider gripping surface, fewer ties are needed. The *TY-RAP* System normally reduces costs by 60%.

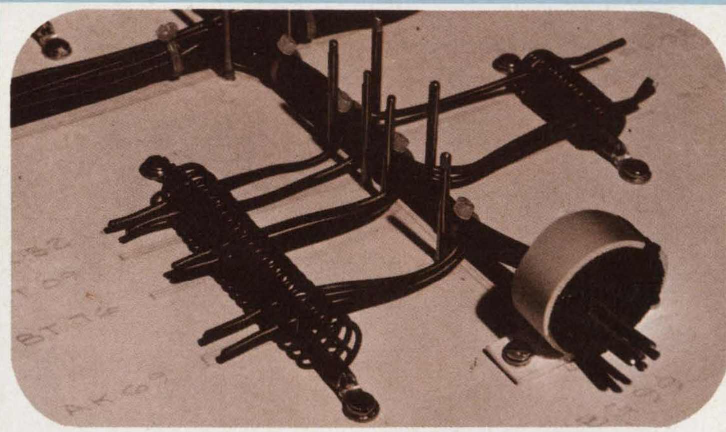
INSPECTABILITY

Just a glance is all that's necessary to inspect *T&B TY-RAP* cable ties. The quality of the tie is immediately obvious. There are fewer points of inspection with *T&B TY-RAP* cable ties.

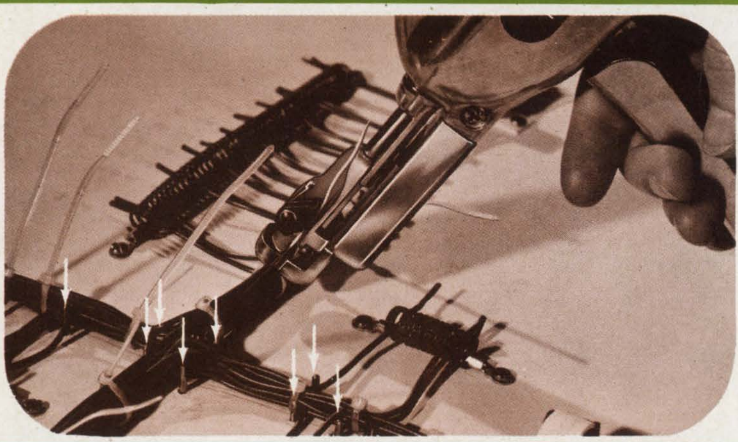
T&B ENGINEERED **THOMAS & BETTS**



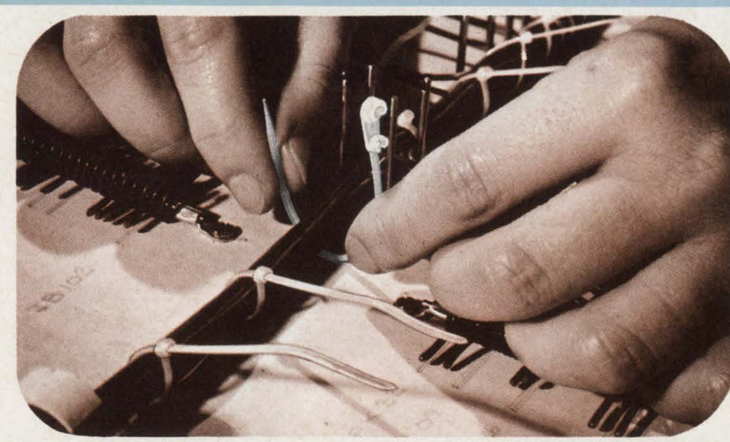
1 **NEW Mechanized Harness Board** allows further cost reductions and increased production. The board controls the height of the wire routing nails. It consists of (A) a stationary perforated metal surface over (B) a wooden backing board which is (C) carried in a movable metal frame controlled by (D) handles located on each side. Unlock the handles and the board (and nails) lower to (E) a preset level. It's an entirely new way of harnessing.



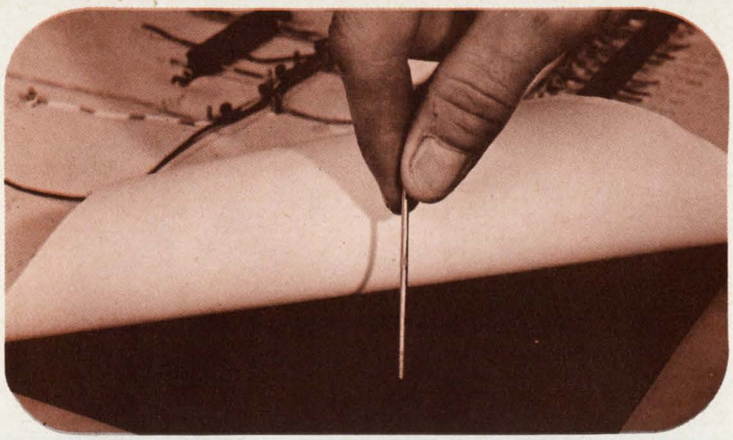
4 **Plastic Coated Spring Accommodates Wire Breakouts** quickly, safely and easily. This new *T&B TY-RAP* harnessing aid can be used over and over without loss of the protective plastic coating. Available in varying lengths, the spring is fitted with fasteners for mounting to board.

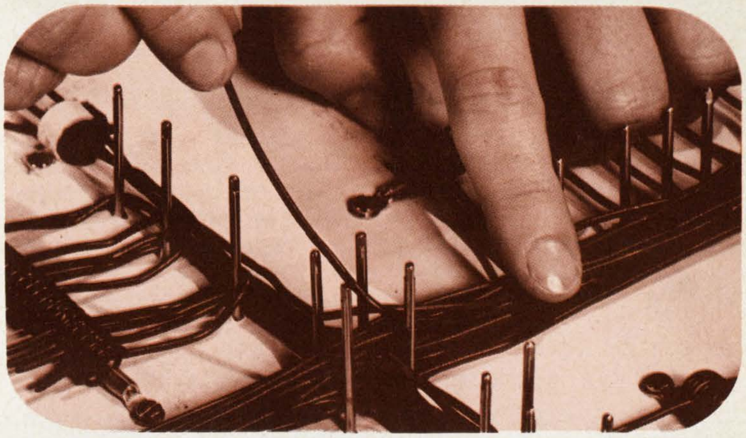


7 **Drop Nails and Apply Ties** to complete the harness with maximum convenience. This feature of the *T&B TY-RAP* harness board increases the ease and speed of applying and tying the cable ties. Further speed and convenience is gained with the new *T&B TY-RAP* pistol-tool WT-295. One squeeze of the trigger and the tying is completed.



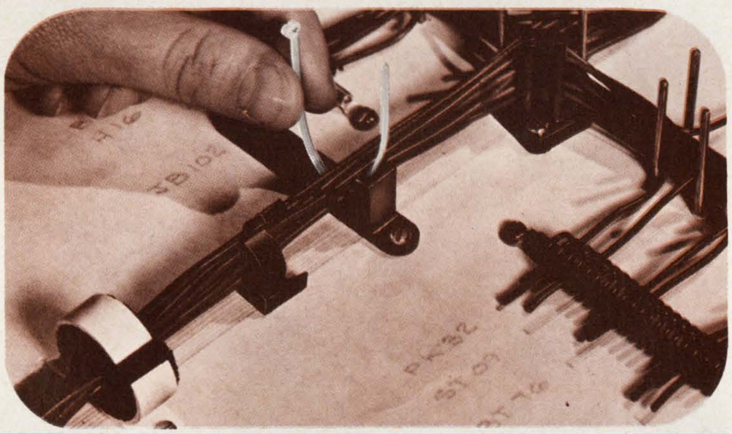
8 **Position Clamps and Identifying Straps** directly on the harness for further time saving and reliability. As the harness is being fabricated, the *T&B TY-RAP* clamp/tie can be installed. It serves two functions — as a tie and as a clamp. By pre-positioning the clamp, the installation of the harness in the equipment is made quicker and easier.

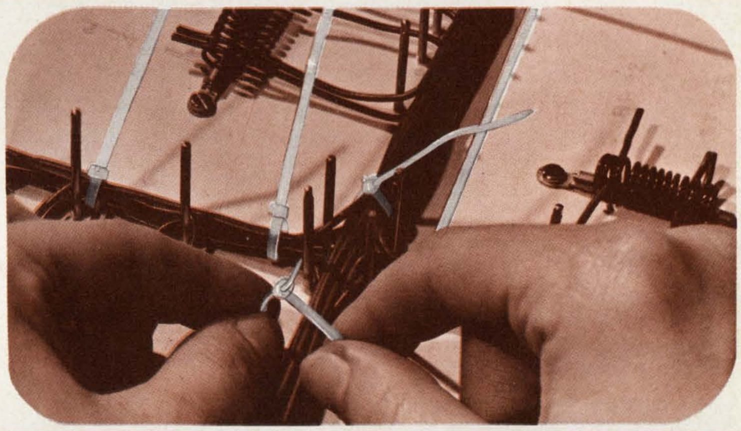




2 **Insert Routing Nails** through wiring diagram into perforated holes and screw down. While routing hardware is necessary and desirable during the wire layout stage, it is cumbersome and tends to slow tying operations. The *T&B TY-RAP* "Pop-Up" Board eliminates the problem. It allows routing pins to be adjusted to optimum height for all harnessing operations — they can be dropped level with the board's surface for tying.

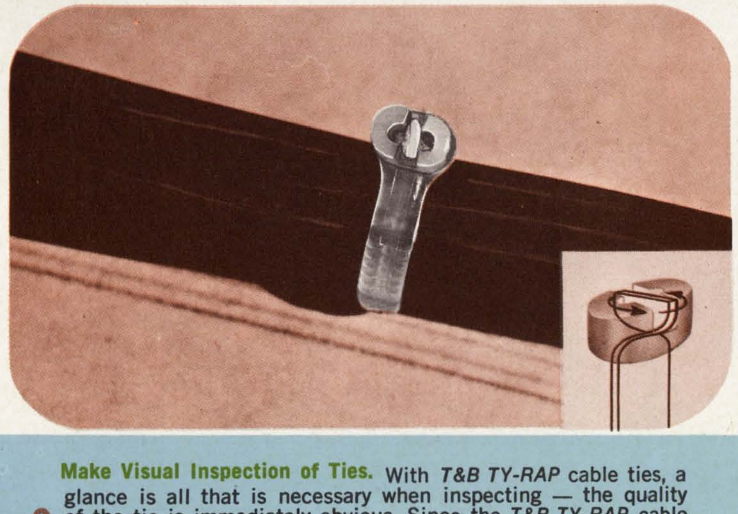
3 **Routing Wires for a Complex Harness** is convenient with the adjustable nails. With the *TY-RAP* harness board, the nails can be set at maximum height when the operator begins or they can be raised as the bundle increases. *T&B TY-RAP* harnessing aids mounted on the board add to routing convenience and efficiency. A variety of *T&B TY-RAP* tools, ties, clamps and harnessing aids allow fabricators to pick and choose the most efficient ways to simplify their harnessing work.





5 **Set Up Harness Board Aids** to suit your present fabrication. Shown here are smooth, molded, nylon corner posts, plastic chutes and bundle retainers. These simplify wire routing and hold harness above board for easy tying. The new *T&B TY-RAP* bundle shaper-retainer has a slotted foam center which expands to accept the wires as they are positioned for harnessing.

6 **Form Harness** by strategically positioning *TY-RAP* ties wherever bundle separates or turns. The new friction grip head allows *T&B TY-RAP* cable ties to hold bundle without being completely tied. The advantage of forming the harness is mainly ease in handling for increased speed in complete tying.



9 **Make Visual Inspection of Ties.** With *T&B TY-RAP* cable ties, a glance is all that is necessary when inspecting — the quality of the tie is immediately obvious. Since the *T&B TY-RAP* cable tie is a molded nylon one-piece tie, there is nothing to come loose or vibrate. With *T&B TY-RAP* tooling, every tie is the same no matter how many different operators fabricated the harness.

I am interested in learning how I can reduce costs in my wire tying and fastening operations. Please send me the following:

☐ *TY-RAP* SYSTEM HANDBOOK AND SAMPLES

☐ COST REDUCTION EVALUATION FORMS

☐ T&B SALESMAN

Name____________________ **Title**__________

Company____________________________

Address____________________________

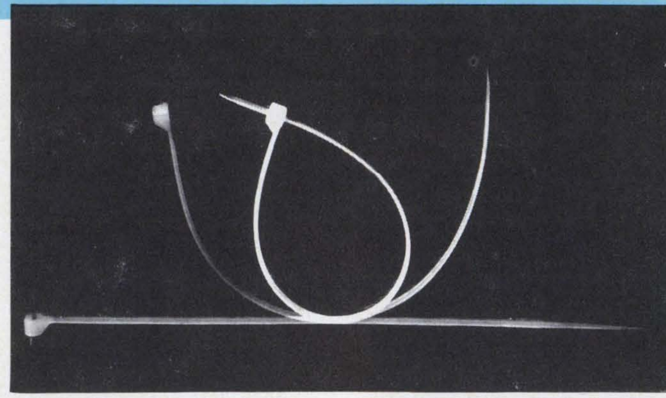
City____________ **State**________ **Zip**______

I am interested in ☐ HARNESSING ☐ POINT-TO-POINT WIRING.

Here's why you get more value with T&B TY-RAP cable ties

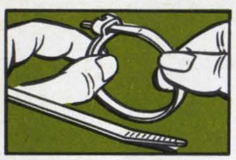
There are two types of *TY-RAP* cable ties — the twist type and the self-locking type. Each has the same basic features as indicated. The twist type is designed for high speed, large volume tying where production tools are advantageous for harness making. The self-locking type has a stainless steel barb molded into the head of the tie. This permits us to give you the self-locking feature with the advantages of a one-piece tie. The self-locking type is particularly well suited for point-to-point wiring — when used with the WT-199 tool, it is quite practical for harness fabrication.

Contact your *T&B TY-RAP* specialist for more information. Ask him to conduct a cost reduction evaluation study for your wiring and harnessing.



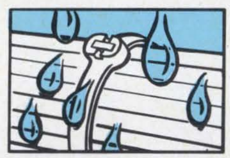
these benefits make Thomas & Betts' *TY-RAP* cable ties UNIQUE

Special Environment Materials Although ***TY-RAP*** cable ties, clamps and mounts function well in adverse conditions, they can be supplied in special materials to withstand environmental extremes. Many ties, clamps, and mounts can be ordered composed of materials such as: Penton for resistance to corrosive chemicals such as rocket fuels; Zytel 105 nylon for applications where ties are continuously exposed to direct sunlight; and stainless steel for withstanding temperatures to 1200°F.



Easy to work with — the patented turned up tail saves time . . . they act as a "handle" for the operator — they can't lie flat to the surface. The tail also orients the tie — you just continue in the direction of the raised tail to complete the tie.

EASIER to thread than ever because of improved designs. Just slip the tapered tip into the eye of the ***TY-RAP*** tie and pull through quickly and easily. Friction grip ridges hold tie in place conveniently for complete tying.



Fungus inert *TY-RAP* cable ties withstand a wide range of climatic conditions. Even in hot humid climate where fungus grows easily — the ties are not affected. This is a major improvement over other methods where these adverse conditions cause rotting and breaking. ***TY-RAP*** cable ties of Zytel 101 have self-extinguishing characteristics. Material meets MIL-M-20693A. ***TY-RAP*** ties meet MIL-S-23190A.

Extended temperature range of the ***T&B TY-RAP*** cable tie permits use from —65°F to +225°F with short duration exposures to 400°F. However, usable temperature range is dependent on required life, temperature, time, cross section thickness, load applied and environment. Contact your T&B specialist for application suggestions above 225°F.

Wide gripping surface provides better gripping power. You benefit two ways — less ties are required than with string and protects wire insulation.

Stipple finish gives the ***T&B TY-RAP*** cable tie a gripping power found in no other method. Protects the cable insulation.

Smooth, molded nylon ***TY-RAP*** ties are easy on operator's hands — even after hours of installing. Smooth corners and edges mean also that the ties are stress free.

Many Colors Available For applications where color coding is required, or where color harmony is desired, you can choose from ten colors for ties, clamps, and mounts.

SOLD COAST-TO-COAST THROUGH AUTHORIZED T&B DISTRIBUTORS

FOR MORE INFORMATION, RETURN THIS COUPON TODAY OR CIRCLE NUMBER ON READER-SERVICE CARD:

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132—COST REDUCTION EVALUATION FORMS
133—T&B SALESMAN TO CALL

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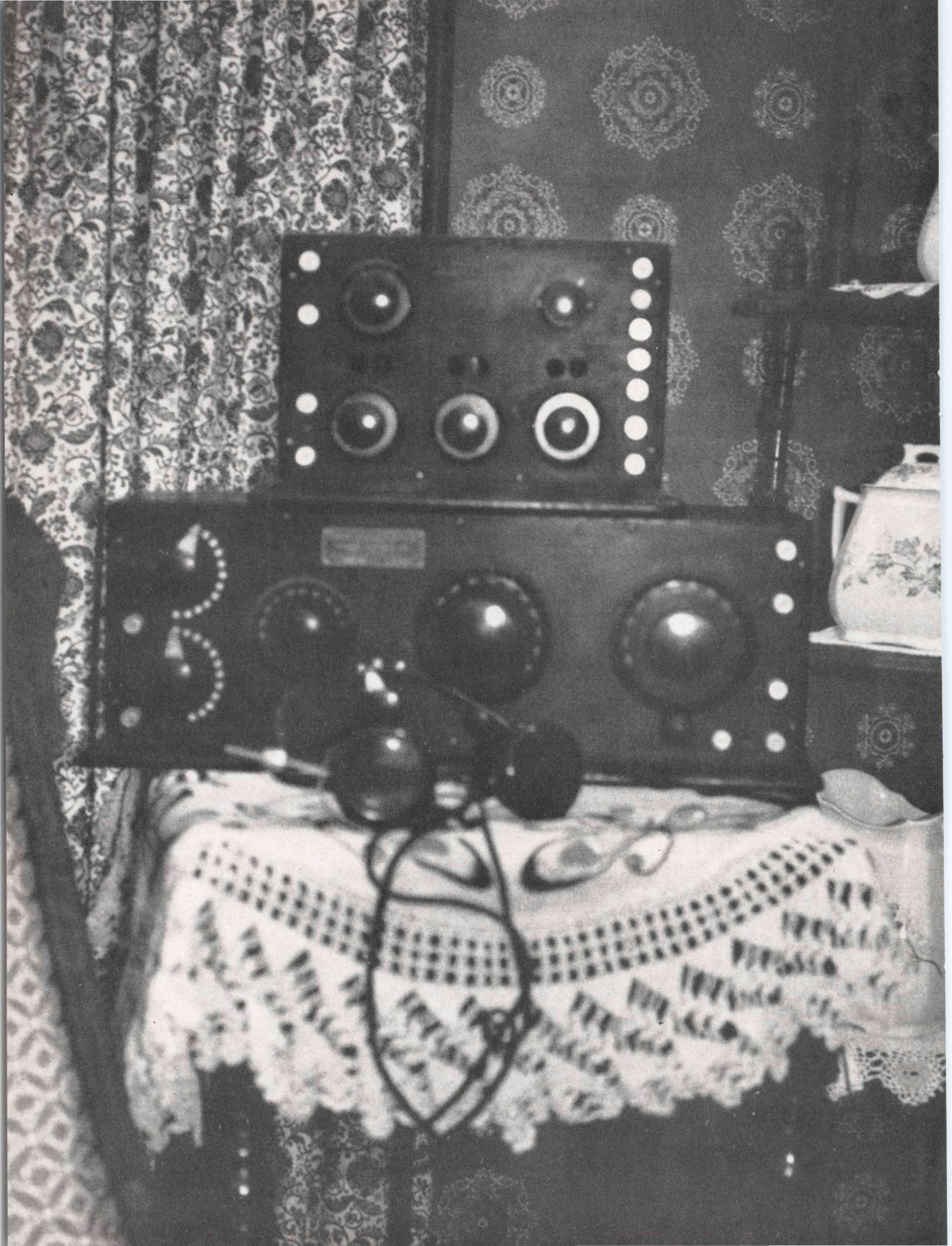

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Before you live with that old design...

check with us

Forty-five years ago this individually tuned, multiple-stage radio was the last word. Then came ganged condensers and the *superhet!* Within several years this old design was dead . . . and so were many firms that tried to live with it.

Today's kaleidoscopic state of the art leaves no time for living with old designs or material specs for want of new materials. Fact is, there's no need to wait. Many of tomorrow's unique materials are already available . . . from Dow Corning.

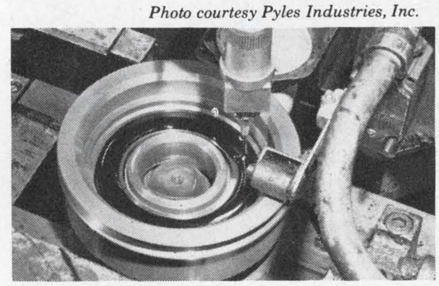
Dow Corning, the acknowledged leader in silicone research and development for over twenty years, has a history of producing materials to meet unheard of performance requirements . . . and materials is our *only* business.

Tired of that old design or material spec?
Write Dept. 3511, Electronic Materials Department, Dow Corning Corporation, Midland, Michigan 48640.
Or phone (517) 636-8940 for more information and the name of the Dow Corning representative in your area.

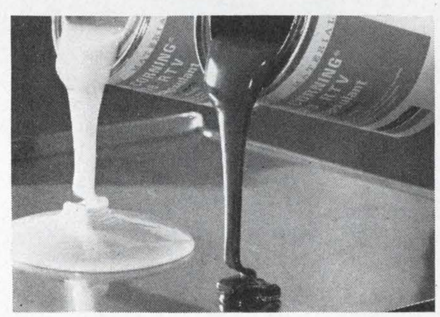
New family of RTV encapsulants made to suit your production

Variable cure, 15 min. – 24 hrs...
Dow Corning® 3110, 3112 and 3120 RTV encapsulants can be cured with any one of three types of catalysts. Fast curing rates are provided by the F-type catalyst; standard rate cure by the S-type and heat accelerated cure by the H-type. Inventory is simplified by this approach to silicone rubber RTV's since each catalyst produces comparable results with each base.

Photo courtesy Pyles Industries, Inc.



Designed for automatic dispensing...
The less critical, 10:1 mixing ratio of base to catalyst assures proper cure when automatic mixing and dispensing equipment is used. The normal ratio of 10:1 can be varied, with working time, pot life and cure rate decreasing as more catalyst is used. To facilitate automatic mixing and dispensing, the base material is packaged in straight side steel drums in 10, 50 and 450 pound sizes.



Viscosity can be changed...
Dow Corning 3110 RTV encapsulant has a low viscosity . . . pours easily around intricate shapes. Both Dow Corning 3112 and 3120 RTV encapsulants have medium viscosity. However, by adding up to 10% of Dow Corning® 200 electronic fluid in 20 centistoke viscosity, all three can be thinned without noticeable change of electrical or physical properties . . . pot life, working and curing time increase.

We're a materials producer exclusively. Let us tailor a material to your need.

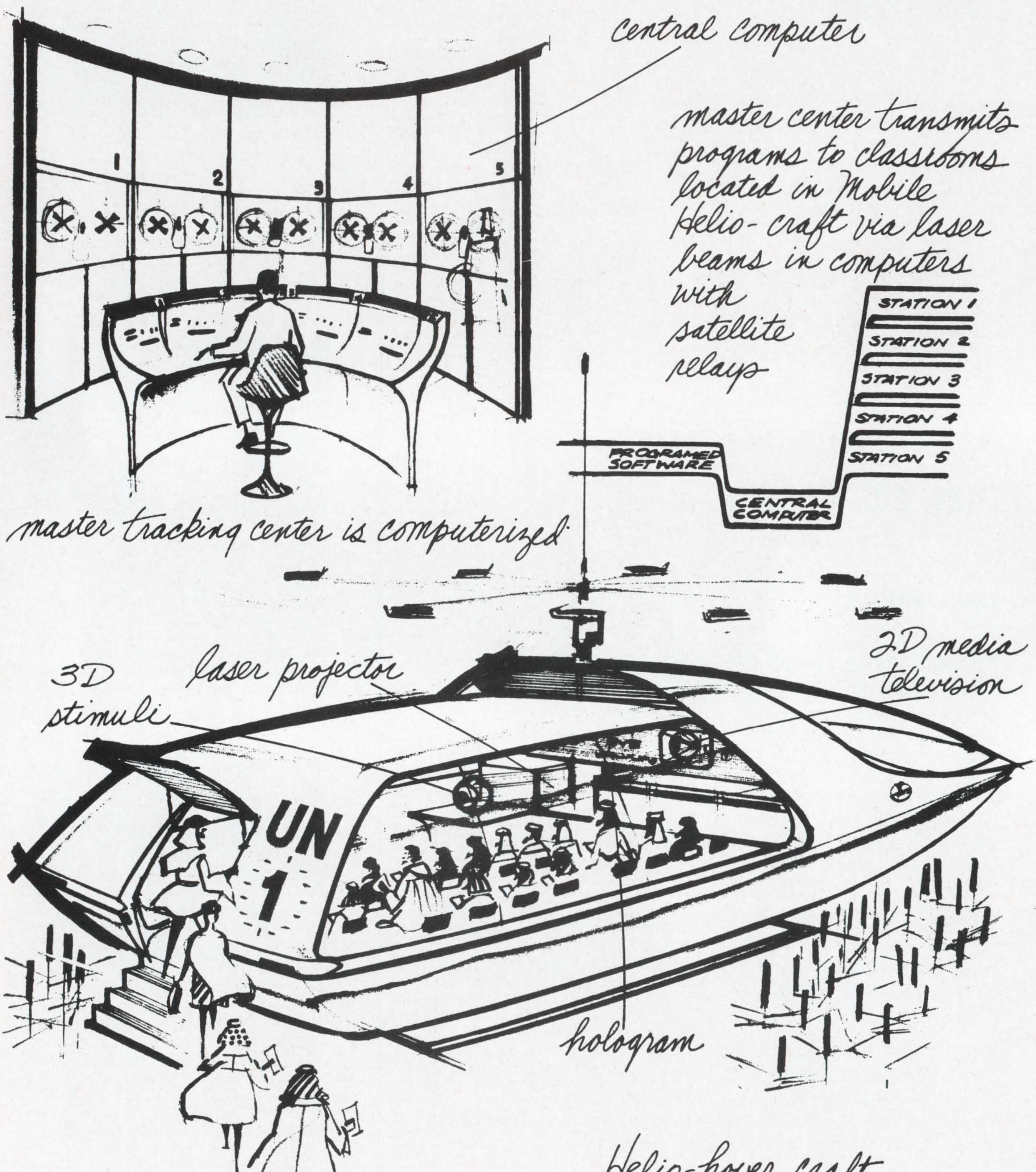
ON READER-SERVICE CARD CIRCLE 33

DESIGNERS 1985

THE DESIGNER: Raymond Loewy/William Snaith, Inc.

THE DESIGN: Teaching Flotilla

THE TRACING MEDIUM: Bruning Five Hundred



In the actual prize-winning Bruning advertisement, this design was printed on an actual sheet of Bruning "Five Hundred" tracing paper inserted into the magazine. The copy on the opposite page was visible through the tracing paper.

8-32

1 Watt output . . . 5dB gain!

TRW again breaks the Gigahertz barrier with this new 2 GHz addition to the TRW family of Ultra High Frequency transistors! They are the finest broadband transistors you can buy—the only power transistors capable of GHz operation in simple, straight through circuits.

As doublers or triplers these transistors will reach 3 GHz with cool efficiency. In the 600 to 700 MHz range their gain and efficiency are phenomenal!

And you get this remarkable performance from a 28 volt power source, 1 Watt output, 5 dB gain!

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EDITORIAL

It's time the U.S. encouraged industry to sound off

Executives in industry are often unhappy with Government procurement policies and the competence of Government technical judges. They make no bones about telling others of their dissatisfaction. But they complain to the wrong people.

They voice their protests to colleagues, to reporters for technical publications (after quickly adding: "Don't quote me on this"), even to their wives. They almost never place their criticisms where they might count the most—before the Government.

Management seems to fear that if it put it on the line too strongly to a Government agency, the agency would retaliate against the complainant when the time came for placing further contracts. Yet, strangely, many criticisms might help to improve relations with the Government and, in the long run, even result in the Government's getting a better product for its money.

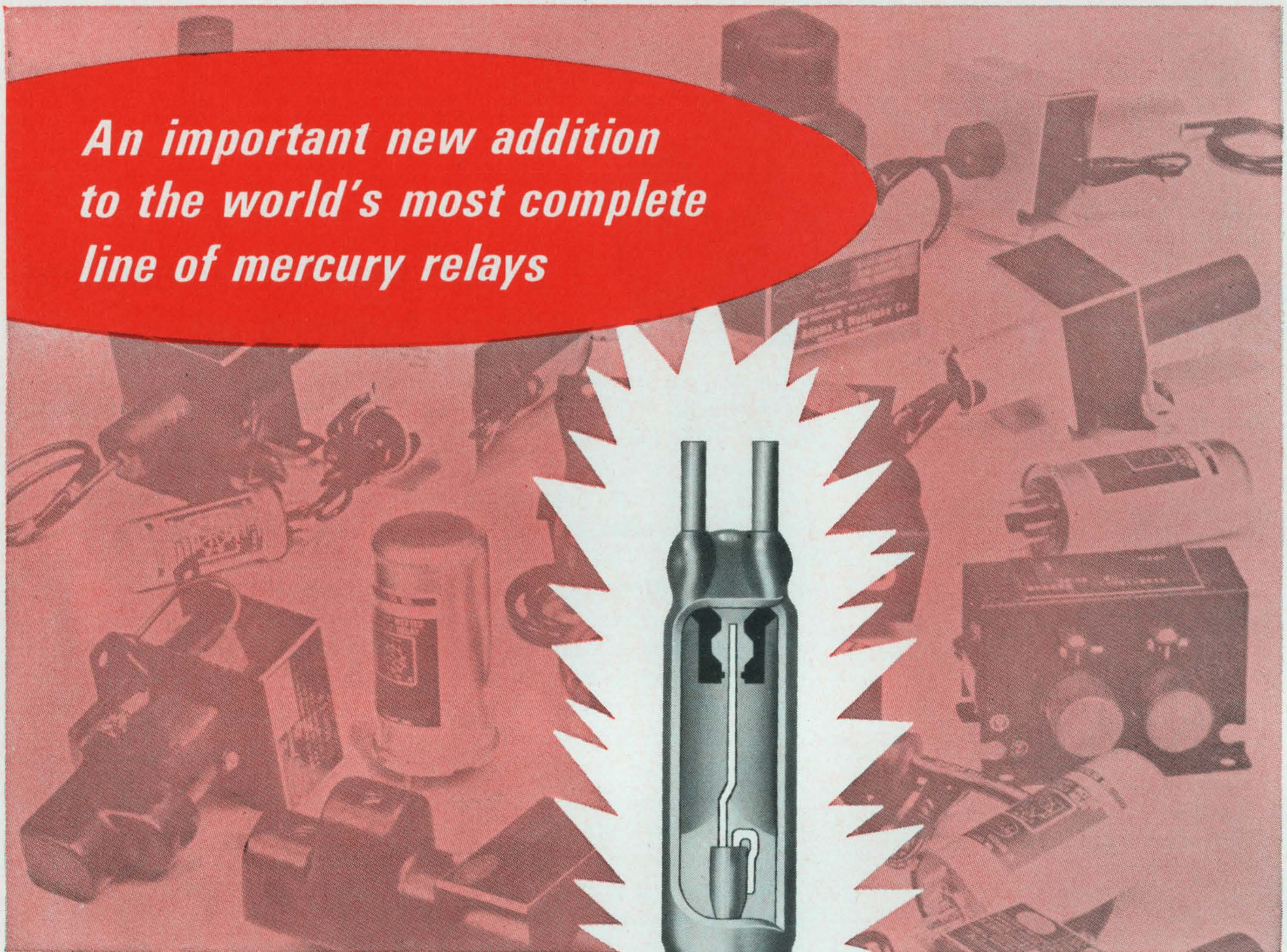
A typical case is the contractors' almost universal distrust of the system for awarding Government work. Comments such as these are commonplace: "They made the selection with a dart board," or, "The winner was chosen beforehand by politicians who want to spread the money around."

Many conscientious Government engineers would like to see more give and take between contractors and the Government, because they recognize that problems do exist. But they are unwilling to try to buck the bureaucracy; their own position in it is too insecure.

A constructive contribution has now appeared from inside the Government. Two Navy scientists have put forward a plan to improve the Government's decision-making and to make contract awards more objective. The plan, devised by Dr. John Craven of the Deep Submergence Systems Program, and Dr. Alfred Skolnick of the David Taylor Model Basin, calls for breaking up contract proposals into groups of equal value. Mathematical formulas would then be applied to the individual parts and a computer can be used to yield numerical merit scores. This technique, they say, would give the contract selection board a wider basis for making its decisions. And it would also, they believe, give the contractor with over-all competence but no "big name" prestige a better crack at projects.

It could be a start toward meeting the covert criticisms of Government procurement. But to encourage open discussion at all times, why not carry the proposal a step further? Why not an impartial review board to screen all complaints about contracts and to guarantee that no reprisals result?

NEIL SCLATER



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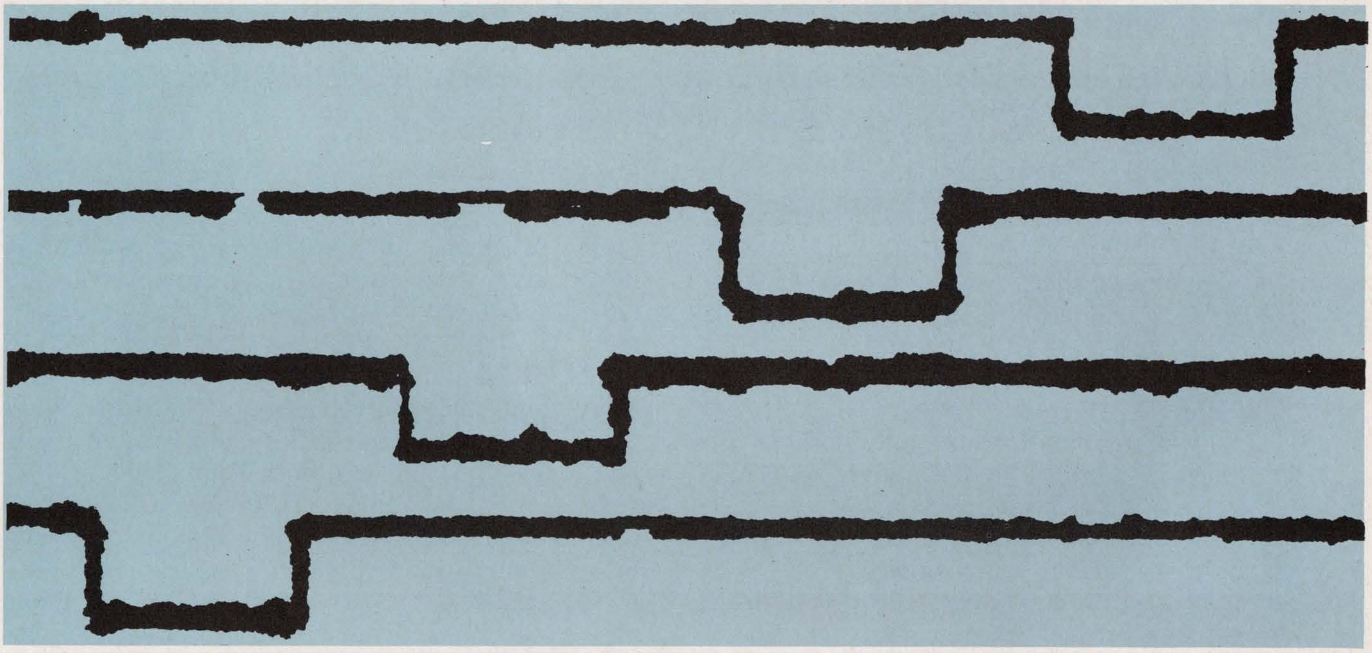
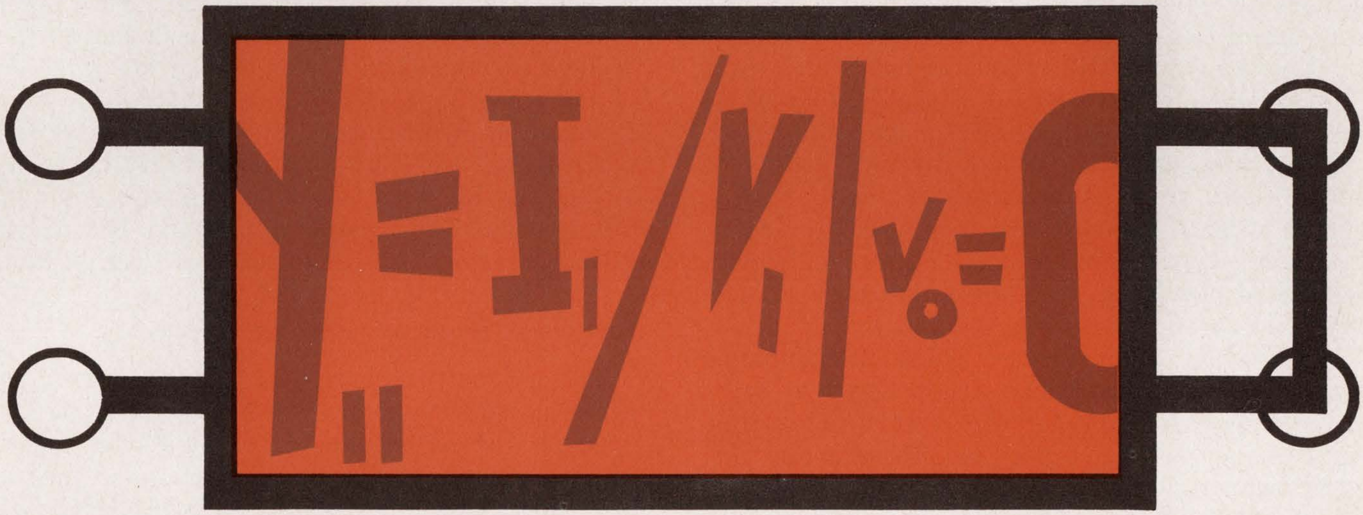


Four-phase logic in MOS arrays achieves a tremendous reduction in power and chip area per function by exploiting the unusual properties of the basic MOS device. Page 62



Y-parameters simplify the design of mixers. If two-port theory is used with Linvill and Stern stability factors, it is easy to make a complete analysis for optimum performance. Page 68

Also in this section:

Use four-phase MOS IC logic

when power and chip area are at a premium. Multiphase dynamic arrays will operate at 10-MHz clock rates.

Four-phase logic, which employs a repeating cycle containing four clock pulses, can increase potential speed and decrease power dissipation when used in MOS arrays. It exploits the unusual properties of the basic MOS device.

A transistor in a MOS array has three valuable logic functions:

- It can store information on its input gate.
- It can pass current in both directions and hence charge and discharge such a gate.
- It can control the flow of information by serving as a switchable load device.

MOS dynamic logic takes advantage of all three of these unusual properties to achieve enormous reductions in power and chip area per function.

In the two-phase clock system, for example, power consumption averages 2 mW per node at a clock rate of 1 MHz. As many as 100 shift-register stages have been integrated into a single chip. By increasing the number of clock phases to four, size and power can be still further reduced, and speed simultaneously increased. In a typical four-phase circuit, compared with its two-phase counterpart, power dissipation is reduced by two orders of magnitude, speed is increased by more than a factor of four, and chip area is halved. Previously, comparable performance was obtained only with advanced processing techniques that used complementary n- and p-channel devices.

The basic principles of two-phase MOS dynamic logic (see Box 1) are illustrated in Fig. 1. A negative voltage (logic *1*) clocked to *Data In* at ϕ_2 time is stored on the node capacitance there. At ϕ_1 time this information is clocked through the first inverter and stored on the node capacitance at *A* as a *0*. At ϕ_2 time it is clocked through the second inverter to *Data Out* as a *1*. Thus the condition at *Data In* appears at the output delayed by one clock period. This circuit has the logical properties of a Type-D or delay flip-flop. It can be used as a recirculating shift-register stage or, with the addition of feed-back and appropriate gating circuitry, it can be transformed into a sample-and-hold, R-S, or J-K flip-flop. Figure 2 shows the logical gating required to convert the delay circuit to a J-K flip-flop, together with a timing diagram and schematic of the two-phase MOS circuitry used to implement the J-K.

Joel Karp, Group Supervisor, and **Elizabeth deAtley,** Senior Engineer, Advanced Array Technology, Microelectronics Div., Philco-Ford Corp., Santa Clara, Calif.

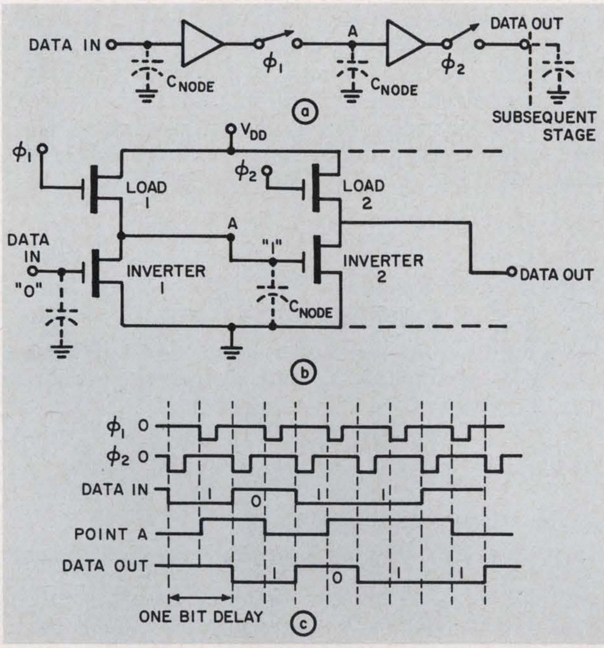
The MOS dynamic logic circuit consists of a delay stage plus control gating. The delay stage can be made in at least three ways: two with two-phase circuitry and one with four-phase.

Both two- and four-phase dynamic logic store charge internally. While the load device is off, information is stored on the node capacitance, which consists of the capacitance of a pn junction, metal interconnections, and the metal gate (see Fig. 1b). A typical node capacitance for a fan-out of one in an MOS circuit is about 0.4 pF. The RC time constant of this capacitance with an impedance of 10^{14} ohms is 40 seconds, which may be neglected in practical circuit design. The upper limit to storage time, then, is determined by the leakage current of the drain-to-body pn junction of the preceding stage. This leakage current is a function of temperature and the size of the preceding device. With a minimum-sized device at 125°C, the RC time constant is on the order of milliseconds. Thus, clock rates must be in the kilohertz range or higher to ensure no loss of data.

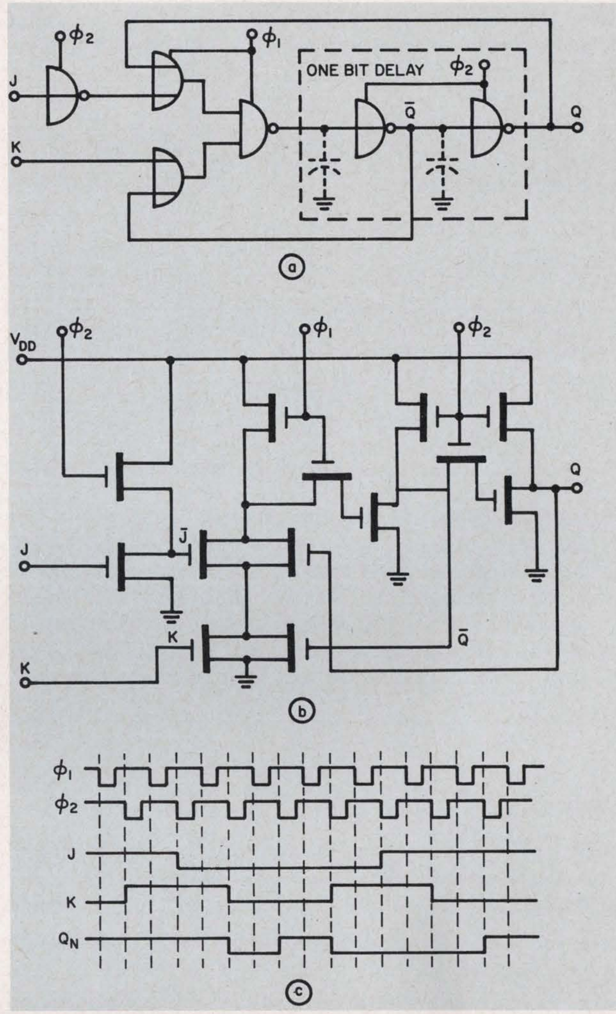
Four-phase precursor used big inverter

The earliest two-phase delay stage is shown in Fig. 3a. Isolation is provided by transistor *T2*, which is turned off except during the ϕ_1 pulse, when the state at *Data In* is inverted and passed to point *A*. The major disadvantage of this circuit is that considerable chip area is taken up by the two series inverters (*T1* and *T2*). To obtain the desired output zero level at *A*, as well as to minimize the time required to discharge the node capacitance through two inverters, the combined resistance of these devices must be approximately the same as that of a single inverter in a standard load-inverter pair. Therefore, each of these devices must be larger than a single inverter. For this reason the circuit is no longer used in MOS integrated subsystems, where chip area is at a premium. It was, however, a significant step in the

1. Basic principles of MOS dynamic logic



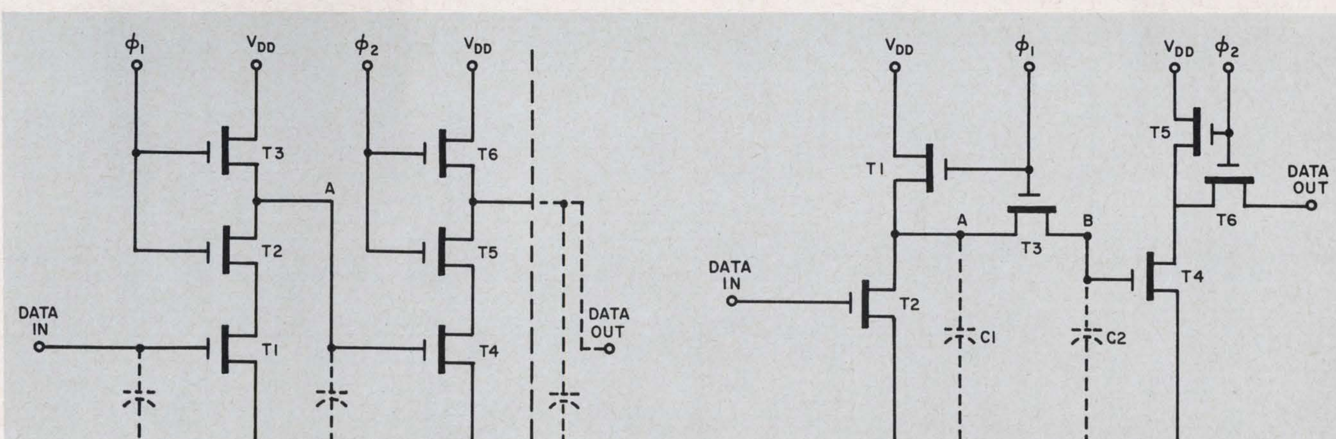
1. **The node capacitance** stores charge.



2. **A J-K flip-flop** can be designed with four gates and a basic delay stage. The block diagram (a) represents the array layout (b). The timing diagram (c) shows the relationship between the J and K inputs and the output, Q, after any number, n, of cycles.

To illustrate the operation of dynamic logic, a data pulse will be followed through a delay stage. In Fig. 1a a pulse is stored on the input node capacitor. At ϕ_1, it is inverted and clocked to *A* to await ϕ_2. Then it is inverted again and clocked into a subsequent delay stage.

In the schematic of this delay stage (Fig. 1b), the input pulse (logic *0*) resides on the gate of *inverter 1* until a clock pulse at ϕ_1 turns on the *load 1* transistor. Both *load 1* and *inverter 1* then conduct and the potential at *A* falls to ground. At ϕ_2, *inverter 2* is tested by *load 2*. Since *inverter 2* is nonconducting, current flows from V_{DD} through *load 2* to *Data Out*. Thus (see Fig. 1c) the state of *Data Out* is the same as *Data In* was the previous cycle.



3. **The early version of the two-phase dynamic logic delay stage** (a) uses four inverters—T1, T2, T4 and T5. These must be ten times larger than the load transistors, T3 and T6. Its modern counterpart (b) makes use of the fact that the MOS can conduct current in two directions. Thus one MOS can charge and discharge a gate.

2. MOS current equations and speed calculations

The basic current equations for the nonsaturated and saturated regions of operation, respectively, of a single MOS-FET are:

Nonsaturated region

$$I_{DS} = k[2(V_{GS}-V_T)V_{DS}-V_{DS}^2]. \quad \text{(i)}$$

Saturated region

$$I_{DS} = k(V_{GS}-V_T)^2. \quad \text{(ii)}$$

The value of k in the above equations is determined by certain process constants, which may be lumped together and called k', and the ratio of the width W and the length l of the device channel. Thus:

$$k = k'W/l. \quad \text{(iii)}$$

Since the resistance of a device is inversely proportional to its k value, a large ratio of

$$k_I/k_L = (W_I/l_I)/(W_L/l_L) \quad \text{(iv)}$$

(where k_I and k_L are the process constants of the inverter and the load, respectively) is equivalent to a large load resistance. Most of the voltage is then dropped across the load, and the output zero level is low. In general, the lower the output zero level required for a given *1* input, the larger the ratio of k_I/k_L must be. In a two-phase circuit, this ratio is on the order of 10:1.

To calculate the speed of a device, the time required to charge the node capacitance through the short-circuit resistance of the load device must be determined. Hence, the short-circuit current must be known. This may be obtained from Eqs. i and ii:

Saturated region

$$I_{SC} = k_L(V_{GG}-V_T)^2. \quad \text{(v)}$$

Nonsaturated region

$$I_{SC} = k_L[2(V_{GG}-V_T)V_{DD}-V_{DD}^2]. \quad \text{(vi)}$$

Equation vi for nonsaturated short-circuit current may be simplified by introducing the parameter, m, where:

$$m = V_{DD}/[2(V_{GG}-V_T)-V_{DD}]. \quad \text{(vii)}$$

Then:

$$I_{SC(nonsat)} = k_L V_{DD}^2/m, \quad \text{(viii)}$$

and the short-circuit resistance:

$$R_{SC} = V_{DD}/I_{SC} = m/k_L V_{DD}. \quad \text{(ix)}$$

In a two-phase system, turn-on time, through an inverter with a k value approximately ten times that of the load, is usually negligible compared with turn-off time.

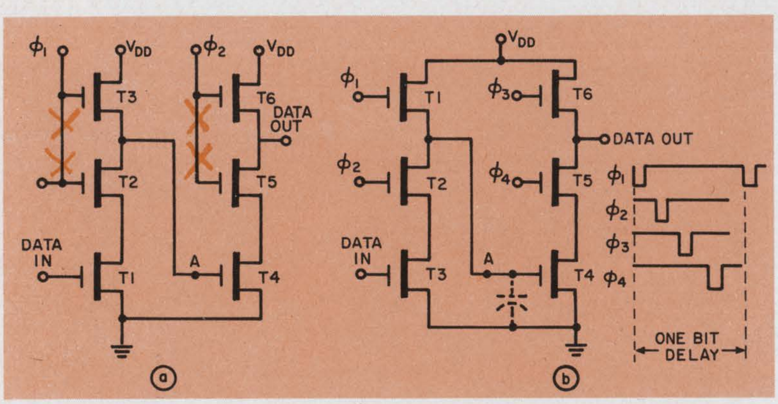
development of four-phase logic.

The circuit in Fig. 3b is a much more efficient design. Here *T2* is a minimum-size coupling device which uses the bilateral properties of the MOS-FET to charge and discharge the node capacitance at *A*. Because it is not required to carry much current and does not affect the k ratio of the inverter and load, its size may be determined solely by layout considerations. This device may be as small as 10 by 10 microns.

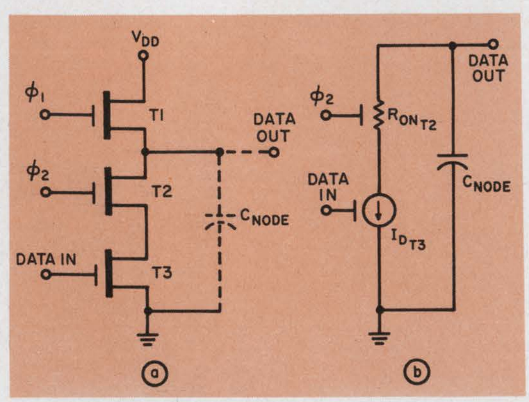
Four-phase evolves from early circuit

The idea of using a four-phase clock in a MOS system evolved from the earliest delay stage (Fig. 4a). By breaking the clock lines at the points shown in Fig. 4a and adding two new clock phases, the storage capacitance at *A* can be precharged to a *1* level at ϕ_1 time and the information at *Data In* can be sampled during ϕ_2 time. The capacitance at *A* remains charged to a *1* if the input is a *0* or discharges to *0* if the input is a *1*. The same sequence of precharging and data sampling occurs in the second tier of devices at ϕ_3 and ϕ_4 times, respectively, and the data input is shifted to the next stage.

No dc path to ground exists at any time. Thus current flows only while the node capacitances are being charged and discharged. Furthermore, there



4. **The four-phase delay stage** (b) evolved from the early two-phase delay stage (a). Breaking the gate connection between the load transistor, T3, and the first inverter, T2, prepares the two-phase stage for the addition of two extra clock phases. T1 precharges the gate of T4, which then discharges through T2 and T3 at ϕ_2 if T3 is enhanced (turned on) by a charge on its gate.



5. **Calculate the turn-on time of four-phase circuit** with the schematic (a) and equivalent circuit (b). The total precharge time of approximately 14 ns allows a clock rate of 10 MHz, compared with 2 MHz for the two-phase circuit.

3. Two-phase MOS delay stage limited to about 2 MHz

At 25°C, $k_L = 0.9 \times 10^{-6}$ μmhos/V and $k_{T3} = 7.5 \times 10^{-6}$ μmhos/V (see Box 2). The other pertinent circuit values (see Fig. 3b) are:

$$C_1 = 0.2 \text{ pF},$$
$$C_2 = 0.4 \text{ pF},$$
$$V_\phi = 24 \text{ V},$$
$$V_{DD} = 12 \text{ V},$$
$$m = 0.46 \text{ (from Eq. vii)}.$$

Because $k_{T3} >> k_L$, turn-off time may be approximated by assuming $R_{SC_{T3}}$ to be a short circuit. Thus:

$$C_{NODE} = C_1 + C_2 = 0.6 \text{ pF};$$
$$R_{SC_{T1}} = m/k_L V_{DD}$$
$$= 0.46/0.9\times10^{-6}\times12$$
$$= 43 \text{ k}\Omega.$$

The time constant τ_{SC} for charging C_{NODE} through the short-circuit resistance of the load device is:

$$\tau_{SC} = R_{SC} C_{NODE}$$
$$= 43 \text{ k}\Omega\times0.6 \text{ pF} = 25.8 \text{ ns}.$$

On the assumption that five time constants are required to charge points *A* and *B* to the required *1* level, the total turn-off time is approximately 130 ns.

The turn-on time through an inverter with a *k* value about ten times as large as that of the load is negligible. Thus each clock pulse width is approximately 130 ns, and the total delay time through a single shift-register stage, with the circuit values used in the example, is about 260 ns. This gives a maximum clock frequency of 4 MHz at 25°C. Of course, for guaranteed operation over the entire military temperature range, the *k* values would be considerably lower than those in this example, and the maximum frequency would be on the order of 2 MHz.

Although this type of two-phase circuit is relatively slow, it can be useful where high speed is not of the essence, as in most orbital satellite systems. Two-phase MOS circuits do have an edge over the bipolar logic circuits where power dissipation is an important consideration. Even with its slow speed, the two-phase MOS's speed-power product is better than that of its bipolar counterpart.

This delay circuit is used to implement the J-K flip-flop shown in Fig. 2.

is no dc "voltage divider" action in this circuit, and thus no need for the inverter and load devices to have different resistance values. Therefore, all devices may be of minimum size (10 μ x 10 μ).

As a result of the reduction in device size, the over-all chip area is greatly reduced. With this new type of circuit, up to 200 delay stages can be integrated in the same chip area that is presently required for 100 two-phase delay stages.

The four-phase circuit is four times as fast as the two-phase. In a four-phase circuit (see Fig. 5a) turn-on time cannot be neglected as it can in a two-phase circuit. It may be approximated with the equivalent circuit shown in Fig. 5b. To calculate the turn-on time, the on resistance of *T2* must be determined:

$$R_{ON} = 1/[2k(V_{GS} - V_T - V_{DS})], \qquad (1)$$

where V_T is the turn-off voltage and k is a constant determined by the process. With a large clock voltage, V_{GS} is large and $R_{ON_{T2}}$ may be neglected. Thus the voltage at the drain of *T3* in Fig. 5a is approximately equal to V_{out}. As long as $V_{in(1)} - V_T \leq V_{out}$, *T3* is saturated and the current flowing in the circuit is a constant current equal to:

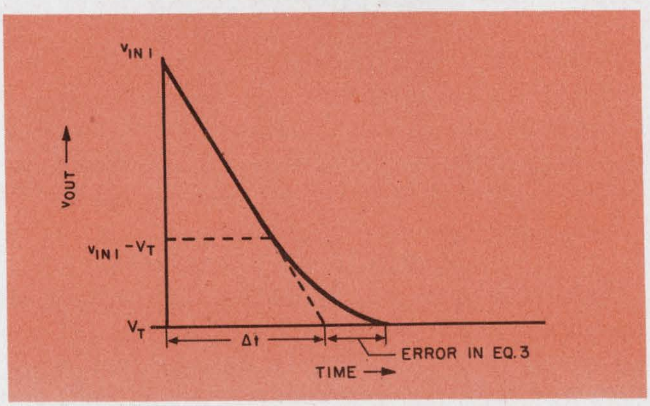
$$I_{DS} = k_{T3}\,(V_{in(1)} - V_T)^2. \qquad (2)$$

When $V_{in(1)} - V_T > V_{out}$, *T3* is nonsaturated, and the current in the circuit decreases with V_{out}, as indicated by Eq. i (see Box 2), the expression for drain current in a nonsaturated device. The turn-on time, Δt, may, however, be approximated by assuming that the current remains constant until V_{out} reaches turn-off, V_T. The turn-on time (see Fig. 6) is given by:

$$\Delta t \approx C_{NODE}\,\Delta V/k_{T3}\,(V_{in(1)} - V_T)^2. \qquad (3)$$

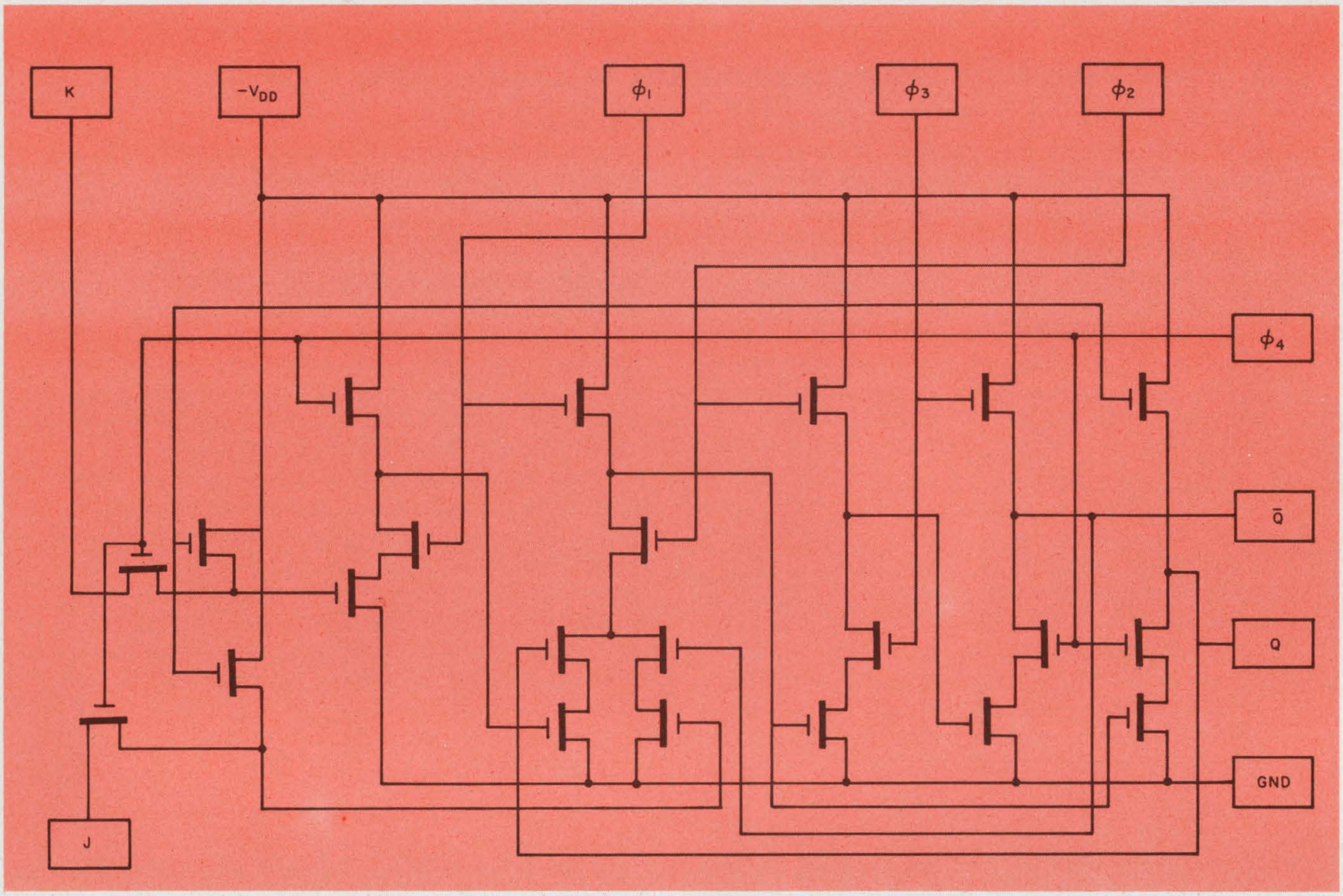
In a four-phase system, on the assumption of operation at 25°C and minimum-size devices:

$$k = 4.2 \text{ μmhos/V},$$
$$C_{NODE} = 0.3 \text{ pF},$$
$$V_T = 5 \text{ V},$$
$$V_{DD} = 12 \text{ V},$$
$$V_{in(1)} = 10 \text{ V},^*$$
$$V\phi = 24 \text{ V}.$$



6. **A small error is introduced** in the turn-on time approximation when a trapezoid is fitted under the curve of V_{out} vs time. This approximation is adequate in a rough calculation since turn-on time is also a function of temperature.

*$V_{in(1)}$ is usually 1 or 2 volts less than V_{DD} because of the coupling of a noise spike through the gate-to-source capacitance of the load device at ϕ_1 time.



7. **Current cannot flow directly from supply to ground** in this four-phase J-K flip-flop. Power is dissipated only when current charges or discharges the gates of the MOS transistors. Power dissipation is thus reduced two orders of magnitude compared with a two-phase flip-flop operating at comparable speeds.

Then the turn-on time is:

$$\Delta t = [0.3\times10^{-12}\times(10-5)]/[4.2\times10^{-6}\times(10-5)^2]$$
$$\approx 14 \text{ ns.}$$

With the same circuit values as above and the same procedure as that used previously to calculate turn-off time in a two-phase circuit, the following equations result:

(From Eq. vii, Box 2)

$$m = 12/[2(24-5)-12]=0.46;$$

(From Box 3)

$$R_{SC_{T1}} = m/k_L V_{DD}$$
$$= 0.46/4.2\times10^{-6}\times12$$
$$= 9.1 \text{ k}\Omega;$$

(from Box 3)

$$\tau_{SC} = R_{SC} C_{NODE}$$
$$= 9.1\times10^3\times0.3\times10^{-12}$$
$$= 2.73 \text{ ns.}$$

where τ_{SC} is the short-circuit time constant.

If it is assumed that five time constants are required to charge C_{NODE} to V_{DD}, then the total precharge time is $5 \times 2.73 = 13.65$ ns, or less than the turn-on time. Each clock pulse width must thus be at least 14 ns long and the total of any one clock (and hence the delay through a single delay stage) must be 56 ns. This gives a maximum clock frequency of approximately 18 MHz at 25°C (or about 10 MHz over the full temperature range)—a 4-1/2:1 increase in clock frequency over the two-phase circuit.

Since no dc path to ground exists in a four-phase system, power is dissipated only in charging and discharging the node capacitance. The average power per node in a four-phase system is given by the expression:

$$P_{av}/node = F\, C_{NODE}\, V_{DD}^2, \qquad (4)$$

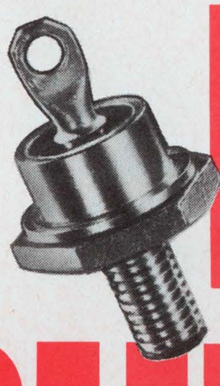
where F is the clock frequency.

If the four-phase circuit used in the foregoing speed calculations were operated at 1 MHz (the operating frequency of a two-phase system), its average power dissipation per node would be:

$$P_{av}/node = 0.3\times10^{-12}\times12^2\times10^6$$
$$= 43.2\ \mu\text{W}.$$

This is a reduction of almost two orders of magnitude over the two-phase system. At an operating frequency of 10 MHz, the four-phase system dissipates approximately 0.432 mW per node—almost a factor of five less than a two-phase system operated at 1 MHz.

A schematic diagram of a J-K flip-flop implemented with four-phase logic appears in Fig. 7. ■ ■



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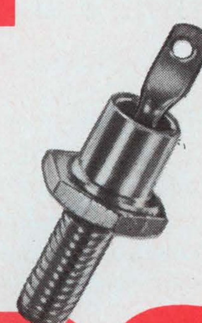

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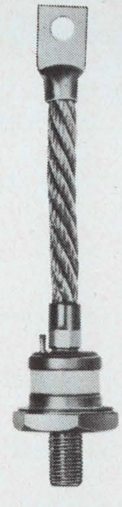

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Y-parameters simplify mixer design.

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Mixer stages perform the function of frequency conversion in a signal chain. In receivers, mixers commonly transform the incoming signal frequency to an intermediate frequency, or transform one intermediate frequency to another in multiple-conversion receivers. In transmitters, the increasing use of the suppressed-carrier single-sideband (SSB) mode of communication has led to much wider use of mixers because frequency multiplier stages cannot be used in an SSB signal chain.

Design of small-signal high-frequency amplifiers has reached a high degree of sophistication through two-port parameter analyses. These techniques have been well documented. However, literature on the theoretical and practical design aspects of the solid-state mixer is less plentiful and often less precise than that on amplifier design.

This article, then, will present general considerations for mixer design and device selection, and several specific mixer circuits to demonstrate the application of the procedures developed.

Six factors govern good design

In the design of mixers, the following factors are of considerable importance in obtaining a good circuit:

- Frequencies (RF, LO, IF and derivatives).
- Stability.
- Gain.
- Network design.
- Local oscillator injection.
- Device selection.

Each factor will be considered separately.

Undesirable frequencies must be eliminated

Mixing action is achieved by means of a nonlinear device. Many different frequency components will therefore be present in the output of the circuit. These frequency components fall into three categories:

- Spurious mixer products—all frequency components in the output of the mixer other than the desired sum or difference output component.
- "Crossovers" or "birdies"—Undesired mixer frequency components that fall within the mixer output pass band.
- Intermodulation (distortion products)—A special class of spurious mixer products falling within the exciter pass band, and resulting from interaction between signal components fed into the mixer.

A problem with any mixer is spurious output signals. In addition to the obvious outputs of the local-oscillator frequency, the input RF signal frequency and the undesired sum or difference frequency, many other spurious output signals may be present. Many of these additional spurious outputs are due to third- and higher-order distortion characteristics that the nonlinear device exhibits in addition to the second-order distortion used to produce the desired mixing action.

There may likewise be spurious output signals ("crossovers" or "birdies") at both the desired output frequency and other frequencies. The "off-frequency" signals may be attenuated by tuned circuits following the mixer, but the only recourse for eliminating spurious outputs at the desired output frequency may be to use an entirely different mixing scheme.

Literature on the selection of mixing frequencies to minimize spurious outputs is plentifully available (see Bibliography).

This article assumes that the designer has already selected suitable mixing frequencies and is ready to proceed with the actual mixer design.

C and k factors used for stability

The stability problem may be regarded as basically a two-port calculation. In the design of high-frequency amplifiers, the Linvill stability factor may be used to determine the potential stability of the transistor. The Linvill stability

Ernest Klein, Applications Engineer, Motorola Semiconductor Products, Phoenix, Ariz.

factor C is computed from the following expression:

$$C = |y_{12}y_{21}|/[2g_{11}g_{22} - \mathrm{Re}(y_{12}y_{21})].$$

If C is less than 1, the transistor is unconditionally stable; if C is greater than 1, the transistor is potentially unstable.

The C factor is a test for stability under a hypothetical worst-case condition; that is, with both input and output terminals of the transistor open-circuited. With no external feedback, an unconditionally stable transistor will not oscillate under any combination of load and source admittances. If a transistor is potentially unstable, then with certain source and load admittances oscillations will occur.

The C factor is used to determine the potential stability of the transistor, but it is often desirable to compute the relative stability of actual circuits. Stern (see Bibliography) has defined a stability factor k for this purpose. The k factor is similar to the C factor except that it takes into account finite source and load admittances connected to the transistor. The expression for k is:

$$k = 2(g_{11} + G_s)(g_{22} + G_L)/[|y_{12}y_{21}| + \mathrm{Re}(y_{12}y_{21})].$$

If k is less than 1 the circuit will be unstable; if k is greater than 1 the circuit will be stable. Note that while the C factor simply predicts potential stability of a transistor with an open-circuited source and load, the k factor provides a precise stability computation for a specific circuit. As such, it can be used to check stability of circuits in cases where C is greater than one.

For the collector circuit of the mixer, a stability factor could be calculated at the output frequency, and for the base circuit a stability factor could be calculated at the input frequency. The greatest risk of oscillations occurs at the output frequency since the impedance level at the collector is higher.

From the k factor, we see the desirability of having low source and load frequency impedance.

If the output port presents a low impedance or short circuit at the input frequency, and the input port presents a low impedance or short circuit at the output frequency, then oscillations will not occur.

Should it be impossible to meet the above stability conditions as calculated from the k factor, an IF trap circuit could be used at the input of the two-port network and an RF trap circuit at the output of the two-port network.

For gain, watch the frequencies

Conversion gain is defined as:

$$A_c = IF\ Power\ out/RF\ Power\ in.$$

Depending on the frequencies of operation, the mixer conversion gain will vary as does the gain of any amplifier designed for operation at different frequencies. The gain, however, will be comparable to that obtained in an amplifier designed for the same IF frequency of operations.

Glossary

C = Linvill's stability factor
k = Stern's stability factor
G_s = Real part of the source admittance
G_L = Real part of the load admittance
g_{11} = Real part of y_{11}
g_{22} = Real part of y_{22}
L_s = Series inductance
L_p = Parallel inductance
G_p = Real part of parallel admittance
R_s = Series resistance
A_c = Conversion gain
C_p = Parallel capacitance
LO = Local oscillator
RF = Radio frequency
IF = Intermediate frequency
agc = Automatic gain control
Y_{in} = Input admittance
Y_{out} = Output admittance
Y_{in}^* = Conjugate input admittance
Y_{out}^* = Conjugate output admittance
Y_S = Complex source admittance
|| = Indicates "in parallel with"
Q_s = Series q
ω = Radian frequency
C_T = Total capacitance
C_s = Series capacitance
X_s = Series reactance

Network design and LO injection also count

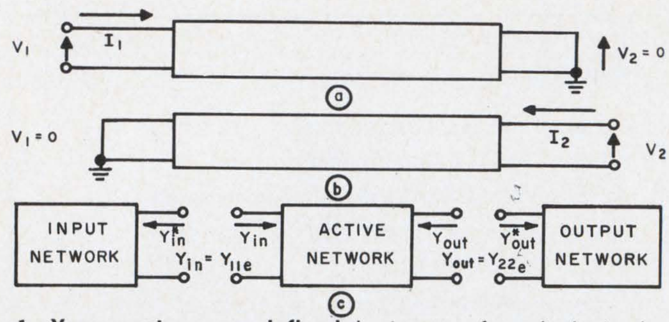
The primary considerations in the design of the input and output networks are conversion gain, stability, and attenuation of off-frequency spurious output signals.

For injecting the LO (local oscillator) signal, there are basically two methods: base injection or emitter injection. Fewer stability problems are encountered, especially in the vhf and uhf frequency ranges, with base injection than with emitter injection.

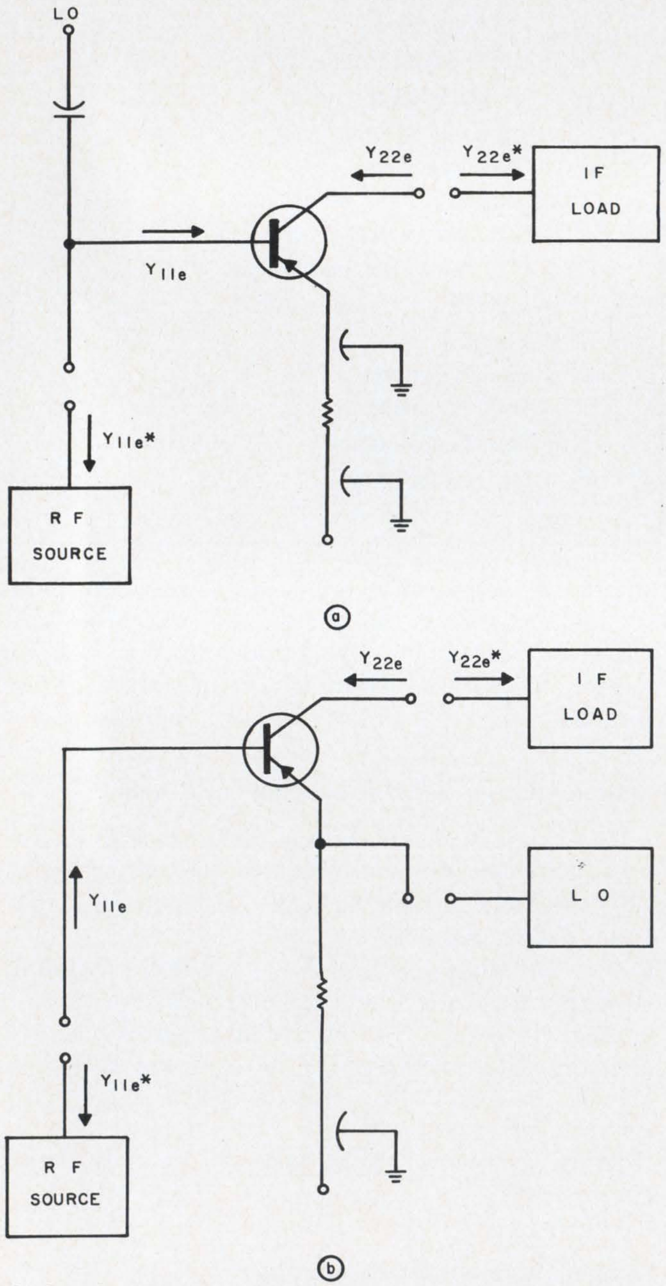
These problems will be explored in more detail further on.

What matters in device selection

Since a transistor is a nonlinear device, any transistor could be used as a mixer. However,



1. **Y-parameters are defined** in terms of equivalent circuits. Conditions for y_{11e} are shown in (a), for y_{22e} in (b), and the functional mixer block diagram in (c). For proper operation, active network input and output admittances should be matched to their conjugate admittances in input and output networks.



2. **Local oscillator signal** can be injected either at the base (a) or emitter (b). The first method is preferred since it lends itself to a simpler network design.

certain characteristics make some transistors more desirable than others:

- Frequencies—The device must be capable of operation at the input, output and local oscillator frequencies.
- Gain—The device gain will be within 3 dB when used as a mixer as opposed to an amplifier designed at the output frequency in the unneutralized condition. Therefore, the device must be capable of the desired gain at the output frequency.
- Stability—A device for which the C factor is less than 1 over the input-output-frequency range would be desirable though not necessary, as already explained.
- Operating Mode—Depending on the application, either an agc or a non-agc device may be chosen.
- Input Capacity—A device with a low input capacity, C_{in}, provides for easier impedance matching.

Developing the design theory

The design theory of a mixer circuit will be interpreted in terms of equivalent circuits with emphasis on impedance matching techniques for both the input and output of the transistor to the respective networks.

The basic mixer circuit can be explained in terms of the following equivalent circuits: For maximum circuit stability with the input circuit at the RF frequency, the output may be considered to be a short circuit. From the equivalent circuit (see Fig. 1a):

$$y_{11e} = I_1/V_1|_{V2\,=\,0},$$

where y_{11e} is the common-emitter short-circuit input admittance of the transistor.

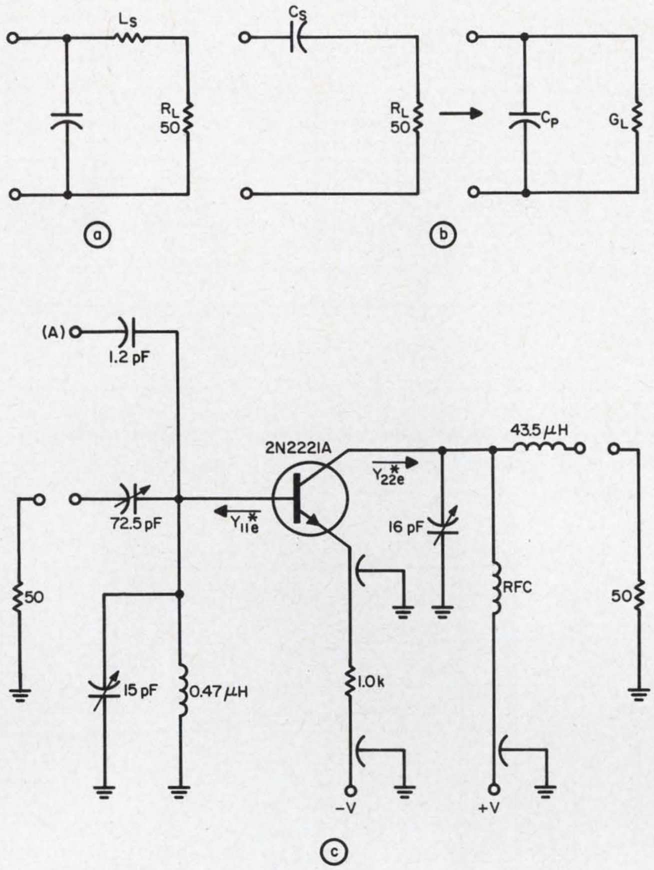
For the output circuit at the IF frequency and for maximum circuit stability, the input circuit may be regarded as a short circuit at the IF frequency. From the equivalent circuit (see Fig. 1b):

$$y_{22e} = I_2/V_2|_{V1\,=\,0},$$

where y_{22e} is the common-emitter short-circuit output admittance of the transistor.

Under these conditions in the network shown in Fig. 1c, Y_{in} represents the input admittance of the transistor and is equal to the small-signal common-emitter input admittance y_{11e} at the input frequency. Y_{out} represents the output admittance of the transistor and is equal to the small-signal common-emitter output admittance y_{22e} at the output frequency.

For maximum conversion gain, the input network should be conjugately matched to the transistor input admittance. The output network should similarly be conjugately matched to the transistor output admittance. Therefore, in Fig. 1c, Y_{in}^* is the conjugate admittance of Y_{in}, and



3. **30-MHz-RF-to-5-MHz-IF mixer** can be designed in a few easy steps. See text for details.

Y_{out}* is the conjugate admittance of Y_{out}.

In the design of a mixer circuit using base injection for both input and LO signals, as long as the base does not receive sufficient drive from the LO signal to move operation out of the small-signal region, the small-signal common-emitter short-circuit input admittance will constitute the design criterion for the source admittance. As the LO level is increased, however, the transistor is driven harder into conduction. The input admittance of the transistor changes to a large-signal input admittance, and this new large-signal input admittance then becomes the design criterion for the source admittance.

If operation is in the small-signal region (see Fig. 2a), the source of the input frequency should constitute y_{11e} conjugate and at the output frequency a short circuit, and the load should appear as y_{22e} conjugate at the output frequency and a short circuit at the input frequency.

In Fig. 2b, emitter injection is used for the LO signal with base injection for the input signal. In this case the emitter cannot be bypassed at the LO frequency but must be bypassed at the input frequency. This, therefore, requires a network presenting to the emitter a short circuit at the input frequency and an impedance that is the conjugate of the LO source impedance at the LO frequency. This is a difficult design problem, particularly if the LO and input frequencies are very close together and are in the vhf or uhf frequency range.

Putting the theory to work

These design techniques and requirements are to be applied to various circuit examples. These are of a general nature for use over the vhf and uhf frequency ranges. They have not been designed for any particular application other than to illustrate design theory and design variations. Three basic circuits are discussed:

- A mixer converting a 30-MHz RF signal to a 5-MHz IF signal with a 35-MHz LO injection frequency with base injection for both the LO and the RF signals. The device used is a 2N2221A transistor.
- A mixer converting a 250-MHz RF and a 300-MHz LO to a 50-MHz IF frequency using base injection of the RF and LO frequencies. Here a MM1941 non-agc transistor is applied.
- A mixer circuit of the same scheme as the preceding one but using a 2N3308 agc transistor.

These circuits were designed and conversion gain measured as a function of a number of different parameters.

Mixer converts 30-MHz to 5-MHz IF

This mixer design (see Fig. 3c) uses a 2N2221A transistor and converts a 30-MHz signal to a 5-MHz IF signal. First, the admittance parameters are obtained at the desired frequency. For the 2N2221A (I_C = 2 mA, V_{CE} = 10 volts):

$$y_{11e} = (6.25+j\,9.5) \text{ mmhos at 30 MHz},$$
$$y_{22e} = (0.27+j\,0.28) \text{ mmhos at 5 MHz}.$$

Consequently, the design criterion for the input network is:

$$y_{11e}^* = (160\ \Omega || -50.5\text{ pF}),$$

and for the output network:

$$1/y_{22e}^* = (37\text{ k}\Omega || -9.0\text{ pF}).$$

Assume that the load to which the output network must be matched is 50 ohms. Also assume the network to be of the low-pass-filter type such that the higher frequencies will be attenuated (cf. Fig. 3a).

The circuit Q may be defined as follows for the series case:

$$Q_s = (1/G_p R_s - 1)^{1/2},$$

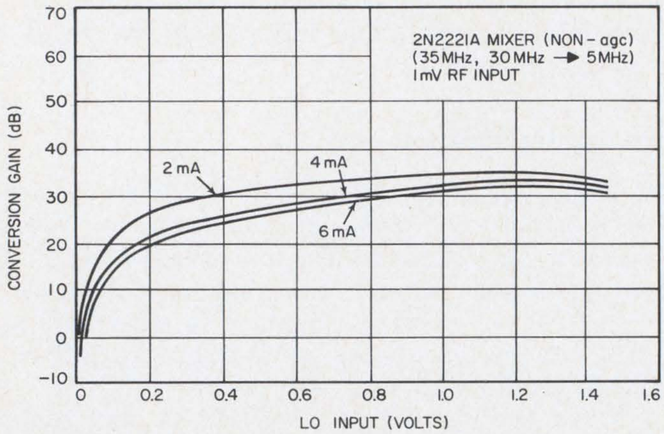
where G_p is the real part of the parallel admittance and R_s is the series resistance.

$$Q_s = (37\text{ k}\Omega/50-1)^{1/2} = 27.3.$$

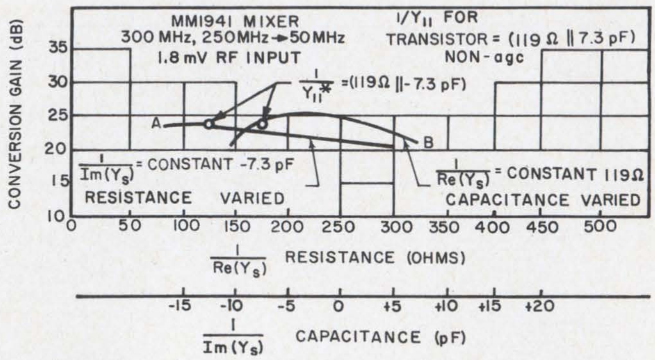
From:

$$Q_s = \omega L_s/R_s,$$

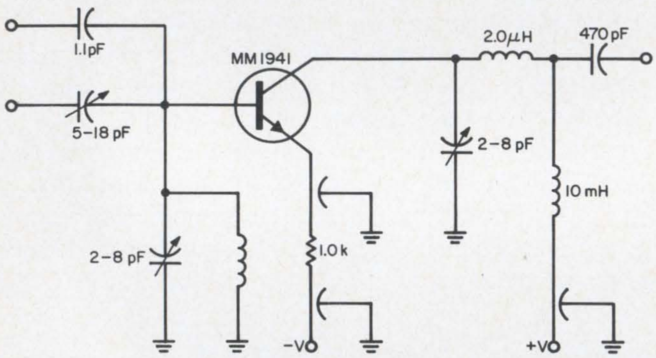
we may compute the required inductance L_s:



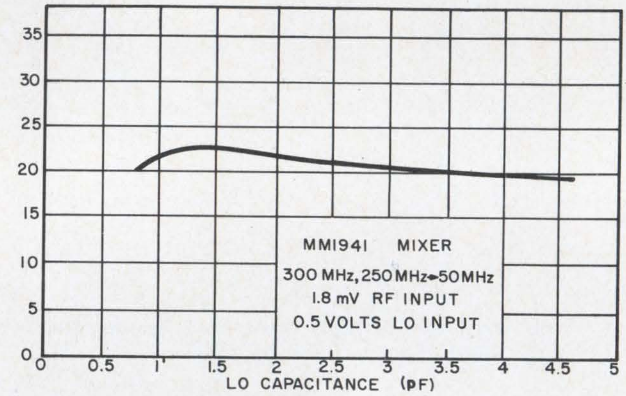
4. **Increase in collector current** in the circuit using 2N2221A mixer decreases conversion gain.



6. **Effects of changing RF source impedance** on conversion gain confirm that the maximum conversion gain occurs at the point where the source admittance presents the conjugate of the transistor input admittance to the transistor.



5. **250-MHz-RF-to-50-MHz-IF mixer** (non-AGC) is designed using the procedure developed in the text. Performance curves for this circuit are shown in Figs. 6 through 10.



7. **Local oscillator input capacitance** affects conversion gain only to a slight degree.

$$L_s = (27.3)(50)/(5.0\times10^6)(6.28) = 43.5\ \mu\text{H}.$$

The reflected parallel inductance, L_p, may be computed from:

$$L_p = L_s(1+1/Q_s^2).$$

In the above case $L_p \approx L_s = 54.5\ \mu$H.

The required capacitance for resonance at 5 MHz may be calculated from:

$$f = 1/2\pi(LC)^{1/2},$$

where $L = 43.5\ \mu$H. In this case, the total capacitance $C_T = 25$ pF. From the y-parameter equivalent of the transistor, the imaginary part represents 9.0 pF of capacitance. Therefore, an additional capacitance of $(25.0-9.0)$ pF $= 16$ pF is needed.

For the input network, again assuming a 50-Ω termination, a transforming network is used, as illustrated in Fig. 3b with its equivalent.

With the relationships described previously:

$$Q_s = (1/G_p R_s - 1)^{1/2}$$
$$= (160\ \Omega/50-1)^{1/2} = 1.47.$$

From:

$$Q_s = X_s/R_s,$$

we obtain:

$$C_s = 1/\omega Q_s R_s$$
$$= 1/(3.0\times10^7)(6.28)(1.47)(50) = 72.5\ \text{pF},$$

and

$$C_p = C_s/(1+1/Q^2)$$
$$= 72.5/(1+1/2.17) = 49.5\ \text{pF}.$$

The required inductance for resonance at 30 MHz is $L = 0.6\ \mu$H. Using $L = 0.47\ \mu$H and a variable capacitor for tuning also produces the desired result.

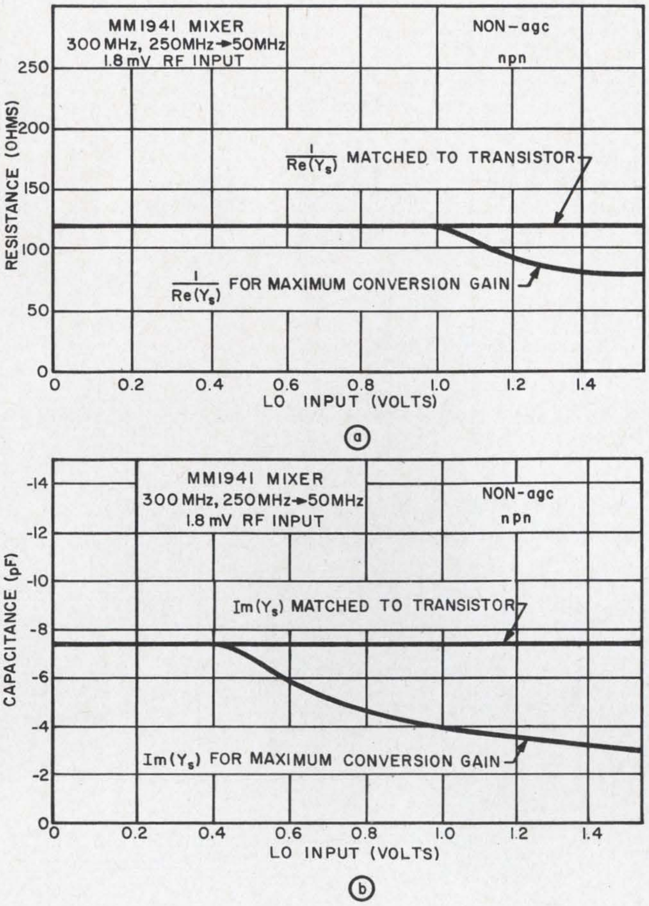
The complete circuit is shown in Fig. 3c.

The curve in Fig. 4 gives conversion gain as a function of LO input levels for different collector currents. Since the y-parameters are a function of collector current, a new set of parameters was used to design the matching networks for the different collector currents.

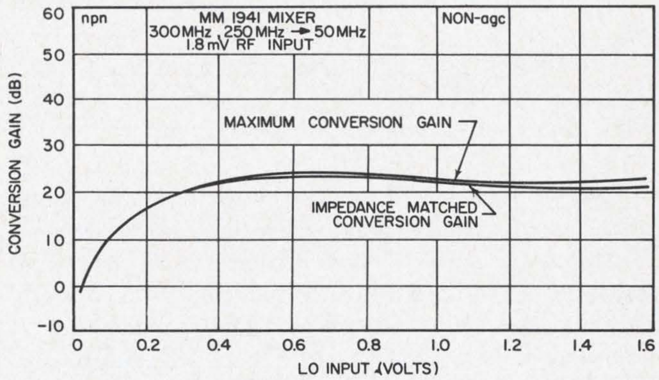
The LO voltage is measured at point *(A)* in Fig. 3c. In all following circuits the LO voltage is measured at this point.

250-MHz mixer with a non-agc transistor

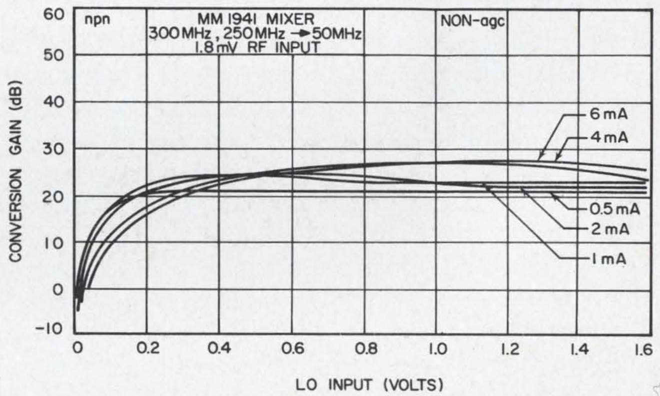
The following results are obtained with an MM1941 silicon npn transistor in a 250-MHz mixer converting to a 50-MHz output frequency. The circuit (Fig. 5) shows the transistor and matching networks for both the input and output.



8. **As the LO signal is increased,** input admittance of the transistor changes, since it leaves its small-signal region of operation.



9. **Impedance matched conversion gain** begins to deviate from the maximum tuned conversion gain once the transistor is driven beyond its small-signal region of operation by the LO signal.



10. **Nearly constant conversion gain** can be obtained by keeping transistor current low.

Figures 6 through 10 show various curves obtained with the circuit of Fig. 5.

Figure 6 shows the relation between conversion gain and source admittance for changing values of RF source admittance. For the transistor used, $y_{11e} = 8.4 + j\,11.5$ mmhos, and $1/y_1{}^1{}_e = (119\ \Omega \parallel 7.3\ \text{pF})$. Curve *A* shows the variation in conversion gain as the real part of the source admittance is varied while the imaginary part is held constant at -7.3 pF. Curve *B* shows variation in conversion gain as the imaginary part of the source admittance is varied while the real part is held constant at 119 Ω. These confirm that maximum conversion gain occurs very near the point where the source admittance presents to the transistor the conjugate of the transistor input admittance.

Figure 7 gives conversion gain as a function of LO injection capacitor size for a constant injection voltage at 300 MHz.

Figure 8a is a curve of the measured real part, and Fig. 8b is a curve of the measured imaginary part, of the source admittance for maximum conversion gain for different levels of LO input voltage. These indicate that the input admittance of the transistor changes as the LO drive is increased beyond the transistor's small-signal region of operation.

Figure 9 is the difference in conversion gain for different LO input levels, when the source admittance is matched in conjugate form to the transistor parameters, and when the source admittance is tuned for maximum conversion gain. As can be seen, maximum conversion gain occurs at an LO level where operation was still in the device's small-signal region.

Figure 10 gives conversion gain as a function of LO input voltage for different transistor currents. At the higher current levels, the conversion gain changes somewhat over the range of LO input voltage; at the lower currents, however, the conversion gain remains nearly constant.

250-MHz mixer with an agc transistor

The same design procedure is used to design a mixer circuit at 250 MHz with a 50-MHz output frequency and a 2N3308 silicon pnp transistor. This transistor is suitable for an agc circuit, unlike the MM1941, which is not commonly used in an agc mode. The 2N3308 and its associated input and output matching networks are shown in Fig. 11.

Figure 12 shows that the effect of agc action takes place between 2 mA and 4 mA of collector current.

The preceding circuits are based on base injection of both the RF and LO signals. The emitter was always bypassed and was therefore at RF ground.

For emitter injection of the LO, it was found that circuit oscillations were harder to control than in the case of base injection. This would indicate that the input RF network was not appearing as a short circuit to the IF frequency. It was also found that the effect of RF signal frequency and LO level on conversion gain is more pronounced in this case than in the case of base injection of the LO. Moreover, the optimum LO level shifts upward in accordance with increased emitter current.

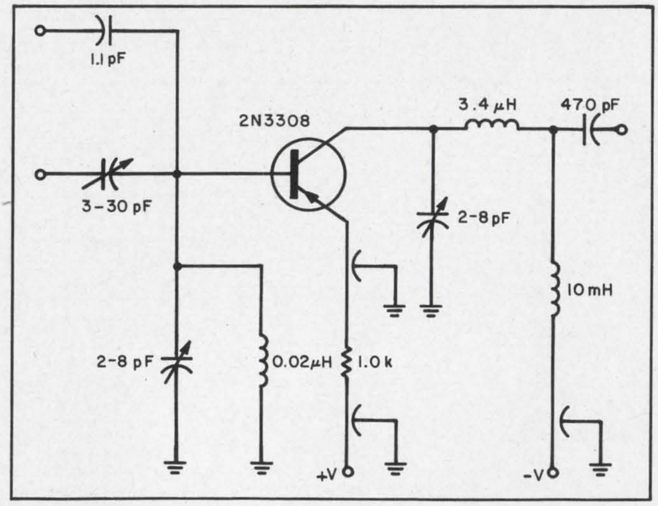
In addition to selecting a circuit at the input to match the transistor input admittance and a circuit at the output to match the transistor output admittance, other factors must be considered. A suitable network should be chosen to reduce spurious or undesired frequency components at the output due to the nonlinear character of the mixer itself. At the input, the network may be used to obtain a desired selectivity if frequency components other than the desired input signal are present.

From the curves of conversion gain as a function of local oscillator input level, the following conclusions can be drawn:

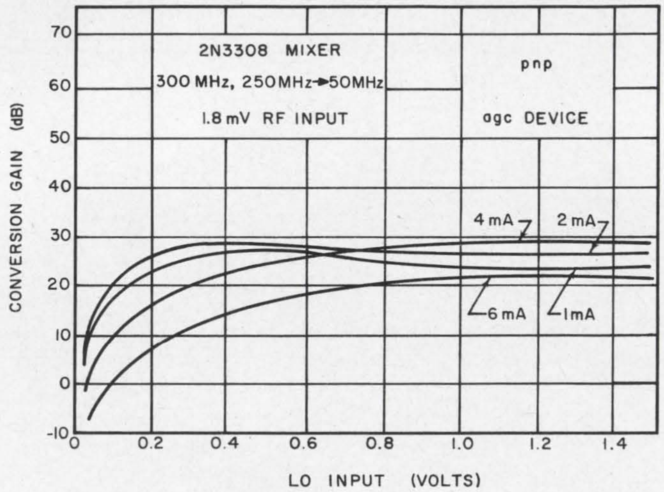
- The level of operation can be left up to the individual designer. It is relatively unimportant, as far as conversion gain goes, so long as the level does not exceed the region of small-signal operation.
- A suitable coupling capacitor in the vhf frequency range was found to be about 1 pF. This value, in the case of base injection, does not appreciably alter the transistor input admittance from the theoretical value of y_{11e} without local oscillator injection.
- A good design criterion for the choice of a bias point of operation for the transistor, if noise in the device and associated circuitry is not taken into account, is that used for small-signal amplifier design.

An additional general comment can be made at this point about the importance of the layout. As in all cases of high-frequency design, the layout must not disturb the calculated values of components. Thus, leads must be kept short and proper shielding must be provided. Otherwise, particularly in cases where the circuit is potentially unstable, added capacitance and inductance may cause mixer oscillations.

Another matter for attention is the circuit component tolerances. While standard components have been used throughout, a number of variable



11. **250-MHz-RF-to-50-MHz-IF mixer** circuit can be designed with an agc device (2N3398).



12. **Agc action in the circuit of Fig. 11** takes place between 2 mA and 4 mA of collector current.

capacitors have been incorporated. One reason for their incorporation is to provide the designer with some means of adjustment to account for component tolerances. Another is to make it possible to compensate for unavoidable "sloppiness" in the breadboard.

To conclude, the theoretical approach of this article combined with good breadboard layout and proper component choice should yield results that agree closely with calculated performance. ■ ■

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Design transistorized regulators

for your power supplies quickly and effectively with this easy-to-use technique.

A better approach to the design of transistorized regulator circuits for power supplies than constant reference to descriptions and analyses of specific circuits in the literature is a general one. A general approach covers all cases and enables the designer to visualize the over-all problem as well as aspects that he might otherwise overlook. It shows, for instance, that the same regulator output impedance can be obtained with an emitter-output as with a collector-output transistor.

Design approach defined

The crux of designing a transistor-regulated supply is to provide a dc voltage output (V_{out}) that is constant within specified limits, and self-regulating against changes in load current, input voltage and temperature. In many applications, one or more of these parameters will remain constant, thus simplifying the design. Furthermore, transient response to input impedance over a frequency range may be specified.

The general technique to be described applies specifically to regulators. Regulators involve some error (ΔV_{out}) for any change in output current or input voltage. It is this that distinguishes them from servos, which by definition incorporate an integrator in the feedback loop and have zero error after responding to an output change.

Approximations are used in this design approach, and are derived by means of an iterative calculation. This technique works well since the characteristics of a voltage regulator are such that it keeps the output voltage constant. So by taking either a change or no change in output to be a defined state, the other circuit conditions that must occur to agree with the defined condition can be calculated independently. The results are much more accurate than are the values of the passive and active components used, owing to production tolerances. There is, then, little point in going through a laborious, exact derivation. This general design approach also assumes that the regulator output impedance is much smaller than the load impedance—a condition again implicit in any voltage regulator.

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Basic circuit shows relationships

As shown by the simple block diagram of Fig. 1, a regulator requires a reference voltage, some kind of comparator, and a feedback amplifier. The comparator compares the output voltage with the reference and is characterized by having a transconductance, g_{m_c}. Thus, a change in output voltage will generate a change in current from the comparator, which is equal to the product of comparator transconductance and output voltage change.

The current output from the comparator is amplified in a current amplifier that has a gain A_i, and is then available to the load. The output impedance for such a simple regulator, if it is assumed to have a nonvarying input voltage with zero impedance, can readily be determined by the ratio of change in output voltage to change in output current:

$$\Delta I_{out} = \Delta V_{out}\, g_{m_c} A_i; \qquad (1)$$

therefore:

$$R_{out} = \Delta V_{out}/\Delta V_{out}\, g_{m_c} A_i = 1/g_{m_c} A_i. \qquad (2)$$

The output impedance of the regulator may thus be lowered by increasing either the comparator transconductance or loop current gain, or both. This is an extremely important conclusion. It eliminates the myth that an emitter-output regulator transistor will provide a lower output impedance than a collector-output regulator. If both loops contain the same comparator transconductance and current gain, either configuration will have the same output impedance. Therefore, either pnp or npn transistors may be used as a regulator in any application, with selection dependent on such factors as price, power rating, voltage rating, rather than on the required output polarity.

Equations 1 and 2 show the true relation of the comparator to the circuit. The designer can thus attempt to maximize the comparator transconductance, in many cases by the simple expedient of using the lowest practical impedance in the voltage divider that is generally provided to reduce the feedback voltage to the same magnitude as the reference. The relationship shows that for multiple stages in the feedback amplifier, optimum design is for maximum current gain.

General case includes input and output effects

The simple circuit of Fig. 1 is invaluable for describing the basic idea of a transistorized voltage regulator, but is not complete enough to evaluate a general design. Although it shows a voltage source, it in no way indicates the effect of this source on output impedance or regulation.

Figure 2 is a model of slightly greater sophistication which includes parameters for the source impedance and coupling to the load. Since transistors are inherently current-amplifying devices and the rest of the circuitry is described in terms of currents, the coupling between input and load is selected as a transconductance, $g_{m_{in}}$. The value of this transconductance may be determined by allowing the voltage, V_1, from the source to vary incrementally while the output voltage is held constant. The change in output current for the change in supply input voltage ($\Delta V_{out} = 0$) is then the input transconductance, $g_{m_{in}}$. It should be noted that this change may occur through all stages of the feedback amplifier. Generally, the design should attempt to minimize this effect by methods that will be described later.

If we assume that the load-current drain is large with respect to that used in the regulator amplifiers and reference, then any change in load current will provide an identical (or nearly so) change in current drain from the source. This change in source current will generate a change in voltage equal to $\Delta I_{out} R_s$ at the input to transconductance $g_{m_{in}}$.

The output impedance of the supply is determined by considering the combined effect of the two transconductances, $g_{m_{in}}$ and g_{m_c}, for an incremental change in output current. The change in input voltage due to the source resistance and output current change causes an output current contribution equal to:

$$-\Delta I_{out} R_s g_{m_{in}}.$$

The regulator circuit proper must therefore provide the sum of two currents: the increase in load current, and the decrease in the input transconductance current (since this input contribution is negative). Since the regulator feedback loop current must equal the sum of the input transconductance current and the increase in output load, we can write:

$$g_{m_c} A_i \Delta V_{out} \equiv g_{m_{in}} R_s \Delta I_{out} + \Delta I_{out}, \qquad (3)$$

or:

$$g_{m_c} A_i \Delta V_{out} = \Delta I_{out}(1 + g_{m_{in}} R_s), \qquad (4)$$

and:

$$R_{out} \equiv V_{out}/I_{out} = (1/g_{m_c} A_i)(1 + g_{m_{in}} R_s). \qquad (5)$$

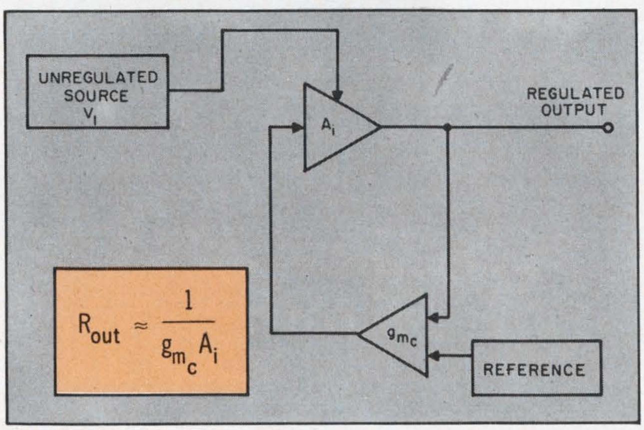
It may readily be observed from Eqs. 2 and 5 that the output impedance for the general case is increased from the simple case (zero source impedance) by the term:

$$R_s\, g_{m_{in}}/g_{m_c} A_i.$$

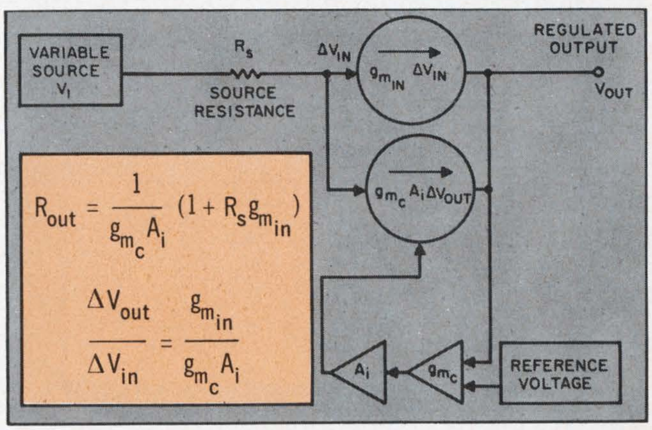
Thus, if $R_s\, g_{m_{in}}$ is small in comparison with 1, no improvement in regulation can be made by lowering the source impedance or source-to-load coupling, and the design is optimum from this point of view.

Another parameter of importance is the change in output voltage for a change in input voltage (due to power line change, for example). This relationship can also be obtained by considering the $g_{m_{in}}$ term. The change in available load current due to the change in input voltage will be:

$$\Delta I = \Delta V_{in}\, g_{m_{in}}. \qquad (6)$$



1. **Simple series regulator has three elements**: a reference voltage, a comparator and a feedback amplifier. The regulator output impedance is inversely proportional to the comparator transconductance and the loop current gain.



2. **Source impedance and coupling to the load are considered** in this more detailed model of a series regulator. The model allows calculation of the effects of both input and output load variations.

Since the regulator proper must supply the change in current, the change in output voltage will be approximately:

$$\Delta V_{out} = \Delta I/g_{m_c} A_i = \Delta V_{in}\, g_{m_{in}}/g_{m_c} A_i. \qquad (7)$$

And the ratio of output-voltage to input-voltage change is:

$$\Delta V_{out}/\Delta V_{in} = g_{m_{in}}/g_{m_c} A_i. \qquad (8)$$

Thus, the model allows calculation of the effects of both input and output load, and any combination.

Examples demonstrate technique

Use of this technique can be illustrated by the design of actual regulators of different degrees of complexity. It should be noted that the division of circuit functions is not so apparent in the simplest regulators where few components have to perform all the operations.

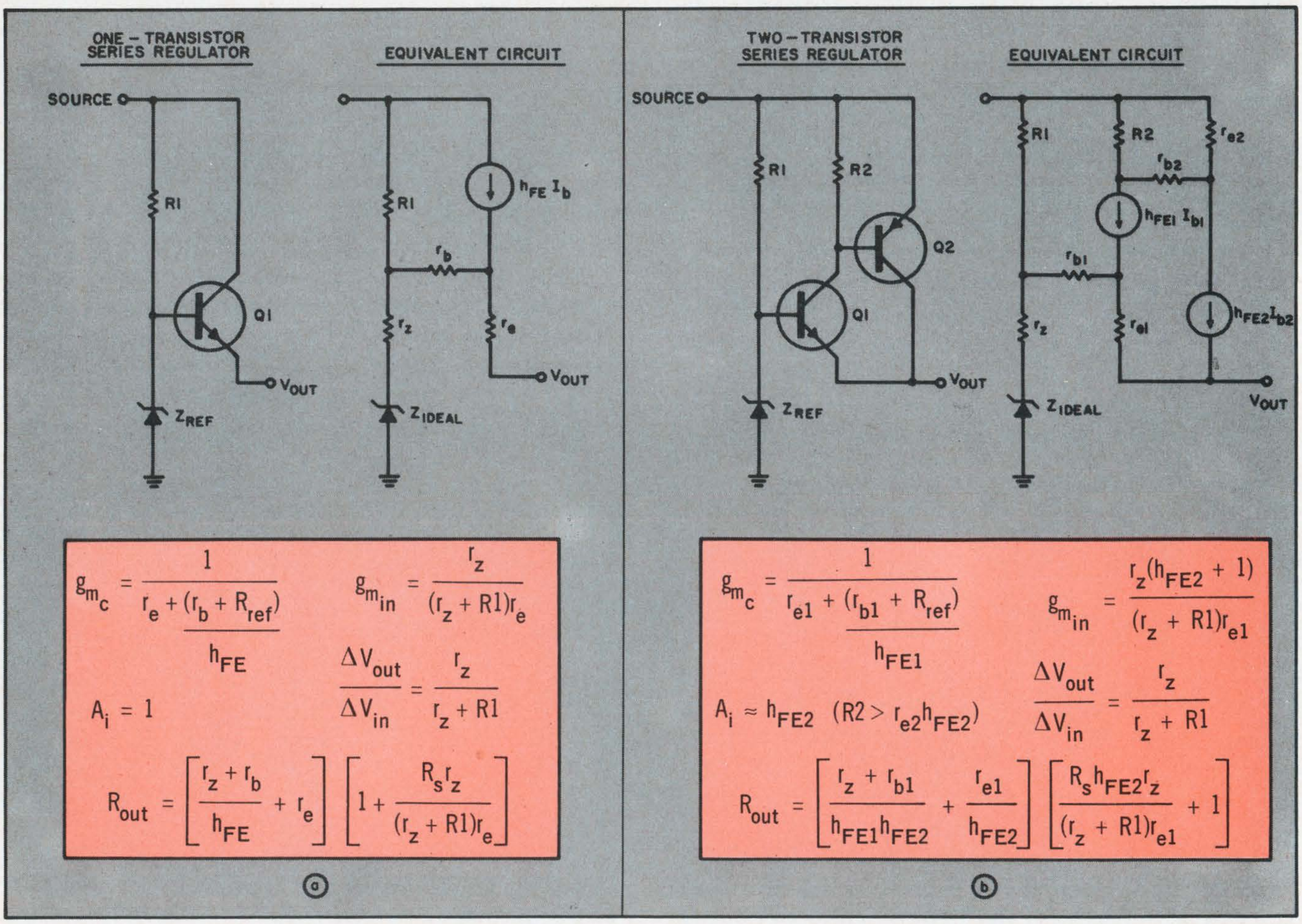
As a first example, Fig. 3 shows two simple arrangements of one and two transistors used as series voltage regulators. In Fig. 3a, the single transistor is part of both the comparator and the current amplifier. A Zener voltage-reference diode is used and a reasonable degree of temperature stability can be obtained if Zener and transistor have similar drift characteristics and are thermally connected by means of a heat sink or potting compound. An analysis of the equivalent circuit of Fig. 3a shows the output impedance to be:

$$R_{out} = \left[\frac{R_{ref} + r_b}{h_{FE}} + r_e\right]\left[1 + \frac{R_s r_z}{(r_z + R1) r_e}\right], \qquad (9)$$

where:

R_{ref} = combined parallel impedance of the Zener and resistor $R1$ (for most applications $R_{ref} \approx r_Z$),
r_b = transistor base resistance,
r_z = Zener impedance,
h_{FE} = transistor current gain in the common-emitter mode,
R_s = source impedance,
r_e = transistor emitter resistance (roughly equal to $26/i_e$, where i_e is in mA).

Thus this configuration can never provide an output impedance lower than $26/i_{load}$ regardless of how low a source impedance or how high a current gain the transistor provides. Connecting one or more additional transistors in tandem in the conventional super-alpha or Darlington-pair



3. **Design technique is illustrated** by these two basic regulator types. The one-transistor arrangement (a) can never provide an output impedance lower than $26/i_{line}$. The two-transistor configuration (b), which uses a pair of complementary transistors, can provide a much lower output impedance.

arrangement cannot avoid this basic limitation.

A much lower output impedance than is available from the configuration of Fig. 3a can be obtained from the circuit of Fig. 3b, which is a pair of complementary transistors. An analysis of the equivalent circuit of Fig. 3b shows that the output impedance approaches the following:

$$R_{out} = \left[\frac{R_{ref} + r_{b1}}{h_{FE1}h_{FE2}} + \frac{r_{e1}}{h_{FE2}}\right]\left[1 + \frac{R_s\, h_{FE2}\, r_z}{(r_z + R1)\, r_{e1}}\right], \quad (10)$$

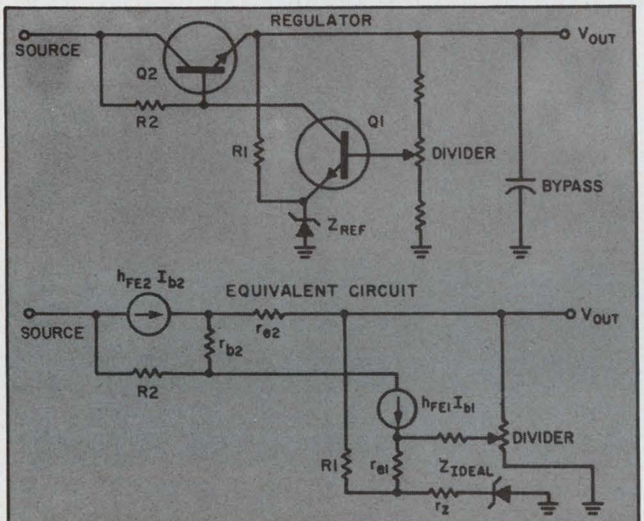
where:

R_{ref} = combined reference impedance,
r_{b1} = base resistance of *Q1*,
r_z = Zener impedance,
r_{e1} = emitter resistance of *Q1*,
R_s = source impedance,
h_{FE1} = common-emitter current gain of *Q1*,
h_{FE2} = common-emitter current gain of *Q2*,

Equation 7 shows that a reduction in r_{e1} will be advantageous in lowering the output impedance. This indicates that the bias resistor, *R2*, should be made as small as possible without losing regulation. In the case of a regulator controlling a highly variable load (such as to supply a pulse amplifier), optimum operation will probably result when the circuit is biased so that *Q1* supplies almost all of the load current in the minimum drain case. The fact that r_e is a function of demand current complicates the problem for the general case, and its effect should be investigated for each individual problem.

The simple equivalent circuit shown for Fig. 3b does not completely describe the design problem, for it does not take into account the effect of the diode offset (about 0.5 volt). If a higher bias voltage than the source being regulated is available, the circuit can be optimized by biasing *Q1* at close to the smallest expected demand current, and using the higher supply as the transistor's source. *R2* can then be made as large as possible, so that it does not shunt the input to *Q2*. The temperature problem can be at least partially solved by selecting Zeners and transistors with similar temperature characteristics. This is not always possible at the desired voltages.

The circuits of Fig. 3 are practical and have been used many times to provide regulation with fairly low output impedance, some immunity to temperature variation, and reasonable transconductance with respect to input voltage. They suffer, however, from several inadequacies. No means of output voltage adjustment is easily available, and selection of Zeners at a specific voltage is generally impractical since they are normally sold with 10% tolerances, 5% at a significant cost increase, and 1% on special order. It is impossible to maintain a high-accuracy output where limited regulation but good stability are required. The effects of temperature and input-voltage variation are difficult to overcome. Finally, the reference Zener receives current from a nonregulated supply, which in itself precludes high stability for the unit.



$$K = A_v \frac{(r_{e1} + r_z)h_{FE1}}{(r_{e1} + r_z)h_{FE1} + R_{divider}}$$

For the usual design: $K \approx A_v \approx$ feedback ratio of divider

$$g_{m_c} = \frac{K}{r_{e1} + r_z};\ \text{if } r_z \ll R1 \quad \Big| \quad g_{m_{in}} = \frac{h_{FE2}}{R2 + r_{b2} + r_{e2}h_{FE2}}$$

$A_i = h_{FE2}$; if $r_{e2}h_{FE2} \ll R2$ (if not calculate for the current lost in R2)

$$R_{out} = \left(\frac{r_{e1} + R_{ref}}{Kh_{FE2}}\right)\left(1 + \frac{h_{FE2}R_s}{R2}\right) \quad \Big| \quad \frac{\Delta V_{out}}{\Delta V_{in}} = \frac{r_{e1} + R_{ref}}{R2K}$$

4. **Variable output voltage is provided** by this two-transistor regulator. This arrangement has a higher output impedance and poorer efficiency than that of Fig. 3b.

More complex regulator analyzed

The next level of regulator complexity appears in Fig. 4. In this regulator, transistor *Q1*, the Zener diode and the voltage divider network provide the reference and comparator. The current output of this portion of the regulator, which is dependent on the comparator transconductance, is amplified by the current gain of transistor *Q2*.

In the analysis of the circuit of Fig. 4, the effect of the voltage divider can be accounted for by a term *K*, where:

$$K = A_v \frac{(r_{e1} + r_z)\, h_{FE1}}{(r_{e1} + r_z)\, h_{FE1} + R_{divider}}. \quad (11)$$

And for the usual design case:

$K \approx A_v \approx$ *feedback ratio of divider.*

Then:

$$g_{m_c} = K/(r_{e1} + r_z),$$

if $r_z << R1$;

$$A_i = h_{FE2},$$

if $r_{e2}\, h_{FE2} << R2$ (if not, calculate for the current lost in $R2$);

$$g_{m_{in}} = h_{FE2}/(R2 + r_{b2} + r_{e2}\, h_{FE2}).$$

The output impedance is therefore:

$$R_{out} = \left[\frac{(r_{e1} + R_{ref})}{K\, h_{FE2}}\right]\left[1 + \frac{h_{FE2}\, R_s}{R2}\right], \quad (12)$$

where:

$R_{ref} = r_z$ in parallel with $R1$,

R_s = source resistance.

And:

$$\Delta V_{out}/\Delta V_{in} = (r_{e1} + R_{ref})/R2\, K. \quad (13)$$

The configuration of Fig. 4 offers several improvements over the simpler arrangements of Fig. 3. First, the Zener voltage does not establish the output voltage directly since the feedback can be set with the potentiometer. Most of the Zener bias current can come from the regulated output voltage, thus decreasing the input transconductance. Also, the output voltage can be varied over some reasonable range, although not to zero volts.

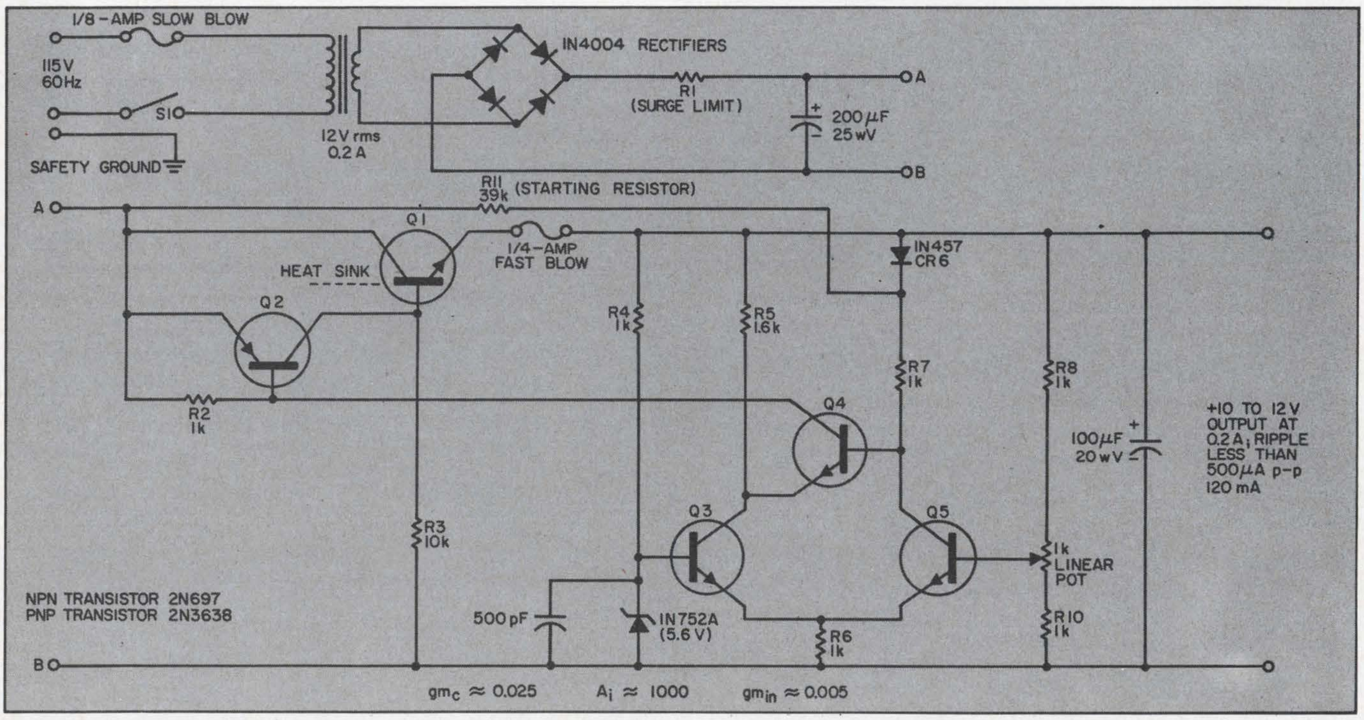
Although the regulator of Fig. 4 does not have good temperature stability inherent in its design, the drift of Zener voltage and base-to-emitter voltage of *Q1* can be matched to some extent, if desired. The bias current in the Zener diode is dependent on both the input voltage and the load current, and this tends to increase both output impedance and input transconductance. For similar applications, therefore, the circuit of Fig. 4 will have a higher output impedance and poorer efficiency (more power lost in the regulator circuitry) than that of Fig. 3.

Technique yields complete supply

Figure 5 shows a series-regulated power supply designed by the techniques described. The circuit, which supplies up to 200 mA at 12 volts, features a differential amplifier in the comparator section. The use of the differential amplifier allows the designer to select a reference Zener near the zero temperature-coefficient point (around 6 volts). The differential amplifier will have good balance if both sides are biased at about the same current level.

The use of a cross-coupling transistor (*Q4*) as an output device to the following current amplifier effectively isolates the comparator from input supply variations and allows for a small input transconductance. Input transconductance in this application is caused primarily by the output impedance of pnp transistor *Q2*, which will typically be greater than 20 kΩ at 2 mA. This impedance drives the 10-kΩ load of *R3* and the parallel input-impedance of *Q1* (typically again 10 kΩ at dc).

The comparator transconductance is approximately 1/40; and the feedback loop current gain is $(h_{FE1}\, h_{FE2})/2$ (to allow for the bias resistor, *R2*), or something greater than 1000. This is obtained from the transconductance of the differential amplifier with cross-coupled output, which is approximately $1/r_e$ multiplied by the input divider gain of 0.5. The source impedance due



5. **Differential amplifier is used** in the comparator section of this regulated supply. The comparator is isolated from supply input variations by cross-coupling transistor Q4, allowing for a small input transconductance.

to transformer winding, diodes and the series resistor is about 20 ohms. Thus, the maximum output impedance is:

$$\begin{aligned} R_{out} &= 1/g_{m_c} A_i \times (1+R_s \times 0.005) \\ &= 40/1000 \times (1+20 \times 0.005) \\ &= 0.04 \times 1.1 \\ &\approx 0.04 \text{ ohm.} \end{aligned}$$

The variation of output with input changes (which may vary considerably because of transistor tolerances) is approximated by:

$$\Delta V_{out}/\Delta V_{in} = g_{m_{in}}/g_{m_c} A_i = 0.005/50 = 0.0001.$$

Measurements on several supplies of the circuit of Fig. 5 produced these typical characteristics:

$$R_{out} = 0.02 \text{ ohm},$$
$$\Delta V_{out}/\Delta_{in} = 0.00003.$$

A few remarks are pertinent in describing the circuit of Fig. 5. This type of feedback is not self-starting, and diode *CR6* and resistor *R11* are required, to drive transistor *Q4* in the absence of output voltage, and turn transistors *Q2* and *Q1* on. When the output rises to the design point, most of the current through *R7* will come through *CR6* rather than *R11*, and the differential amplifier will not be unbalanced by the starting resistor.

The differential amplifier and cross-coupling transistor *Q4* have a tendency toward oscillation at high frequencies, unless the base of the reference transistor is at a low impedance. The positive feedback for oscillation occurs from collector to base of *Q3* because of the transistor's internal capacitance and the low emitter impedance of *Q4*. Some supplies oscillated at about 10 MHz, especially in the form of ringing when supplying a pulse load. This was eliminated by shunting the reference Zener with a 500-pF capacitor.

Use of cross-coupling transistor *Q4* is a valuable technique for differential-to-single-ended output conversion, because the output point is a current source with very little dependence on common-mode voltage. This contributes greatly to the low input-transconductance of the regulator. It does not provide much additional gain, only ×2 over a conventional single-ended output, but it is inexpensive, especially with modern epoxy-encased units, and is well justified.

Ac characteristics found conventionally

The concepts covered in this article are complete for the dc characteristics, which are the primary concern of most power supply regulators. However, there are ac characteristics of significance in any closed loop and the designer must consider both stability and transient response to complete his design. The technique described allows determination of circuit configuration and its dc characteristics. The ac characteristics, however, still have to be found using more conventional analysis. ■ ■

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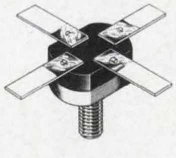

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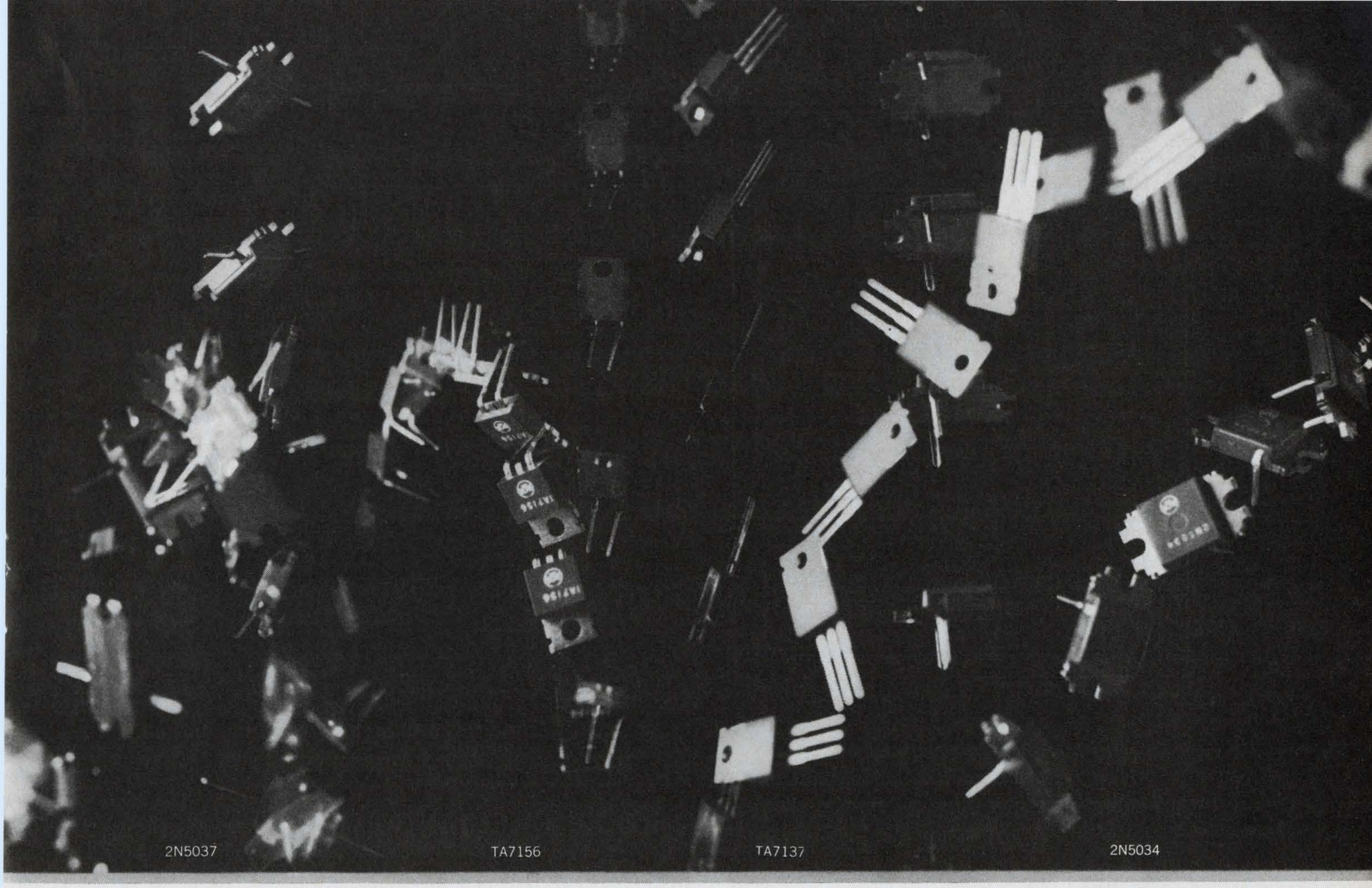

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TA7155 TA2911	TO-66 equivalent P.C. type	60 V @ R_{BE} = 100 ohms	4A	25-100 @ 0.5A	3.5 °C/W	36 W
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Serial comparison technique improves

performance of automatic test systems. Any number of bits may be handled with a minimum of hardware.

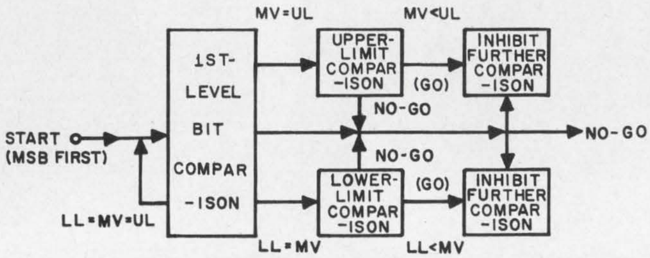
Many tape-programed test systems operate by comparing measured data with reference limits stored on the tape. Common comparison techniques usually require the loading of both upper and lower comparison limits from tape into upper- and lower-limit registers; then the measured value is compared against these limits. If the number of bits to be compared is large, the number of registers necessary to store the upper and lower limits becomes correspondingly large and expensive. A serial comparison technique, on the other hand, is an effective method of reducing hardware and expense.

Serial comparison offers several advantages, among which are:

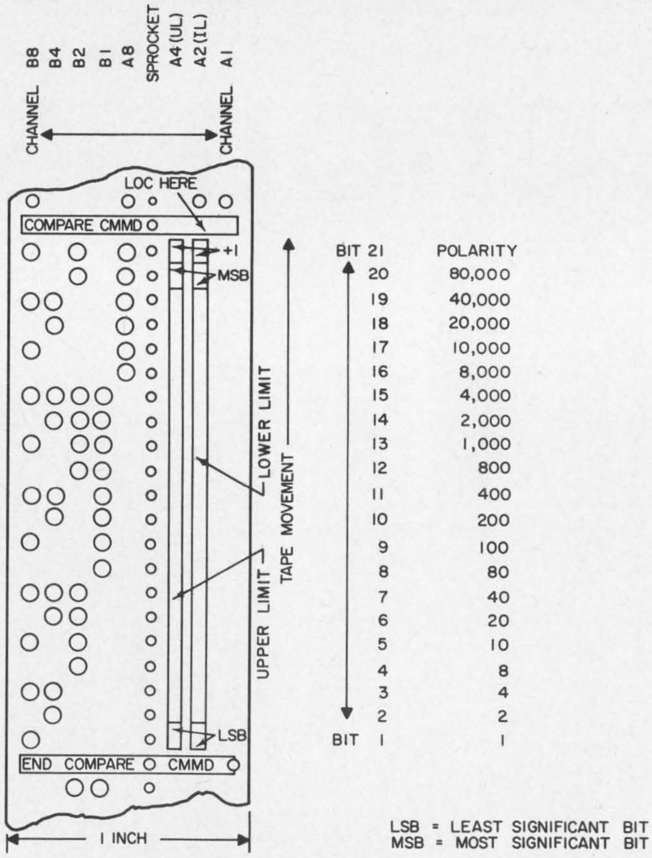
- Any number of bits may be compared serially with no appreciable increase in hardware costs.
- The technique will work for any coding system (BCD, binary, Gray code with a Gray-to-binary converter, etc.) in which the bit weight is greater than or equal to the previous bit weight. Examples of this would be the BCD 8421 or 4421 codes.
- The technique will work for any system in which the limits may be read serially from a magnetic- or punched-tape, drum, disk, core or other memory device.
- A slight change of format enables any number of bits to be compared.

The logical comparison flow for the serial technique is illustrated in Fig. 1. Bits are compared serially, most significant bit (*MSB*) first. Comparison can be made with negative or positive lower limits, measured values, or upper limits. A *go* comparison will result when the lower limit is less than or equal to the measured value and the measured value is less than or equal to the upper limit. If the measured value (*MV*) is equal to the upper limit (*UL*), all further comparison is made against the upper limit; if the measured value is

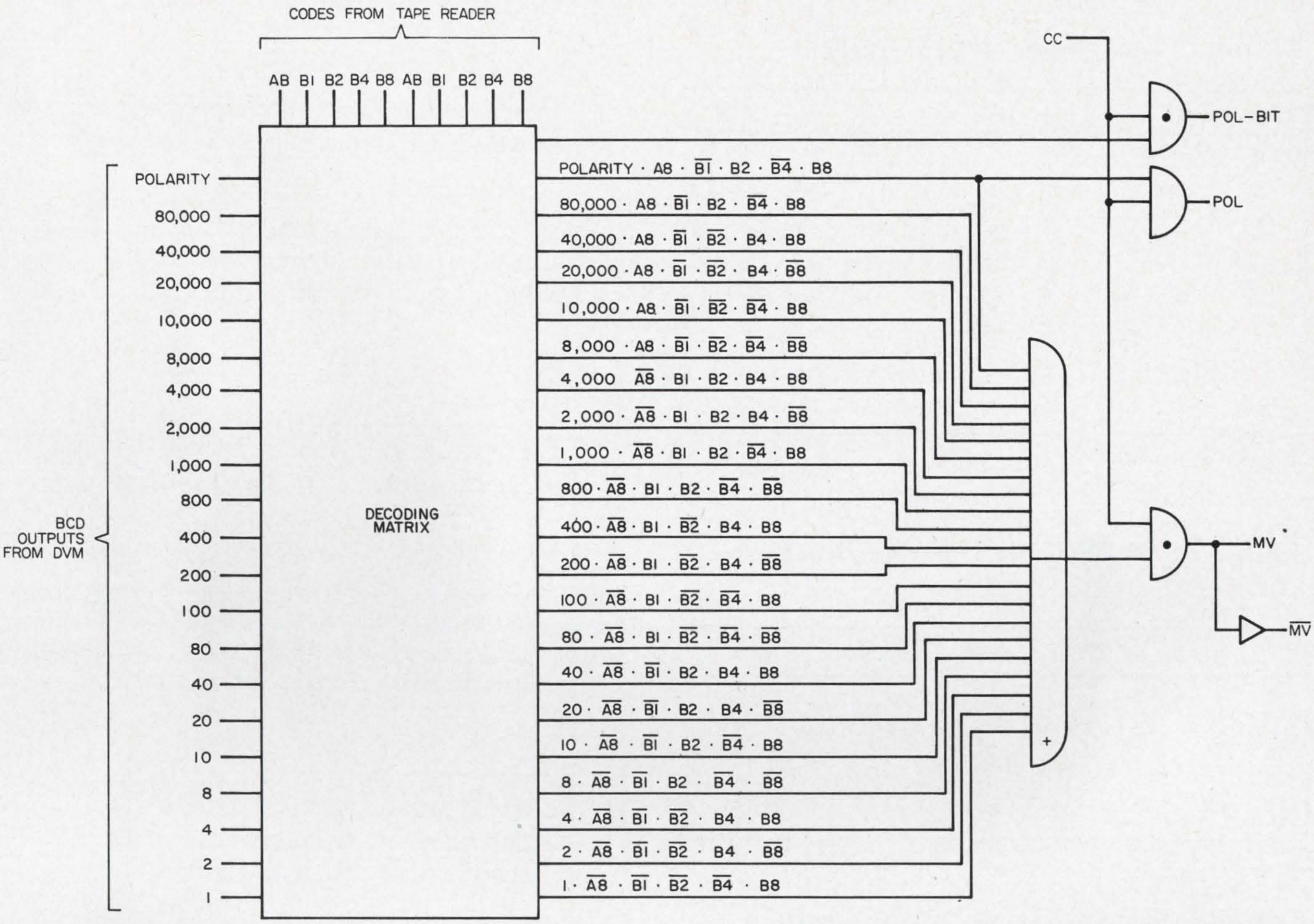
Glen D. Jones, Research Engineer, Autonetics, Div. of North American Aviation, Inc., Anaheim, Calif.



1. **Serial comparison offers lower cost** and less hardware in tape-programed test systems. Measured data are compared against reference limits programed on the tape.



2. **An eight-level tape is used to illustrate** the operation of the serial comparison techniques. Channels A8 through B4 will indicate (in code) which bit is contained in channels A2 and A4. Channel A4 will contain the upper reference limit in binary coded decimal (BCD) while the lower limit, also in BCD, will be in channel A2.



3. **A decoding matrix permits selection of bits** from the digital voltmeter used to make measurements on the equipment under test. The output of this matrix is routed to the comparison circuitry.

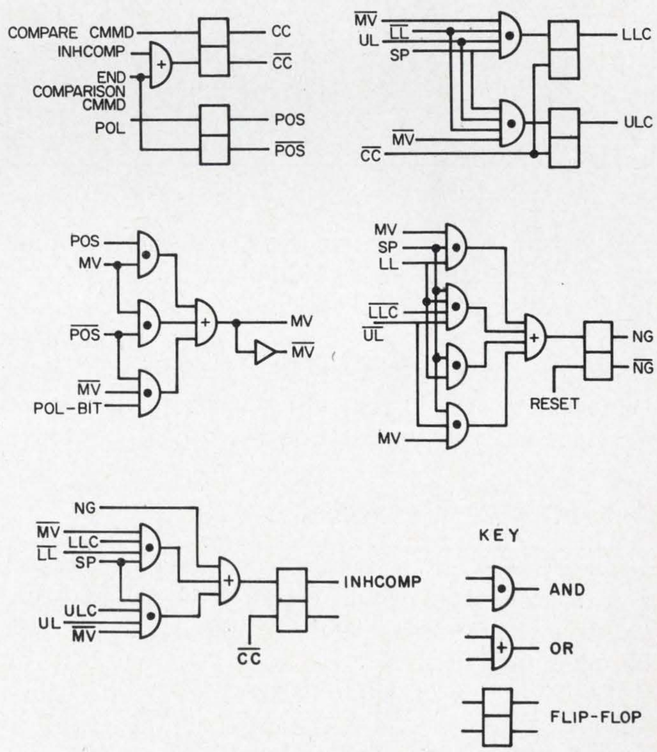
equal to the lower limit (*LL*), all further comparison is made against the lower limit; and if $LL = MV = UL$, comparison is continued at the first-level comparison. Comparison will then continue until a *go*, *no-go* or *end comparison* command is received.

DVM output used to show how system works

In the system to be described, the output of a digital voltmeter (DVM) is used; making upper and lower limits both the same enables a comparison of bit patterns to be made, as in the case of the logic states of digital circuitry.

An eight-level tape format (Fig. 2) is used in the comparison system. Channels *A8* through *B4* will indicate in code which bit is contained in channels *A2* and *A4*. Channels *A2* and *A4* will contain the lower and upper limits, respectively. The tape will be read the sign bit first, then the most significant bit (*80,000*'s bit) and so on. The *end comparison* command will contain a bit in channel *A1* to distinguish it from any bit combinations that may be present between the *comparison* command and the *end comparison* command.

The decoding matrix (Fig. 3) provides the



4. **Logical gating is performed by these comparison circuits.** The outputs of the decoding matrix (Fig. 3) are routed to the comparison circuits.

Table 1. First-level truth table

Condition	LL	MV	UL	LLC	ULC	NG
1	0	0	0	—	—	—
2	0	0	1	1	—	—
3	0	1	0	—	—	—
4	0	1	1	—	1	—
5	1	0	0	—	—	1*
6	1	0	1	—	—	1
7	1	1	0	—	—	1*
8	1	1	1	—	—	—

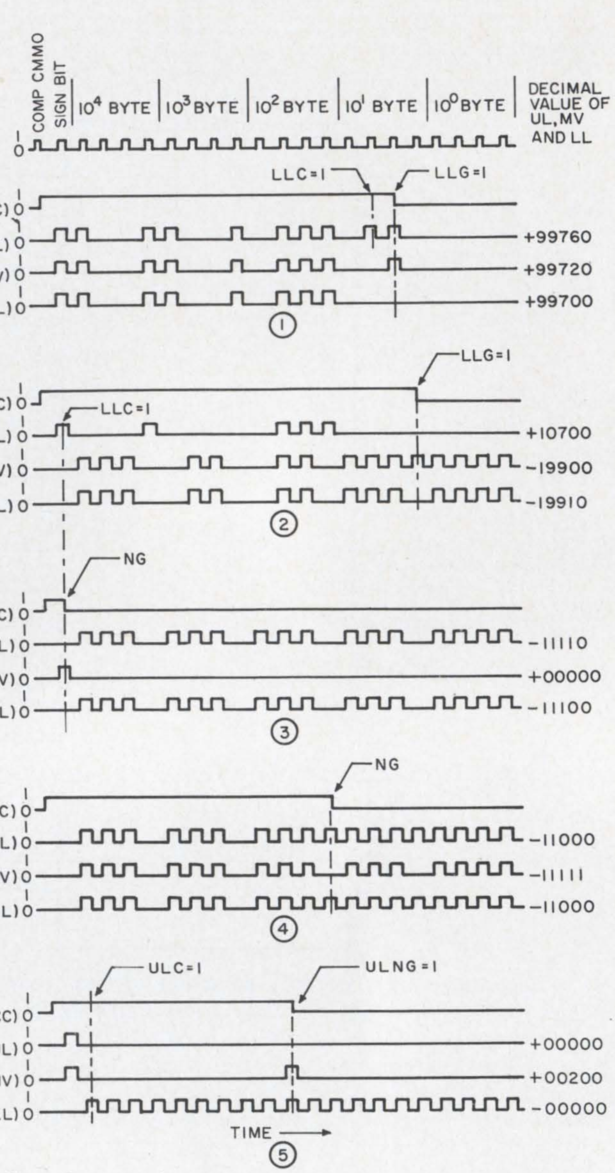
*Programing error UL < LL

Table 2. Second-level lower-limit comparison truth table

Condition	MV	LL	LLNG	LLG
1	0	0	—	—
2	0	1	1	—
3	1	0	—	1
4	1	1	—	—

Table 3. Second-level upper-limit comparison truth table

Condition	MV	UL	ULNG	ULG
1	0	0	—	—
2	0	1	—	1
3	1	0	1	—
4	1	1	—	—



5. **Sample waveshapes show operation of serial comparison** circuitry. The abbreviations used are explained in Table 4.

means for selecting from the DVM the bits that are to be serially compared against the upper and lower limits as read from tape channels *A2* and *A4*. The output of this matrix *(MV)* is routed to the comparison circuitry, (Fig. 4). This matrix is composed of AND gates which perform the logical gating indicated on each output line.

Sign bit determines process

On receipt of a *compare* command, several logical steps are performed in a serial manner. Positive comparisons (polarity bit equals *1*) will be explained first.

The sign bit is selected first by the decoding matrix (Fig. 3); then the rest of the word is compared serially against the upper and lower limits bit by bit, using the logic of Table 1. If condition 3 (measured value is greater than upper or lower limits), 5 (lower limit is greater than measured value or upper limit), 6 (measured value is less than lower limit or upper limit) or 7 (lower limit is equal to measured value which is greater than the upper limit) is met, a *no-go* is detected and no further comparison is made. If condition 2 (lower limit is equal to the measured value which is less than the upper limit) is obtained, all further comparison follows the logic of Table 2. If condition 4 (lower limit is less than the measured value which is equal to the upper limit) is obtained, all further comparison follows the logic of Table 3. If condition 1 or 8 (lower limit equals measured value equals upper limit) is detected, further comparison follows the logic of Table 1.

If a *no-go* has not been detected, comparison will be performed on the next most significant bit; the logic used on this bit will be dependent on the previous bit comparison. If either a *go* or *no-go* command is detected, no further comparison will be made.

To compare a measured value against negative limits, a restriction is placed on the device which assembles the eight-level codes on tape: when a negative limit, upper or lower, is programed on tape, all bits except the sign bit must be inverted (the sign bit will be *0* if the limit is negative). A negative measured value is modified in a similar manner (see Figs. 3 and 4). Its sign bit, which is negative (logic *0*), is not modified. All the following *MV* bits will be inverted. In this fashion either negative or positive measured values may be compared against positive and/or negative limits.

Logical mechanization of this comparison technique is shown in Fig. 4. Note that the flip-flops trigger on the *1*-to-*0* transition. Pertinent abbreviations and logic equations are explained in Table 4.

Examples demonstrate operation

Several comparison examples are given in Fig. 5. On receipt of a *compare* command, a serial comparison will proceed as illustrated.

In example 1 the upper limit, measured value, and lower limit are the same value until the *40*'s bit; at this point all further comparison is made on the lower limit (*LLC=1*). On the *20*'s bit a *go* is detected (*LLG=1*) and no further comparison is made (*CC=0*).

Example 2 illustrates a negative measured value and lower limit comparison. Note the inversion of the measured value and the lower limit. The measured value is inverted as it is read from the DVM; the lower limit is stored inverted on tape.

When the measured value is larger than the upper and lower limit a *no-go* is detected, as shown in example 3.

Example 4 illustrates the detection of a *no-go* when the measured value is less positive than the lower limit (*100*'s bit).

In example 5 all comparisons after the *80,000*'s bit are made on the upper limit (*ULC=1*). At *400*'s bit a *no-go* is detected (*ULNG=1*).

Although the examples illustrated here are for a BCD 8421 system, this technique will work equally well for other coding systems where the weight of each ascending bit is equal to or greater than the previous bit.

The hardware necessary to perform this comparison technique stays essentially the same (excluding the decoding matrix) for any number of bits being compared. Thus the hardware cost compared with that of a parallel comparator remains essentially constant for any number of bits being compared. ■ ■

Table 4. System abbreviations and logic equations

An asterisk (*) denotes a flip-flop input logic equation. Flip-flops are triggered when the input signal goes from logic **1** to logic **0**. Triggering thus occurs on the trailing edge of the sprocket pulse. A · means AND; + means OR; ‾ over a term means NOT.

Abbreviations used are:

LLC—lower-limit comparison	NG—no-go
ULC—upper-limit comparison	CC—compare command
ULG—upper-limit go	POS—positive
LLG—lower-limit go	MV—measured value
ULNG—upper-limit no-go	UL—upper limit
LLNG—lower-limit no-go	LL—lower limit
INHCOMP—inhibit compare	SP—sprocket
POL—polarity (**1** = pos.; **0** = neg.)	CMMD—command

The logic equations are:

$$^*\mathrm{CC}=\mathrm{COMPARE}\ \mathrm{CMMD} \qquad ^*\overline{\mathrm{CC}}=\mathrm{END\ COMPARISON\ CMMD}\cdot\mathrm{INHCOMP}$$

$$^*\mathrm{POS}=\mathrm{POL} \qquad ^*\overline{\mathrm{POS}}=\mathrm{END\ COMPARISON\ CMMD}$$

$$\mathrm{MV}=\mathrm{POS}\cdot\mathrm{MV}+\overline{\mathrm{POS}}\cdot\mathrm{MV}\cdot\mathrm{POL\text{-}BIT}+\overline{\mathrm{POS}}\cdot\overline{\mathrm{MV}}\cdot\mathrm{POL\text{-}BIT}$$

$$^*\mathrm{LLC}=\cdot\overline{\mathrm{LL}}\cdot\overline{\mathrm{MV}}\cdot\mathrm{UL}\cdot\mathrm{SP} \qquad ^*\overline{\mathrm{LLC}}=\overline{\mathrm{CC}}\cdot\mathrm{SP}$$

$$\mathrm{LLG}=\mathrm{MV}\cdot\overline{\mathrm{LL}}\cdot\mathrm{LLC}\cdot\mathrm{SP}$$

$$^*\mathrm{ULC}=\overline{\mathrm{LL}}\cdot\mathrm{MV}\cdot\mathrm{UL}\cdot\mathrm{SP} \qquad ^*\overline{\mathrm{ULC}}=\overline{\mathrm{CC}}\cdot\mathrm{SP}$$

$$\mathrm{ULG}=\overline{\mathrm{MV}}\cdot\mathrm{UL}\cdot\mathrm{ULC}\,\overline{\cdot\,\mathrm{SP}} \qquad ^*\overline{\mathrm{NG}}=\textbf{reset}$$

$$^*\mathrm{NG}=\mathrm{LL}\cdot\mathrm{MV}\cdot\mathrm{SP}+\overline{\mathrm{UL}}\cdot\mathrm{MV}\cdot\mathrm{SP}+\mathrm{LL}\cdot\overline{\mathrm{UL}}\cdot\mathrm{SP}\,(\overline{\mathrm{LLC}}+\overline{\mathrm{ULC}})$$

$$^*\mathrm{INHCOMP}=\mathrm{ULG}+\mathrm{LLG}+\mathrm{NG} \qquad \overline{^*\mathrm{INHCOMP}}=\overline{\mathrm{CC}}$$

A **no-go**, when detected, may cause the automatic test equipment that employs this comparison technique to respond in a certain manner, for example, to print out results, remove power, stop tape, etc. For this reason, a **reset** from the test equipment is shown resetting the **no-go** flip-flop. A normal **go** comparison will inhibit any further bit comparisons until another **compare** command is received. A **go** condition will exist when $\mathbf{LL} \leq \mathbf{MV} \leq \mathbf{UL}$.

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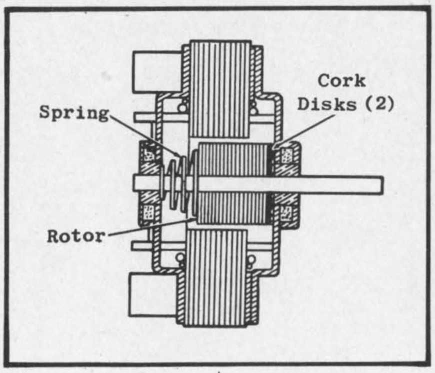

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Among the stronger: *steel, aluminum, brass, copper, vinyls, phenolics, cellulosics, polyesters, polyurethanes, nylon; butyl, nitrile, SBR, natural rubber, most types of neoprene; most woods.*
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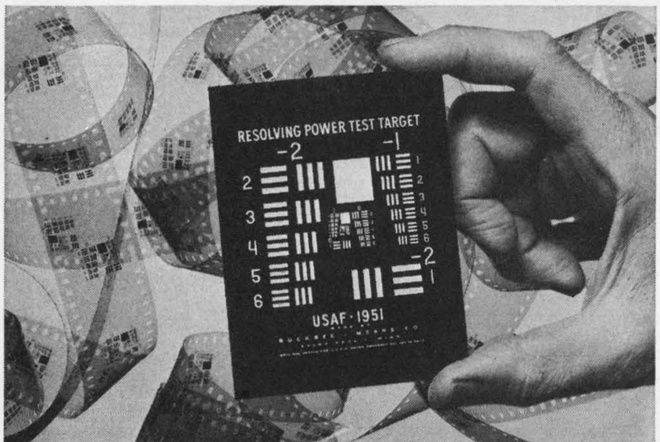

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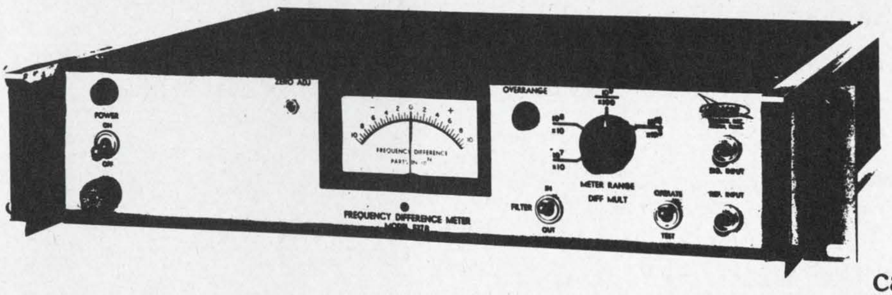

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Mix delay lines and transmission lines

for a lossless, wideband network in which all ultrasonic delay lines can be driven by a single source.

Low loss, wide-band operation and reasonable impedance levels are the hitherto mutually exclusive requirements that have to be considered when several ultrasonic delay lines are driven by a single source.

This problem can now be solved by taking a transmission line and forming a network that uses the ultrasonic delay lines as its parallel branches.

The delay lines, consisting of two transducers and the quartz or glass delay medium, appear as capacitors in the equivalent-circuit representation of Fig. 1. These capacitors, combined with the distributed or lumped inductances of the transmission line, can be made to behave as an essentially nondispersive network, with input and output impedances that are almost entirely resistive. The result is wide-band operation, without appreciable losses, at impedance levels compatible with most system requirements.

The network may be low-pass, high-pass or bandpass and may be designed by conventional filter-design techniques.

The drive signal activates the ultrasonic delay lines in a sequence which is staggered according to the delay in the transmission line segments that separate the ultrasonic lines. In a typical network, such as that shown in Fig. 1, the delays of the ultrasonic lines, as well as their center frequencies, may vary over wide limits. The only requirements for proper operation are that all transducers have the same capacity, and the center frequency of each line be within the bandpass characteristics of the network. In most cases the additional delay due to the distribution network is a negligible quantity, since the ultrasonic delay lines may be trimmed to compensate for it. Meanwhile, the bandwidth requirements will normally dictate delays for the distribution network in the nanosecond range.

When the network is properly terminated in its characteristic impedance, the driver sees only a largely resistive component (see the Table). Even though the capacitance of the illustrated delay system is about 600 pF, the parallel combination reduces this value to below 35 pF.

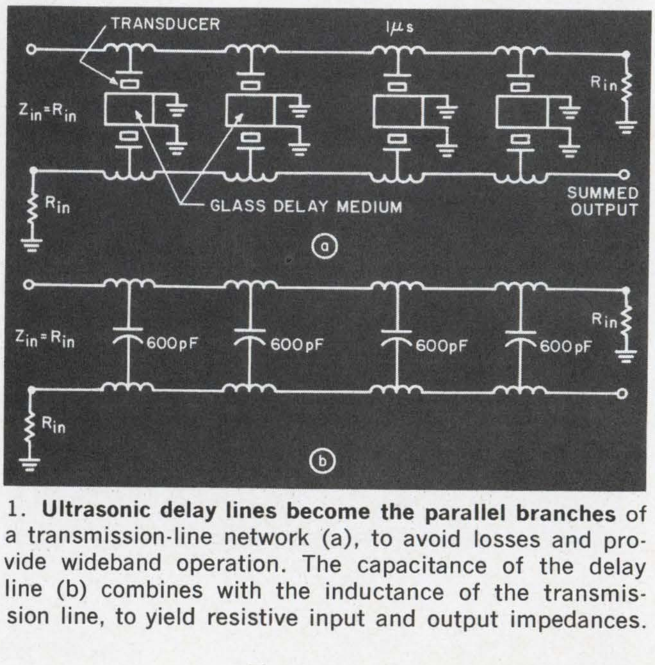
The transducers also look back into an essentially nonreactive source. Since they are not tuned, the responses of the delay lines approximate their acoustic responses.

The design criteria may be specified as:

- The bandwidth of the network must be at least slightly larger than the bandwidth requirement for the delay line or lines.
- The impedance level of the network is dictated by the transducer's capacitance.

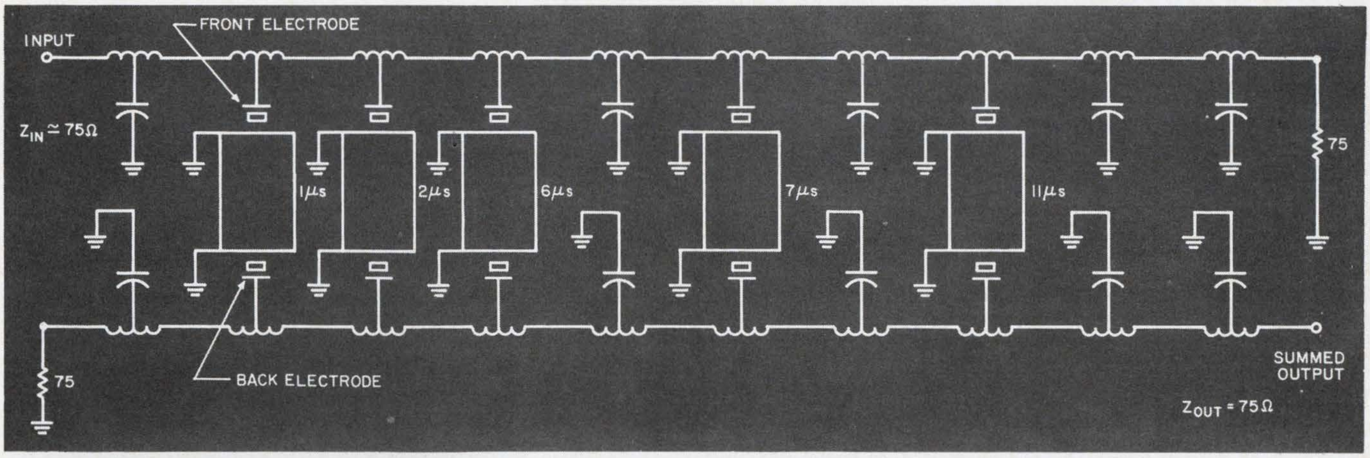
Table. Impedance characteristics

Frequency (MHz)	Reactance (pF)	Resistance (ohms)
20	−25.8	61
25	−31	69.5
30	−26	71
35	−32	73
40	−25.5	78



1. **Ultrasonic delay lines become the parallel branches** of a transmission-line network (a), to avoid losses and provide wideband operation. The capacitance of the delay line (b) combines with the inductance of the transmission line, to yield resistive input and output impedances.

R. Michel Zilberstein, Senior Project Engineer, LFE Electronics, Waltham, Mass. (now at Microsonics, Inc., Weymouth, Mass.)



2. **Prototype of delay network is flexible;** up to 10 delay lines may be inserted. If fewer are needed, the lines may be replaced by properly grounded capacitors. In this circuit all capacitors, including the transducers' capacitances, are 62 pF, and the distribution network delay is about 35 ns. The coupling inductances are selected to yield input and output impedances of 75 ohms at a center frequency of 30 MHz, which is determined by the ultrasonic elements. For the calculations that lead to these values, see the design example in the text.

- The network's phase shift must be linear; otherwise, the system will exhibit dispersion.
- The mechanical layout must be compatible with high-frequency network design; i.e., ground loops and inductive leads must be avoided.

The connection scheme, illustrated in Fig. 1, is completely reversible: it can also be used to sum the signals in several lines into a common output.

The basic design procedure for a low-pass distribution network requires a knowledge of the transducer's capacitance, C_t, and the upper cutoff frequency, f_{cutoff}. The maximum distributed section delay due to a transmission-line segment, T_s, which is compatible with the upper frequency limit is:

$$T_s = 1/(\pi f_{cutoff}). \quad (1)$$

The inductance of a segment depends on the transducer's capacitance:

$$L = T_s^2/C_t. \quad (2)$$

The network's impedance is:

$$Z = (L/C)^{1/2}. \quad (3)$$

If the impedance is not compatible with circuit requirements, transformer coupling may be used; or the value of C_t may be changed either by trimming or by padding; or T_s may be varied.

Example illustrates the technique

Assume the following requirements: the impedance of the network should be 75 ohms and the transducer's capacitance, 62 pF. These criteria will determine the inductances of the sections and all other parameters.

The inductance is found with the aid of Eq. 3:

$$L = Z^2C \cong 0.34\ \mu\text{H}.$$

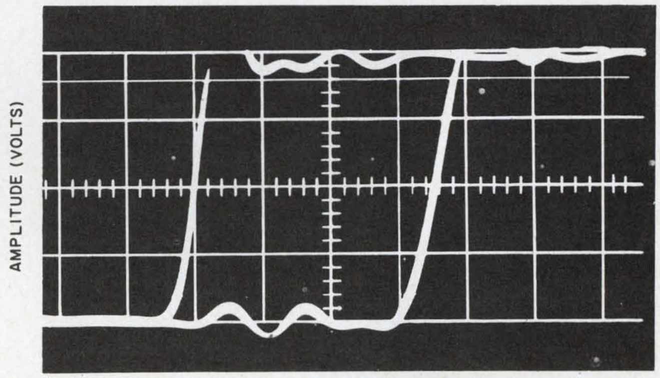
The section delay is derived from Eq. 2:

$$T_s = (LC_t)^{1/2} \cong 4.5\ \text{ns}.$$

Eq. 1 yields the cutoff frequency:

$$f_{cutoff} = 1/T_s\pi \cong 70\ \text{MHz}.$$

The value of f_{cutoff} is adequate to operate components at a center frequency of 30 MHz, with bandwidths of 70-80%.



3. **Oscilloscope trace shows total delay** of the network in Fig. 2. The horizontal scale is 10 ns/cm, therefore the delay is about 35 ns.

The physical layout of the network is optional. If phase linearity is as important as bandwidth, an m-derived approach is mandatory. For the above example, a solenoid design, with $m = 1.2$, was selected.

A prototype of the network was assembled, as shown in Fig. 2. The transmission line was designed to accept up to 10 transducers. If fewer are needed, dummy elements can be substituted in place of the delay lines. The dummy elements are properly grounded capacitors that have the same values as the delay line transducers.

In the circuit of Fig. 2, all dummy capacitors and the capacitances of the transducers are about 62 pF. The inductors that couple the sections were selected to provide input and output impedances of 75 ohms. The total delay of the network at the operating frequency of 30 MHz is about 35 ns, as shown by the oscilloscope traces in Fig. 3. ■ ■

Acknowledgment:
I am grateful to D. Leach for his assistance.

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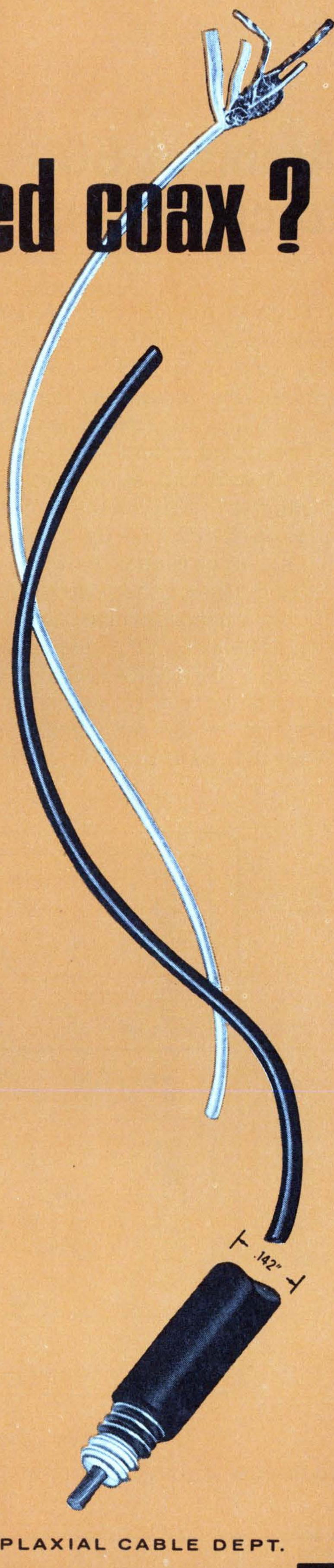

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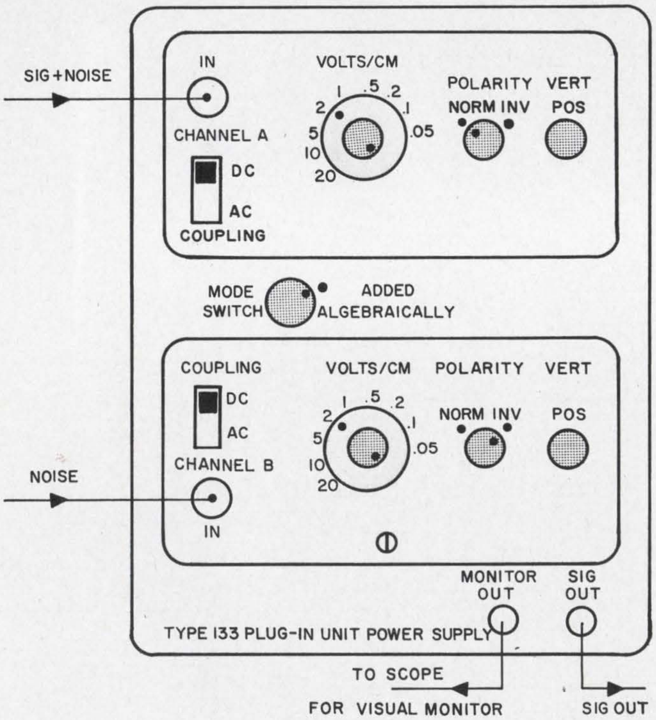
Ambient 60-Hz hum used to cut 60-Hz hum in equipment

This technique for reducing 60-Hz hum is particularly useful in breadboarding and temporary laboratory setups. A Tektronix CA plug-in preamplifier is used in conjunction with a Tektronix 133 plug-in power supply unit.

The signal is applied to the channel *A* input of the CA unit and an unshielded banana jack cable is hung onto the channel *B* input. This acts as an antenna for the 60-Hz environmental hum.

Both input control switches are placed in the dc position. One of the polarity switches is in normal and the other is inverted, depending on the desired output polarity. The mode switch is set in the ADDED ALGEBRAICALLY position. The vertical amplifier control (volts/cm) on channel *A* is adjusted for desired signal from the output jack on the 133 unit, and the vertical amplifier control on channel *B* (volts/cm) is adjusted for maximum hum reduction.



60-Hz hum is nulled out with this hook-up.

Basically, this circuit adds signal and hum to hum, shifted by 180°, in order to obtain clean and simple hum reduction. Obviously, this technique works only when the interfering hum is in phase or is 180° out of phase.

Louis J. Brocato and Frederick A. Wise, Designers, Armed Forces Radiobiology Research Institute, National Naval Medical Center, Bethesda, Md.

VOTE FOR 110

Simple circuits control dc motor speed

Canceling the *iR* component of a permanent-magnet dc motor armature is a good way to achieve fairly precise control of the motor speed. It is a useful alternative to a feedback tachometer.

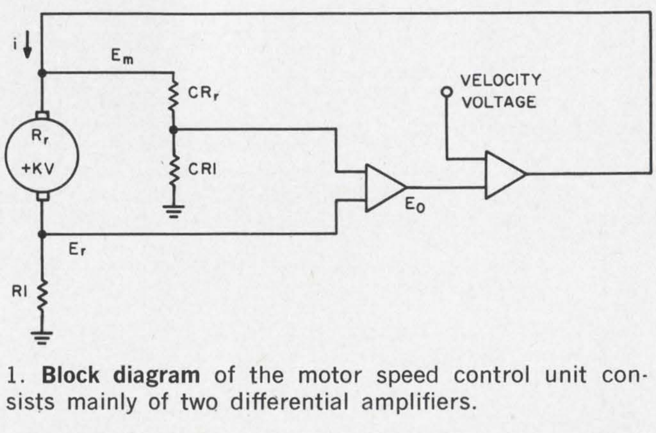
In the system shown in Fig. 1, the total voltage across the motor and *R1* is given by:

$$E_m = i\,(R_r + R1) + KV,$$

where *V* is the motor speed and *K* is the voltage per unit speed induced in the armature by the motor magnetic field. The circuit neglects armature reaction, which is small at low speeds.

The voltage E_o at the output of the difference amplifier of unity gain is given by:

$$\begin{aligned} E_o &= E_m\,CR1/C(R1 + R_r) - E_r \\ &= [i(R1 + R_r) + KV]\,[R1/(R1 + R_r)] - iR1 \end{aligned}$$



1. **Block diagram** of the motor speed control unit consists mainly of two differential amplifiers.

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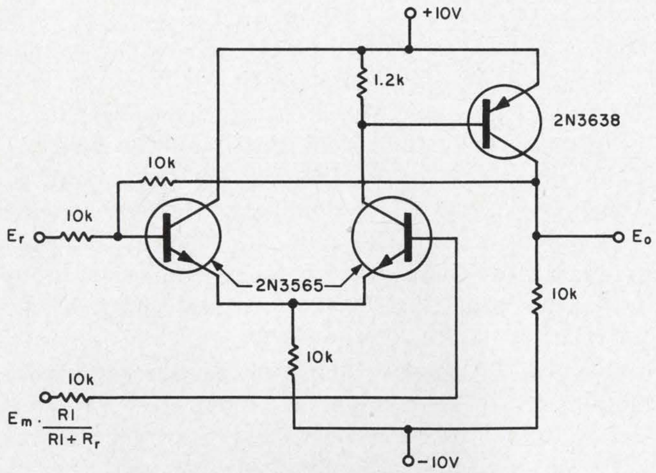


2. **One possible circuit** for a differential amplifier can be built with three transistors.

$= KVR1/(R1 + R_r)$.

The only variables here are E_o and V, so that the output voltage is directly proportional to the motor speed. This voltage may now be applied to a second amplifier and compared with the desired velocity control voltage. The error signal is used to drive the motor.

Figure 2 gives the circuit for an inexpensive difference amplifier. The motor drive amplifier may take many forms; e.g., a phase control with a Triac, a variable pulse width generator, or a direct dc control.

Hans Weigert, Raytheon Co., Lexington, Mass.

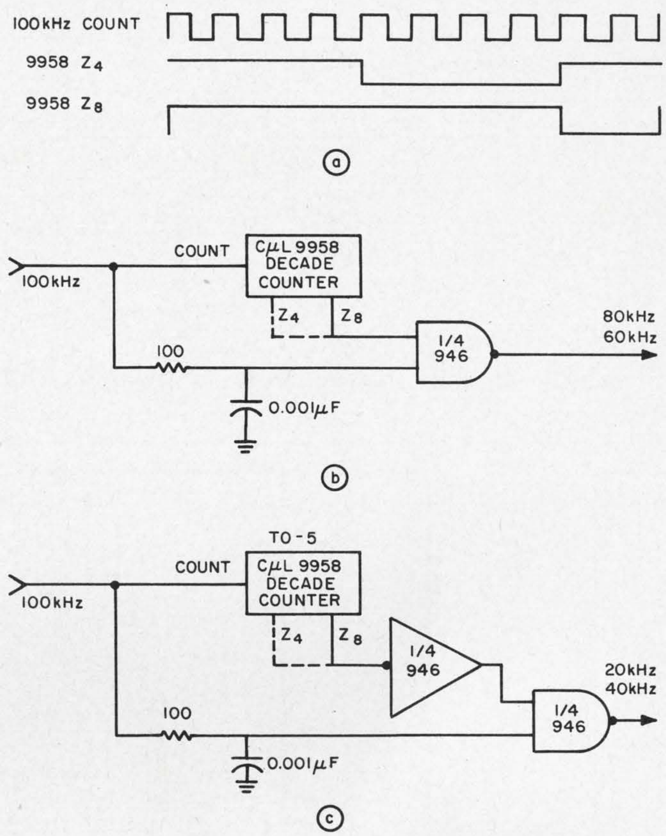
VOTE FOR 111

Integrated logic converts frequency

A microcircuit binary-coded-decimal counter can be used to obtain frequencies of 80 kHz, 60 kHz, 40 kHz or 20 kHz from a 100-kHz reference by the simple addition of, at most, two gates.

The circuit of Fig. 1b uses the Z_4 output of the 9958 to inhibit four pulses out of every 10 in order to produce 60 kHz from the 100-kHz input. The same circuit, employing the Z_8 output produces 80 kHz by inhibiting just two pulses out of every ten. The addition of an inverter, as in Fig. 1c, produces 40 kHz if the Z_4 output is used, and 20 kHz if the Z_8 output is used. *R1* and *C1* provide an approximately 300-ns delay to compensate for the delay of the 9958.

This converter approach is particularly useful in the design of low-frequency, digital, phase-coherent synthesizers where subsequent frequency division reduces the phase jitter. Cascading similar devices offers a simple means to obtain



Frequency conversion can be achieved with couple of ICs. Timing diagram is shown in (a), 100-kHz conversion to 60 or 80 kHz in (b), and 100-kHz conversion to 20 or 40 kHz in (c).

otherwise difficult nonintegral frequencies from a standard reference frequency.

Phase jitter may also be reduced by following the converter with a tuned amplifier. Reconversion to digital form may then be accomplished by use of a 710 differential comparator.

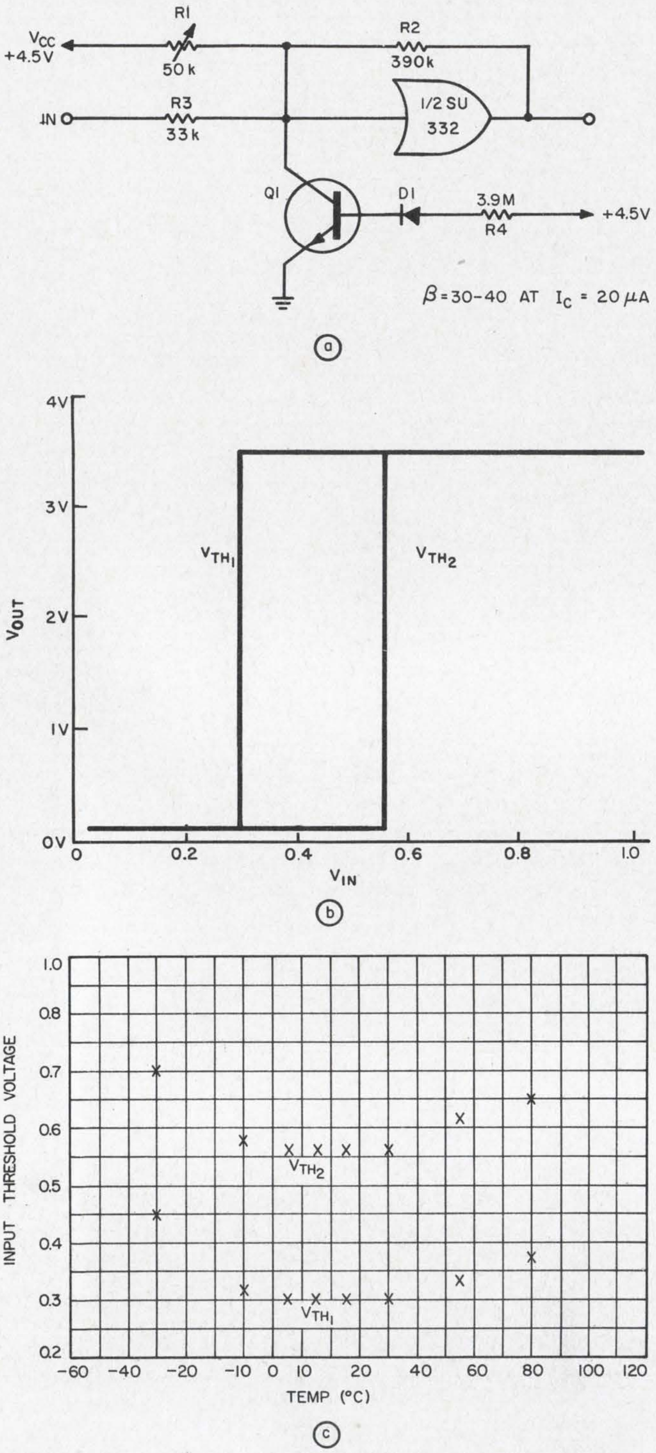
Francis J. Honey, Research Engineer, Denver Research Institute, University Park, Denver, Colo.

VOTE FOR 112

Integrated switching circuit used as a discriminator

Frequently in automatic control or measuring systems there is a need for a discriminator or level detector. Usually there is considerable digital logic associated with the system. If the logic selected requires reasonably low input current at the switching threshold and is a noninverting, or dual inverting type, it may be used to advantage as a discriminator. Signetics SU300 series or Texas Instruments series 53 are excellent for this purpose. If input impedance is no problem, the technique may be applied with any type of digital logic.

Figure 1a shows the technique implemented



Voltage level discriminator uses only one IC and (for temperature compensation) one transistor (a). The hysteresis in the transfer characteristic (b) depends on the value of R2. Temperature stability is demonstrated in (c).

with half of a Signetics SU332 dual 3-input OR gate. Resistors *R1* and *R3* may be adjusted to accommodate the available reference voltage, the required input impedance and the desired discrimination level. Resistor *R2* may be as low as 750 ohms and as high as infinite, depending on the amount of hysteresis required. As an aid to design, the typical voltage and current threshold of the SU332 are 2.0 volts and 20 μA, respectively.

If no temperature compensation is required, *R4*, *D1* and *Q1* may be omitted. If this compensation is required, *R4* should be calculated on the basis of I_C of *Q1* = I_{IN} of the SU332 at the threshold. Diode *D1* is any silicon small-signal diode and *Q1* is any silicon transistor with a β of 30 to 40. This temperature compensation decreases the input impedance and must be taken into account in the calculation of *R1*, *R2* and *R3*.

Figure 1b shows the transfer characteristic obtained with the component values shown in Fig. 1a. Note that V_{TH} may be varied by potentiometer *R1* with no appreciable effect on any of the other characteristics of the circuit.

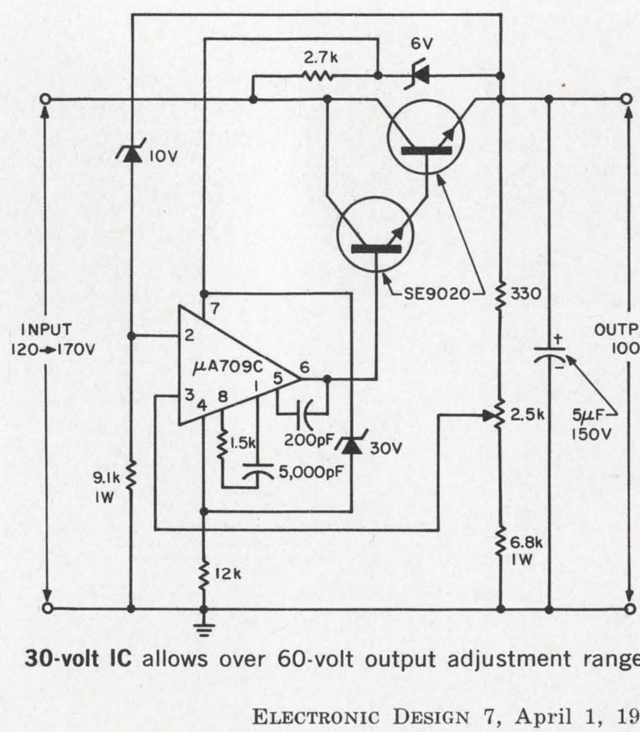
Figure 1c indicates the stable temperature characteristic obtained with the temperature compensation network of Fig. 1a tailored to the input characteristic of the SU332.

Arvid Rosenboom, Engineer, Signetics Corp., Sunnyvale, Calif.

VOTE FOR 113

Low-voltage IC controls high output voltages

Normally, the μA709C is capable of 28-volt output swings when biased at its maximum V_{CC} of 30 volts. The 100-V dc regulator circuit here uses a single μA709C as the control element, but in a modified bootstrap configuration that accomplishes two objectives:



30-volt IC allows over 60-volt output adjustment range.

■ It allows greater than 60 volts' output adjustment range.

■ It operates within its specified power supply range.

When operated in this manner, both the regulation (better than 0.01%) and the range of nominal output voltages (up to 250 V) are better than standard ground-referenced circuitry.

The bootstrap effect is accomplished by the 30-volt Zener diode. This stabilizes the voltage across the operational amplifier at a level that is both within the μA709's rating and that tracks the output voltage within the control range of the operational amplifier over a wide range of output voltages.

Robert Ricks, Applications Engineer, Fairchild Semiconductor, Mountain View, Calif.

VOTE FOR 114

Pulse bursts generated with all-IC logic

A pulse-burst generator has been developed that is useful in testing certain types of digital systems. The logic/circuit diagram shows a configuration that generates a burst of 48 pulses when activated by the falling edge of an input trigger pulse. The circuit is implemented entirely with digital integrated circuits.

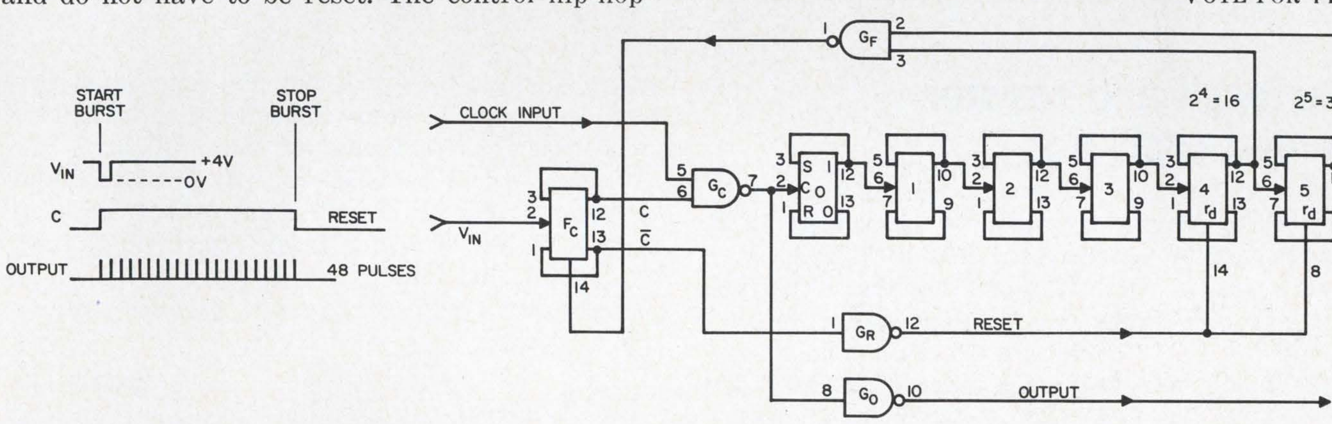
The circuit's main elements are the counting flip-flops (0 through 5) and the control flip-flop, F_c. In operation, line *C* is low (0 V) until the control flip-flop is triggered on by the input pulse, V_{in}. When *C* goes high (logic *1*), control gate G_c is activated, so that pulses may enter the binary counter. It remains active until shut off by the control flip-flop, which is reset by feedback gate G_f. This gate ends the count when stages 4 and 5 are at *1*. Stages 0 through 3 are at *0* at this time and do not have to be reset. The control flip-flop complementary output, *C*, is inverted by reset gate G_r, which resets stages 4 and 5 back to logical *0*. The Signetics SE424J flip-flop resets to *0* when the direct reset input goes to *0*. Normal flip-flop operation occurs when there is a *1* input to *rd*, as during the burst interval. Output gate G_o reinverts the burst pulses and buffers the output.

This generator, which develops a burst of 48 pulses when triggered, may be adapted for bursts of different pulse counts by wiring the proper counter outputs into the feedback gate. Stages wired into the feedback gate must also be connected to the reset line.

The circuit is operable up to 10 MHz with burst lengths depending upon the number of flip-flops used. A supply voltage of 4.5 Vdc operates the circuit.

Paul Galluzzi, Electrical Engineer, Electronics Division, Laboratory for Electronics, Inc., Boston, Mass.

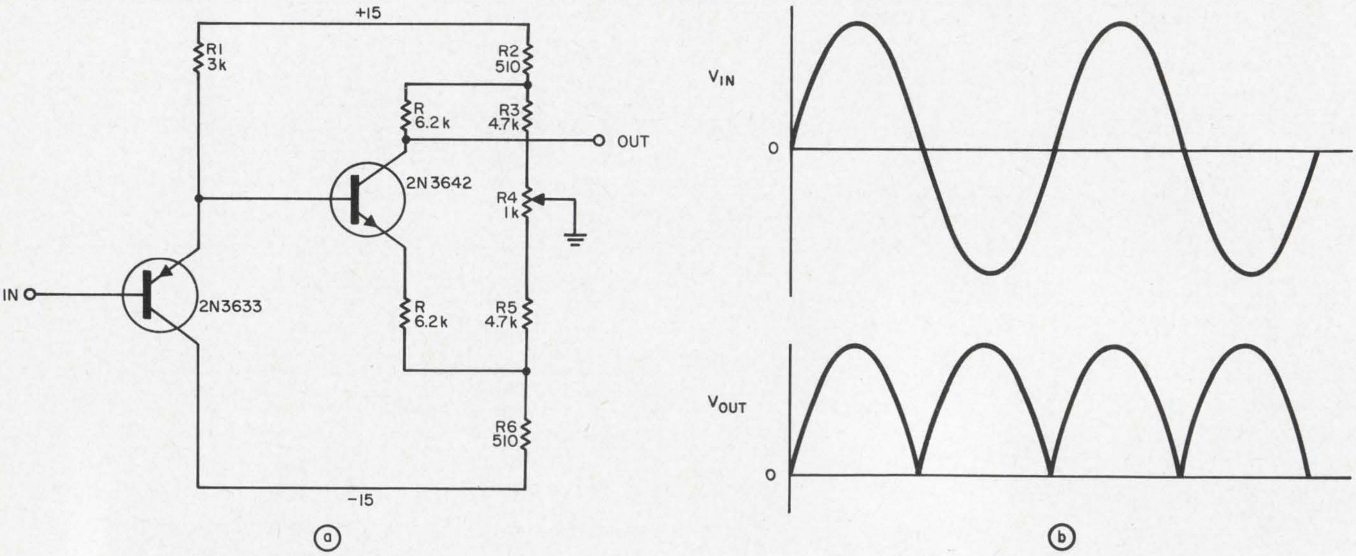
VOTE FOR 115



Accurate pulse bursts can be generated with just two types of ICs.

Two-transistor circuit makes dc-coupled full-wave rectifier

Full-wave rectification with dc coupling is provided by this simple two-transistor circuit (**Fig. 1a**). Transistor *Q2* is biased so that it just reaches saturation when its base voltage is +0.6 volt. The base-collector and base-emitter diodes are then forward-biased, making both collector and emitter voltages nearly zero volts. Then if the base voltage rises above +0.6 volt, the collector will follow it through the base-collector diode. Equal resistors in the collector and emitter leads provide unity gain with inversion, if the base voltage is less than



Full-wave dc-coupled rectifier is built with only two transistors (a). Input and output wave shapes are shown in (b).

+0.6 volt, since *Q2* then is in its active region. The collector voltage of *Q2* therefore is always positive and equal to the base potential.

Emitter-follower *Q1* buffers the signal source from the impedance variations exhibited by *Q2* as it changes from the active to saturated regions. This variation is roughly 2β, since the input impedance of *Q2* is approximately βR in the active mode, and $R/2$ in the saturated mode. Moreover, since *Q1* is complementary to *Q2*, the 0.6-volt offset in *Q2* and its temperature dependence are nearly eliminated.

Resistors *R2* through *R6* form a balancing network to allow the bias point of *Q2* to be set. The best way to adjust this circuit is to apply a zero-based sine wave to the input, and adjust *R4* for constant amplitude pulses at the output (Fig. 1b). With zero volts at the input, the output voltage can be made very nearly zero volts if *Q1* and *Q2* are properly selected.

James F. Teixeira, Sylvania Electronic Systems, Inc., Applied Research Laboratory, Waltham, Mass.

VOTE FOR 116

Photocell and resistor unload oscillator

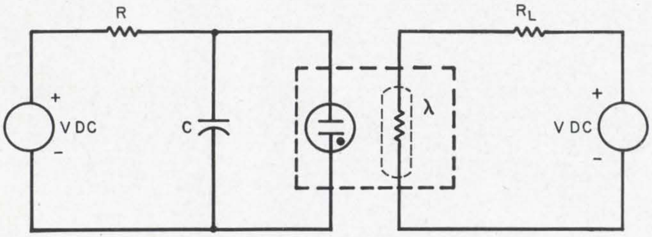
The usefulness of a neon lamp relaxation oscillator can be greatly increased by the addition of a photocell and a resistor (see schematic). This completely isolates the oscillator from the output so that load variations can have no effect on the frequency.

Obviously, this technique can be extended to many applications where complete isolation of two or more circuits is desired. Choice of the photocell depends on the frequency of the oscillator.

Several other applications may include audio amplifier interstage coupling, monitoring of neon lamp counter readouts, frequency dividers and multipliers and others.

Irving M. Gottlieb, Electrical Engineer, Menlo Park, Calif.

VOTE FOR 117



Complete isolation of the neon relaxation oscillator from the output is achieved by addition of a photocell.

IFD Winner for Dec. 6, 1966

Saul A. Ritterman, Assistant Professor, Bronx Community College, N. Y.
His Idea, "Phase-shift oscillator cuts costs and size of VCO," has been voted the $50 Most Valuable of Issue Award.

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For further data and detailed specifications, contact your nearest Bourns sales office or representative, or write the factory direct.

Coil Operating Table

Standard Coil Resistance	VOLTAGE ADJUSTED Nominal Operating Voltage	Maximum Pull-In Voltage at +25°C	at +125°C	Drop-out Voltage Min.
70	6.0	3.0	3.9	0.3
280	12.0	6.0	7.8	0.6
1500	26.5	14.0	18.0	1.4

Coil characteristics applicable at +25°C unless otherwise specified.

Various terminal types and mounting styles are available adding flexibility to fulfill your design requirements.

BOURNS

BOURNS, INC., TRIMPOT DIVISION • 1200 COLUMBIA AVE., RIVERSIDE, CALIF.
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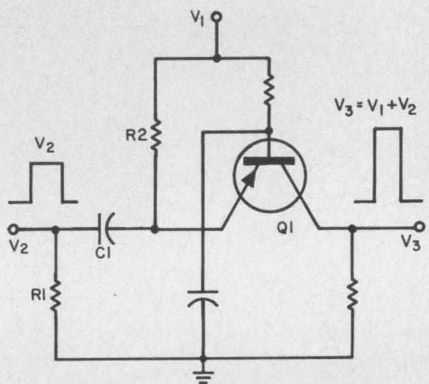
TRIMPOT® AND PRECISION POTENTIOMETERS—RELAYS—MICROCOMPONENTS: TRANSFORMERS, INDUCTORS, RESISTORS AND CAPACITORS

One-transistor circuit ups pulse amplitude

Problem: Supply a pulse voltage, higher than that normally available from emitter-follower circuits.

Solution: A simple circuit stores the voltage and discharges through common-base switching.



Capacitor *C1* is charged through *R1* and *R2* to the supply line voltage, V_1. With no input pulse, both the emitter and base of the transistor are at the same potential, and the collector is cut off. With an input pulse, V_2, the potential of *C1* with respect to ground is increased by V_2. The emitter becomes more positive than the base and the transistor is switched on. This results in an output pulse, V_3, that is equal to $V_1 + V_2$, minus negligible losses in *C1* and the transistor.

In order for *C1* to reach approximately full charge between pulses, the ratio of charging interval to charging time constant must be much greater than the ratio of discharge interval to discharge time constant.

In tests, this circuit has produced a good output waveform at about twice the amplitude of the supply line voltage, V_1.

For further information, contact: Technology Utilization Officer, Goddard Space Flight Center, Greenbelt, Md. 20771 (B66-10480).

CAREER INQUIRY – confidential

7

Respond to the career opportunities advertised in this issue. Fill out and send us this handy resume. **Electronic Design** will do the rest – neatly typed copies of this form will be mailed to the companies of your choice, indicated by the circled Career Inquiry Numbers at the bottom of this page.

Name			**Home Phone**
Home Address (Street)	City	State	ZIP Code
Age	**U.S. Citizen** ☐ Yes ☐ No	**Security Clearance**	

Prime Experience	Secondary Experience

Desired Salary	**Availability Date**

Employment History – present and previous employers

Company			
City, State			
Dates	to	to	to
Title			
Specialty			

Education – indicate major if degree is not self-explanatory

Degree			
College			
City, State			
Dates	to	to	to

Additional Training – non-degree, industry, military, etc.

Professional Societies

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Career Inquiry Numbers:

900	901	902	903	904	905	906	907	908	909
910	911	912	913	914	915	916	917	918	919

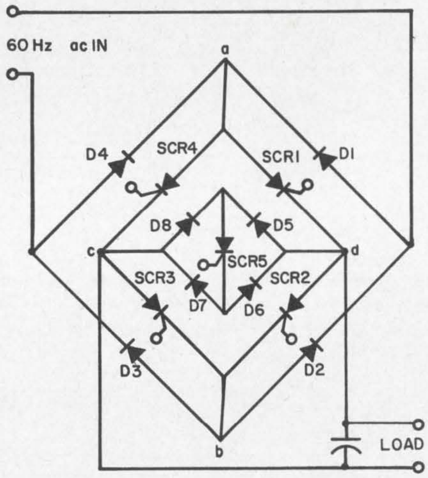
ELECTRONIC DESIGN
850 Third Avenue
New York, New York 10022

NASA TECH BRIEFS

Solid-state circuit controls dc motor

Problem: Devise a solid-state circuit that can reverse and break dc motors, besides controlling their speed. These actions are required for accurate positional control of large inertial loads.

Solution: A full-wave bridge rectifier circuit in which the gating of silicon-controlled rectifiers (SCRs) controls output polarity.



Braking is provided by an SCR that is gated to short-circuit the reverse voltage, generated by reversal of motor rotation.

Diodes *D1* through *D4* form a conventional full-wave bridge, providing full-wave pulsating dc voltage between points *a* (positive) and *b* (negative). Point *a* is connected to a bridge consisting of *SCR1* through *SCR4*. When *SCR1* and *SCR3* are gated, an external load will see point *d* positive with respect to point *c*. If *SCR2* and *SCR4* are gated, the opposite condition will exist.

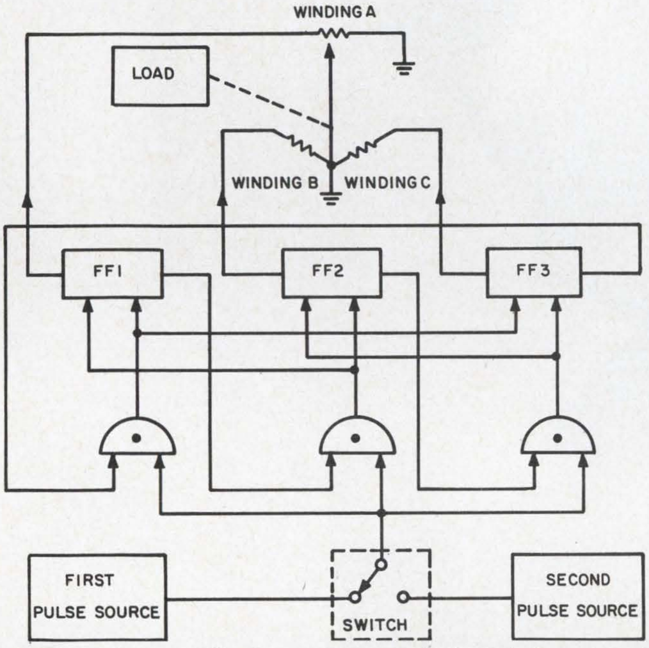
Braking is accomplished by gating *SCR5* after removal of the gate signals from *SCR1* through *SCR4*. *SCR5* then short-circuits the voltage generated by the armature rotation.

For further information, contact: Technology Utilization Officer, Jet Propulsion Laboratory, 4800 Oak Grove Drive, Pasadena, Calif. 91103 (B66-10486).

Ring counter reverses multiphase motor rotation

Problem: Reverse the direction of rotation of a multiphase motor without changing the phase wiring of the supply current source. Relay-operated systems are bulky and present maintenance problems due to contact-arcing and burning.

Solution: A solid-state three-phase counter reverses the rotation of the motor by changing the phase sequence.

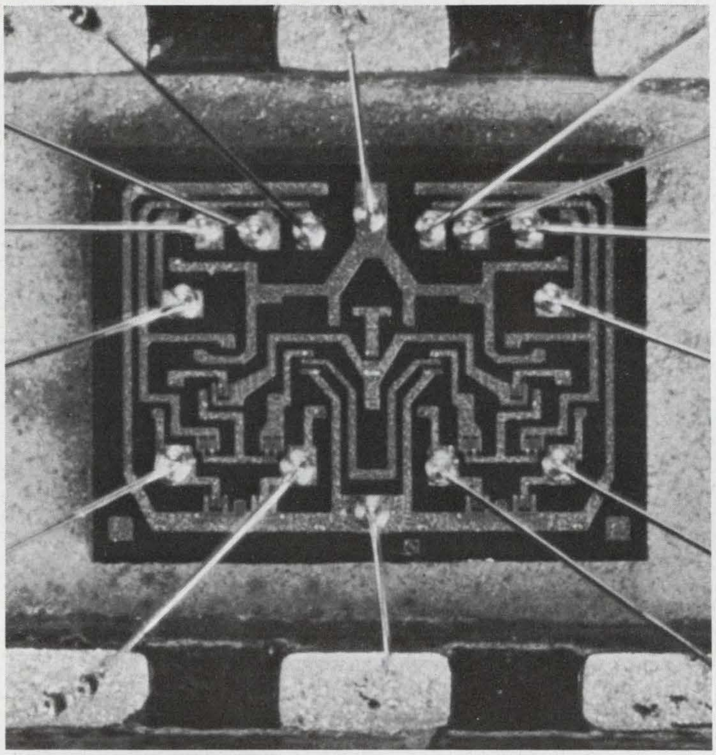


The three flip-flops have their high-current output terminals connected to the three individual phase windings of the three-phase motor. In operation, each pulse source supplies pulses at a repetition rate of 180 per second since the motor is 60-Hz, three-phase. With the switch connected to the first pulse source, the initial pulse turns flip-flop 1 ON and current is applied to winding *A* of the motor. The second pulse switches flip-flop 1 OFF and flip-flop 2 ON, removing current from motor winding *A* and applying it to motor winding *B*. The third pulse switches flip-flop 2 OFF and flip-flop 3 ON, removing current from motor winding *B* and applying it to motor winding *C*. The fourth pulse switches flip-flop 3 OFF and flip-flop 1 ON and the sequence is repeated.

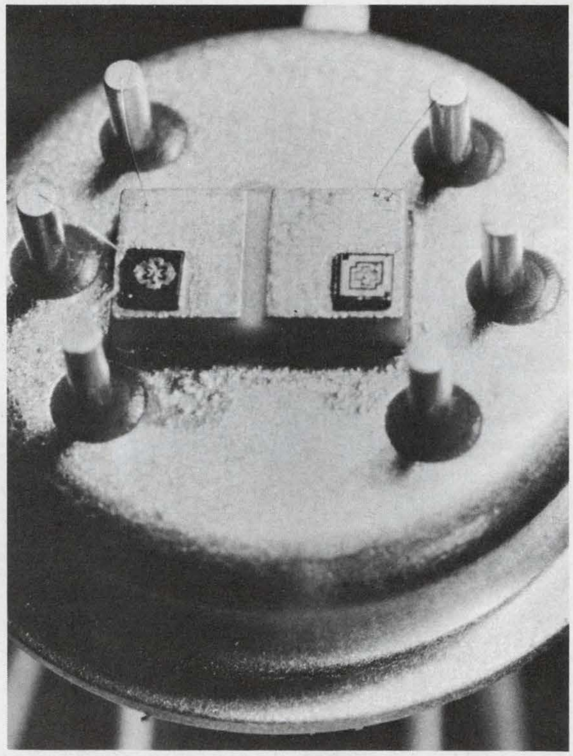
To reverse the motor direction of rotation, the switch is connected to the second pulse source and the action is reversed with flip-flops 3, 2, and 1 being turned ON and OFF in that order, thus powering motor windings *C*, *B*, and *A* in that order.

Avard F. Fairbands of Space Technology Laboratories, Inc., under contract to Jet Propulsion Laboratory (JPL-SC-166).

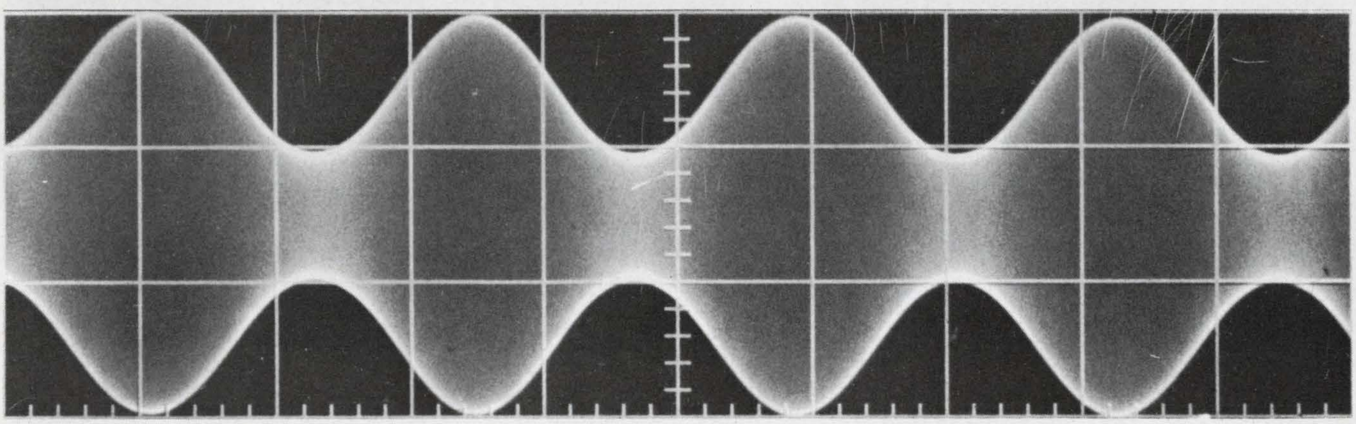
Products



New logic family tops ECL speed. Propagation delays of 2 ns are specified for E^2CL. Page 112

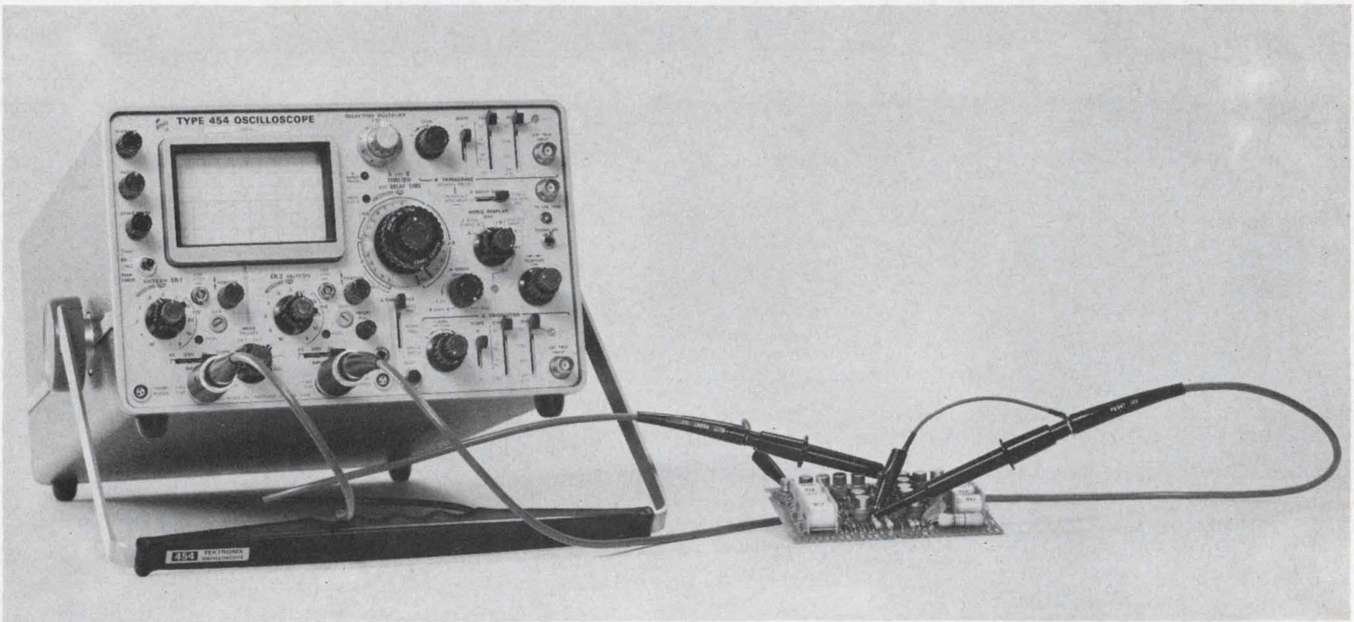


Complementary medium-power duals receive JEDEC registration. Page 114



Look at 150-MHz signals like this 50% modulated AM display. A new real-time scope has 150-MHz bandwidth and 2.4-ns rise time—both specs taken at the probe tip. Page 106

Also in this section:



Real-time scope boasts 150-MHz bandwidth and 2.4-ns rise time at the probe tip

Tektronix, Inc., P. O. Box 500, Beaverton, Ore. Phone: (503) 644-0161. P&A: $2550; rack-mount, $2635; 90 days.

Real-time oscilloscope performance is now available in a frequency range previously occupied by samplers. The design of the CRT and associated circuitry provide the Tektronix model 454 with an over-all bandwidth capability of 150 MHz and a rise time of 2.4 nanoseconds.

The new oscilloscope system, shown above, was engineered to meet the industry's need for measuring such phenomena as 2-to-5-ns rise-time pulses for logic circuits and radar systems, and the 80-to-150-MHz modulated carriers used in various kinds of communications, such as FM and aircraft systems.

Twelve years ago real-time scopes were limited in bandwidth to about 30 MHz; in recent years they have reached 100 MHz. Sampling scopes with rise times of less than 1 ns and bandwidths up to several GHz have been produced, but these values applied only in repetitive signal applications. For single-shot performance in general-purpose use, an instrument was required with 150-MHz, 2.4-ns dual-trace vertical, 150-MHz triggering, 5-ns/div sweep speeds, and delayed sweep.

To accomplish this, all the blocks of the system must be designed with capabilities beyond those of the over-all system. The bandwidths of the particular components must be at least 225 MHz, and the rise times 1.65 ns or less, to obtain the requisite all-around performance.

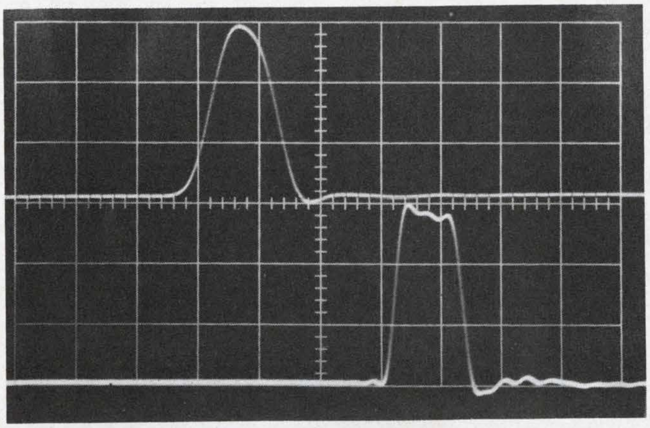
The preamplifier and the main amplifier employ silicon semiconductors with f_t ratings above 1 GHz. The vertical-deflection-system rise time is 2.4 ns. The over-all rise time of the CRT, main vertical output amplifier, and bifilar delay line is 1.65 ns.

The CRT has a frame-grid construction that reduces beam current intercept to approximately 30% rather than the 50% associated with radial-field mesh tubes. The 9-mil center spot, in conjunction with the 14-kV acceleration potential, produces a bright trace with good resolution.

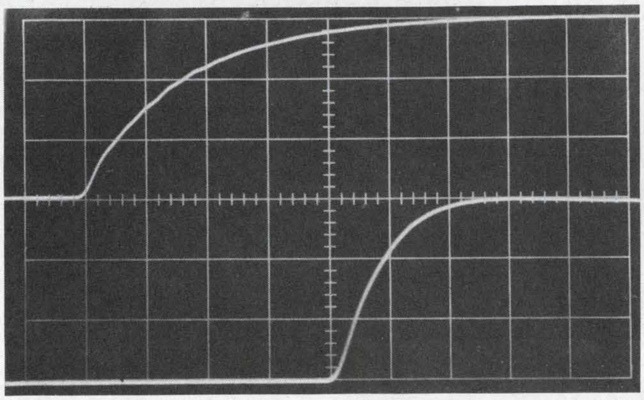
The vertical deflection system consists of six sets of deflection plates and separating coils. These form a lumped element LC delay network, or artificial delay line. Since the deflection plate capacitance is part of the artificial transmission line, the effective deflection plate impedance driven by the output amplifier appears resistive rather than capacitive as in a conventional CRT.

The rise time of the CRT is approximately 0.8 ns, equivalent to 400 MHz.

To ensure full specified performance at the tip of the probe, passive and active voltage and current probes were designed for compatibility with the bandwidth and rise time of the oscilloscope. The passive probes have rise times of less than 1.2 ns. This is achieved by using a resistive center



1. **Waveform aberrations and irregularities show up** at higher speeds. The same pulse is shown on a 50-MHz 7-ns scope (top trace) and the 150-MHz scope (lower trace).



2. **Improved performance** is obtained with FET probe (lower display). Passive probe with 10.3-pF input and resistive center conductor yields upper display.

conductor for critical damping, and a special termination effective up to 290 MHz. The bayonet probe tip is designed to avoid excessive ringing due to the series inductance of a ground lead.

For applications requiring low input capacitance and no attenuation, a FET probe was designed to provide a probe-to-scope performance of 130-MHz bandwidth and 2.7-ns rise time (see "No loss of gain above 30 MHz with high-Z FET scope probe," ED 19, Aug. 16, 1966, p. U124). Figure 2 above shows a comparison of pulses taken with active and passive probes.

The horizontal system called for circuits that could trigger up to above 150 MHz, a calibrated delayed sweep, and sweep speeds extending from 5 ns/div to 5 s/div. These circuits trigger on fast rise time pulses or high-frequency sine waves. Automatic triggering allows discrete trigger level selection and a bright base line with no signal.

The CRT has an illuminated internal graticule. Two front panel switch positions convert the unit to a calibrated X-Y oscilloscope with less than 3° phase shift from dc to 2 MHz. The calibrated X-Y deflection range is from 5 mV/div to 10 V/div.

CIRCLE NO. 250

Phase angle standard from 4 to 500 kHz

Dytronics Co., Inc., 4800 Evanswood Dr., Columbus, Ohio. Phone: (614) 885-3303. P&A: $3450; 1 wk.

A primary phase angle standard for operation over the frequency range from 4 to 500 kHz is available. The unit will produce precise phase shifts over a 360° range, and will measure the phase shift through an unknown device or between two signals. The absolute accuracy is ±0.05 from 4 to 10 kHz and ±0.02 from 10 to 50 kHz, with slightly decreasing accuracy to 500 kHz. The output impedance is 1.6 ohms. The unit is entirely self-contained, including the tuned null detector.

CIRCLE NO. 252

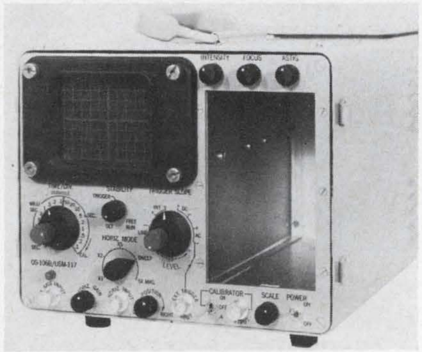
Digital multimeters with 6th digit overrange

Lear Siegler, Inc., Cimron Div., 1152 Morena Blvd., San Diego, Calif. Phone: (714) 276-3200.

A series of digital multimeters have full five-digit display with sixth-digit overrange. All front panel controls are externally programable. With polarity and range preprogramed, filter out, balance time is 20 ms. Accuracy is within 0.001% of full scale and 0.005% reading. The input signal leads are floating and isolated from the case, power line ground and printer output.

CIRCLE NO. 253

Solid-state scopes with plug-in preamps

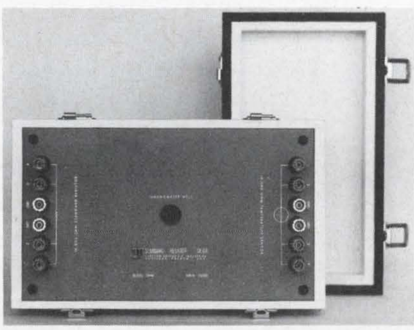


American Electronic Laboratories, Inc., P. O. Box 552, Lansdale, Pa. Phone: (215) 822-2929.

Compact, solid-state oscilloscopes designed for use with either a single-channel or dual-channel plug-in preamplifier are available in two models. The units are portable and weigh only 25 lbs. Both models are designed to meet the environmental requirements of MIL-E-16400, to meet corrosion, humidity, spray and temperature-altitude tests, to perform within RF interference limits, and to remain inert against fungus. The bandwidth of the main amplifier is dc to 10 MHz.

CIRCLE NO. 254

Resistance standard stable to 1 ppm/year



Electro Scientific Industries, Inc., 13900 N. W. Science Park Dr., Portland, Ore. Phone: (503) 646-4141. P&A: $550; 60 to 90 days.

A portable resistance standard provides a 10-kΩ starting point for resistance measurements and is designed for bench use. It consists of a resistive element and internal temperature sensor mounted inside a hermetically sealed oil-filled container. Stability is less than ±1 ppm per year.

CIRCLE NO. 255

Relay test set is fully automatic

Datascan, Inc., 1111 Paulison Ave., Clifton, N. J. Phone: (201) 773-8803.

An operate, release and bounce-time relay test set provides a highly accurate measurement and visual readout of transfer time and bounce time of conventional electromechanical relays. Said to be the only fully automatic system available for testing these relay characteristics, the unit provides a clearly visible, in-line decimal readout in milliseconds of operate time (or release time) and bounce on two separate displays.

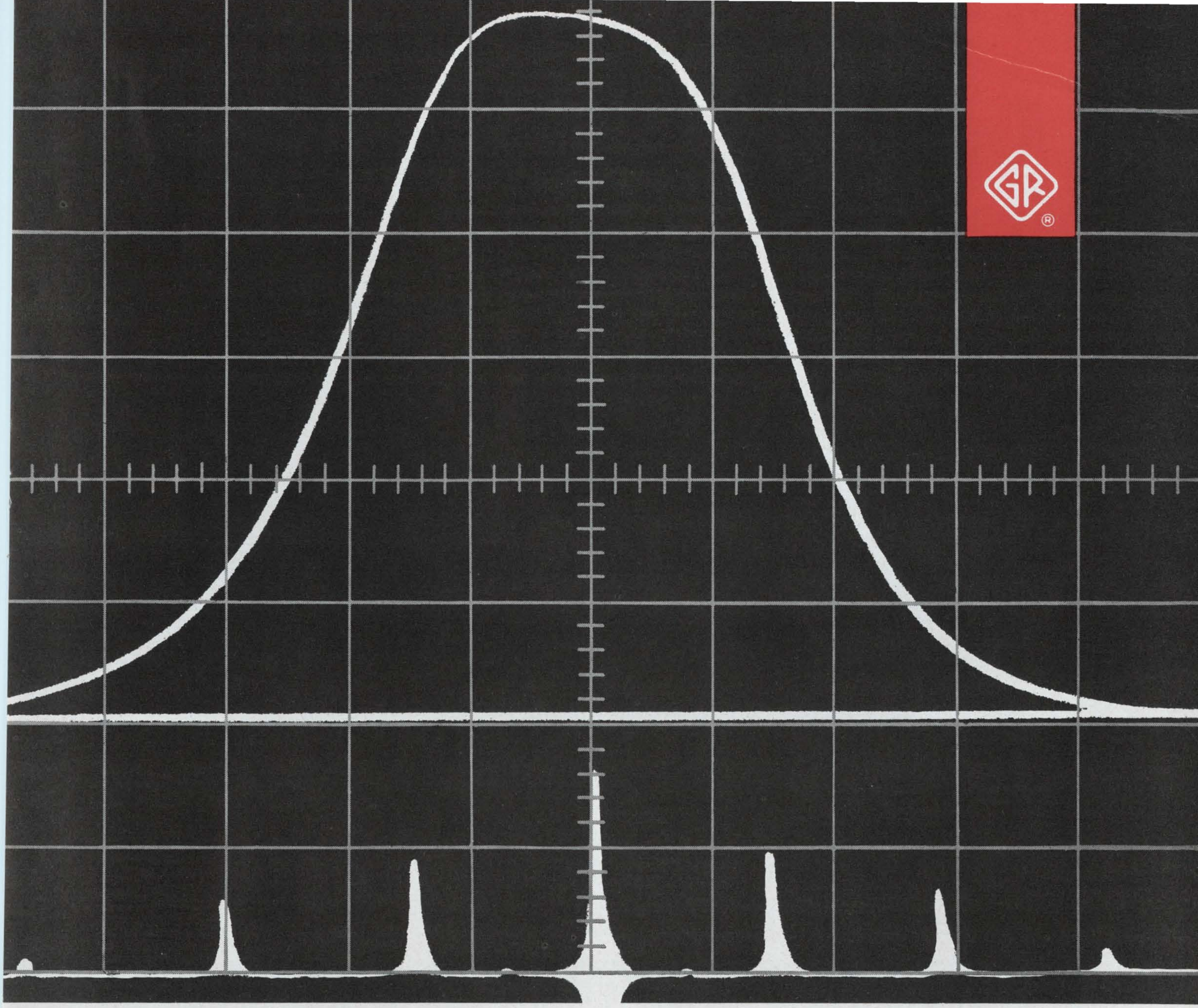
CIRCLE NO. 256

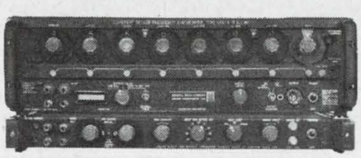
Portable thermometer is accurate to 0.05°C

YSI Systems and Special Products Div., Box 279, Yellow Springs, Ohio. Phone: (513) 767-7242. P&A: $795; 90 days.

Laboratory accuracy is claimed for this portable transfer standard thermometer designed for field use. The absolute accuracy is ±0.05°C over a range from −40°C to 100°C. It has direct reading in temperature to 0.01°C on a dial, and additional resolution to 0.003°C from a calibrated nulling meter that indicates ±0.5°C from the dial indicated temperature.

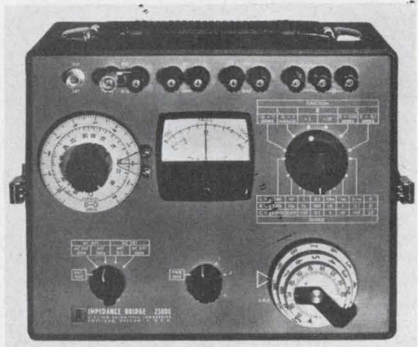
CIRCLE NO. 257





Type 1160-P2 Sweep and Marker Generator used with a Type 1162-A Synthesizer.

Impedance bridge has high dial resolution



Electro Scientific Industries, Inc., 13900 N. W. Science Park Dr., Portland, Ore. Phone: (503) 646-4141. P&A: \$470; stock to 30 days.

The accuracy of this portable impedance bridge is rated at 0.1% for resistance, 0.2% for capacitance and 0.3% for inductance. Comparative measurements can be made with even greater precision because of the 12,005 divisions of dial resolution. The ac-dc null detector allows resolution of full accuracy on all ranges with a sensitivity of 20 μV on dc and 10 μV on ac. The single front-panel meter provides a sharp visual display for both ac and dc null balances.

CIRCLE NO. 258

Vibrating membrane cap measures 8 x 10^{-17} A

Amperex Electronic Corp., 230 Duffy St., Hicksville, N. Y. Phone: (516) 931-6200.

When employed in an electrometer, this vibrating membrane capacitor has successfully measured currents as weak as 500 electrons per second (8 x 10^{-17} A). This criterion of performance makes it usable as a sensor for dosimeters, gas chromatography current detectors, picoammeters, pH meters and transducer monitors. Driven by a high-frequency electric field and housed in an evacuated glass envelope, this new sensor offers input impedance greater than 10^{15} ohms and temperature dependence of 15 μV/°C. The high-frequency electric-field drive effectively isolates the drive frequency from the signal output.

CIRCLE NO. 259

Wide-range oscillator has 4-digit readout

Hewlett-Packard, 1501 Page Mill Rd., Palo Alto, Calif. Phone: (415) 326-7000. P&A: \$695; 6 wks.

Frequencies between 10 Hz and 1 MHz can be selected with 4-place precision on a new test oscillator. Frequency selection is made with detented rotary controls. Each of four controls selects a decimal digit of the desired frequency and a fifth control selects one of the four decade ranges. A vernier frequency control provides infinite resolution where needed between digital steps. The fifth control, in selecting a range, sets the decimal point and displays the units of measurement; i.e., Hz or kHz. With the 4-place numerical readout, this results in a complete in-line display of frequency selected and assures that there can be no ambiguity in its reading.

CIRCLE NO. 260

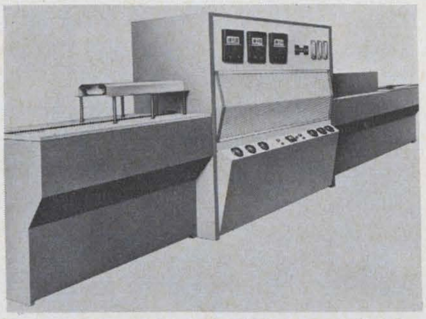
Submin peak detector reads 10-ms transients

Roveti Instruments, 1643 Forest Dr., Annapolis, Md. Phone: (301) 974-0816.

Transients as short as 10 ms can be reliably detected and locked in with this unit to indicate the cause of failure in solid-state equipment. The unit has a floating input so it can monitor positive or negative levels from 50 mV to 50 V at any point in the equipment. An external resistor will increase the upper end of the range to hundreds or thousands of volts (sensitivity is 20,000 Ω/V). Front-panel controls include a sensitivity adjust, a reset control and the memory readout. It is applicable to transient monitoring in electronic equipment and verification that safe voltage and current levels have been maintained.

CIRCLE NO. 261

Cermet furnace for microcircuit firing



C. I. Hayes, Inc., Cranston, R. I. Phone: (401) 461-3400.

Greater production uniformity in firing of hybrid circuits is promised by this new cermet furnace. It is designed for high-quality firing of thick-film resistor and conductor microcircuits to assure a precise, dual plateau temperature profile on every run. The conveyor belt holds temperature within ±1°C from edge to edge. There is no temperature drop when operations change from "no load" to "working."

CIRCLE NO. 262

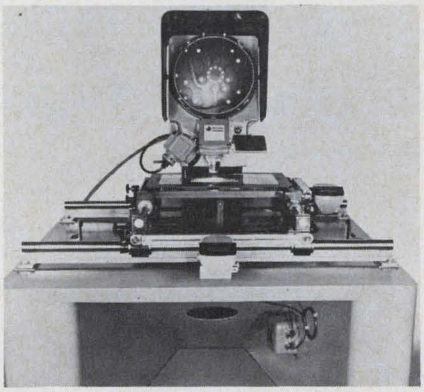
Solder station places IC flatpacks

Hughes Aircraft Co., 2020 Oceanside Blvd., Oceanside, Calif., Phone: (714) 722-2101.

A fully mechanized reflow solder station capable of picking up, placing and reflow soldering a complete IC in 8 seconds is offered. The work station features magazine feeding of the flatpacks, thus eliminating hand loading and orienting of the devices in a pick-up station, or preloading the PC boards. The over-and-under design of the stylus and detent plate affords the operator a clutter-free area.

CIRCLE NO. 263

Optical scanner has digital X-Y display



Stocker & Yale, Inc., Marblehead, Mass. Phone: (617) 631-0038. Price: $5242.

Large area measuring, accurate over the entire field to 0.0008 in., precision tape punching of coordinate positions, simplified PC board inspection and rapid registration of multilayers of transparent flat sheets are claimed for this optical measuring scanner. It has three standard coordinate table diameters up to 24 x 24 in.

CIRCLE NO. 264

New logic family claims higher speeds and easier interfacing

Westinghouse, Molecular Electronics, Box 7377, Elkridge, Md. Phone: (301) 796-3666. P&A: less than $5 per gate function (100); stock.

A new monolithic logic family, called E²CL, claims a speed record of more than twice that set by ECL. Two-ns propagation delays with useful fanouts of 3 are specified for the E²CL, compared with 5-ns delays of the conventional ECL circuits.

Like ECL, the new family is based on nonsaturating, current-mode operation of the transistors, and uses two transistors in a differential pair to perform the basic current-shifting from one transistor to the other.

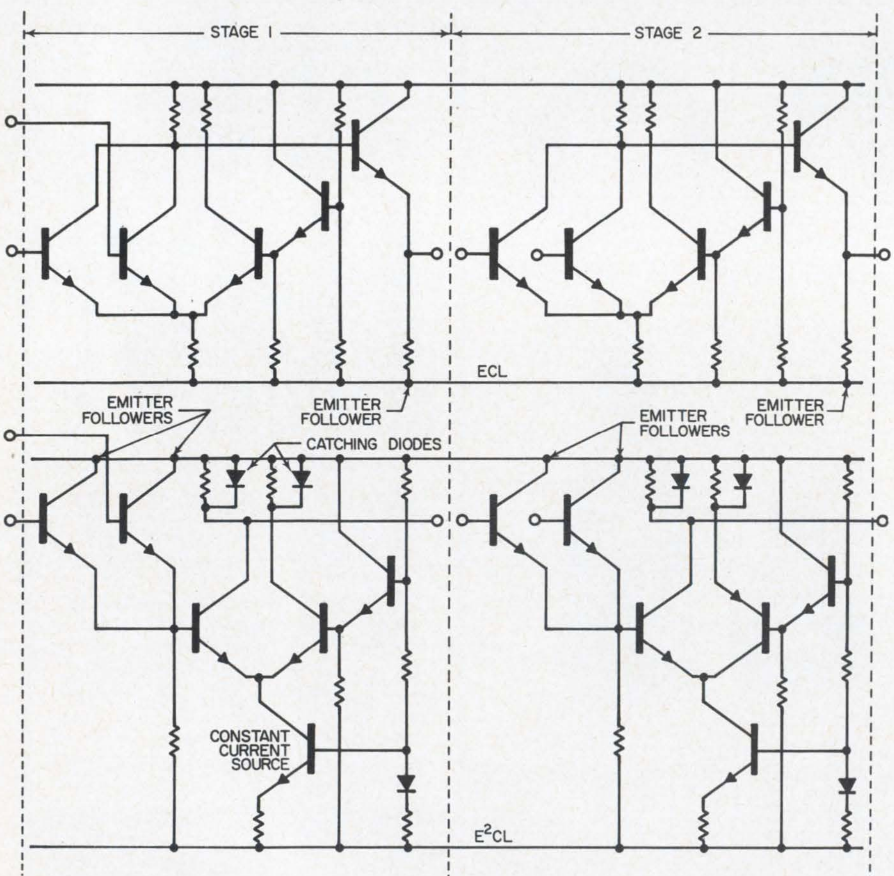
The differences can be seen from the circuits compared in the figure. In E²CL, the emitter-follower buffers are moved from the output to the inputs. Each E²CL is now an emitter buffer that feeds the base of the left-hand transistor of the differential pair, rather than remaining one of several transistors in parallel with the left-hand differential transistor, as in ECL. This arrangement affords several advantages:

- The Miller capacitance of the ECL transistors is eliminated, making E²CL an inherently faster logic circuit.
- The more positive logic level (logical *1* for NAND logic) is raised from its floating level in ECL to the level of the positive voltage supply, which can then become system ground. This reduces noise and oscillation, and eliminates the need for another power supply level. It also facilitates interfacing with standard DTL and TTL circuits.
- Fanouts are increased because all inputs are buffered. In slower operation, there is no noticeable loading with up to 10 fanouts.
- Power dissipation is lowered from the 100-mW/gate levels frequently encountered in ECL to 60 mW/gate in E²CL.
- The output is constant for both directions of logic swing. This facilitates matching with transmission line interconnections.

Increased speed and ease of interfacing make E²CL applicable in central processors of large computers.

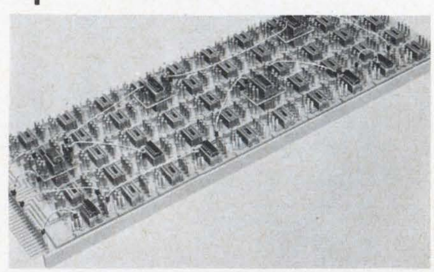
The new family includes circuits designed to interface with transmission-line interconnections. Some of the units are supplied without catching diodes in parallel with the collector resistors, so that the designer will have greater freedom of choice of line terminations. Because of the grounded positive logic level, it is easier for the designer to terminate lines by placing a 75-Ω resistor from line to system ground.

CIRCLE NO. 251



Comparison of ECL and E²CL circuits: in the E²CL the emitter-follower buffers are moved from the output to the inputs.

Breadboard tests up to 50 ICs

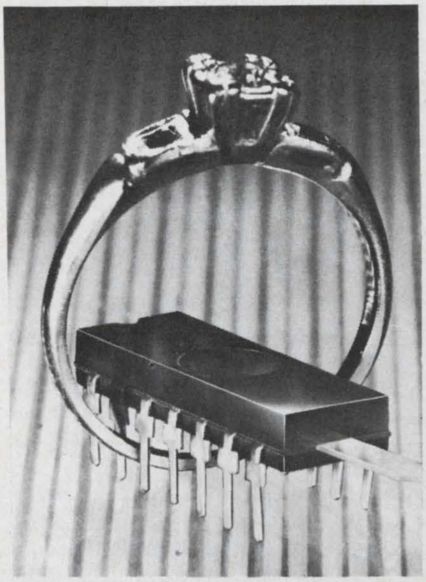


Augat, Inc., 33 Perry Ave., Attleboro, Mass. Phone: (617) 222-2202.

Solderless interconnection is featured throughout in this breadboard, which tests up to 50 ICs. Sockets have large entry holes for easy insertion and gold-plated wiping contacts. The breadboards are designed for use as individual units, or for flatpack and TO-5 stacking on multistation panels. Stacking is accomplished by the use of adapters and jumpers.

CIRCLE NO. 265

IC audio amplifier delivers one watt



General Electric Co., Semiconductor Products Dept., Electronics Park, Syracuse, N. Y. Phone: (315) 456-2798. P&A: $3.70 (1 to 99), $2.45 (100 to 999), $2.20 (1000 to 9999), $1.78 (10,000 to 100,000), $1.59 (over 100,000); stock.

A low-cost linear integrated circuit audio amplifier delivers one watt to a speaker or headphones. Previous audio amplifier highs have been in the 100-mW-or-less range from Amperex, Westinghouse and National Semiconductor Corp.

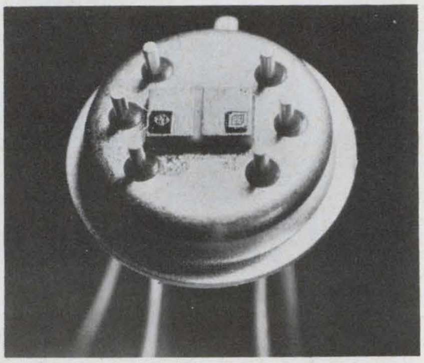
The PA 222 chip contains the equivalent of six transistors, six resistors and one diode. The circuit is housed in a dual-in-line eight-lead silicone-plastic package with a provision for an external heat sink. The PA 222 audio amplifier is designed to operate from power supplies of up to 22 to 24 volts. Frequency response at one watt is typically from 70 Hz to 14 kHz with a noise output of −60 dB relative to one watt.

An extra measure of reliability has been designed into the chip. A negative loop prevents failure due to thermal runaway. If the junction temperature of the device rises, the feedback circuit decreases output collector current, maintaining this temperature below a critical value.

The unit is designed for use in consumer and industrial applications such as tape recorders, phonographs, intercoms or sound projectors.

CIRCLE NO. 267

Complementary duals JEDEC-registered

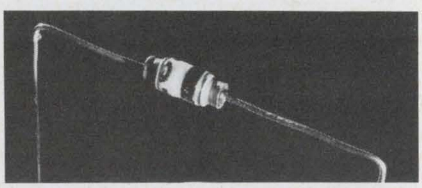


Texas Instruments, Inc., P. O. Box 5012, Dallas. Phone: (214) 238-3741. P&A: $9 and $7.20 (100 to 999); stock.

JEDEC registration for complementary-paired dual transistors has been awarded to the 2N4854 and 2N4855. The medium-power devices are the first npn/pnp duals in TO-5 type packages to receive this designation. The 2N4854 and 2N4855 epitaxial planar silicon transistors feature a wide range of h_{FE} over a collector-current swing of 100 μA to 300 mA. Packaged in a low-profile, 6-lead package similar to the standard TO-5, the devices are suitable for ns-range switching and general purpose amplification (to 100 MHz) applications, handling up to 2 W.

CIRCLE NO. 268

Silicon diodes for RF switching



Crystalonics, Div. of Teledyne, Inc., 147 Sherman St., Cambridge, Mass. Phone: (617) 491-1670. P&A: $6 to $12; stock.

Three new RF switching devices are epitaxial junction silicon diodes featuring a low R_{ON}-C_{OFF} product. Typical forward resistance is 3 Ω at only a few mA of bias current. Off capacitance is typically 1.2 pF at 10 V reverse bias. Applications include RF detectors, antenna switches, diode quad modulators.

CIRCLE NO. 269

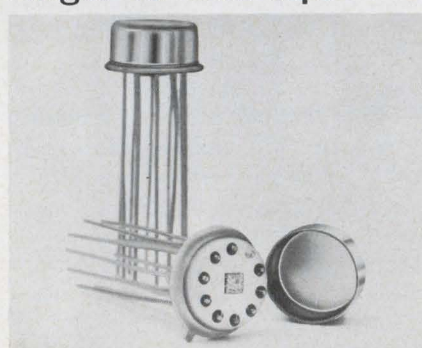
Power transistors have low saturation voltage

Solitron Devices, 1177 Blue Heron Blvd., Riviera Beach, Fla. Phone: (305) 848-4311.

Low leakage currents, freedom from secondary breakdown, a flat gain curve and low saturation voltages are featured in a line of silicon power transistors. They are capable of dissipating 145 W at 25°C and have a collector current rating of 15 A. Applications include power supplies, audio amplifiers, inverters, converters, relay drivers and series regulators.

CIRCLE NO. 270

Monolithic op-amp used single- or dual-input

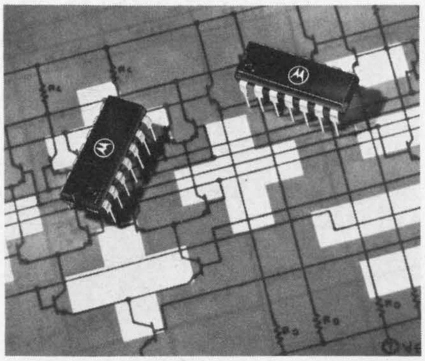


Continental Device Corp., 12515 Chadron Ave., Hawthorne, Calif. Phone: (213) 772-4551.

Manufactured with silicon planar epitaxial construction on a single monolithic substrate, this op-amp may be used as a single- or dual-input amplifier. The unit provides low offset voltage (1 mV) and current (30 mA) along with excellent thermal stability and high common-mode rejection capabilities. Maximum supply voltage is ±18 V. Open-loop voltage gain is 60,000 V/V.

CIRCLE NO. 271

Series gating doubles full adder speed



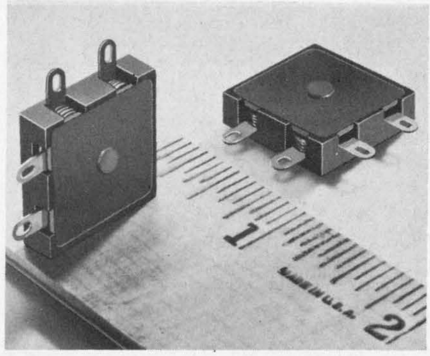
Motorola Semiconductor Products, Inc., P. O. Box 955, Phoenix. Phone: (602) 273-6900. P&A: $5.15 (1000 to 4999); stock.

A new concept in logic circuitry more than doubles the operating speed of IC full adders and subtractors. Called series gating, this approach is found in a new full adder and a full subtractor. The adder and subtractor eliminate the delay-producing cascaded gates required for conventional designs. Instead, the complete gating function—whether sum, carry, difference or borrow—is performed simultaneously. This represents a savings in gate delays of at least one and frequently three or more. Coupled with the inherently high speed of current-mode ECL circuitry, the series gating technique provides a 4 or 5 to 1 reduction in propagation delay compared to other monolithic full adders.

The adder is dubbed MC1019 and the subtractor MC1021. While the slowest propagation delay in the adder is extremely short (15 ns for the addend to sum or carry) the design is such that highest speed response is provided where it will most improve system performance. For example, in the adder, the carry input-to-output propagation delay is the shortest: 8 ns. This means that in a parallel or ripple adder, the propagation of the carry across the adder will be as short as possible. Both circuits are designed for operation from a −5.2-Vdc power supply. The ac fanout is 15. Both are housed in a 14-pin Unibloc plastic package, a dual-in-line configuration with 100-mil spacing between adjacent leads. The devices are rated for operation over the commercial/industrial temperature range of 0 to 75°C.

CIRCLE NO. 272

Selenium rectifier in small package

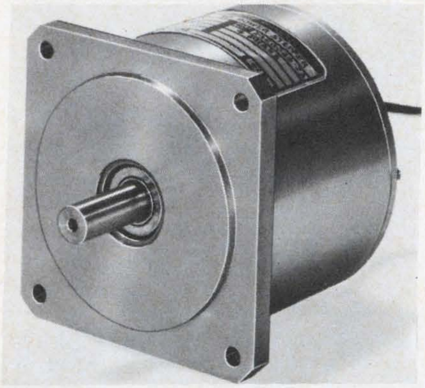


Sarkes Tarzian, Inc., Semiconductor Div., 415 N. College Ave., Bloomington, Ind. Phone: (812) 332-1435. Price: 57¢ (1,000); 50¢ (10,000).

A selenium bridge rectifier measures only 3/4 in. square by 0.2 in. thick, and is rated at 132 Vac input and 110 Vdc output at 200 mA dc. It has applications in motor speed controls, relays, circuit breakers, power supplies, communications equipment, industrial timers, voltage regulators, test equipment, battery conditioners and other areas.

CIRCLE NO. 273

Stepper motors have stepped-up torque



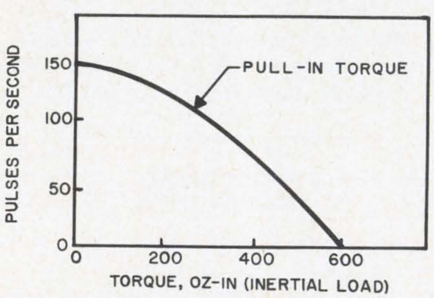
Wright, Div. of Sperry Rand Corp., Durham, N. C. Phone: (919) 682-8161. P&A: $100 to $250; 8 wks.

Larger mechanical loads can now be driven by pulse-operated servo motors. A line of seven proportionally sized stepping motors with step angles of 15° have stall torque ratings from 15 to 600 ounce-inches and stepping rates of 150 to 250 steps per second.

The high efficiency of the motors permits the use of smaller SCRs and low-cost logic circuits as controlled pulse sources. Operated in this manner, a large variety of mechanical systems such as paper tape, carriage, belt, azimuth, hydraulic and others, can be driven directly by these motors.

The motors have 12-pole permanent-magnet alnico-5 armatures. Stator windings are tapped for clockwise and counterclockwise rotation. Duty is continuous where mounting and ambient temperature conditions limit the winding temperature to 155°C.

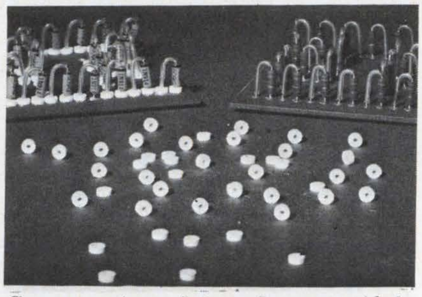
The 135-W motor has a voltage-per-phase rating of 28, and a current-per-phase rating of 4.8 amps. The speed is 150 steps per second, controlled.



Pull-in torque characteristic of the 135-W stepper motor.

CIRCLE NO. 274

Mounting pads vanish after soldering

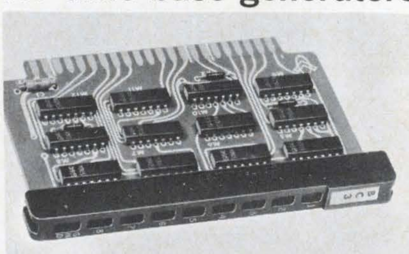


Sawyer Associates, Inc., 3 Alpha Dr., Chelmsford, Mass. Phone: (617) 256-6583.

Designed to eliminate two major problems in flow-soldering, Van-o-pads vanish when dissolved in water or solvent after the solder connection has been made. They act as solid component anti-wetting supports during the flow-solder operation. The pads facilitate conformal coating by eliminating oil-filled capillaries which cause blow holes, pin holes and voids. Used under components in high density printed circuit boards, they eliminate open-circuit breakdowns due to lead separations resulting from a thermal cycle. Components can be positioned to within a few thousandths of an inch of the board, minimizing salvage and rework and improving PC board life.

CIRCLE NO. 275

12-stage counter card for time base generators

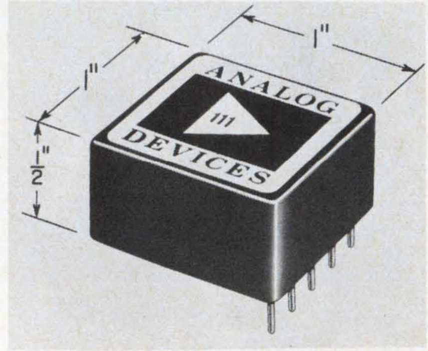


Control Logic, Inc., 3 Strathmore Rd., Natick, Mass. Phone: (617) 655-1170.

A 12-stage counter card, useful in time base generators and for frequency division, is capable of operation in binary or BCD code. The 12 flip-flop stages may be used as a 4- to 12-bit binary or as a 1- to 3-digit BCD counter. Two or more cards may be used to construct counters of any length.

CIRCLE NO. 276

Differential op-amp claims lowest cost

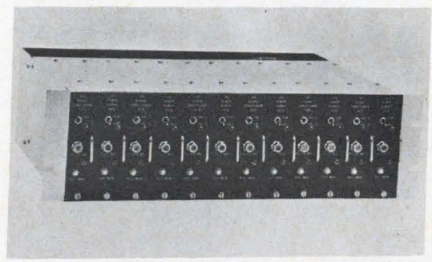


Analog Devices, 221 Fifth St., Cambridge, Mass. Phone: (617) 491-1650. P&A: $9.75 to $13 (1000); stock.

Claiming lowest cost, this op-amp has a bandwidth of 1.5 MHz, while full power response is 20 kHz. The differential input impedance is 200,000 Ω; common-mode input impedance is 50 MΩ. The amplifier can be used open-loop in comparator, zero-crossing detector and other high-gain circuits, and performs in such closed-loop configurations as ac and dc amplifiers, meter drivers, buffer amplifiers, relay-drivers, integrators, precision oscillators, bandpass amplifiers and bridge amplifiers.

CIRCLE NO. 277

Plug-in cards for signal conditioning

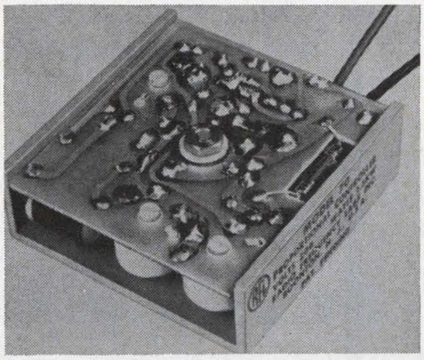


Systems Research Corp., 2309 Pontius Ave., Los Angeles. Phone: (213) 477-4573. Price: $275.

For signal conditioning applications where the most important considerations are flexibility, stability and isolation bridge conditioner and isolated power supply, plug-in printed circuit cards are mounted next to each other in a standard 19-in. rack. Twelve modules (6 channels) fit a 5-1/4-inch rack adapter.

CIRCLE NO. 278

Proportional controller all solid-state

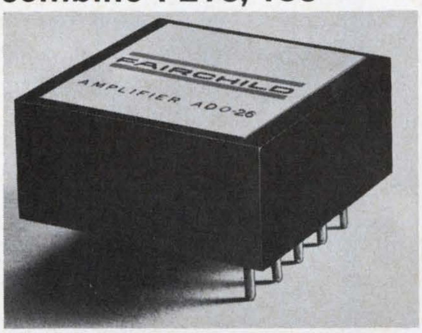


RFL Industries, Inc., Boonton, N. J. Phone: (201) 334-3100. P&A: $30; stock to 2 weeks.

An all solid-state nonindicating proportional controller has power handling capability of up to 200 watts. Weighing six ounces, this 3 x 3 x 1-inch controller delivers precisely the power required to control temperature, light or any desired load to ±0.1°C.

CIRCLE NO. 279

Hybrid op-amps combine FETs, ICs



Fairchild Instrumentation, 475 Ellis St., Mountain View, Calif. Phone: (415) 962-2076. PA:& $45, $70 and $98 (1 to 9); stock.

Hybrid operational amplifiers combine FET input devices and integrated circuit amplifiers. Drift characteristics of the ADO-26 are 1 μV/°C and 2 μV/8 hr. In addition, amplifier gives 10^{12}-Ω input impedance and 10-pA offset current. The ADO-27 has an input drift of 5 μV/°C and 5 μV/8 hr, with an open-loop gain of 140,000. The ADO-29 economy version has 25-μV/°C drift, a gain of 140,000 and the 10^{12}-Ω input impedance. The hybrids are enclosed in a 1.13 x 1.13 x 0.5-inch plastic-encapsulated case.

CIRCLE NO. 280

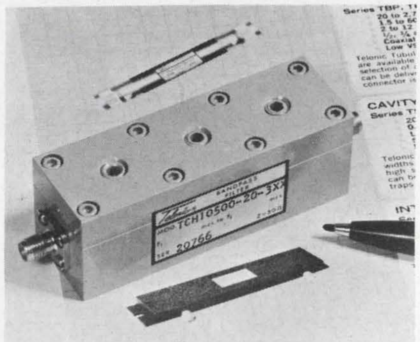
Miniature bandpass filter operates to 12 GHz

Telonic Engineering, Box 277, Laguna Beach, Calif. Phone: (714) 494-7581. P&A: From $195 to $280; 6 to 8 wks.

Miniature bandpass filters with center frequencies from 6 to 12 GHz are slightly more than 2 inches long, and are capacity loaded, iris-coupled, TM_{010}-mode cavities of 0.05 dB Chebyshev design. They have 3-dB bandwidths from 0.1% to 1.0%. Performance features are low insertion loss, high Q, and low vswr and ripple in the passband.

CIRCLE NO. 281

All-silicon op-amp has 20-MHz bandwidth

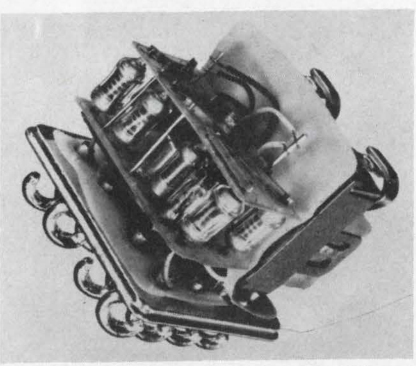


Data Device Corp., 240 Old Country Rd., Hicksville, N. Y. Phone: (516) 433-5330. P&A: $48 (1 to 9); stock to 10 days.

Frequency for full output greater than 500 KHz with a unity gain bandwidth of 20 MHz are features of a new op-amp. A 90-dB gain and drift of less than 10 μV/°C and 0.8 nA/°C are claimed. Applications include high slewing rate servo systems; rate, velocity or acceleration detectors or limiters, and high-speed sampled data systems.

CIRCLE NO. 283

Power relays handle 10 A

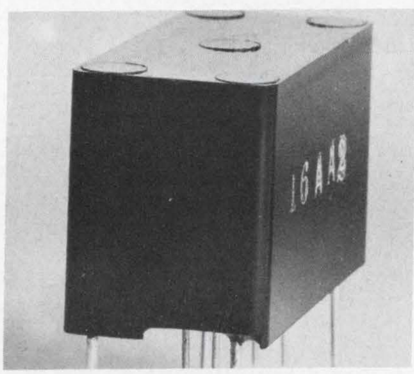


Giannini-Voltex, 12140 E. Rivera Rd., Whittier, Calif. Phone: (213) 723-3371. P&A: $50; 8 wks.

A dpdt power relay is capable of handling 10 A with a signal of 10-mW power. A low-level signal can be utilized to affect control of the relay directly and still have the unit capable of meeting environmental requirements of the aerospace and military industry. The size and weight of this unit are 1.025 x 1.025 x 0.935 inches and 1.6 ounces respectively.

CIRCLE NO. 282

IC logic relays in 0.3-oz modules



Sensitak Instrument Corp., 531 Front St., Manchester, N. H. Phone: (603) 627-1432. P&A: $6.30 (1 to 9); stock.

A rated life of 10 million operations and a weight of 0.3 oz are features of this solid-state logic relay. They consist of an IC amplifier and a reed switch output. Standard units are for operation on 6, 12 or 24 Vdc consuming less than 200 mW. They do not require standby current.

CIRCLE NO. 284

circuit problems?

Signalite

solves them with Glow Lamps

Signalite Application Engineers Have Solved Problems In The Following Areas:

• Voltage Regulators • References • Photo-Cell Drivers • SCR Triggers • Timing • Photo Choppers • Oscillators • Indicator Lights • Counters • Voltage Dividers • Surge Protectors • Logic Circuits • Flip-Flops • Memory • Switches • Digital Readouts

Signalite's neon glow lamps are among the most versatile and reliable circuit components available to the design engineer. They combine long life, close tolerance and economy, and are manufactured with a broad range of characteristics to meet individual application requirements. For a creative approach to your design problem, check with Signalite's Application Engineering Department first.

SIGNALITE APPLICATION NEWS

is used to communicate new and proven techniques and applications of Signalite's neon lamps and gas discharge tubes. Signalite Application News provides a forum for an exchange of ideas to keep the design engineer aware of the versatility of neon lamps and their many applications. Copies are available from your Signalite representative or by contacting Signalite.

READER-SERVICE 95

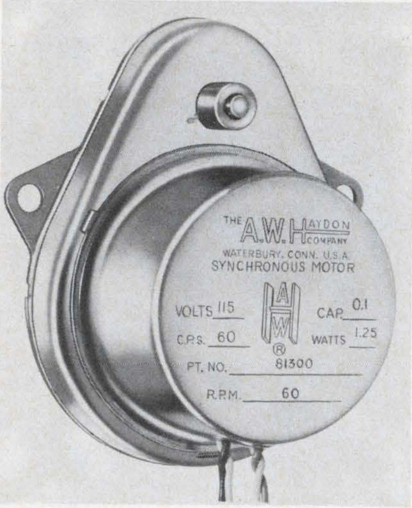
"Applications of Neon Lamps and Gas Discharge Tubes" by Edward Bauman has just been published by Carlton Press. This book contains 160 pages, liberally illustrated with circuit drawings, design information and many practical down-to-earth applications for neon glow lamps. Copies of this hard cover edition may be obtained by writing directly to Signalite Incorporated, 1933 Heck Avenue, Neptune, New Jersey 07753. Enclose check, money order or P.O. for $2.95 plus 25¢ for shipping and handling.

READER-SERVICE 96

Signalite INCORPORATED

NEPTUNE, NEW JERSEY 07753 (201) 775-2490

Synchronous motor delivers high torque



A. W. Haydon Co., 232 N. Elm St., Waterbury, Conn. Phone: (203) 756-4481.

For use in timing and drive applications, this synchronous reversible motor delivers an output torque of 0.75 ounce-inch at 300 rpm directly from the rotor at an input of 1.5 W. It will operate efficiently with inputs as low as 0.2 watt. A phase-shift capacitor is used for single-phase operation, and rotation may be reversed by changing one connection. For two-phase operation, no capacitor is required.

CIRCLE NO. 285

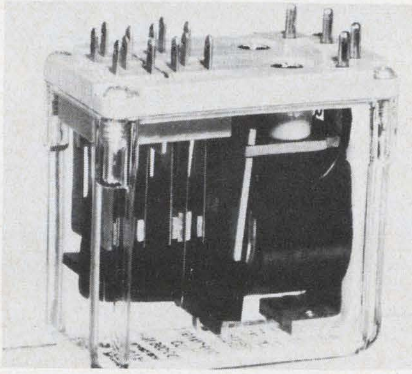
10-V op-amps have low offset current

Fairchild Instrumentation, 475 Ellis St., Mountain View, Calif. Phone: (415) 962-2076. P&A: $45, $38, $65; stock.

A series of 10-V, 20-mA op-amps is offered in three models. All feature low offset current. Two models have a gain of 30,000 and a gain-bandwidth of 2 MHz. The third has a gain of 100,000. All units are encapsulated in 1.145 x 2.02 x 0.5-in. cases.

CIRCLE NO. 286

Industrial relay has 4pdt, 10-A contacts



Cook Electric Co., 2700 N. Southport Ave., Chicago. Phone: (312) 348-6700. P&A: $4.50 to $9; stock to 2 wks.

Featuring 4pdt, 10-A contacts, this relay claims 20% less panel space than previous 3-pole models. Other features include plug-in or quick-disconnect terminals, arc barriers between adjacent poles, silver-cadmium-oxide contacts and full-load contact life of more than 1/2-million operations. Coil ratings are from 6 to 120 V, 60 Hz or dc.

CIRCLE NO. 287

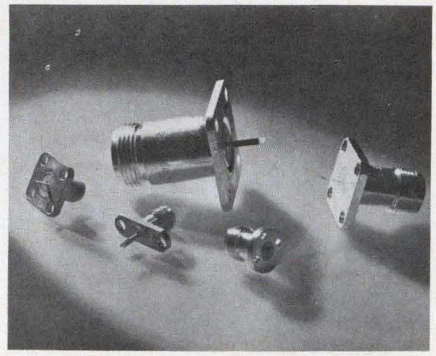
Spdt coax switch operates to 11 GHz

Transco Prod., Inc., 4241 Glencoe Ave., Venice, Calif. Phone: (213) 391-7291.

Designed to perform through 11 GHz, this spdt coax switch withstands vibration in a 25-G sine or random environment. A choice of actuators is available: latching (no holding power), fail safe (no springs) or pulse, 20 ms or less (optional solid-state driver for high impedance). A choice of RF connectors and operating voltages, ac or dc, is available.

CIRCLE NO. 288

Stripline connectors meet MIL specs

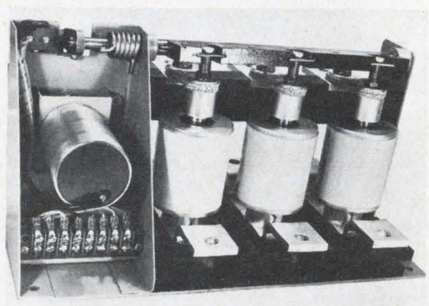


Star-tronics, Georgetown, Mass. Phone: (617) 774-0577.

A complete line of impedance-matched stripline coaxial connectors is designed to meet all applicable MIL specs. They are available in both in-line and right-angle mounting configurations. Included in the line are units capable of meeting all standard connector interfacing situations. Teflon insulation and silicone rubber gasketing is used throughout the line. Either gold or tarnish-resistant silver plating may be specified on all metal surfaces.

CIRCLE NO. 289

Vacuum contactor gives a million operations



ITT Jennings Div., P. O. Box 1278, San Jose, Calif. Phone: (408) 292-4025.

A 3-phase, 600-V 300-A contactor is designed for use in equipment that requires NEMA size 4 and 5 contactors. Erosion-resistant contacts offer long life without adjustment or contact maintenance at rated current. Mechanical and electrical life are guaranteed in excess of one million operations, and five million is typical.

CIRCLE NO. 290

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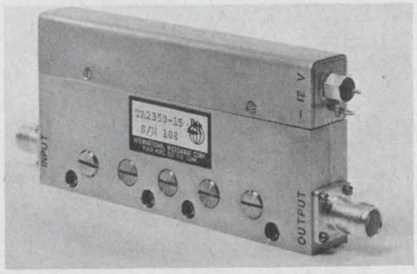
ON READER-SERVICE CARD CIRCLE 58

Telemetry preamps operate in S-band

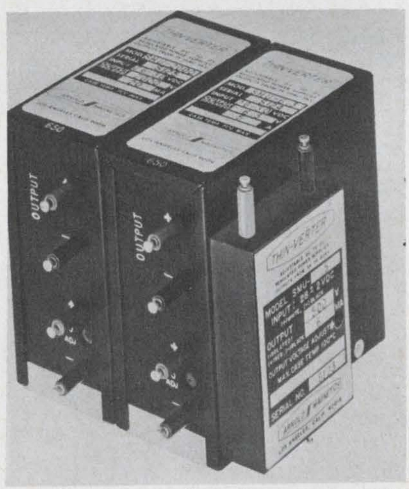


International Microwave Corp., River Rd., Cos Cob, Conn. Phone: (203) 661-6277.

Two transistor preamplifiers for telemetry applications are offered, featuring low noise figure, high burnout rating and low power consumption. The units are of rugged, block construction and are available in either uncased or weatherproof enclosures. The units cover the 1.435-to-1.535-GHz and the 2.2-to-2.3-GHz bands. Both models have 25-dB gain and max RF input of 5 W peak, 500 mW average.

CIRCLE NO. 311

Power supply modules for microwave tubes

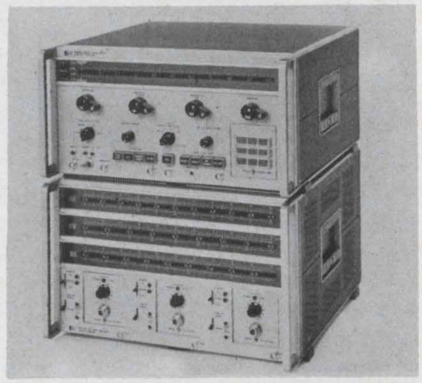


Arnold Magnetics Corp., 6050 W. Jefferson Blvd., Los Angeles. Phone: (213) 870-7014. Availability: stock to 60 days.

Power supply modules for a wide range of TWTs, BWOs and klystron tubes are offered. The modules supply voltages for filament, helix (beam), anode and grids. They have output voltages from 3 to 5000 Vdc. Input voltages are available for either 28 Vdc or 115 V rms, 50 to 500 Hz.

CIRCLE NO. 312

Control unit broadens microwave sweep range



Hewlett-Packard, 1501 Page Mill Rd., Palo Alto, Calif. Phone: (415) 326-7000. P&A: $850 (RF unit holder), $375 (control unit); stock.

A sweep capability of more than an octave is achieved by a control unit used with H-P's sweep oscillator and appropriate RF units. The control unit, with its nine band-selector buttons, replaces the usual BWO RF unit as the plug-in for the sweep oscillator main frame. It supplies power for, and controls, as many as three RF unit holders, each of which accommodates three RF units (single-band sweep oscillators). Each holder provides coverage for three bands with three RF unit plug-ins. The sweep range of each plug-in is approximately an octave in width; available plug-ins can cover from 2 to 40 GHz, and one has a range that extends from 100 kHz to 110 MHz.

CIRCLE NO. 313

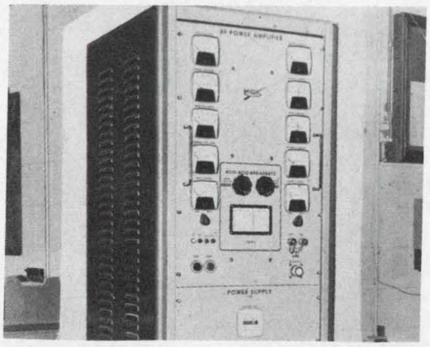
Gas laser has 250-W output

Korad Corp., 2520 Colorado Ave., Santa Monica, Calif. Phone: (213) 393-6737. Availability: 60 to 90 days.

A CO_2 gas laser, which operates indefinitely with an output up to 250 watts, uses a flowing gas mixture of carbon dioxide, nitrogen and helium. Efficiency is rated at 10 to 15%. It is especially suited for cutting operations, welding, spectroscopy, bloodless surgery, and biochemical applications. The device can vaporize materials with melting points higher than 3000°C.

CIRCLE NO. 314

1-kW amplifier spans 40 to 1000 MHz



Microwave Cavity Labs., Inc., 10 N. Beach Ave., La Grange, Ill. Phone: (312) 354-4350.

A 1-kilowatt RF cw tetrode amplifier covers 40 to 1000 MHz with four modular bandchange cavities. It is designed for installations where maximum utility and flexibility and high power efficiency are required from equipment operating in limited space. Each cavity is tuned manually and equipped with front-panel dial counter readout and frequency vs dial calibration chart. The max vswr is 2. Nominal input and output impedances are 50 ohms.

CIRCLE NO. 315

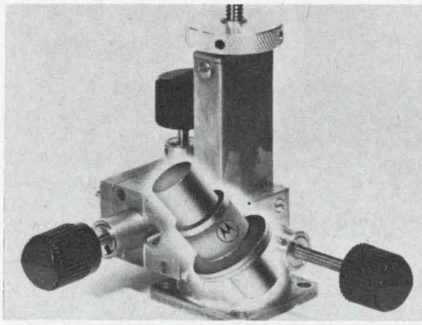
Coax diode spdt switches at 200 ns

Microwave Associates, Burlington, Mass. Phone: (617) 272-3000.

Diodes are replaceable in this coax spdt diode switch. It operates from 1020 to 1100 MHz with a switching speed of 200 ns. Peak power is 4 kW; average power is 25 W. Isolation is 40 dB and insertion loss is 0.6 dB. The device has been designed for use in "hot switch" applications, and is suited for antenna lobing in compact military and commercial IFF systems.

CIRCLE NO. 316

Step recovery varactor gives 1 W at 10 GHz



Motorola Semiconductor Products, Inc., P. O. Box 955, Phoenix. Phone: (602) 273-6900. P&A: $47 (1-99), $31 (100 and up); stock.

A step recovery varactor with an output power capability of 1 W at 10 GHz is now available. The device can be used in the radar band of 8.5 to 9.6 GHz as a driver for high power tubes or as a multiplier for solid-state local oscillators. It can also be used in microwave link communications equipment.

CIRCLE NO. 317

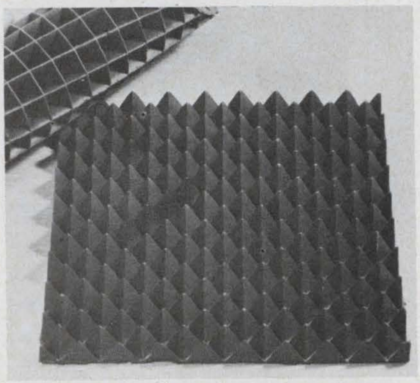
YIG preselector aids spectrum analysis

Hewlett-Packard, 1501 Page Mill Rd., Palo Alto, Calif. Phone: (415) 326-7000. P&A: $2950; 4 to 6 wks.

A tracking preselector enhances the usefulness of wide-sweeping spectrum analyzers by simplifying the spectrum display. The YIG preselector reduces intermodulation products and spurious, image and multiple responses that would otherwise clutter the display. Designed primarily for use with the manufacturer's spectrum analyzers, the new preselector is a voltage-tunable narrowband filter that functions as a sweep-tuned RF stage over a range of 1.8 to 12.4 GHz. It automatically tracks the analyzer's scan, passing signals to which the analyzer is tuned while rejecting others. Undesired responses are reduced by at least 35 dB. The preselector uses a YIG crystal that functions as a high-Q bandpass filter tuned by a magnetic field. The signal that controls the magnetic field, and hence the YIG's resonant frequency, can originate in an external source or in the internal sweep circuits.

CIRCLE NO. 318

Microwave absorber conforms to your shape

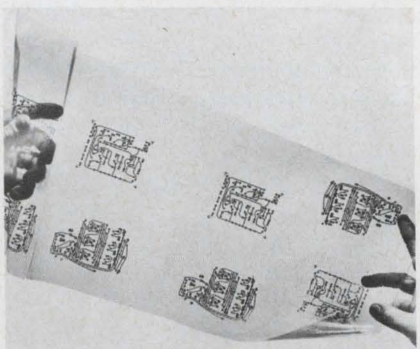


Emerson & Cuming, Inc., Canton, Mass. Phone: (617) 828-3300. P&A: $45/sheet; 10 days.

Eccosorb RMP is a flexible pyramidal microwave absorber made from silicone rubber. It can be draped over complex shapes and readily conforms to curved surfaces. The high temperature capabilities of the silicone matrix makes the material useful in applications that generate heat. Power reflection is 2% maximum at frequencies above 2.4 GHz.

CIRCLE NO. 319

Copper-clad laminate for flexible circuits



Lash Laboratories, 6152 Mission Gorge Rd., San Diego, Calif. Phone: (714) 283-2208. P&A: from $1.29/ft²; 3 to 4 wks.

Polyimide film is clad with electrolytic copper without an adhesive, thus preserving electrical, thermal and chemical properties of the film dielectric. It comes in dielectric thicknesses of 0.0009, 0.0019 and 0.0029 in. The film is non-flammable, will not melt and has no known organic solvent.

CIRCLE NO. 320

5-MHz crystal in cold-welded holder

Reeves-Hoffman Div., Dynamics Corp. of America, 400 W. North St., Carlisle, Pa. Phone: (717) 243-5929.

Five-megahertz fundamental quartz crystals in cold-welded enclosures have frequency-time stability of 1 part in 10^9 per day. The units are capable of withstanding temperature exposures up to 400°C without affecting bond strength or aging stability. Operating temperature is −40 to 70°C and Q is 5 x 10^5 minimum at 1 mA. The holder is cold-weld conforming to HC-6/U, or round transistor C-type.

CIRCLE NO. 321

Molybdenum alloy for metallizing ceramics

Transene Co., Inc., Route One, Turnpike, Rowley, Mass. Phone: (617) 948-2501. P&A: $45 per lb.; stock.

A metallizing preparation for ceramics, especially useful for the fabrication of reliable, high temperature, metal-ceramic seals is available. It contains a novel, reactive molybdenum alloy with a eutectic phase at the ceramic-metal interface during the firing process. The metallization leads to a fine, dense, metallic structure, uniformly bonded to the ceramic body, with interdiffusion. Strong bond strength and hermeticity result.

CIRCLE NO. 322

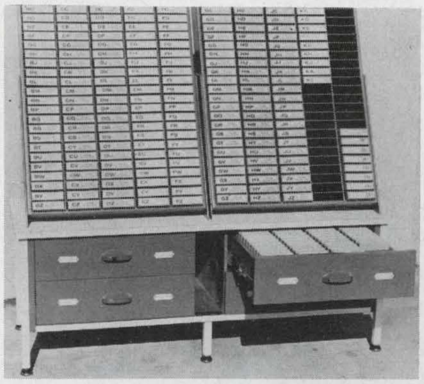
Epoxy compound for plastic semiconductors

General Electric, 1 River Rd., Schenectady, N. Y. Phone: (518) 374-2211.

A cast epoxy material compounded for use in semiconductors is capable of reaching 200°C without degradation to the encapsulant. The plastic compound is expected to contribute to improved environmental, electrical and mechanical reliability of plastic semiconductor devices. Other characteristics include higher thermal conductivity and flame resistance.

CIRCLE NO. 323

MIL-specs available microfilmed



Information Retrieval, Inc., Div. of Ascam, 801 Welch Rd., Palo Alto, Calif. Phone: (415) 326-8380. PA&: $250 (console), $49 (racks); stock.

A military specifications system has information organized in subject-significant data packages filed at random in 16-mm microfilm cartridges. The file is updated each 30 days by adding one or more cartridges containing added data packages and existing data packages which have been changed. An index, by title and specification number, showing the file locations of current data is published for each update period. Superseded data is thus retained in the file but is separately indexed.

CIRCLE NO. 324

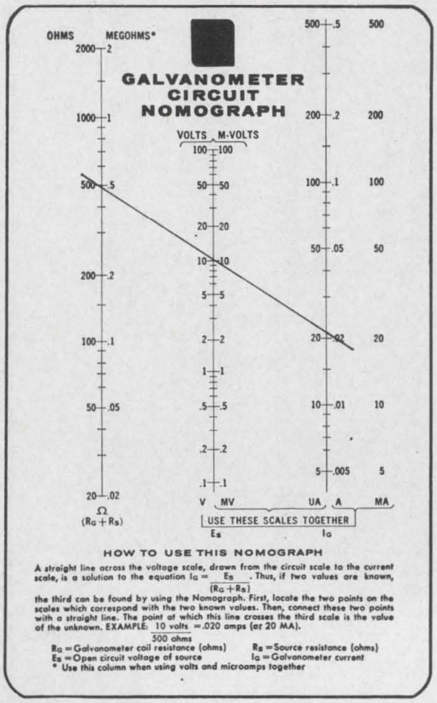
Uhf direction finder has 3500 channels

Servo Corp. of America, 111 New South Rd., Hicksville, N. Y. Phone: (516) 938-9700.

Designed for shipboard and land-based installators, this direction finder operates over the 225-to-339.5-MHz range. It features 50-kHz channel spacing. Twenty programed channels are available with manual override and selection of any of 3500 channels. The antenna system consists of a medium-aperture circular array of 16 vertical polarized dipoles. The application of Doppler technique stimulates the rotation of an antenna about a fixed point and results in phase modulation of a received wave front. The readout is digital.

CIRCLE NO. 325

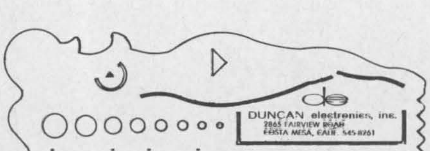
Design Aids



Galvanometer nomograph

A pocket-sized plastic chart lists galvanometer characteristics and gives a nomograph to relate galvanometer circuit values. The front side contains tables listing characteristics of electromagnetic and fluid-damped galvanometers. The reverse side has the nomograph giving relationships between current, resistance and source voltages. Test Instruments Div., Honeywell, Inc.

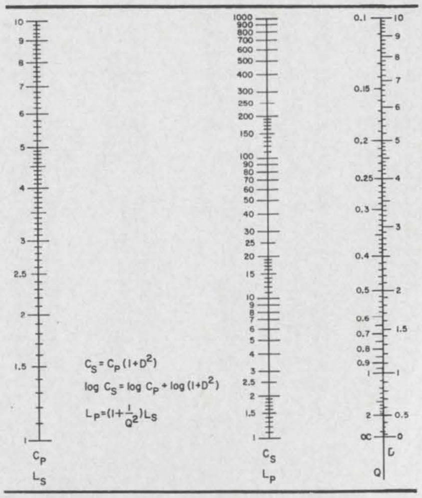
CIRCLE NO. 326



Nonlinear pots

This fabulous French curve and do-it-yourself nonlinear function kit make it a snap to specify nonlinear potentiometers. Included in the kit are 12 common functions including curves, equations, schematics and design parameters. Six blank overlay sheets are furnished to trace the specified curve and outline the potentiometer specs. A 4-page brochure gives typical curves, formulas, circuits, resistances and conformities. Quite a package!

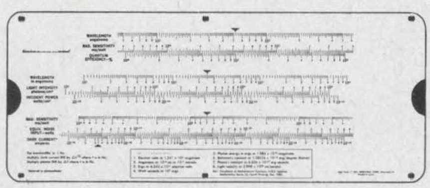
Available on company letterhead from Duncan Electronics, Inc., 2865 Fairview Rd., Costa Mesa, Calif.



Impedance nomograph

Simplify the conversion from series to parallel (or vice versa) inductance and capacitance. This nomograph covers values of dissipation factor up to 10 (Q down to 0.1). Given a parallel capacitance and dissipation factor, equivalent series capacitance is quickly found. General Radio Co.

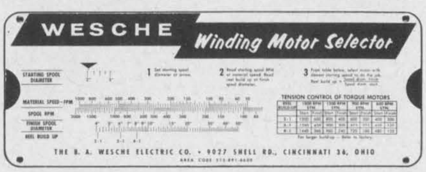
CIRCLE NO. 327



Photoelectric slide rule

Relate wavelength, radiant sensitivity, light intensity and equivalent noise input with this handy slide rule. In addition, a table gives useful expressions in photoelectric calculations together with conversion factors. The reverse side of the rule has a multiplier phototube selector chart matching over 50 types for your particular application. Photoelectric Div., Electro-Mechanical Research, Inc.

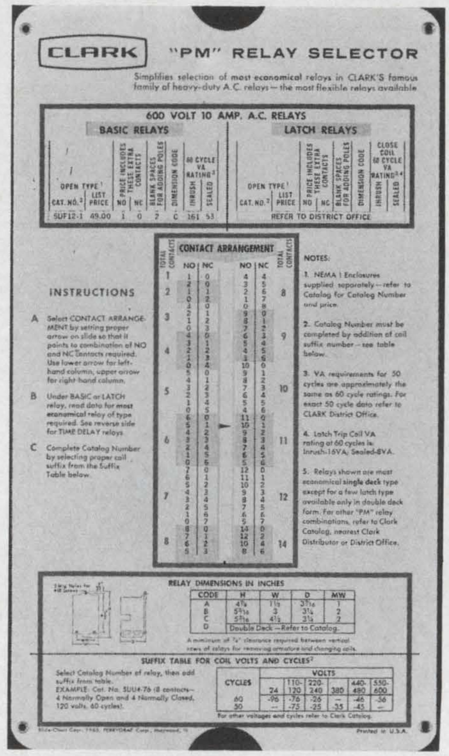
CIRCLE NO. 328



Winding motor selector

Winding problems are quickly solved by this slide rule. It determines the rating and speed of required winding duty motors from the initial data of web, spool diameter at start and spool diameter at finish. B. A. Wesche Electric Co.

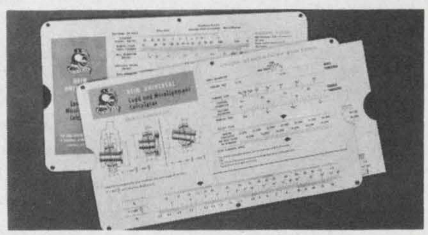
CIRCLE NO. 293



Magnetic relay selector

Select heavy-duty ac relays at a glance with this magnetic relay selector. The slide-chart lists contact arrangements and ratings, coil voltage and cycles and dimensions for 600-V, 10-A magnetic relays. Included on the slide-chart are basic, latch and time delay relays. Contact arrangements range from 1 NO contact to a total of 14 NO and NC contacts in various combinations. By setting the arrow on the required contact arrangement for a particular type of relay, the most economical unit for the job is shown in a window. Clark Control Div. of A. O. Smith Corp.

CIRCLE NO. 329



Load, misalignment rule

Bothered by mechanical problems in your electronic design? This slide rule quickly calculates load ratings and misalignment of rod ends and spherical bearings used in push-pull linkages and misalignment correction. A copy of Heim Universal's 32-page catalog is also included. Heim Universal Corp.

CIRCLE NO. 330

Application Notes

Milliwatt RTL

A summary of mW resistor-transistor logic with design rules for employing the company's ICs is available. Information is also given on noise margins, propagation delay, and power consumption. Sprague Electric Co.

CIRCLE NO. 331

Worst-case logic

Worst-case methods are applied to logic system design to assure device operation within a predetermined set of compatible performance limits. This 9-page brochure includes tables and charts. Signetics Corp.

CIRCLE NO. 332

Arbitrary waveforms

New methods for analyzing arbitrary waveforms are discussed in detail in a 38-page monograph. Three fundamental kinds of analysis—spectrum, correlation and probability—are reviewed, and their relative usefulness compared. Spectral Dynamics Corp.

CIRCLE NO. 333

Power supply/amplifiers

This note analyzes similarities between power supplies and operational amplifiers, and describes the circuit modifications which achieve the conversion of a dc power supply into a high-power operational amplifier with frequency response to 20 kHz. It also discusses the use of the PS/A as a bipolar power supply capable of fast programing by resistance, current, or voltage, and how it is used as a high-power constant voltage or constant current amplifier with unusually low distortion. Harrison Div., Hewlett-Packard.

CIRCLE NO. 334

Differential transformers

Linear variable differential transformers and similar instruments are the subject of a 20-page bulletin. Schevitz Engineering.

CIRCLE NO. 335

New Literature

Components catalog

A 116-page 1967 spring catalog of electronic equipment of major manufacturers has been issued. Lafayette Radio Electronics Corp.

CIRCLE NO. 336

Ratio measurement

Measurement of ratio as a calculated value derived from two absolute voltage measurements is time-consuming and subject to operator error and source instability. These objections are eliminated by the use of a ratiometer. A twelve-page booklet describes the instrument and its application. Dana Laboratories, Inc.

CIRCLE NO. 337

Germanium and silicon

Three pocket-size booklets covering germanium and silicon semiconductors are available. Miniature, hermetically sealed discrete components electrically and mechanically compatible with ICs are also covered. Texas Instruments, Inc.

CIRCLE NO. 338

Data acquisition

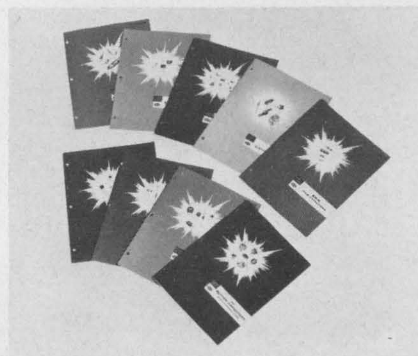
Multiple input systems for real-time data acquisition, process control and scientific research are covered in a 16-page illustrated brochure. Specs accompany descriptions of the units. Monsanto Midas.

CIRCLE NO. 339

Phase meters

Formulas and circuitry illustrate a discussion of phase and time measurements and applications of phase meters. A table of comparative specs on a number of competitive phase meters is included in the 8-page brochure. Ad-Yu Electronics, Inc.

CIRCLE NO. 340



Components catalog

A two-color, 150-page catalog consists of nine sections, each devoted to one of the manufacturer's component lines. Ceramic disc and tabular capacitors, feed-thru and button capacitors, mica and film capacitors, trimmers, semiconductors and filters are covered. Erie Technological Products, Inc.

CIRCLE NO. 341

Diode matrices

An extensive discussion of diode matrices is available in a 61-page handbook fully illustrated with matrix charts, schematics and logic drawings. The matrices discussed make use of the manufacturer's line of monolithic diode matrices. Radiation, Inc.

CIRCLE NO. 342

Operational amplifiers

A 93-page handbook takes us from a general discussion of op-amps through performance and circuit characteristics to a variety of applications. Technical and performance data, curves and schematics are provided for a number of popular circuits. Radiation, Inc.

CIRCLE NO. 343

Microwave notes

Three small brochures called Micronotes, with text, diagrams and formulas, deal with higher-power diode duplexing, avalanche oscillators and varactor bridge doublers, respectively. Microwave Associates.

CIRCLE NO. 344

High-voltage transistors

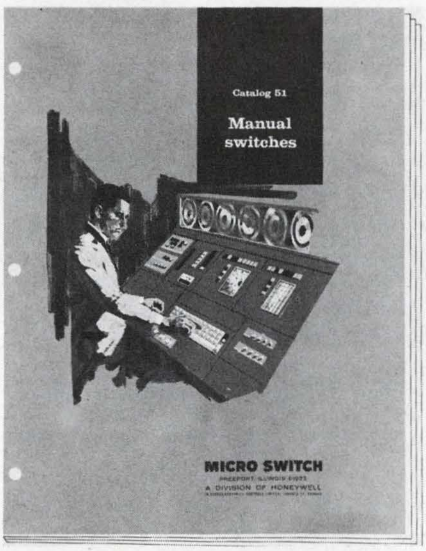
Specifications for a line of high-voltage npn transistors are detailed in a 6-page folder. Included are 200-V to 1-kV military and industrial npn silicon transistors. Diagrams are included. Industro Transistor Corp.

CIRCLE NO. 345

Module line

A foldout with three data sheets and a price list deal with a line of op-amps, comparator relays, log-amp systems and power supplies. Circuits and specs are included. Data Device Corp.

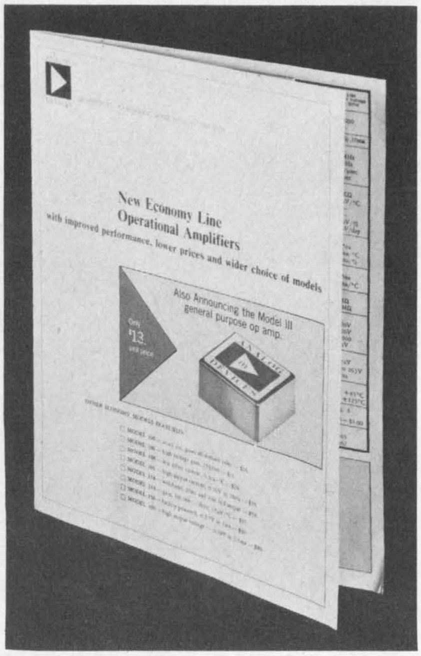
CIRCLE NO. 346



Manual switches

Detailed specifications, mounting instructions, applications and circuit data on manual switches are presented in a 44-page, full-color catalog. It is divided into 12 categories of switches, including lighted and unlighted pushbutton switches and indicators and toggle switches. Human factors in panel design are also discussed. Micro Switch, Div. of Honeywell.

CIRCLE NO. 347



Op-amp specs

Nine different op-amps are fully specified in a 4-page brochure, with prices. Performance curves and dimensioned drawings are included. Analog Devices.

CIRCLE NO. 348

Data printers

Data calculators and printers that add, multiply or divide and record on 2-1/4-inch tape are discussed in six foldouts. Photos, diagrams and specs are included. Victor Comptometer Corp.

CIRCLE NO. 349

Transducer amplifiers

A four-page catalog on its transducer amplifier systems designed to provide optimum signal conditioning for ac transducers gives technical description, curves, and charts of linearity and normalized frequency response characteristics. Natel Engineering Co., Inc.

CIRCLE NO. 350

Computer programs

NASA has issued a catalog of 22 computer programs developed for its own use and now available to industry. The publication outlines mathematical programs and digital-computer programing techniques that are available at a nominal charge.

Available for $1 (NASA SP-5069) from Clearinghouse, Federal Scientific and Technical Information, Springfield, Va.

IC assemblies

A catalog describing the manufacturer's IC logic assemblies is offered. A wide selection of logic functions is available for use in any phase of digital equipment development. Included in the catalog are data sheets describing arithmetic-logic circuits, decoders, straight binary counters, up-down counters, shift registers and basic elements such as NAND gates, J-K flip-flops or R-S flip-flops. Cambridge Thermionic Corp.

CIRCLE NO. 351

Rotary relays

A 26-page catalog on rotary relays for use in environmentally severe signal-switching functions in military and aerospace applications is available. It contains illustrated specification sheets on a series of subminiature 4pdt and 2pdt relays, microminiature dpdt crystal can relays and an expanded line of microminiature relays. Couch Ordnance, Inc.

CIRCLE NO. 352

Nuclear equipment

Nuclear physics research equipment, including ion sources, scattering chambers, semiconductor detectors and electronic instrumentation, is treated in a 98-page publication. About one-half is devoted to the basics of construction and operation. Detailed reference information on application and selection of various instruments and accessories is given. Ortec, Inc.

CIRCLE NO. 353

Plugs and switches

A short form catalog of 25 pages containing condensed descriptions and illustrations of every electronic component stocked by the manufacturer is available. Switchcraft, Inc.

CIRCLE NO. 354

Transistors for FM

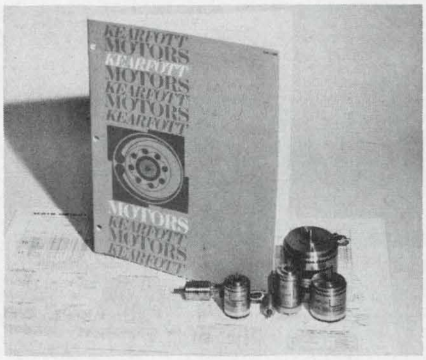
The adaptability of alloy-diffused transistors to high-quality FM reception is treated in 15 pages of text, curves and schematics. Coil specifications are included. Mullard, Inc.

CIRCLE NO. 355

Transmitter-combiners

Transmitter-combiner installations that may include two to eight transmitters, some multiplexed onto one antenna and others multiplexed onto multiple antennas, are treated in a 6-page brochure. The number of transmitters is limited only by the amount of insertion loss allowable in the system. RJ Communication Products, Inc.

CIRCLE NO. 356



Precision motors

Nearly 200 different motors are described in a 31-page catalog with photos, curves and specs. The line includes stepper, synchronous, servo, viscous damped, inertial damped, braked and special service motors. Practical design formulas to aid in servo problems are included. Kearfott Div. of General Precision.

CIRCLE NO. 357

Voltage measurement

A small 28-page catalog describes the manufacturer's line of ac voltage measuring devices for AM and FM signals. The instruments are applicable to analysis and recording in acoustics, environmental testing, noise control, fatigue and vibration, and others. B&K Instruments, Inc.

CIRCLE NO. 358

Precision potentiometers

A 6-page brochure summarizes custom-designed conductive plastic and wirewound potentiometers and elements, and provides specific data on the company's standardized lines. Included are rotary and linear motion models, and linear and nonlinear functions. New England Instrument Co.

CIRCLE NO. 359

Pressure-sensitive tapes

Masking, electrical, packaging and protective tapes in a wide variety of materials and colors are described in a full-color catalog. Ordering information is included. Mystic Tape Div. of the Borden Chemical Co.

CIRCLE NO. 360

Ball bearings

Engineering data on ball bearings—single-row, double-row, angular-contact, self-aligning, thrust and precision—form the subject of a detailed 92-page catalog. Diagrams, tables and a nomograph are included. SKF Industries, Inc.

CIRCLE NO. 361

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To make reasonable efforts to insure accuracy of editorial matter.

To publish promptly corrections brought to our attention.

To reserve the right to refuse any advertisement deemed misleading or fraudulent.

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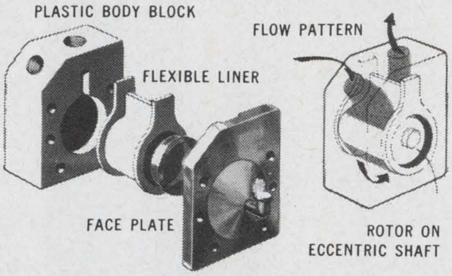
PLASTIC SEALLESS PUMP

. . . no corrosion, no contamination, no leakage
Standard capacities are from 1/3 to 40 gpm



A rotor, mounted on an eccentric shaft in this plastic pump, rotates within a liner to create a progressive squeezing action on fluid trapped between the liner and the body block. All metal parts and mechanical action takes place inside the liner where fluid never reaches. This completely eliminates the need for stuffing boxes or shaft seals, guaranteeing no leakage.

The pump is self-priming, operates wet or dry and is suitable for extremely corrosive fluids, abrasive slurries or viscous materials. Applications include pumping of acids, alkalies, distilled water, diatomaceous earth slurries, electroplating solutions, ceramic tile glaze as well as shear sensitive emulsions.

Standard capacities are from 1/3 to 40 gpm with discharge pressure up to 50 psi. Materials of construction include Teflon, polypropylene, linear polyethylene, Bakelite or stainless steel for body blocks and Viton-A, Kel-F elastomer, Hypalon, Neoprene and Buna-N for the liner. These are the only parts in contact with the fluid.

For additional information, write Vanton Pump & Equipment Corporation, Hillside, New Jersey or telephone Area Code 201 926-2435.

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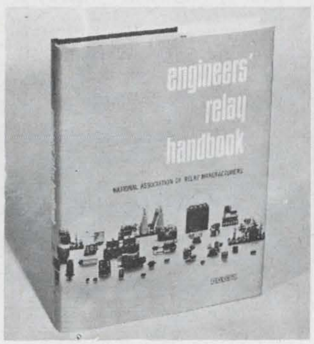
Engineers' Relay Handbook



A definitive work that is fast becoming a standard reference text for the relay user. Prepared and edited by the National Association of Relay Manufacturers, this book is a complete guide to the principles, properties, performance characteristics, application requirements, specifications, and testing of relays. Systems and product engineers will find the *Handbook* an indispensable help in determining the correct types of relays for their applications. For further information about this unique sourcebook, write Dept. ED

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Adjustable 0-34V, 1.5A Power Supply

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Manufacturers

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This 8-page catalog provides design data on the complete group of DZUS 1/4-turn self-locking fasteners for standard, high speed and panel applications, as well as universal high strength multiple thread fasteners for high tensile and shear stresses. Dzus stud assemblies, wire forms and receptacles offer an exceptional, wide variety of combinations from stock to fit specific fastening requirements. Diagrams and tables give full details for rapid, unlimited design selection. Condensed Catalog No. S-2 or comprehensive Catalog No. D-3 are available on request.

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FREE SAMPLES ON REQUEST

FEATURES: • Molded encapsulation • Welded leads • Precise dimensions • Mounting feet • Damage resistance • Extended foil construction • Modern appearance • Operation up to 125C • Negligible capacitance change from 0C to +65C. • Minimum insulation resistance (.1 uf) 3×10^{11} ohms at 25C and 3×10^{9} ohms at 125 C • Typical dissipation factor at 1000 Hz less than .05% over temperature range 50° C to 125° C. • Polycarbonate dielectric.

Schweber Electronics
Westbury, New York 11591
516/334-7474

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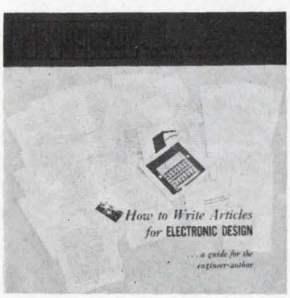
How To Write Technical Articles



A guide for the engineer-author, "How to Write Articles for Electronic Design" shows how easy it is to write for publication—once the engineer knows what to write and how to write it. The Author's Guide includes a complete run-down of the types of articles published by Electronic Design—plus detailed instructions on how to prepare technical articles and short special features. A MUST for every "would-be-writer" in the electronics industry. Send for your complimentary copy by circling the number to the right.

Electronic Design
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Designer's Datebook

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Apr. 5-10
International Exhibition of Electronic Components (Paris) Sponsors: Five specialized French professional societies under patronage of the Fédération Nationale des Industries Electroniques (EIA of France); J. Amiel, Air France, 1350 Sixth Ave., New York, N. Y. 10019. CIRCLE NO. 394

Apr. 10-15
International Conference on Electronics and Space (Paris) Sponsor: Two specialized French professional societies under patronage of the Fédération Nationale des Industries Electroniques (EIA of France); J. Amiel, Air France, 1350 Sixth Ave., New York, N. Y. 10019. CIRCLE NO. 395

Apr. 14-21
Mesucora 67 (International Exhibition and Congress on Measuring and Test Equipment and Automation) and Physics Exhibition (Paris) Sponsor: Société Francaise de Physique (French Physics Society); J. Amiel, Air France, 1350 Sixth Ave., New York, N. Y. 10019. CIRCLE NO. 396

Apr. 5-7
International Conference on Magnetics (Washington, D. C.) Sponsor: Magnetics Group, IEEE; D. I. Gordon, U.S. Naval Ordnance Lab., Silver Springs, Md. 20910. CIRCLE NO. 397

Apr. 5-6
Biomechanics Symposium (Rock Island, Ill.) Sponsor: U.S. Army Rock Island Arsenal, Augustana College; Col. H. A. Snyder, Rock Island Arsenal, HQ. U.S. Army Weapons Command, Rock Island, Ill. 61201. CIRCLE NO. 398

Apr. 17-19
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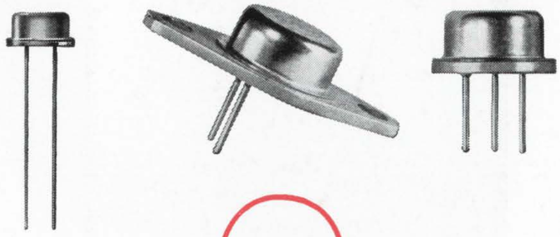

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