Electronics®

Coaxial cavities for varactor multipliers: page 56
An industrial use of optoelectronics: page 76
New way to protect military communications: page 80

May 17, 1965
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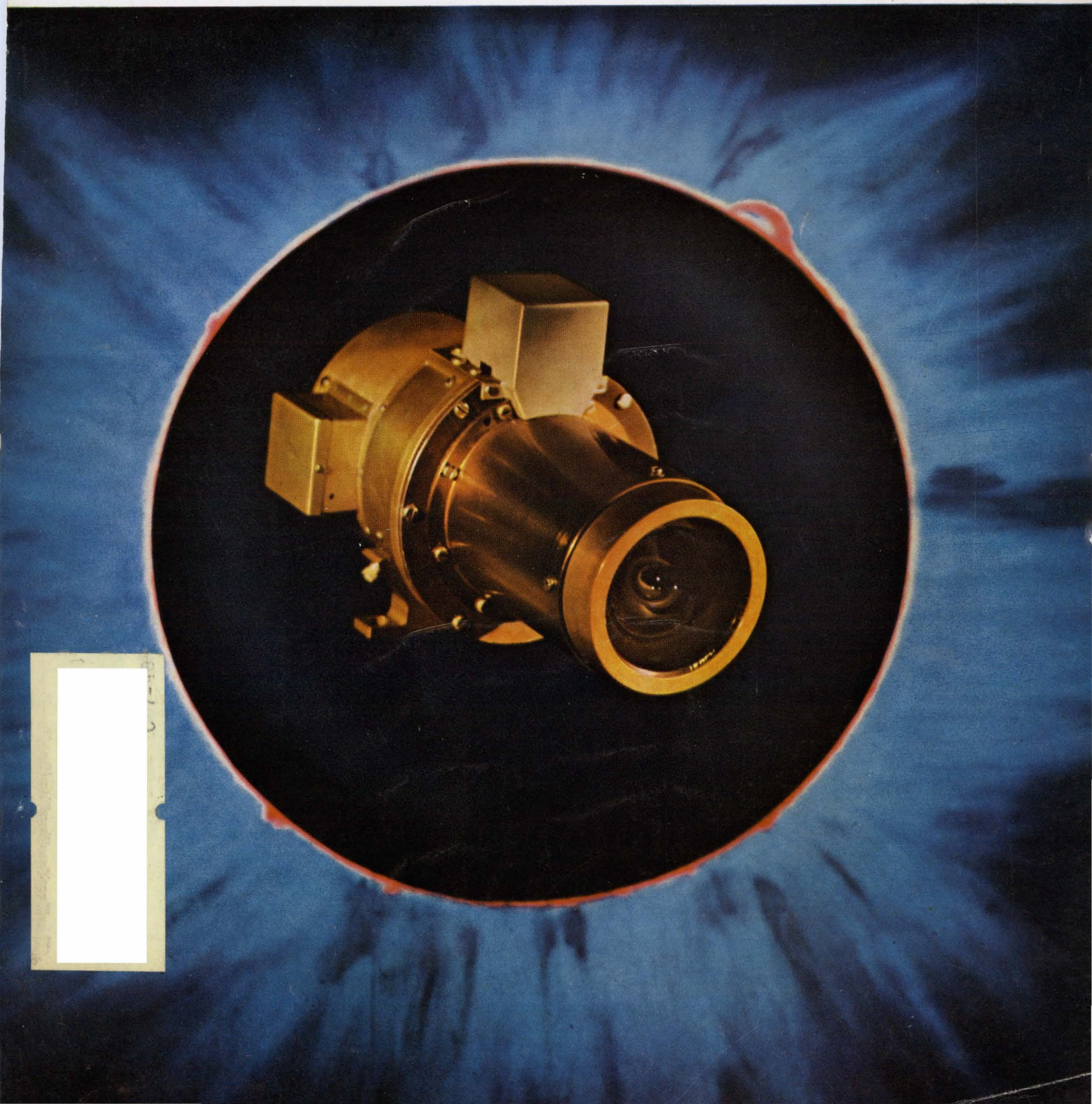
Below: Tv's toughest challenge is interplanetary space: page 80



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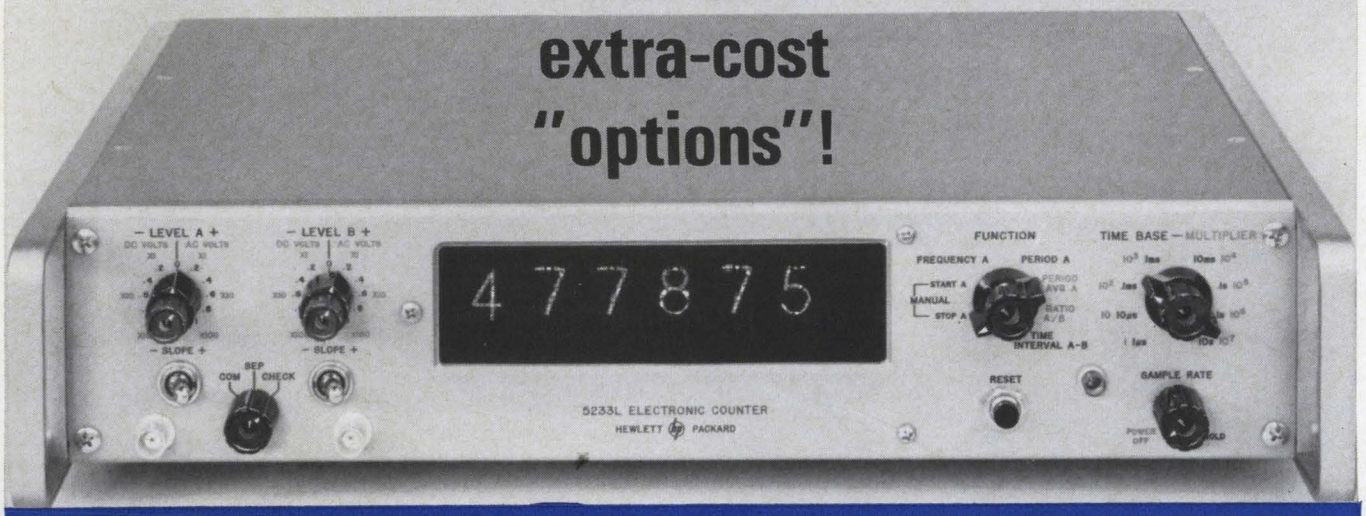

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5212A Counter	Same as 5512A except offers neon columnar display			$925
5214L Preset Counter	Measures rate, time, totalizes; measures normalized rate, normalized time, counts N events	300 kc maximum counting rate	5-digit resolution in in-line display; preset N number, from 1 to 100,000; locally or program remotely	$1475
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Electronics

May 17, 1965
Volume 38, Number 10

Electronics Review

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II. Applications

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Electronics: May 17, 1965, Vol. 38, No. 10

Printed at 99 North Broadway, Albany, N.Y.
Second class postage paid at Albany, N.Y.

Subscriptions are solicited only from those actively engaged in the field of the publication. Position and company connection must be indicated on orders. Subscription prices: United States and Possessions and Canada, $6.00 one year, $9.00 two years, $12.00 three years. All other countries $20.00 one year. Single copies, United States and Possessions and Canada 75¢. Single copies all other countries $1.50.

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Readers Comment

Traffic jam

To the Editor:

On reading the story "Northeast Passage" [May 3, p. 30], I recalled a project I worked on several years ago. We considered developing an electronic device which would automatically compute the distance between vehicles, then control their velocities to prevent a collision. We planned to use doppler radar, and to control carburetor fuel input and braking by a precalculated schedule.

At the time, we found the equipment to do this would take up about the same space as a large two-way communications set. With today's technology, however, the equipment would be no larger than a football.

The project collapsed not on technical grounds but because our client found that auto manufacturers did not like the idea at all.

Although I like the idea of electric autos to reduce the noxious gases that almost asphyxiate a driver in heavy traffic, I can't help picturing a gigantic traffic jam of thousands of stalled vehicles during a severe electrical storm or icing situation. The only alternatives would be to supply power by induction or some system of stored energy.

I believe that a system could be built to operate properly, but the cost would probably run closer to $3 billion or $4 billion than the $500 million estimated.

S. Hamilton McNeill
Guarantee Engineering Enterprises, Inc.
Addison, Ill.

Blurred color

To the Editor:

The editorial "Facing color tv problems" [March 22, p. 15] is a strong and undeserved disservice to the American tv industry. It may do great damage to world color television unless the false impression it creates is corrected. The American public is now buying color TV sets as fast as they are made. Is Electronics trying to save

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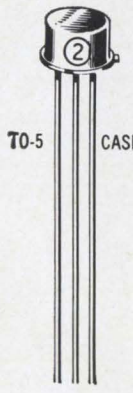

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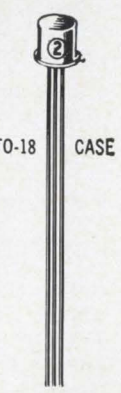
TN61	TN62		40V	30V	50 min.	100 Mc
TN63	TN64		20V	20V	25 min.	20 Mc



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the rest of the world from the same fate?

The editorial is strongly anti-NTSC. It ascribes to NTSC difficulties which apply equally well to Secam and PAL, yet it says nothing of the far more serious defects of Secam, among which are: lower color resolution, poorer compatibility, breakup of horizontal detail, inability to handle weak signals, serious shifts in saturation, inability to provide practical hue and chroma controls, and higher cost of receivers.

Referring now to specific errors in the editorial:

▪ The change in color in the football game, due to changes in cameras and lighting, would also occur with Secam and PAL, because they use the same cameras and the same sunlight; it was the original color that changed. In the case of sundown, the viewer no longer liked the true color and wished to change it to something more pleasing.

NTSC receivers can easily correct for these changes because they have manual hue and chroma controls.

Secam receivers cannot correct for these changes because they have no color controls. Moreover, even the vaunted color stability of Secam did not hold in side-by-side demonstration of six Secam receivers which differed appreciably from each other in hue and chroma, but had no means of correction. Secam cannot provide hue and chroma controls which are both inexpensive and mutually independent. For that reason, Secam proponents claim that such controls are unnecessary.

Color controls must be used to compensate for camera and lighting changes, ambient lighting in the home, individual color preferences, and differences in color vision; in other words, to compensate for causes which apply to all systems equally. These controls are as necessary as the volume control in an audio system.

▪ NTSC receivers do have an automatic hue control; it is inherent in the NTSC signal specifications. These call for a color phase-reference burst having the phase of the color subcarrier when it transmits (B−Y). The continuous wave color-reference signal (3.58 megacycles in the U. S.), generated in the receiver, is phase-locked to the burst by an automatic phase control loop. It is then used to extract the video color signals by synchronous demodulation. The hue is then automatically controlled and maintained by the color reference burst.

However, no automatic hue control can correct for changes in camera characteristics and lighting which affect the color at its point of origination. The phase of the color-reference signal can be shifted manually from its locked value to provide any desired correction in hue. The corrected hue is then maintained automatically by the reference burst.

▪ Poorly registered color tubes produce edge effects which resemble single-sideband distortion, but are much more frequent. Since NTSC, Secam, and PAL use the same color tube, they are subject to the same misregistration. Single-sideband distortion does not occur in an NTSC receiver designed to make full use of the signal. Such a receiver is illustrated on page 100 of the March 22 issue of Electronics. Commercial color receivers, which for reasons of economy provide equal bandwidths for the two components of chrominance, are designed so that the advantages of economy and greater bandwidth are obtained without excessive single-sideband distortion.

▪ Since hue is determined by the phase of the subcarrier, it is true that unwanted phase shifts can produce unwanted hue shifts. These can be and now are effectively controlled. Thus, a round-trip network transmission of 3,000 miles of the NTSC color signal shows no discernible difference between the output and input color.

Charles J. Hirsch
Radio Corp. of America

▪ In his zeal to defend the NTSC system, reader Hirsch missed the point of the editorial—that proponents of NTSC are not willing to face up to the limitations and problems of their system. Secam advocates admit weaknesses. But he reiterates a point that annoys a lot of color tv set owners when he blames broadcasters for some of the trouble. The broadcasters are quick to rebut the charge by blaming the setmakers, leaving the poor owner still with a bleary picture and a sense of frustration.

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People

The nomination of retired Air Force **Gen. William F. McKee** as Federal Aviation Agency Administrator ensures that if the U. S. decides to build a supersonic transport (SST), it will have an able administrator and a supporter in a top development position.

The Senate is expected to give quick approval to the appointment.

McKee is a close associate of Defense Secretary Robert S. McNamara, who heads a cabinet-level Presidential committee to study the SST's potential. Although McKee won't talk about his job until he gets Senate confirmation, the word in Washington is that both he and McNamara favor building the SST quickly, since they think it will be economically profitable.

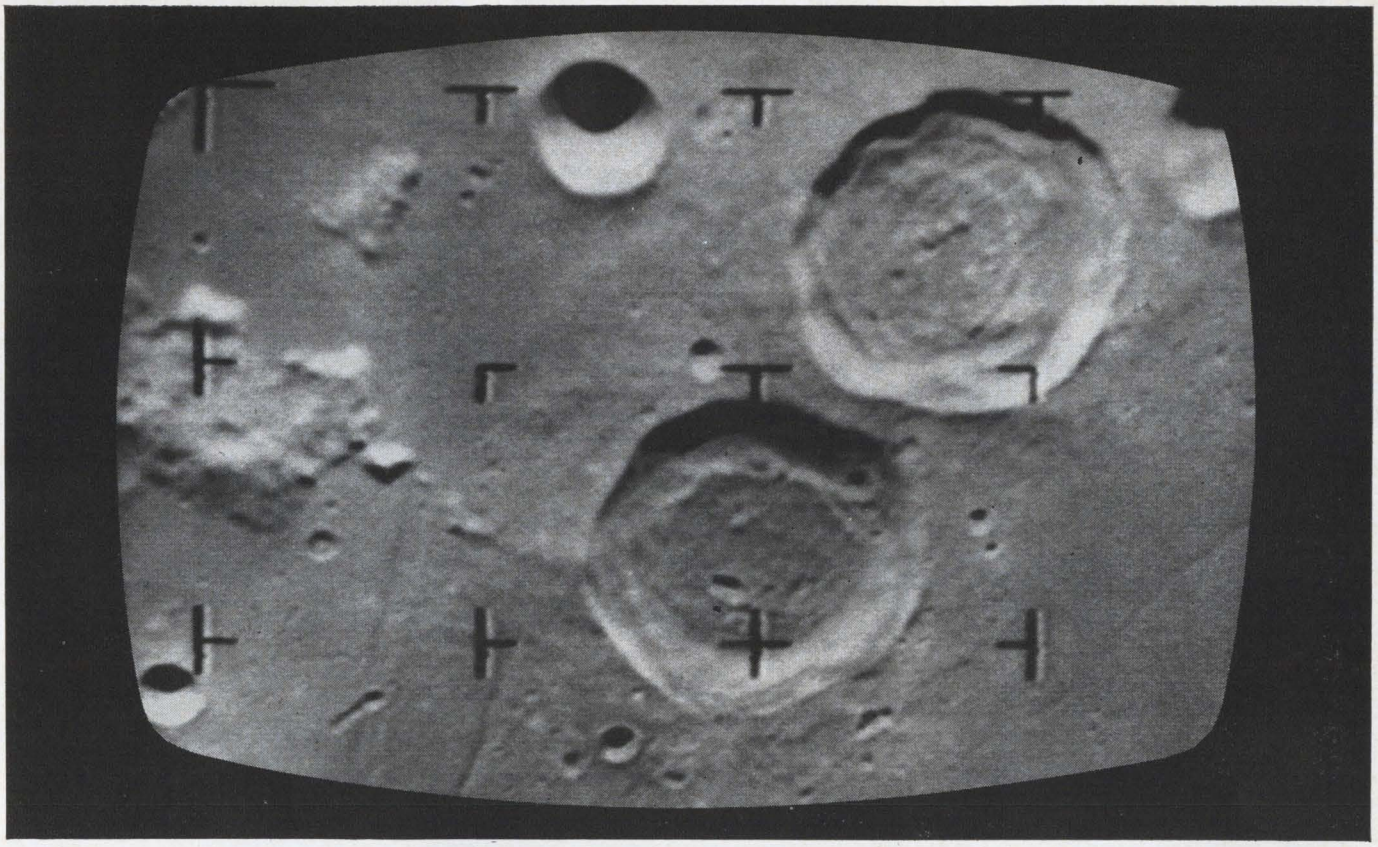
McKee was vice chief of staff of the Air Force until a year ago. Since his retirement from the Air Force, he has worked as assistant administrator of the National Aeronautics and Space Administration.

Gifford Johnson, the new president of the nonprofit Graduate Research Center of the Southwest, is neither an educator nor a scientist. The 46-year-old Johnson is a hard-driving industrialist who served as president of Ling-Temco-Vought, Inc., from 1961 until he resigned last year. His goal, he says, is to further the center's aim of becoming the "MIT of the Southwest."

The major job, he explains, is to lure more top researchers to the center. The institution currently has 70 researchers with doctorates.

Johnson is known by his colleagues as a man who gets a job done, and in doing that job, one associate concedes, "He can be rather snappy with those who work for him."

TV Transmitting Tube For CHANNEL MOON, On Target, On Frequency



The ML-7855 frequency stable Machlett UHF planar triode transmitted all of the moon pictures—sharp and clear—for Rangers 7, 8, and 9. On frequency, and at full power within seconds, the ML-7855 powered TV transmitters have been an outstanding success. In space, in the military service, in the nation's airliners—wherever the highest reliability and performance is required, use of Machlett planar triodes demonstrates the continuing confidence in the capability of the Machlett organization. Whether you require high power/high voltage triodes or tetrodes, UHF planar triodes, X-ray tubes, vidicons, or need assistance in research or design development, write: The Machlett Laboratories, Inc., Springdale, Conn. 06879. An affiliate of Raytheon Company.

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Meetings

Design Engineering Conference, ASME; Coliseum, New York, **May 17-20.**

Society of Photographic Scientists and Engineers Annual Conference, SPSE; Sheraton-Cleveland Hotel, Cleveland, **May 17-21.**

Aerospace Fluid Power Systems and Equipment Conference, SAE; Statler-Hilton Hotel, Los Angeles, **May 18-20.**

Digital Equipment Computer Users Society Spring Technical Meeting, DECUS; William James Hall, Harvard University, Cambridge, Mass., **May 20-21.**

Electronic Reliability Conference, Metropolitan group on Reliability, IEEE; Carnegie Foundation Building, N.Y.C., **May 21.**

Advances in Computing, NYU, ACM, IBM; NYU L. I. Campus, Stony Brook, L. I., **May 21.**

Microelectronics Annual Symposium, St. Louis Section of IEEE; Chase Park Plaza, St. Louis, Mo., **May 24-26.**

International Television Symposium, IEEE/SEV/ASE; Pavillon of Montreux, Montreux, Switzerland, **May 24-29.**

International Federation for Information Processing Congress '65, IFIP/IEEE; New York Hilton, N.Y.C., **May 24-29.**

Armed Forces Communications and Electronics Association Annual Convention, AFCEA; Sheraton-Park Hotel, Wash., **May 25-27.**

Bicentennial Space Symposium and National Conference, NASA, St. Louis Bicentennial Commission; Chase-Park Plaza Hotel, St. Louis, **May 26-28.**

Symposium on Analysis Instrumentation, ISA; Sheraton-Mt. Royal Hotel, Montreal, **May 26-28.**

Cybernation, Automation and Human Responses Annual Conference, ICR; Americana Hotel, N.Y.C., **May 27-29.**

Biomedical Computer Applications Conference, BIO/New York Academy of Sciences; Waldorf-Astoria, N.Y.C., **June 3-5.**

IEEE Annual Communications Convention (Including GLOBECOM VII), CTG/IEEE; University of Colorado, Boulder, Colo., **June 7-9.**

National Electronic Packaging and Production Conference (NEP/CON'65), EPP; Long Beach Arena, Long Beach, Calif., **June 8-10.**

Broadcast and TV Receivers Conference, G-BTR/IEEE; O'Hare Inn, Des Plaines, Ill., **June 14-15.**

Midwest Symposium on Circuit Theory, G-CT/IEEE; Colorado State University, Ft. Collins, Colo., **June 14-15.**

Ocean Science and Ocean Engineering National Conference/Exposition, ASLO, MTS; Washington Hilton Hotel, Washington, **June 14-17.**

Solid State Device Research Conference. IEEE; Princeton Univ., Princeton, N.J., **June 21-23.**

Aerospace Technical Conference and Exhibit, PTGAS/IEEE; Shamrock-Hilton Hotel, Houston, Tex., **June 21-24.**

Joint Automatic Control Conference (JACC), ASME, IEEE, ISA, AIAA, AICE; Rensselaer Polytechnic Institute, Troy, N.Y., **June 22-25.**

Electronic Standards Committee F-1 Meeting, ASTM; Randolph House, Syracuse, N.Y., **June 23-24.**

Fluid Mechanics & Heat Transfer Symposium, USAF, Lockheed Co.; Lockheed Research Labs, Palo Alto, Calif., **June 24-25.**

Summer Power Meeting, G-P/IEEE; Detroit, Mich., **June 27-July 2.**

Electromagnetic Compatibility National Symposium, G-EMC/IEEE; Waldorf-Astoria Hotel, New York, **June 28-30.**

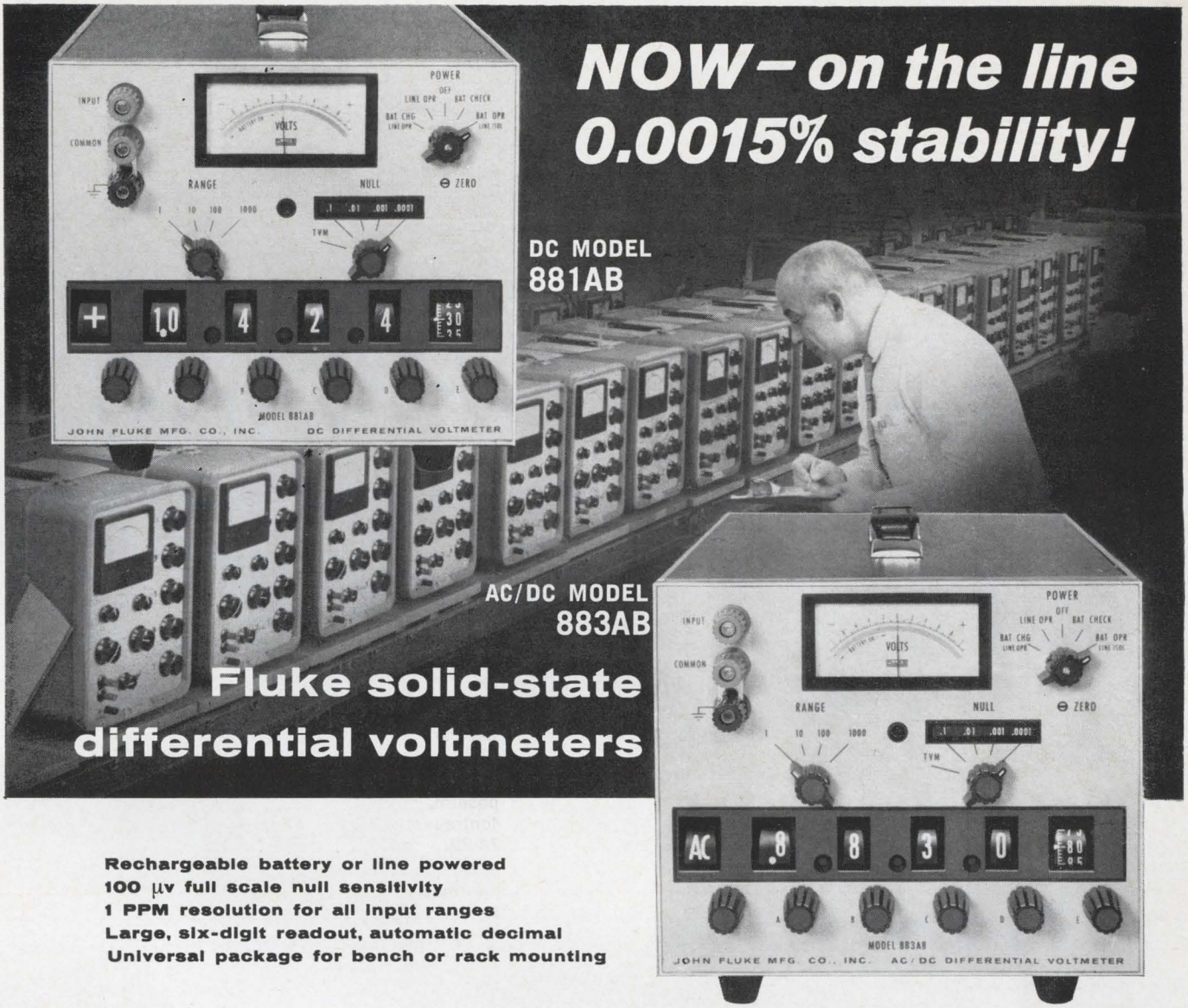
Physics of Quantum Electronics Conference, ONR; San Juan, Puerto Rico, **June 28-30.**

International Data Processing Conference and Business Exposition, DPMA; Benjamin Franklin Hotel and Convention Hall, Philadelphia, **June 29-July 2.**

Microwave Applications of Semiconductors Meeting, IERE-IEE; University College, London, **June 30-July 2.**

Call for papers

Engineering in Medicine and Biology, IEEE, ISA; Sheraton Hotel, Philadelphia, Nov. 10-12. **August 15** is deadline for submission of 1200-word abstracts to Dr. Peter D. Edmonds, Moore School of Electrical Engineering, Univ. of Penn., Philadelphia 19104.



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"B" suffix of model number indicates operation from either rechargeable batteries (30 hours on full charge) or AC line (50-440 cps). Severe common mode problems are eliminated by battery operation, as unit is completely isolated from line.

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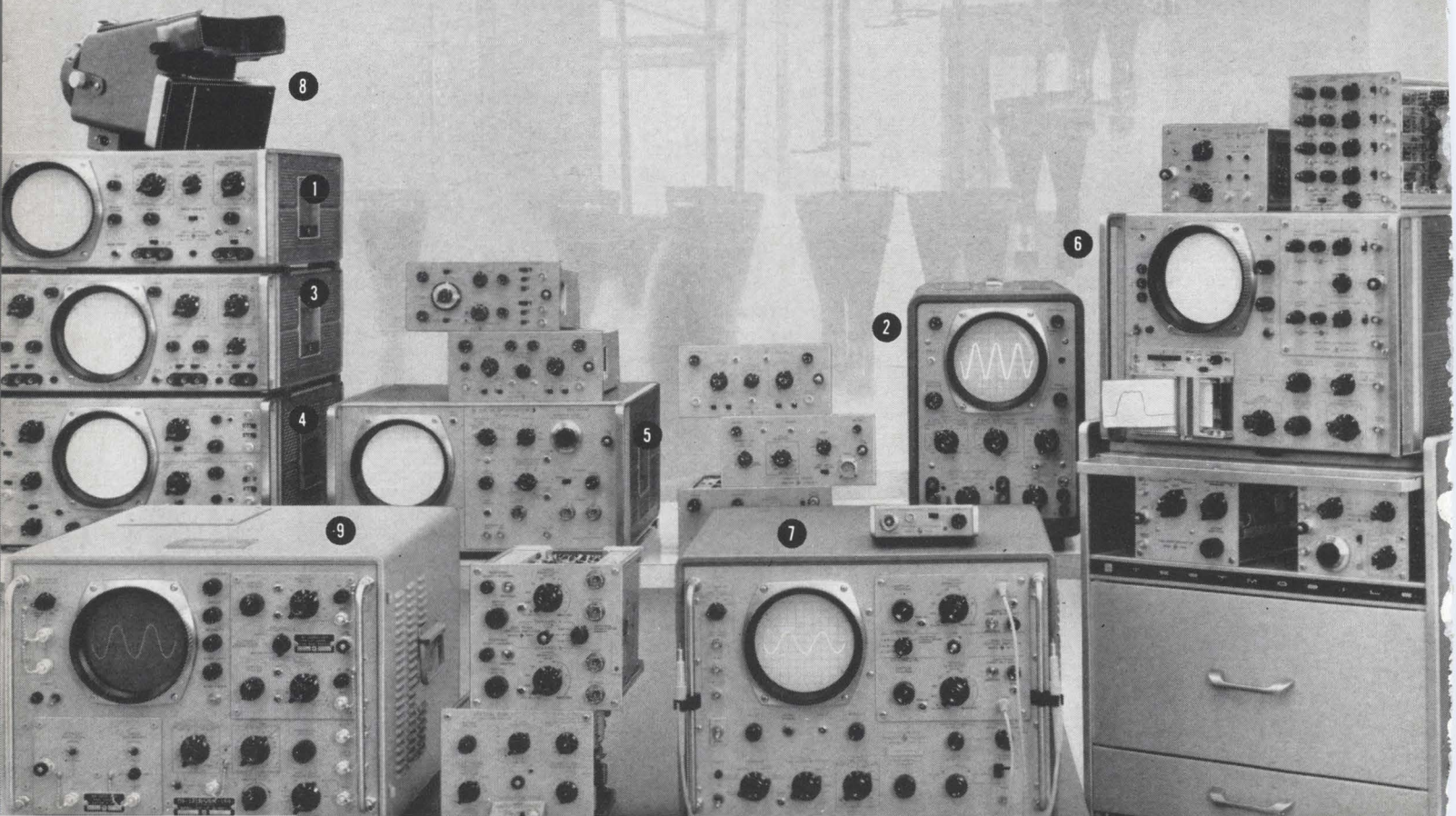


Performance, value from your Hewlett-Packard Oscilloscope:

4000 mc bandwidth—''State-of-the-art'' bandwidth is yours with the hp 185B Sampling Scope. With 185B bandwidths to 4000 mc (90 psec rise time) at sensitivities to 1 mv/cm, more than any other scope offers, you can measure fast switching characteristics or cw signals directly. The hp-developed bridging sampler lets you measure signals in your circuit without disturbing the signal. With the 185B, you get plug-in versatility, too. The specs tell the story.

Dual-beam versatility—With two completely independent horizontal deflection systems, the 132A Dual-Beam Scope lets you view signals on different sweep speeds for measuring fast and slow phenomena simultaneously or observe phase on one channel while looking at a rate function on the other. Add to this unique capability 100 μv/cm sensitivity vertical amplifiers with 92 db common mode rejection, plus a 5 mv/cm horizontal amplifier. Or look at the hp 120B, 122A or 130C. The 120B and 122A, with 10 mv/cm sensitivity, are ideal for production, systems or lab work where high reliability and low cost are important. The 130C, with 200 μv/cm identical vertical and horizontal amplifiers, permits phase measurements of small signals, plus a host of other uses.

Time domain reflectometery, 20 mc bandwidth, or 10 μv/cm sensitivity—These are performance capabilities of the hp 140A Scope . . . all of them possible with 140A plug-ins. Here's the most versatile scope available today, offering the ability to use either two single-size plug-ins or one double-size. With the 1415A Time Domain Reflectometer, a double-size plug-in, you can locate and analyze discontinuities in cables, connectors and other broadband devices, saving time and providing more information than with the vswr approach; with single-size plug-ins you can have 20 mc bandwidth with 5 mv/cm sensitivity or 10 μv/cm sensitivity at 400 kc bandwidth. Other plug-ins available, too.

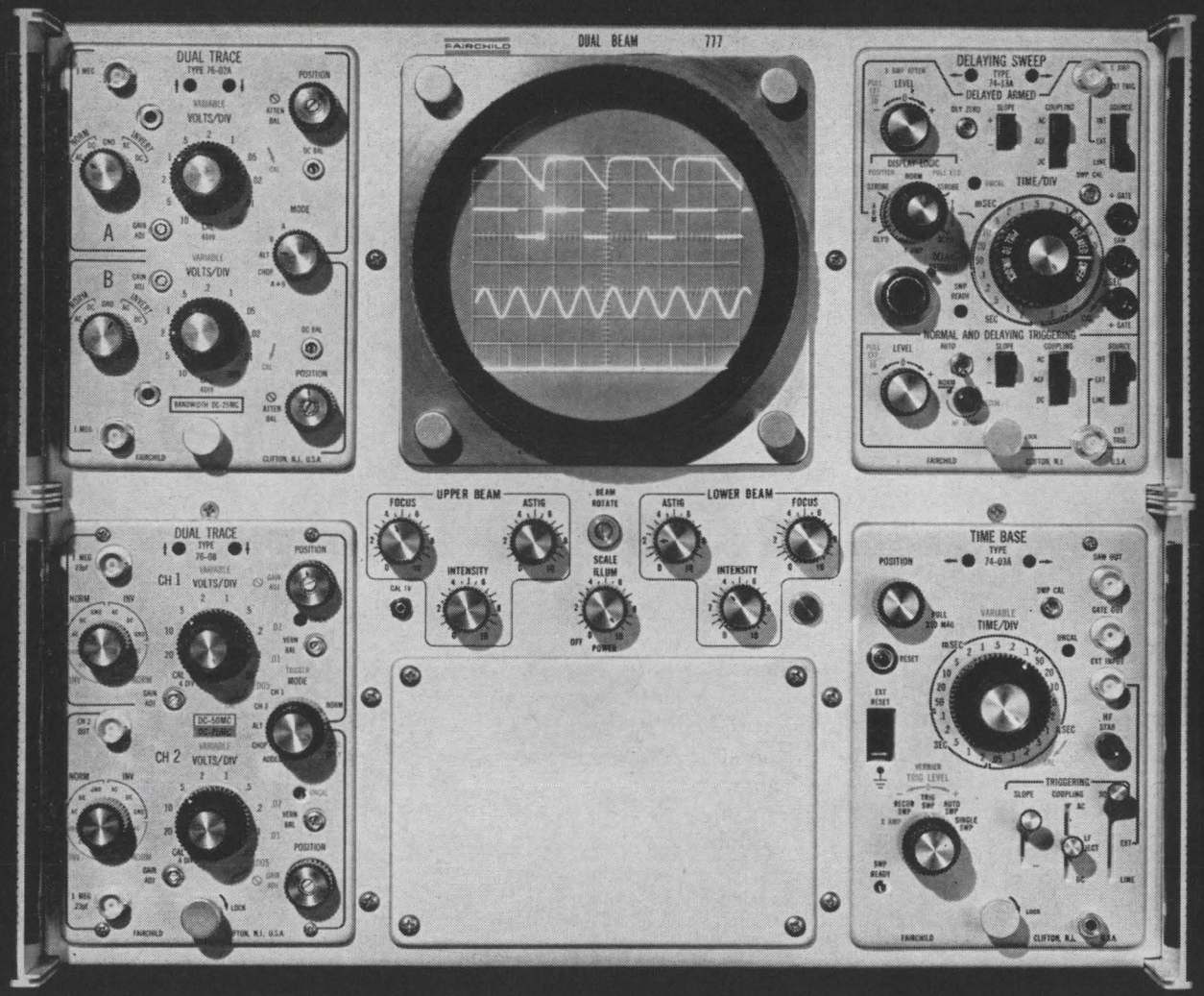
Dual-channel, 1 mv/cm, 50 mc, recorder plug-in—Exclusive performance features make the 175A your best high-frequency scope buy. With the new 1755A plug-in, you can have 1 mv/cm dual-channel performance with 20 mc bandwidth or 50 mc bandwidth at 10 mv/cm and up. Or where more channels are needed, consider the 1754A Four-Channel Plug-in, with 40 mc bandwidth. The 1784A Recorder Plug-in simplifies trace recording by providing a strip-chart record of the crt trace, simply by pushing a button. Other unique plug-ins include a trace scanner for driving an external x-y recorder, sweep delay generator with mixed sweep, and time mark generator.

Hewlett-Packard has a scope just right for your needs. Check the performance and price in the table, then call your hp field engineer for complete information. Or write for data to Hewlett-Packard, Palo Alto, California 94304, Telephone (415) 326-7000; Europe: 54 Route des Acacias, Geneva; Canada: 8270 Mayrand St., Montreal.

HEWLETT hp PACKARD
An extra measure of quality

	Model	Channels	Bandwidth	Sensitivity	Price
1	120B	one	dc to 450 kc	10 mv/cm to 10 v/cm	$ 495
2	122A	two	dc to 200 kc	10 mv/cm to 10 v/cm	$ 695
3	130C	one	dc to 500 kc	200 μv/cm to 20 v/cm	$ 695
4	132A	two (dual beam)	dc to 500 kc	100 μv/cm to 20 v/cm	$1275
5	140A	Versatile plug-in scope; accepts either two single-size or one double-size plug-in; regular time base available at $325; $625 with sweep delay; also accepts 1415A Time Domain Reflectometer for analyzing discontinuities in cables, connectors, strip lines, other broadband devices, $1050			$ 575
	1400A	one	dc to 400 kc	100 μv/cm to 20 v/cm	$ 210
	1401A	two	dc to 450 kc	1 mv/cm to 10 v/cm	$ 375
	1402A	two	dc to 20 mc	5 mv/cm to 10 v/cm	$ 550
	1403A	one	0.1 cps to 400 kc	10 μv/cm to 100 mv/cm	$ 475
	1405A	two	dc to 5 mc	5 mv/cm to 10 v/cm	$ 325
6	175A	50 mc plug-in scope accepts vertical and time base plug-ins; regular sweep plug-in $25; sweep delay, $325; other plug-ins include strip-chart recorder, trace scanner and time mark generator			$1325
	1750B	two	dc to 50 mc	50 mv/cm to 20 v/cm	$ 325
	1751A	one	dc to 50 mc	50 mv/cm to 20 v/cm	$ 160
	1752A	one	dc to 22 mc	5 mv/cm to 20 v/cm	$ 225
	1752B	one	dc to 40 mc	5 mv/cm to 20 v/cm	$ 285
	1754A	four	dc to 40 mc	50 mv/cm to 20 v/cm	$ 595
	1755A	two	dc to 50 mc, 10 mv/cm to 5 v/cm dc to 20 mc, 1 mv/cm	1 mv/cm to 5 v/cm	$ 575
7	185B	Sampling plug-in scope; Model 186A Switching Time Tester plug-in for diode and transistors also available at $1700; Model 1103A Trigger Countdown extends 185B triggering to 10 gc			$2000
	187C	two	dc to 1000 mc (0.35 nsec rise time)	1 mv/cm to 200 mv/cm	$1250
	188A	two	dc to 4000 mc (90 psec rise time)	1 mv/cm to 200 mv/cm	$1500
8	196B	Oscilloscope camera for photographing both internal and external graticule crt, 196A for external graticule crt's only, $395			$ 445
9	170B	Rugged, militarized scope; regular sweep plug-in, $35; sweep delay, $435			$2350
	162C	two	dc to 22 mc	20 mv/cm to 20 v/cm	$ 420

Data subject to change without notice. Prices f.o.b. factory.



HOW MANY SCOPES CAN THIS ONE REPLACE?

A sizeable number, depending upon the range of applications. For this is the Fairchild 777—the most versatile of all industrial scopes. The 777 is a dual beam, dual trace scope in which any four of 20 plug-ins are completely interchangeable in both X and Y cavities. These are the same plug-ins that fit all Fairchild 765 Series scopes. They include DC-100 mc bandwidth, spectrum analyzer and raster display capabilities, sensitivity to 500 μv/cm, risetime to 3.5ns. Other features of the 777 include 6 x 10 cm display area for each beam with 5 cm overlap between beams for optimum resolution... unique 13 kv CRT with four independent deflection structures... solid state circuitry (with all deflection circuitry in the plug-ins)... light weight (44 lbs.). Environmentalized for rugged applications. Price of the 777 main frame: $1,600. The 777 illustrates the Fairchild concept of value through versatility. It helps you beat the high cost of T.O.—Technological Obsolescence. One scope doing many tasks is only part of it. Future state-of-the-art capability is equally important. And service. Fairchild has more service centers than any other oscilloscope manufacturer. Ask your Fairchild Field Engineer in your area for details on this and other new generation Fairchild scopes. Or write for technical data sheet to Fairchild Scientific Instrument Dept., 750 Bloomfield Avenue, Clifton, N.J.

BEAT T.O.* WITH FAIRCHILD

*Technological Obsolescence

FAIRCHILD

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SCIENTIFIC INSTRUMENT DEPARTMENT

Editorial

Confidence in Defense?

When President Johnson went before Congress to ask for an additional $700 million appropriation to finance the fighting in Vietnam, he confirmed what almost all the experts in Washington have been saying [Electronics, May 3, p. 17]. The exception has been Defense Secretary Robert S. McNamara.

Asked at a press conference on April 26 if more equipment would be bought for the stepped-up fighting in Vietnam, McNamara's answer was unequivocal. "We don't have plans to increase procurement above the previously established level," he said.

Eight days later, the President asked for the additional $700 million "for this fiscal year" and laid out a program that indicated that the Pentagon had done considerable homework.

Either the defense secretary was uninformed, or he was lying. In either case, the incident again raises a question that has bothered people in and out of government since McNamara was first sworn in: is this pompous egomaniac qualified to be a cabinet officer?

It is becoming increasingly obvious that our government has not been telling us everything. Less than two years ago, McNamara was issuing statements of confidence on Vietnam. He even predicted that our troops would be out of that jungle country in 18 months. These rosy statements don't mesh with the increased flow of troops into Vietnam these days or the losses of aircraft and life we keep reading about.

McNamara has certainly been one of the most publicized defense secretaries, partly because he is a controversial figure and partly because he has the biggest staff of public relations agents.

Certainly he has imposed his will on the Pentagon, picking projects that he wanted and contractors that he favored; but the jury is still out on how much he has saved—or cost—the taxpayers in dollars and military strength. Indications from Vietnam are that our troops there have had mediocre communications equipment and outmoded aircraft. The mounting casualty list is indeed a high price to pay for statistically-controlled economy.

The difficult Vietnam war is complicated by political considerations. To bring the fighting to a satisfactory conclusion, the President needs the support of Congress, industry, and the taxpayers.

We wonder if they can give their full support if their confidence in the secretary of defense is shaken.

Early Bird's song

Ever since the Communications Satellite Corp. started commercial operations with its Early Bird Satellite a few weeks ago, the world has been treated to a powerful demonstration of what this method of communications can do. And the surface has just been scratched. It now seems clear that communications satellites will untie the bonds that have held back some other electronic developments, such as facsimile.

Early Bird has supplied anyone within its transmission area a front row seat on the world.

A New Yorker has watched, from his living room, East German Vopos hunt a would-be emigrant who tried to cross the Berlin wall. The unscheduled escape was seen live, as it unfolded. A Londoner has turned on his "telly" and watched a policeman patrol the crime-ridden subways of New York.

Seeing the news happen can increase its impact. More significantly, reliable communications between opposing sides could prevent a confrontation which could destroy civilization.

Each of these contributions is wonderful enough to justify communications satellites, but to the electronics engineer, the most significance may lie in the unlocking of restrictions on some other developments.

For example, for years people have been predicting a bright future for facsimile, and its use is indeed growing. But since facsimile requires tremendous bandwidth, it is expensive to transmit over long distance telephone lines or cables. The satellite may resolve that problem.

To take advantage of these capabilities will require a stepup in the development of facsimile equipment. Better and more compact transmitters and receivers are required, for noise can make facsimile copy unreadable. The cost of the terminal equipment has to be reduced, too.

With such improvements, mail will be transmitted overseas by facsimile, and important business mail will be moved that way in the U.S. Most people agree that conventional mail is too slow these days, when events move so quickly and decisions are made so fast.

Performance

that speaks for itself

System Accuracy: ± 0.071% RMS

Total Rotor Null: 0.2 mv/volt

Signal to Noise Ratio: 74 db min.

Components Interchangeable
without losing system accuracy

Clifton Amplifier-Resolver Combination

Let's skip the hot air and talk about the performance of this "state-of-the-art" Amplifier-Resolver Combination built for military airborne use.

This Combination is designed for systems requiring interchangeability of resolver or amplifier without adjustment or trimming. System accuracy of ±0.071% RMS is obtained under any combination of voltage, temperature, and frequency within the given ranges. Voltage range is 0 to 26 VRMS. Frequency range: 380-420 cps. Temperature range −25°C to +95°C. Input impedance is 100 k ohms ± 1%. Total rotor null is 0.2 mv/v of input and fundamental nulls are .05 mv/v. Interaxis error is 3 minutes maximum. Calibration error, 2.5 minutes max. The ratio of the actual output voltage to the undesired output voltage at 20 volts level is 74 db min.

The Resolver is a compensated Clifton Size 11 with the stator as the primary winding. Stator tuned impedance 13.8 k ohms. Stator nominal Q—6.1. Rotor peaking frequency: 40 kc minimum. Weight is 5.5 oz. maximum. Temperature range −55°C to +125°C.

The Dual Channel Booster Amplifier is 1.84" x 1.63" x .75". Power requirements +30 VDC ±2 VDC @ 25 ma. max.; −30 VDC ±2 VDC @ 35 ma. max. Ripple 10 mv max. Weight 2.5 oz. Temp. range −55°C to +125°C. A single channel amplifier 1" x 1.63" x .75" is also available.

'Nuff said? For price and delivery contact any of our sales offices or representatives. Clifton Precision Products, Division of Litton Industries, Clifton Heights, Pa., Colorado Springs, Colo.

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DIVISION OF LITTON INDUSTRIES

Electronics Newsletter

May 17, 1965

Ground stations at half price

Successful satellite communications are opening a multimillion-dollar market in ground stations for countries that aren't ready to build their own. **In a move to tap this new market, Page Communications Engineers, Inc., a subsidiary of the Northrop Corp., has introduced a $500,000 ground station that's a bobtailed version of the American Telephone and Telegraph Corp.'s huge station at Andover, Maine.**

Page says stations of comparable signal-receiving ability cost about $1 million.

Epitaxial process may shrink computer modules

A new epitaxial process for making ferromagnetic oxide films may sharply shrink designs of microcircuit computer modules. With the process, developed by the Autonetics division of North American Aviation, Inc., **computer memory banks can be designed to operate at lower power levels than ever before. The memories can be driven directly by integrated circuits;** unlike most computers, they won't need power amplification.

In the Autonetics process, single crystals can be grown around a polycrystalline conductor for the first time. Autonetics engineers have been able to grow a crystal five mils thick with a gold wire running through its center. There is perfect contact between the current-carrying element and the magnetic material. Since this also results in a completely closed flux loop between them, **lower switching currents and higher signal outputs are possible.**

Within 18 months, Autonetics expects to batch-fabricate epitaxial ferrite memory devices in subsystems.

Color tv: demand outstrips supply

Despite sharp gains in production, about 300,000 people who want to buy color television sets this year won't be able to get them. The Radio Corp. of America says the industry's production of color tubes is expected to fall that far short of the demand. Earlier this year, sales of color tv sets was estimated at 2.6 million in 1965.

RCA, which produced 85% of the color tubes in the United States last year, announced early this month that it will start to ration color tubes to other set makers, because its own needs have outpaced production.

The other tube manufacturers—the National Video Corp.; Sylvania Electric Products, Inc., a subsidiary of the General Telephone and Electronics Corp.; and Rauland Corp., a subsidiary of the Zenith Radio Corp.—are not expected to be able to make up the difference.

Other companies are getting ready to enter the field. The General Electric Co. announced recently that it was going to begin manufacturing tubes. The Admiral Corp. said it was building a $12-million plant, and production should begin by year's end.

6-wheel GI truck runs by electricity

An electrically powered 6-by-6 truck that may be the forerunner of a new breed of quiet, exhaust-free commercial vehicles will be unveiled later this month by the Army. Each of the truck's six wheels is driven by a small 20-horsepower a-c motor. The Army says the vehicle consumes 33% less fuel than comparably sized conventional trucks.

Power to the wheels can be adjusted independently for speed and

torque, so the truck can be maneuvered like a tractor through mud or over rough terrain. The driver adjusts wheel power through silicon controlled rectifier static converters. The truck has been under test for a year by the Army's Tank Automotive Command and by Lear Siegler, Inc.

Although electricity for the test model is generated by a gasoline engine, an Army team at Fort Belvoir is experimenting with hydrocarbon-air fuel cells, which may save even more fuel.

Orbiting sphere is radar standard

A large, hollow aluminum ball was fired into orbit last week to finely calibrate high-power ground radars and satellite communications terminals. The 75-pound sphere, 44½ inches in diameter, soared into space on a Titan 3-A rocket. It rode piggyback with an 80-pound experimental military communications satellite, called LES-2, designed by the Lincoln Laboratory of the Massachusetts Institute of Technology.

LES-2, an acronym for Lincoln Experimental Satellite, is almost a duplicate of LES-1, which was orbited earlier this year [Electronics, Feb. 22, p. 50], but accidentally ended up in the middle of the Van Allen radiation belt. **LES-2's experiments will test the effectiveness of communications in the X-band frequencies, 8,000 megacycles.**

Radar equipment on earth sees the sphere as a target with an area of one square meter, the conventional unit for measurement of radar backscattering cross-section. It is, therefore, a radar measurement standard in orbit, the first of its kind. Because of its shape, it reflects radar echoes uniformly. All other satellites now in orbit are nonspherical and produce echoes that fluctuate widely in strength.

The sphere is also expected to provide additional information about the shape of the earth's gravitational field.

Army testing 50 kw solid state radio

Next week, the Army will begin tests on the most powerful solid state radio transmitter and receiver system ever built. The transmitter, which produces 300 kilowatts peak and 50 kilowatts average output, is the first system of its kind to meet the stiff specifications of the Defense Communications Agency. The system is fully transistorized except for the final amplifier.

Comparably powered vacuum-tube radios were about twice the size of the new gear, which was developed by the Westrex Communications division of Litton Industries, Inc.

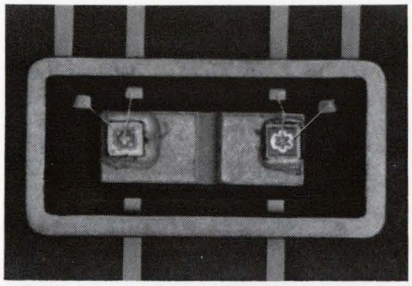
The Westrex equipment, which broadcasts at 2 to 30 megacycles, is versatile as well as powerful. It can simultaneously transmit up to 64 teletype channels; or it can simultaneously send 16 teletype channels, a facsimile channel, a voice channel and 2,400 digital bits of data.

Better laser for communications

Scientists at Bell Telephone Laboratories are said to have produced a gas laser with an output of more than 1.5 watts at a wavelength between 10.5 and 10.7 microns. **The wavelength is called ideal for communications, because it's attenuated relatively little by water vapor or other elements in the atmosphere.**

This month, la Societe Anonyme de Telecommunications in France announced it had produced an output of 1.5 watts in about the same wavelength. **Alan P. Truffer, head of their laser project, said larger versions of the laser should produce 10 watts soon.** The tube contains nitrogen, carbon dioxide, argon and oxygen.

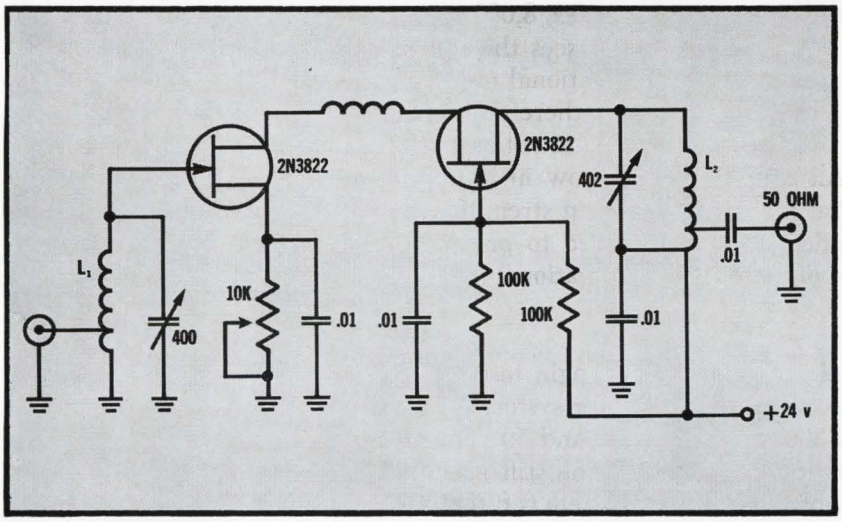
Look to Deeco for fast service on these new small-signal TI semiconductors



Now — complementary transistors in flat package

A new dual silicon transistor offers complementary NPN and PNP active elements in a single flat package. The new device, known as the 2N3838, is now carried in stock. It makes possible smaller high-reliability circuitry including complementary flip-flops and complementary amplifiers.

This new device is one of a rapidly-expanding line of "compatible components" — especially designed to be electrically and mechanically compatible with integrated circuits*. Ask us for a file of compatible component data sheets in a miniature form.



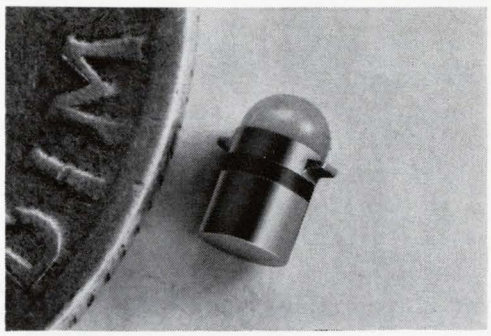
N-channel FET's provide low-noise amplification beyond 200 mc

You can improve RF amplifier performance by using new TI N-channel field-effect transistors. Two 2N3822's, used in the 200 mc cascode amplifier shown above, gave 12 db gain and only 2.5 db noise at 200 mc. Cross-modulation was less than one percent when a 1000 μv, 200 mc signal and a 200,000 μv, 150 mc signal were combined.

The new series, numbered 2N3821, 22 and 24, offers y_{fs} as high as 3000 min at 100 mc. Noise figure is typically 3 db at 10 cps. Gate leakage current is typically 10 pa, and maximum input capacitance is less than 6 pf. Other advantages include zero offset voltage (in chopper applications) and high input impedance.

We have just received a shipment of these new devices and can offer immediate delivery. Call us.

TI cannot assume any responsibility for any circuits shown or represent that they are free from patent infringement.

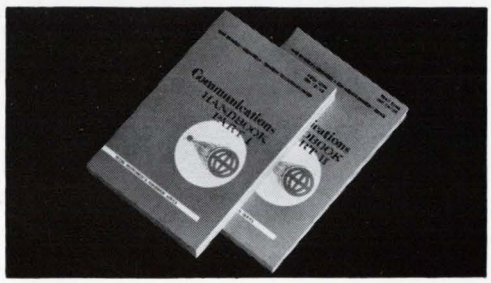


New solid-state light source combines small size and high reliability

The new TIXL01 planar gallium arsenide light emitter gives users of silicon light sensors high efficiency, long life and freedom from the catastrophic failures characteristic of incandescent lamps.

As shown above, the TIXL01 measures only 1/16-inch diameter by 1/10-inch high. Emitters may be mounted directly in 1/16-inch printed circuit boards, simplifying assembly.

We have added these new devices to our stock, ready for immediate delivery. Call us.



Get your new TI Communications Handbook from Deeco

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TIGER TALE #3

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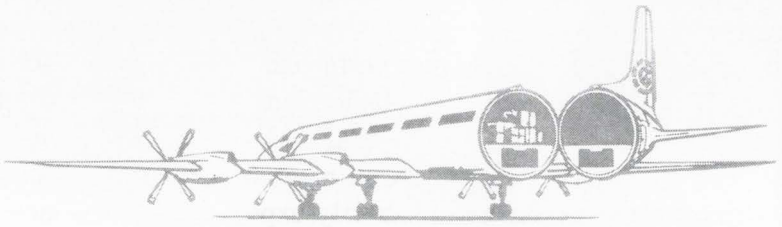


Let Tiger Know-How Show You How!

No matter how you ship now, you owe it to your company to investigate Tigerfreight. Tigers cut total distribution costs and it's the **total** that counts.

Tigers' fleet of CL-44s fly daily coast-to-coast **nonstop.** This kind of fast service means: reduced need for inventories, less capital tie-up, lower taxes on unsold stocks, and savings on financing and handling costs. Entire warehousing operations can even be eliminated.

As these expenses are cut, so is pilferage, theft and spoilage—**all** related to length of time in transit.

Tigers even help you slash costly packaging procedures. Our Swingtail CL-44s easily accommodate cargo without special crating. Tare weight is less. Labor expense of crating and uncrating is cut.

Tigers offer you all these benefits plus low rates. Our new **wholesale** "Blocked Space" rates can save you an additional 15%.

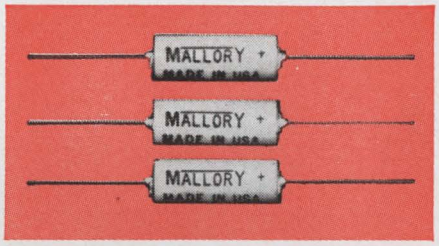
So don't just talk about cutting distribution costs. **Cut 'em!** Call "The Airfreight Specialist." We've got the proof. You can't afford **not** to ship Tigers.

FLYING TIGER LINE

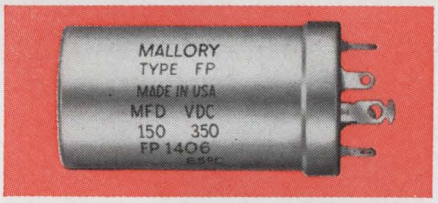
The Airfreight Specialist

When you need entertainment grade electrolytics ...Look at the Mallory line!

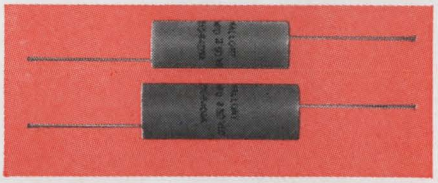
Here's what you'll find. Premium performance in step with—or even ahead of—your own tightened specifications for component quality. Practical designs and low costs that anticipate your own value analysis programs. A broad selection of ratings, sizes and mounting methods are offered and are constantly expanded to keep pace with your requirements.



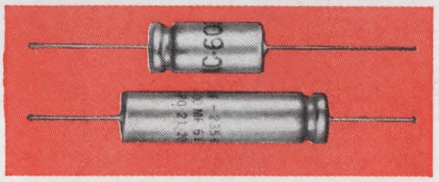
New molded case Type MTA . . . miniature tubulars with outstanding stability and moisture resistance. Now in three case sizes, with ratings from 20 mfd., 50 VDC to 175 mfd., 3 VDC.



Famous FP . . . the original 85°C electrolytic is now better than ever, with higher ripple ratings, lower DCL limits. Sealed aluminum case with vertical twist-prong mounting. Printed circuit Type PFP. Scores of values in singles, duals, triples, quads.

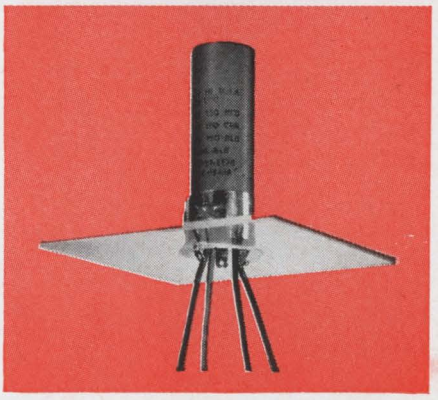


Type TC metal tubulars . . . axial lead type, rated at +85°C operation. New TCW types have improved all-welded construction for low voltage applications.



Miniature metal tubulars . . . Type TT now is available with new electrolytes that extend temperature range to —55°C with good retention of capacitance and ESR values. Ratings from 620 mfd., 3 VDC to 17 mfd., 150 VDC.

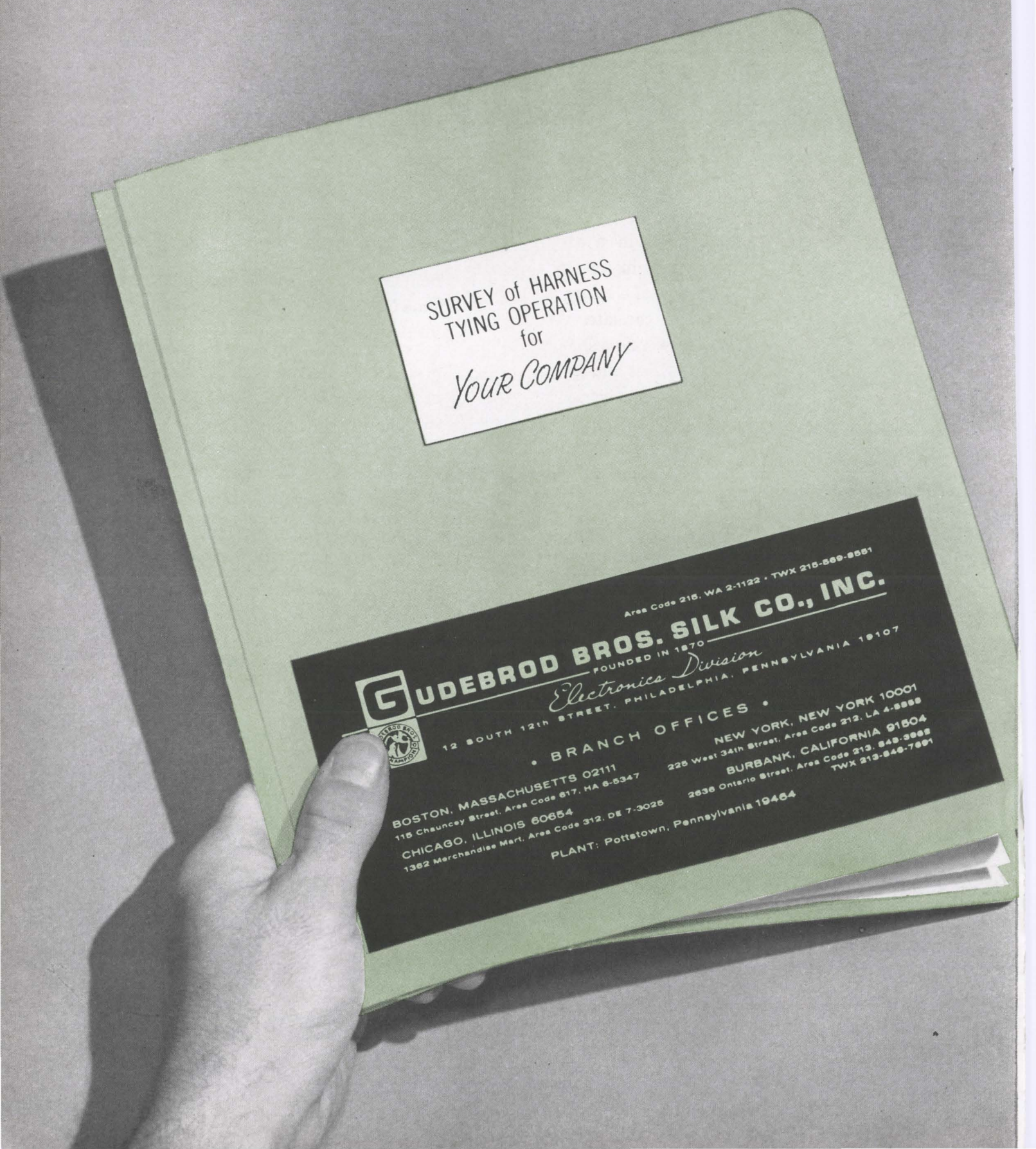
Cardboard tubulars . . . a complete line including new CVM vertical-mount type that snaps into place . . . plus printed circuit types.



For facts and figures, write or call Mallory Capacitor Company, a division of P. R. Mallory & Co. Inc., Indianapolis, Indiana 46206.

MALLORY

CONSIDER YOUR HARNESSING OPERATION . . .



Mr. Executive . . . Would you like to save money while improving the product?

(Take only a minute to read this unique, no cost offer of a survey and report)

There is available at Gudebrod a wealth of experience, gained in a specialized attention to the harnessing of wire cables since the earliest days of electronic equipment. Gudebrod has the latest information on tools and techniques, the latest information on materials and layout, the latest information on government requirements and industry trends. There is no comparable source for such information in the industry. Some companies, in the course of normal business have taken advantage of this Gudebrod experience and knowledge. You, too, can benefit from them. We can recommend ways in which to improve the operation of your harness room—and ways to save money at the same time. Here is what we propose—there are three parts.

First, we arrange, at your convenience, to have a Gudebrod representative make a thorough survey of your harness operation—specifications, methods, materials.

Then, this survey is sent to the Gudebrod Home Office for review by an experienced consultant.

Finally (and most important), a Consultant's Report (as illustrated on the left hand page) is delivered to you. This will contain special, written, confidential recommendations on how *your* harnessing can be improved, how *you* can save money.

With self-interest, Gudebrod believes that by improving the state of the art throughout the industry, they will also improve their own business atmosphere. In your own concern for your company, why not talk to us about a survey of your harness operation—to improve it—to save money? To repeat—you will be involved in no cost or obligation.

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Electronics Division

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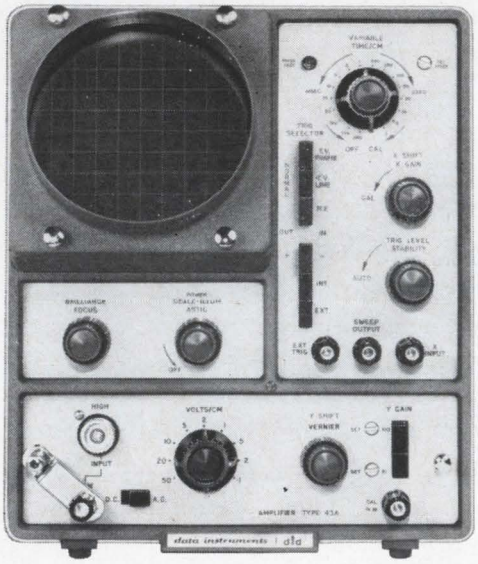

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May 17, 1965

Electronics Review

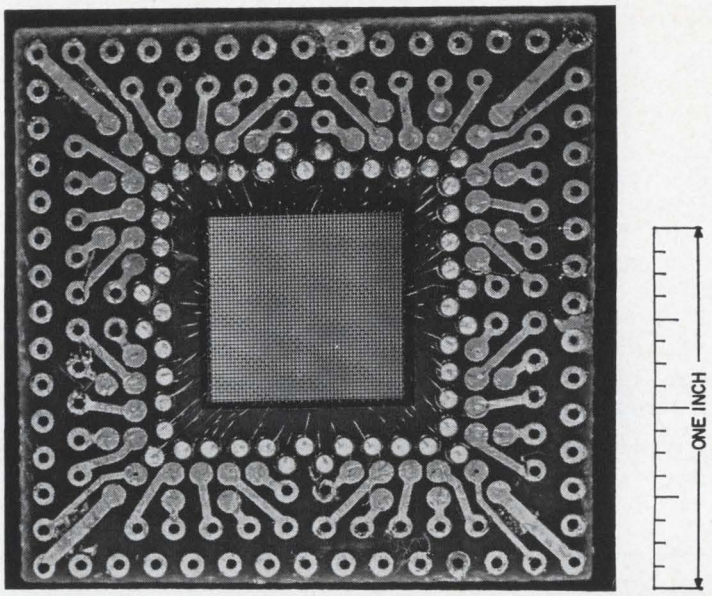
Volume 38
Number 10

Space electronics

No vidicon tube

A matchbook-size solid state television camera may be handling some of the photo assignments when United States astronauts make their trip to the moon. The miniature camera will contain no vidicon tubes and is expected to produce pictures with resolution comparable to that of commercial tv systems.

Crude pictures of moving objects have already been taken with the camera, according to Carl T. Huggins, of the National Aeronautics and Space Administration. However, says the NASA engineer, who is in charge of the project, an operational version is probably still a few years off. The Aerospace division of the Westinghouse Electric Corp. is developing the camera for the space agency.



Tiny television camera developed without vidicon tube uses 2,500 phototransistors as mosaic sensor

2,500 elements. The system developed thus far uses a thin silicon wafer of less than one square inch as a mosaic sensing device. The wafer replaces the vidicon tube of conventional tv cameras and contains 2,500 sensing elements that are switched on digitally by simple counting logic.

Each element is made up of a three-layer phototransistor that controls a current which runs through it. The current, in turn, is modulated by the light that hits each element. Output from each of the elements is stepped up by a video amplifier before transmission.

All the circuitry is in microminiaturized wafers or chips and the power input is four watts and up.

More sensors, less space. Eventually, Westinghouse researchers say, a wafer of about the same size will contain 40,000 sensing elements on its surface. The small number, comparatively, of sensing elements now on the surface leaves wide spaces between each; this is one reason for the crude pictures so far, the engineers explain. The fully developed camera will operate on only ½ watt from a 28-volt power supply and weigh about a third of a pound, including all associated electronics.

Instead of an electron beam to scan each row of sensors, digital logic circuits scan the wafer at 60 frames per second. The scan rate is expected to be slowed eventually to 30, the speed at which commercial tv scans.

Better image. The system produces tv pictures composed of a series of dots rather than lines. With the 2,500-element system, the engineers calculate that the resolution is comparable to a crude 50-line tv system. When the 40,000-element system is perfected, they believe, resolution will be equivalent to 200 lines, about the same as in commercial tv.

Major obstacles will confront the researchers. For one, higher-powered transmitters must be designed to send high-resolution signals over long distances in space. Also, new production techniques must be developed to squeeze the 40,000 elements onto the wafer.

NASA's Marshall Astrionics Laboratory initiated the development of the camera three years ago.

Wanted: Fireflies

A couple of thousand 4-H Club members in Florida are out catching fireflies for the National Aeronautics and Space Administration and shipping them to the agency's Goddard Space Flight Center in Greenbelt, Md.

Scientists at Goddard are developing a life-detection system that uses luciferin, the extract from the tails of fireflies, as the chief ingredient. A big problem, which the Florida youngsters are solving, was the shortage of the extract.

The system works by lighting up when luciferin comes in contact with a compound found in all living things, adenosine triphosphate

(ATP), the same principle that lights a firefly's tail. In a first experiment, the instrument will be sent 100 miles into space with the firefly extract. Energy converted to light and transmitted back to earth will indicate to scientists the presence of microorganisms. NASA scientists believe there are microorganisms at that altitude.

A sensitive photoelectronic system will sense and amplify the light during flight and radio it back to earth. Goddard scientists say the instrument will be able to detect as little as a quadrillionth of a gram of ATP, and evenually hope to reach a sensitivity of one-hundredth of that.

Computers

Self-diagnosis

Computers, which are highly competent at finding defects and prescribing remedies in other systems, are now going in for self-analysis. Circuitry and programing modifications in the newest lines make it possible for a machine to report on a breakdown, say, in a particular printed circuit card—and even suggest the cure, such as replacement of the card.

Such self-diagnosis is being built into computers made by the International Business Machines Corp., the Burroughs Corp. and the Sperry Rand Corp. The savings, for either the customer who owns a machine or the producer who rents it out, can be substantial, because down time for a computer that costs several hundred thousand dollars amounts to a few hundred dollars an hour.

In the IBM System/360 and the Burroughs B5500, a small amount of additional circuitry has been installed, and special programs written to speed up the process of finding and correcting a defect. Sperry's Univac 1108 accomplishes similar results with programing techniques only and no additional hardware.

Isolated areas. In principle, the techniques for self-diagnosis utilize special test programs that put the computer through all its paces. Each part of the program is designed to test generally isolated areas of the computer. If an area is found to contain a defect, the computer is told to look with more detail until the specific faulty circuit card or component is pinpointed.

In the System/360 the objective was to reduce unscheduled maintenance time. The design requires that at least 3% to 10% of the computer be working properly for it to report back the nature and location of its fault. In the B5500, however, at least 15% to 20% of the computer must be functioning correctly for it to act as its own doctor. In both cases, the diagnostic tests are run only when the operator gets a clue that something is wrong.

Sperry, which was concerned with preventive maintenance time, took a slightly different approach. The Univac 1108 executive program runs a confidence check on circuits whenever the machine has a few seconds to spare—for instance, while a tape is being changed.

If a defect is detected, the computer tries the circuit a second time the next chance it gets. If the fault is still there, the machine stops and reports the defect to the operator. But if the defect isn't found on the second check, the computer notifies the operator to analyze the transient fault later.

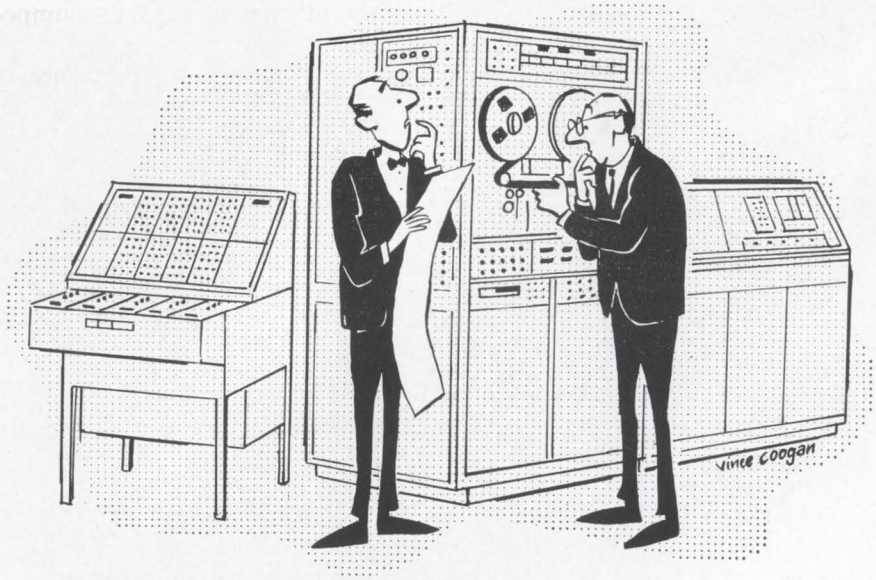
Solid state

An aid for radar

Solid state delay lines may soon be in radar systems if the rapid pace of their development continues. The devices could eliminate bulky coiled-up coaxial cable in some instances, or they might replace special circuits that introduce delays by lowering microwave frequency to an intermediate frequency.

When the Sperry Rand Research Center in Sudbury, Mass., last month announced a device that amplifies as well as delays [Electronics, Apr. 19, p 17], one reaction was: "It would be fine if it weren't restricted to X band and didn't need a cryogenic environment."

A bit warmer. This month, at the Sperry center, researchers did succeed in getting amplification



"The computer says it has a hysterical paralysis in circuit 403B2X, brought on by an Oedipal fixation on a vacuum tube. It wants an analyst who knows Fortran."

plus delay at frequencies below X band and without the cryogenic temperatures. In separate experiments reported last week, they found a technique to make signal delay continuously variable from zero to 50 microseconds—without net gain in this case, but without attenuation either; this work was done at X band, using a liquid helium environment.

Signal delay is an essential feature of some radars. In doppler systems, for example, a delay line momentarily remembers the original, or reference signal. In electronic countermeasures, a variable delay line in a warhead generates phantom radar echoes to mask its true signature, or the warhead's delay line remembers the frequency at which it was detected and shifts the frequency of the return signal. And the pulse-compression technique developed in the 1950's requires delay lines to make the broad frequency-modulated return signal appear at the receiver as a narrow pulse.

Too big. Delay lines, however, are big and bulky. They attenuate signals at the higher frequencies. Usually, the signals are so severely attenuated in the delay process that they must be reamplified to usable levels.

In the Sperry device, the delay function is accomplished with a half-inch-long crystal of yttrium iron garnet. The slowed-down signals are not attenuated by the YIG crystal; the device, in fact, amplifies them while performing the delay function. The solid state unit is a combination of variable delay device and parametric amplifier.

Richard W. Damon and Herman van de Vaart, the developers, have begun testing similar devices for lower frequencies in L and S bands. Only preliminary work has been done at the lower frequencies, but it appears that liquid helium temperatures aren't needed. The liquid helium cooled X band delay line produced a 35-decibel net gain of delayed signals at 8,700 megacycles. The low-power X-band input to the YIG rod was pumped with a signal at twice the frequency —17,400 megacycles.

A big boost. In the initial experiments, a pulsed X-band signal in the nanowatt range was put into the YIG rod. Acting as its own transducer, the YIG converted the X-band input into magnetoelastic waves—a combination of spin waves and sound waves. At the opposite end of the rod the K_U-band pump signal was applied at approximately 100 watts of power to amplify the slow waves parametrically. Delayed 5 to 15 microseconds by the rod, the waves were converted again to X-band pulses and displayed on an oscilloscope with a trillionfold amplification.

The Sperry scientists reported that the device demonstrated at least 4 to 5 Mc bandwidth at the peak X-band amplificaion.

A magnetic field almost parallel to the axis of the YIG rod determined the length of the delay. A change of 20 gauss in the field resulted in a one microsecond change in delay. In the more recently developed technique, delay is varied by changing the time interval between the input pulse and the pump pulse. The delay time of the echo is always twice the delay between the input pulse and the pump pulse. There is no net gain of the delayed signal. Damon and van de Vaart point out that this behavior is quite different from that of parametrically pumped magnetoelastic waves, for which the delay time is determined by the applied magnetic field strength. They attribute the recently observed behavior to parametric excitation of traveling spin waves.

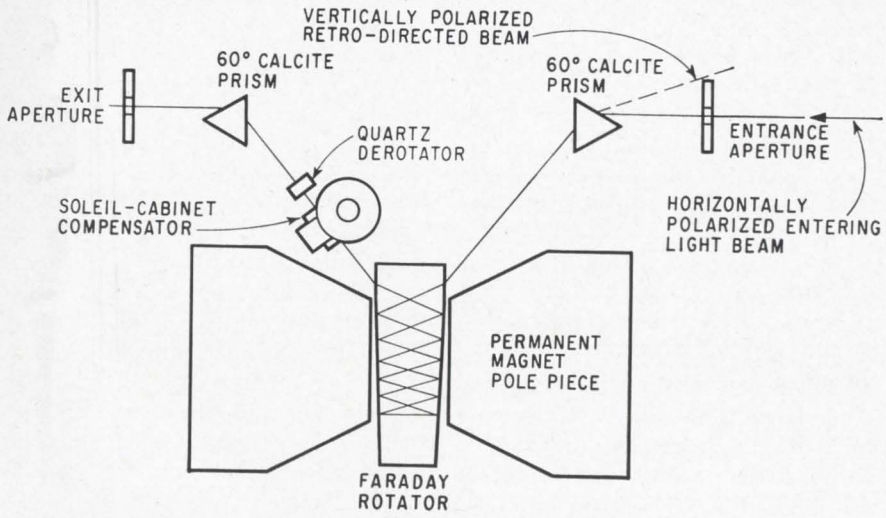
Advanced technology

Laser radar

A new type of laser amplifier, which boosts the power of a laser pulse four times by a factor of 50, for a total amplification of 6¼ million, and then adds even further amplification, will be tested this summer by the Air Force. It will form part of the first high-powered, coherent optical radar system, which will go into operation in about two years.

The amplifier is contained in a system called MOPA by its designers, Electro-Optical Systems, Inc., of Pasadena, Calif. MOPA, an acronym for Master Oscillator Power Amplifier, is made up of a continuous-wave laser oscillator, a modulator, and optical circulators and amplifiers. The Air Force will add a final amplifier to the system.

The first two amplifiers are double-pass and will produce the 6¼ million amplification. Two more single-pass amplifiers will be added; final output power and



Optical circulator will be used in high-powered laser radar system developed by Electro-Optical Systems, Inc.

range are classified. The Air Force will add a fifth amplifier later.

The second two amplifiers are not double-pass because the beam's amplitude is so great by the time it reaches them that they become saturated, and would not amplify on a second pass.

Because the optical radar will operate at a frequency about 1,000 times as high as microwave radar, its resolution will be higher. A microwave antenna array the size of a football field has only one tenth the directivity of a four-inch lens or mirror for a laser radar.

Back and forth. MOPA's oscillator output is pulsed by a Kerr cell modulator. The pulsed beam enters a circulator that directs it through an amplifying laser. As the beam leaves the laser, it is turned around and sent through again. On each pass, the pulses are amplified 50 times. The beam then goes to a second circulator-amplifier combination, which performs another double pass.

The oscillator is an yttrium-aluminum garnet rod doped with neodymium. It is pumped by two iodine-cycle tungsten-filament lamps, in an elliptical cavity with reflecting walls. The laser's output wavelength is 1.06 microns, or 3 x 10^{14} cycles per second.

The modulator, a nitrobenzene Kerr cell with crystal polarizers, shapes the output into pulses that are nearly square. A fast-rising pulse with a flap top is best for obtaining range and doppler range-rate data with the radar, according to EOS.

Optical Circulator. The key to the amplification technique is the optical circulator (see diagram, p. 27). The horizontally polarized beam is deflected by the first prism into the Faraday rotator, which turns the polarization 45° clockwise. When the beam leaves the rotator, it is slightly elliptical. This is corrected by the Soleil-Babinet compensator. The derotator restores the beam's horizontal polarization, and it goes through the second prism into the amplifier. On the return trip from the amplifier, it retraces its steps through the rotator. The changes in beam polarization add up instead of canceling each other out. Polarization becomes vertical, so that the beam is deflected by the right-hand prism to a new direction, and goes into the second circulator.

The beam strikes a Brewster angle on the entrance end of the amplifying rod and is turned to travel parallel to the rod's centerline. As it traverses the rod, it is pumped up by xenon flashtubes. The amplified beam exits perpendicular to a mirror, which reflects the beam back into the rod for further amplification on a second pass.

Manufacturing

Crystal gazing

When a semiconductor processing line starts turning out too many defective devices, the technicians start muttering about "black magic"—their term for gremlins. It's probably wishful thinking, for it would almost be easier to call in a magician than to go through the necessary painstaking analysis of why the devices fail.

One tool for analyzing defects hidden in the semiconductor crystal is x-ray topography—recording an x-ray picture. Such a method, however, may require days to produce a precision topograph of a large slice of silicon on which planar devices and integrated circuits are made.

G. H. Schwuttke, a scientist with the International Business Machines Corp., has developed under an Air Force contract an x-ray technique that provides such topographs of large areas within a few hours, making it practical for use in quality control or process evaluation. The method does not damage the devices and can be used before and after any processing step, including metallization.

Eyestrain. Conventional x-ray microscopy is so slow because the slice must be minutely examined by a finely focused beam. It takes 20 hours to scan an area 12 millimeters in diameter. Schwuttke's x-ray beam is a narrow band which makes topographs of 31-mm slices in three hours.

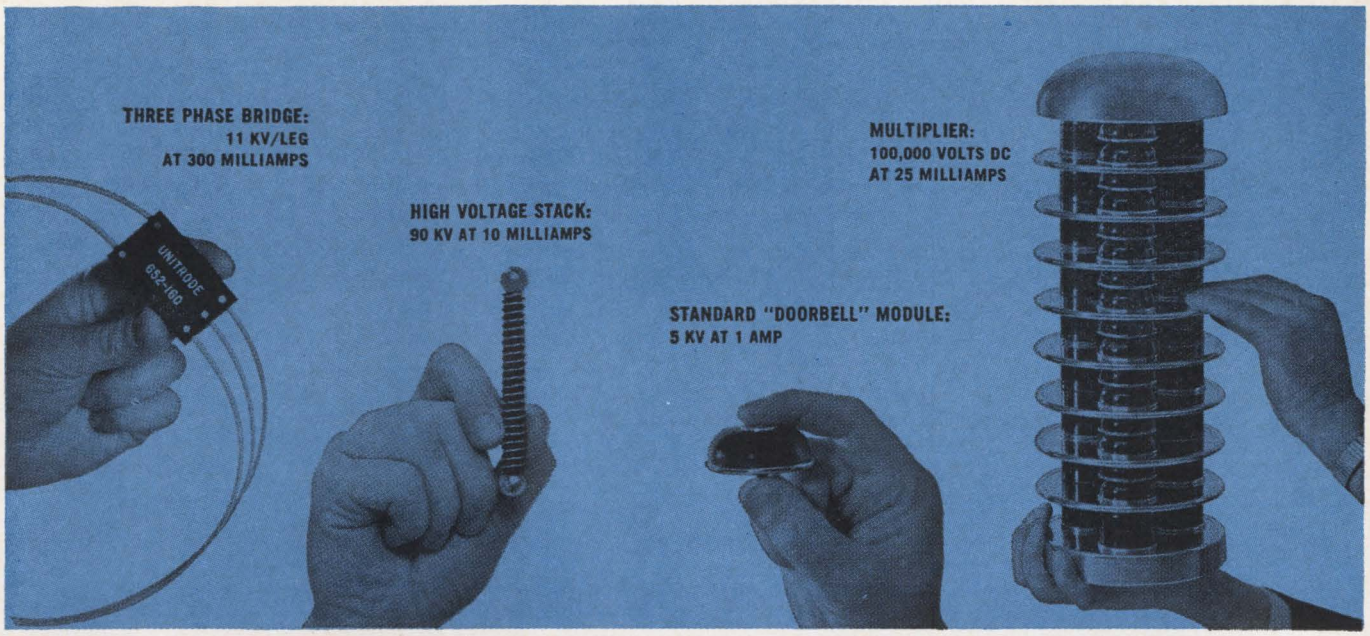
The crystal cannot be examined all at once by a strong x-ray beam because strains in semiconductor crystals reflect x-rays so intensely that they mask the less prominent defects. There is no such thing as a strain-free slice of silicon—strains are introduced as the crystal is grown, during every processing step and even when the slice is mounted for x-ray analysis. Local variations in crystal orientation also appear as strains which reflect x-rays greatly.

Extinction contrast. At the Electrochemical Society meeting in San Francisco May 10, Schwuttke was scheduled to explain how his "extinction contrast" method enables him to obtain clear x-rays of defects, including the tiny strains called microstrains, caused by variations in the amount of doping impurities diffused into different devices on a slice. X-ray analysis can be correlated with electrical tests of the same devices or of integrated circuits.

The radiation from a standard x-ray source is cut down to a narrow band, 50 mm high by ½ mm wide, by passing the beam through slits before it reaches the crystal. As the beam passes through the crystal, part of the beam glances off dislocations or other variations. The horizontal divergence of the beam is controlled by adjusting the slits, so that the beam is of just the right intensity to bring out the type of imperfections that are being studied.

The reflections strike an x-ray film placed behind and to one side of the crystal. The film and the crystal are mounted on a holder that moves them back and forth together, so that film exposure is regulated by the number of times the beam scans the crystal. Scanning also averages out fluctuations in beam intensity, producing a more accurate picture.

An alternate scanning technique



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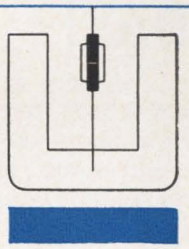

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was devised by Schwuttke to handle situations where varying angles of incidence are needed to obtain reflections from a series of defects. The crystal and x-ray film are oscillated back and forth in front of the beam, as though they were on a pendulum.

Industrial electronics

Green lights for New Yorkers

Ask a New Yorker the fastest way to go crosstown on 42nd Street, and he'll probably tell you: "Walk! It's twice as fast as taking a cab."

Late this fall, though, New York's traffic-weary drivers may start seeing green at the intersections instead of red. If all goes according to plan, the Sperry Gyroscope Co., a subsidiary of the Sperry Rand Corp., will start installing a computer-operated traffic-control system for southern and midtown Manhattan and scattered areas of Brooklyn, the Bronx and Queens.

Keep it moving. Under a $5.5-million contract, Sperry is developing a system that will monitor traffic flow at every major intersection and feed the data into a Univac computer. The computer will then calculate the best traffic-light pattern.

Sperry will get its first chance to test its system any day now. The first test was scheduled to be conducted on April 26, but a strike at its Great Neck, L. I., plant forced a postponement. The test will be conducted at the Sperry labs, using simulated signals.

Financially, the test means a lot to Sperry Gyroscope. About two months ago, the company, hard-hit by a sharp decline in defense orders, laid off some 150 engineers. But if the city decides to install Sperry's system, the company will have the inside track on a $100-million order for additional equipment.

Standing on the corner. Sperry is to install 1,000 radar units on street-corner posts. The radar will count the number of cars and their speed, and transmit the information to the Univac. The master computer will make major decisions on general traffic patterns and transmit those decisions to 19 control systems strategically located around the city. These submaster controllers will make on-the-spot decisions for small traffic areas, taking into consideration the overall traffic pattern. This data, then, will be fed into 2,693 intersection controller units, which will operate the traffic lights.

In the event the radar system proves unsatisfactory for sensing, Sperry is also developing a sonic detector. Both electronic systems will use all solid state equipment.

Triple control. The system will be able to adjust the traffic-light pattern in three ways: cycle length (the total "red" and "green" time); split (the ratio of "red" to "green" time); and offset, or progression (the staggering of "red" to "green," which would allow cars to travel down a street at a fixed speed without hitting a red light).

According to New York's Traffic Department, the system will be the most versatile one ever developed—more sophisticated than traffic-control setups in Toronto or Baltimore. Neither, of those systems, the department explains, can react to unexpected changes in traffic patterns and adjust isolated areas of traffic lights.

For an idea of the foreign approach to computerized traffic control, see the story on page 162 about the system Munich will install next year.

Instrumentation

The untouchables

In industry, it's often necessary to detect minute variations in dimensions without making physical contact. Such problems occur in vibration analysis in checking the tolerance of a precision part under environment stress. In recent weeks, scientists at opposite ends of the United States have devel-

oped two different ways to do this safely.

One instrument, developed by the Weinschel Engineering Co. of Gaithersburg, Md., uses a microwave signal to detect small mechanical displacements in stationary or moving objects. The second device, basically a capacitance sensor, was developed by Turbo-Machine, Inc., of Monrovia, Calif. It uses the sensor as one plate of a capacitor and detects changes in capacitance as the distance from the sensor varies.

High resolution. Weinschel says its instrument can measure displacement to one millionth of an inch; resolutions are one microinch for stationary objects and 10 microinches for moving objects. A portable sensing head aims a microwave signal at the target through a waveguide on the head. For targets more than two feet away, an 11-inch elliptical antenna can be attached to the sensor head. The device detects changes in phase of a reflected 35-gigacycle signal.

Because the device is designed to operate with low levels of reflected signals and is insensitive to magnitude, it can be used for both metallic and dielectric targets. The standard for calibration is a micrometer-driven phase shifter attached to one arm of a reference bridge.

Carl F. Augustine, chief developer of the $12,000 instrument, emphasizes that its high resolution is achieved without the use of expensive phase-locking equipment. Also, all the microwave plumbing is milled in a continuous solid brass piece; this eliminates microphonic and temperature-expansion problems.

Change in phase. The Turbo-Machine device is a proximity detector; it uses a high-frequency reference oscillator that is electronically coupled to a tuned quadrature circuit 90° out of phase. When an object is brought near the tuned circuit sensor, it "loads" the sensor and causes a change in its frequency that is phase-proportional to the distance of the mass. The tuned circuit controls the grid of a gated beam tube

that emits electrons for a time that is proportional to the phase shift. The amount of electron emission is then integrated and displayed as a d-c voltage output, which produces a reading of the distance between the object and the sensor.

Since all metals affect the tuned circuit to the same degree, a calibration for one metal is good for all. Nonmetallic objects require different calibrations.

Although it's not a capacitance sensor in the strict sense, the device is affected by a change in capacitance or inductance. For metals, it operates more like a change in inductance; for nonmetals, a change in capacitance.

Many uses. Turbo-Machine plans to sell its proximity detector to the metalworking, packaging and hydraulics industries, among others. Makers of rotating machinery, particularly gyros and turbines, are Turbo-Machine's prime market targets.

Five of the $995 devices have been delivered to the National Aeronautics and Space Administration for use as airborne tachometers.

Military electronics

That $700 million

The extra $700 million voted for this year by Congress to support the Vietnam fighting means some new business for electronics manufacturers—but not a great deal. The industry's principal beneficiaries will be producers of avionics equipment and radar and communications gear.

Fixed-wing aircraft and helicopters will account for $180 million of the new funds, and electronics companies will receive some fallout from this area. The $100 million budgeted for construction of new harbors and airfields will stimulate orders for radar, communications gear and traffic-control devices.

Replace planes. An estimated $30 million of the aircraft money will go toward buying about 100 helicopters, primarily the UH-1B made by the Bell Helicopter division of Textron, Inc. The U. S. has lost 152 helicopters in Vietnam in the past 4½ years.

The rest of the aircraft funds will go for about 40-fixed-wing planes, mainly fighters and fighter-bombers. In the past 18 months, 43 planes have been lost in Southeast Asia.

The mix of new planes to be bought hasn't been fixed yet. But the choice narrows down to the McDonnell Aircraft Corp.'s F-4; Ling-Temco-Vought, Inc.'s F-8, or its follow-on, the A-7; the Grumman Aircraft Engineering Corp.'s A-6, and the Northrop Corp.'s F-5. The F-5 is a simple jet attack craft that has never been adopted by U. S. forces, but has been sold extensively to allies. The Air Force is currently evaluating it, along with others, for use in providing close support to ground troops.

The F-4, F-8 and F-5 all carry Sidewinder air-to-air missiles made by the Philco Corp. The F-4 is armed with the Raytheon Co.'s air-to-air Sparrow and the F-5 with the Martin Co.'s air-to-ground Bullpup.

Consumer electronics

Video on records

Phonograph records have withstood the incursions of tape recordings because the disks are easier to store and operate. Now they can also "play" pictures together with sound. The Westinghouse Electric Corp. has developed Phonovid, a system that uses standard phonograph-record blanks to reproduce still television pictures as well as sound.

Phonovid provides up to 400 video pictures on any tv receiver in 40 minutes, using two sides of a 12-inch record, called a Videodisc, that plays at 33⅓ revolutions per minute. Westinghouse project manager Copthorne Macdonald says the images are equal in resolution to home tv reception; he expects the principal applications to be multiclassroom instruction,

commercial and industrial training and sales presentation, military training and recording of tv documentaries. The system costs $10,000. The disks can be pressed and mass-produced at much lower cost than tape recordings or slides, he adds.

Slow scan. Instead of scanning a complete picture in 1/30th of a second per frame as in an ordinary tv system, Phonovid scans the picture more slowly—six seconds per frame. Hence video information, which is usually in the three-megacycle range, is brought down to the audio frequency range of 20,000 cycles per second, which can be recorded on an ordinary sound record.

This slow scanning is a common method for transmitting still pictures over low-frequency telephone lines. With Phonovid, a complete picture appears every six seconds on an ordinary tv receiver. This is achieved by using two specially designed scan-converter tubes as memory devices. A scan converter is a two-gun electron tube in which one gun "paints" video information on a target that retains its electronic charge, and the other gun—operating at a different rate—scans the same target area and picks up this information.

In ordinary scan converters, which transcode video information from one scanning standard to another, the two guns work simultaneously.

In the Phonovid converter, one gun "paints" the complete picture in six seconds, then the other electron beam is switched on. It scans the picture nondestructively at the conventional rate of 1/30th of a second per frame, and feeds this information to an ordinarty tv receiver.

Picture storing. Phonovid uses two such scan converters. While one converter is presenting a picture to the tv receiver, the other is storing the next picture to be shown.

Macdonald says Westinghouse did not consider a stero-type recording—with audio on one channel and video on the other—because of the large amount of cross-talk between channels.

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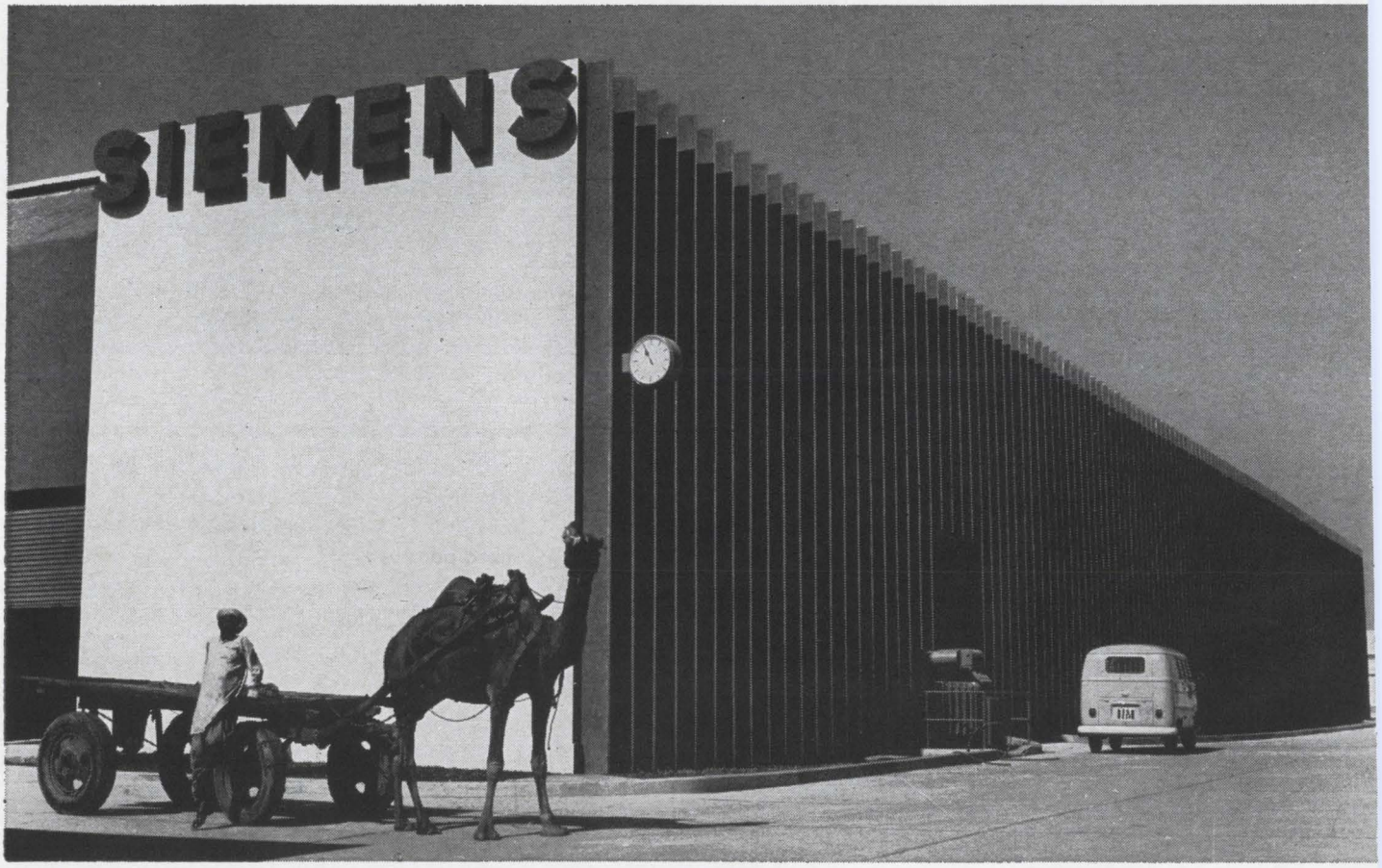

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Electrochemical self-healing is the second protective process. It starts whenever and wherever insulation resistance decreases in the dielectric material. This process operates at any voltage, even as low as 10 mV, changing the metal coating at the point of lowest insulation resistance to a non-conductive oxide—thus eliminating the point electrically.

Less than one breakdown (self-healing) per year and per mF—that is the consistent average shown by tests at nominal voltage. This value, which is for the first year, is even less for succeeding years.

Highly stable capacitance. Overload tests (at 2.2 nominal voltage and at 85°C) show that decrease in capacitance as a result of self-healing is negligible, even after several years.

Small size—low cost. Intricate manufacturing techniques enable MKH (metallized polyester) capacitors to be produced to unvarying standards. They are available with axial or radial leads, in flat compact form. Leads soldered to metallized ends ensure reliable contact. The dielectric is polyester film, widely used for capacitors.

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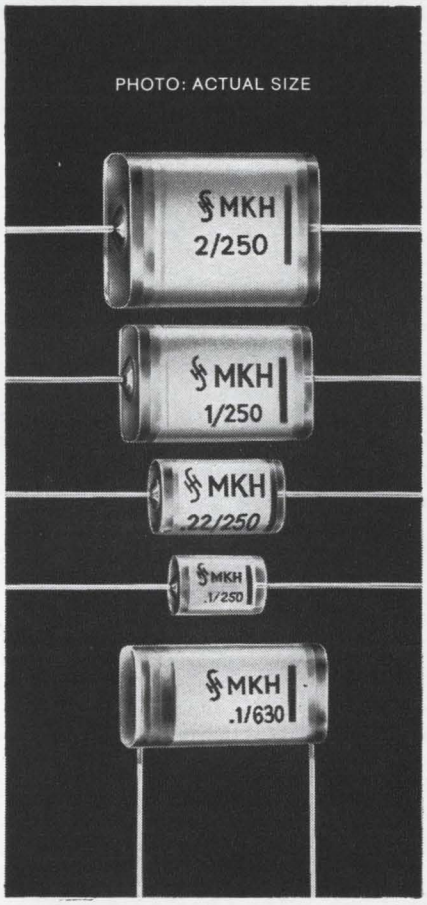

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Something really new from Union Carbide Electronics

A 100,000-picofarad ultra-stable film capacitor, 1/20th the size of glass, mica or porcelain for less than $1.00...the KEMET Flat-Kap.

KEMET Flat-Kap capacitors are produced from a remarkable thin film plastic known as polyparaxylylene. Through Union Carbide research, a unique vapor deposition process (patent pending) has been developed that utilizes this ultra-stable film to produce a film dielectric with properties superior to polystyrene, polycarbonate and similar plastics. Some of the extraordinary Flat-Kap properties are:

Capacitance stability better than 0.1%... reproducible temperature coefficient of -200 PPM/°C from -55 to +125°C...insulation resistance greater than 100,000 megohm microfarads...dissipation factor less than 0.1%—to mention only a few.

Extended foil design Flat-Kaps are coated with moisture-proof materials and encapsulated in rectangular-shaped epoxy cases that conserve printed circuit board space. They can be matched with inductors, wire wound resistors, and other inexpensive components to provide stable performance over a wide temperature range in filters, integrators and timing circuits.

Want more on KEMET Flat-Kaps? Write or call our Kemet capacitor Sales Representative in your area or your local Kemet Department Regional Sales Office. If you have an application in mind, we'll be glad to send you a Flat-Kap to test...free. Union Carbide Corporation, Kemet Department, 11901 Madison Avenue, Cleveland, Ohio 44101.

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UNION CARBIDE

ELECTRONICS

Washington Newsletter

May 17, 1965

R&D bill sailing through Capitol

The Defense Department's $6.6-billion request for research and development funds seems sure of sailing through Congress nearly intact. The Senate is going along with Defense Secretary Robert S. McNamara's $6.6-million budget, and the House has narrowed its reduction to only $114 million from the $500 million it threatened to slice off earlier. It's likely, however, that some reductions will be restored when House and Senate conferees meet soon to work out a final bill.

Although pleas from the Pentagon induced the House to go easier on cutting, Armed Services Committee members zeroed in on two electronics programs. **They sliced $3.7 million from funds asked by the Navy for aircraft development and recommended that the cut be applied to the Integrated Light Attack Avionics System** (ILAAS). The panel fears duplication of effort between ILAAS, the Integrated Helicopter Avionics System (IHAS) and the Mark II avionics system being developed for the F-111 fighter-bomber.

The House also sliced $10 million from missile development funds and recommended that the cut be applied to the $12-million that the Navy wanted for the advanced surface-to-air missile system (ASMS) planned by the Navy. House military experts decided some of this work could be put off for a year in view of efforts under way to improve the Terrier, Tartar and Talos missiles, and of plans to complete development of an interim missile to be used until ASMS is available.

Both the Senate and House are needling McNamara to move faster on a manned bomber to replace the B-52. The House wants him to get into project definition this summer so a contractor can be picked next summer, and is providing $7 million extra for that purpose. **McNamara plans to spend $29 million next year on advanced avionics and new engines, but he is resisting project definition, because this comes too close to a commitment to a new bomber.**

Early Bird: better than anticipated?

While lawyers for the Communications Satellite Corp. are preparing to file proposed rates with the Federal Communications Commission for the public's use of Early Bird, based on the satellite's design capability for 240 voice channels, **Comsat engineers are discovering that the switchboard in space may be able to transmit twice that many voices simultaneously.**

The engineers aren't disclosing details of their recent experiments with a prototype Early Bird, but sources close to the tests indicate the following:

Under ideal conditions, it may be possible to transmit as many as 500 two-way conversations via the satellite; instead of the designed 10 watts of radiated power, the engineers are getting closer to 12 watts from Early Bird; instead of requiring the full statellite capacity for television transmission, they can transmit tv and still have 60 channels available for voice communications. Color-tv transmission tests also are said to have been successful.

The lab results, plus some tests with the orbiting satellite, will not necessarily be duplicated in full-time service on Early Bird. But engineers do think they show that Early Bird has a more versatile capability than was originally believed.

Washington Newsletter

Navy discloses 3 weapons studies

Three new programs for weapons systems have been disclosed by Robert W. Morse, assistant Navy secretary for research and development, in heavily censored testimony before the House Armed Services Committee.

• **The Navy is studying guidance and technical characteristics for a versatile submarine-launched torpedo.**

• **Development is under way to reduce substantially the complexity of large fixed-antenna shipboard radars used for air search and height determination, and to improve their operations.** The Navy wants to use a single antenna with two related radars, to reduce vulnerability to electronic countermeasures, and to provide what Morse called "a means of developing a radar system that may automatically adjust its operational characteristics to [detect and track] targets simultaneously."

• **The Navy also hopes to develop a new rapid-reaction, lightweight surface-to-air missile system for ships that cannot accommodate the Terrier and Tartar defensive missiles.** Possible alternatives being explored: adaptation of air-to-air missile systems for shipboard use, and use of technology from the Army's Mauler missile program.

Lobbyists promote accelerator sites

A political tug-of-war is shaping up over the choice of a site for a proposed $300-million proton accelerator. The battle promises to dwarf the stir caused when Sen. Edward M. Kennedy (D., Mass.) snagged the Space Electronics Center for Boston.

More than two dozen communities have already begun to lobby in Congress, because they recognize that the locality selected will probably become the focal point for research into high-energy physics.

The Atomic Energy Commission has asked a panel of the National Academy of Sciences to recommend a site by June 15, and **the agency plans to make a final selection by year's end.**

Civilian role gains in military buying

The Pentagon is building up the role of civilians, at the expense of the military, in selecting manufacturers of military equipment. The hope is to avert another public controversy like the long, bitter struggle between Defense Secretary McNamara and Sen. John L. McClellan (D., Ark.) over the award of the F-111 fighter-bomber contract. McClellan received much of his verbal ammunition indirectly from the military source-selection board that recommended the Boeing Co.; McNamara, however, overruled the board in favor of the General Dynamics Corp.

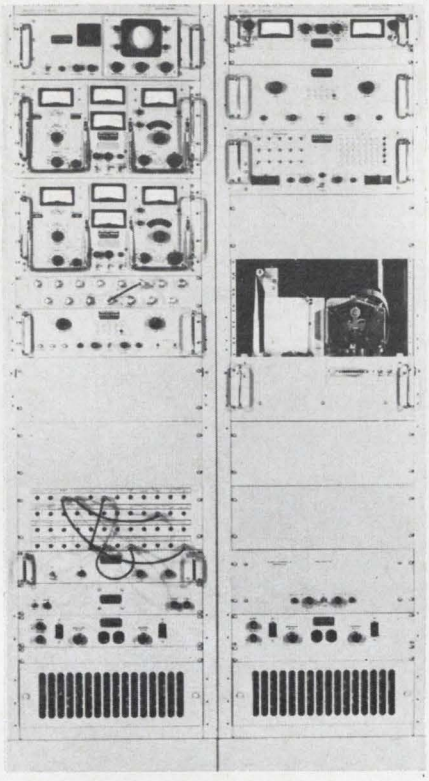
A directive by Deputy Defense Secretary Cyrus R. Vance curtails the authority of military technical officers to make final recommendations for awards. It places civilian technicians and policy makers at each stage of evaluation and selection.

McNamara hears industry gripe, but...

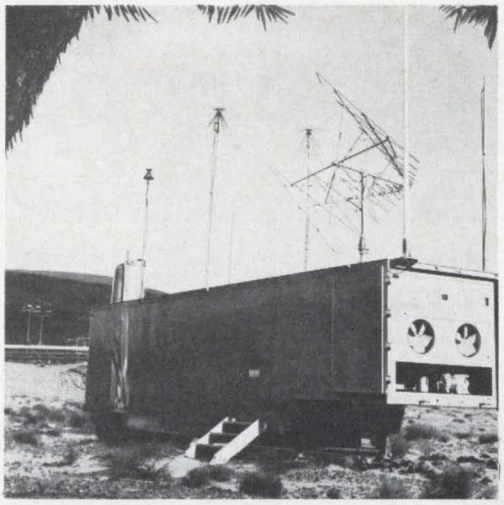
Defense Secretary McNamara is turning a sympathetic ear to a persistent complaint from the electronics industry. **He acknowledged that there is "considerable merit" in the claim that companies doing research and development for the government should get more than only recovering costs.**

He also told the House Armed Services Committee, in testimony just made public, that he remains unyielding on the government's right to own developments it finances.

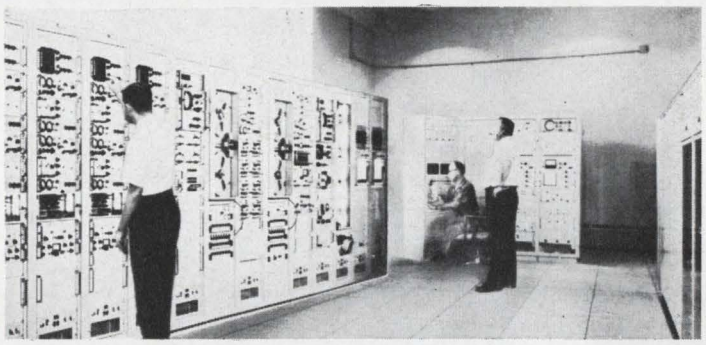
SYSTEMS OR PRODUCTS, DEI has full capability for quick reaction



RF data acquisition Products and Systems . . . From VLF to 30 gc. DEI RF Products and Systems satisfy complex acquisition or communication requirements.



Surveillance, RFI and Intercept Instrumentation . . . Laboratory, mobile van, airborne or shipboard, the complete installation from antenna to data storage, decoding and processing can be provided.



Data Processing Products and Systems . . . Real time processing pre-detection recording or dynamic signal simulation from off-the-shelf hardware.

When system problems arise, consider the following . . . .

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SEQUENTIAL SWITCHING—
Compact, Efficient, Low Cost with
CLARE *STEPPING SWITCHES*

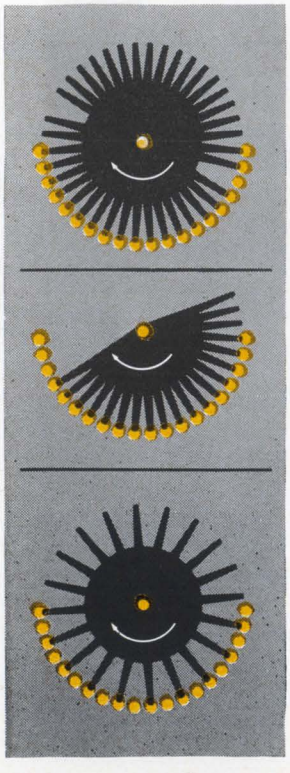
Counting • Totalizing • Sequence Control • Monitoring

■ Where circuit requirements call for selecting, interrupting, or changing connections in response to momentary impulses of current, CLARE's full line of rotary stepping switches provides exactly the device you need.

Compact and ruggedly built, CLARE Stepping Switches have many new, improved features which contribute to longer service life, greater capacity and unusual freedom from maintenance. Contacts are bifurcated for maximum operating reliability. They may be gold plated for low-level switching, with consistently low contact resistance. Your choice of terminals: taper tabs, solder, or plug-in. Special units available to meet airborne shock and vibration requirements.

ONLY CLARE GIVES YOU ALL THIS:

1 *Special Purpose Shorting Switches...for Test and Encoding Circuits*



"All but one"
Ideal for the classic "multi-conductor cable" test for leaks, shorts, continuity, etc. Shorts all circuits except one together, making possible sequential testing of each circuit individually.

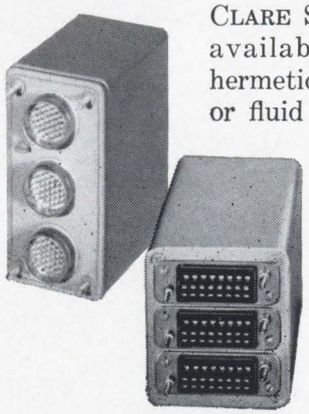
"Progressive"
Useful for location of trouble sources in test circuits. Provides incremental increases and decreases in power as required by some control systems. With self-interruption, can effectively provide bi-directional control.

"Alternate"
An excellent code conversion device, generating a wide variety of coded control outputs. Useful in transmitting special coding in sequential repetition. Readily adaptable to binary coded decimal encoding.

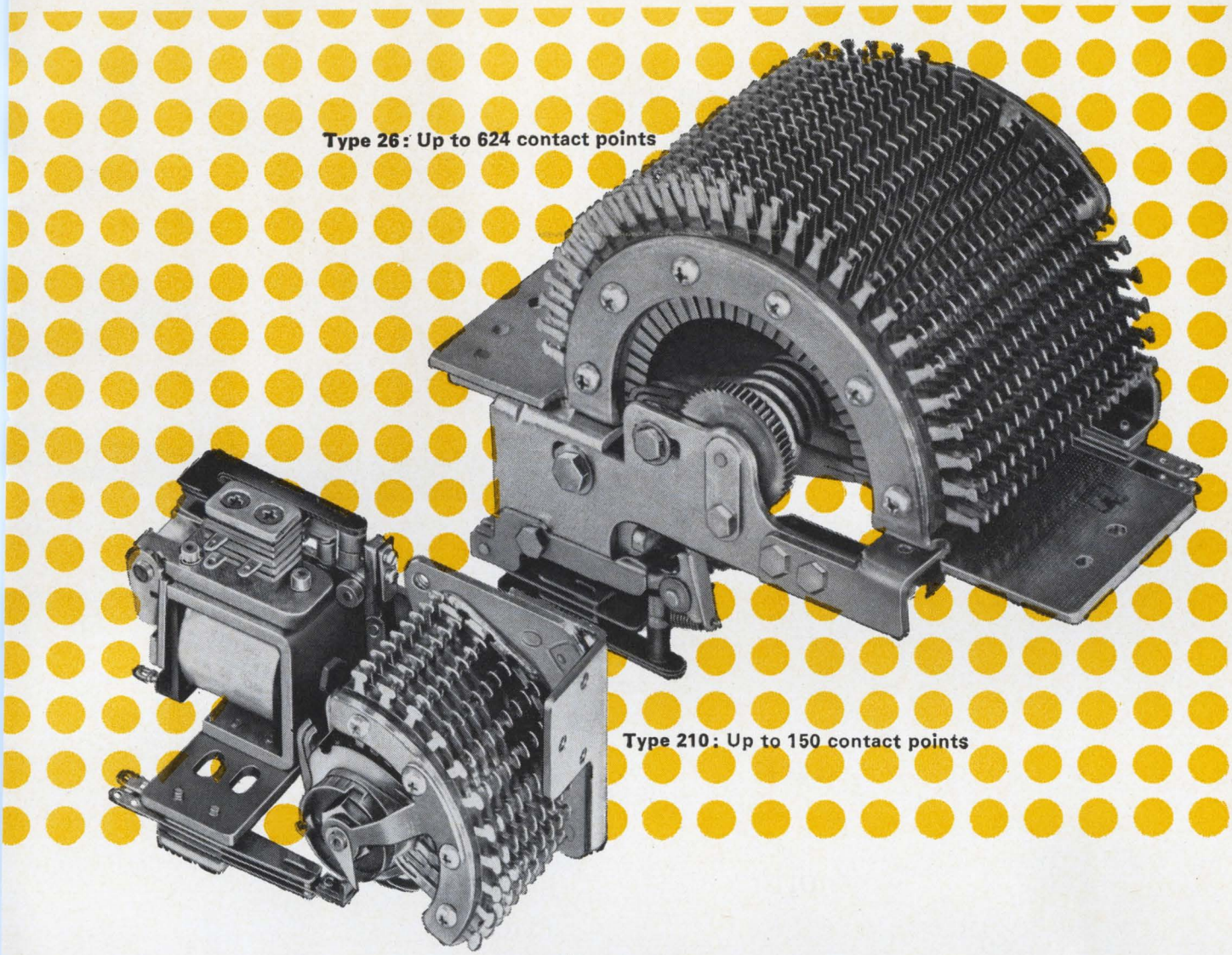
2 *High Voltage Sequential Control Capacity*

CLARE will provide special stepping switches to stand off voltages up to 2500 volts. Number of switch levels available depends upon voltage.

3 *Special Enclosures for Adverse Environments*

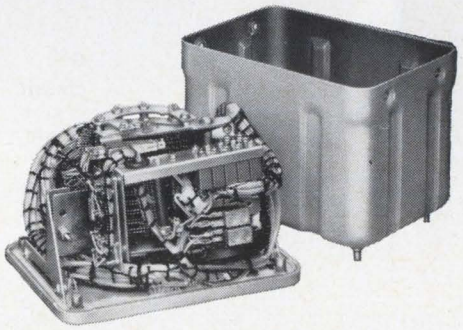


CLARE Stepping Switches are available in dust covers or hermetically-sealed in nitrogen or fluid to minimize undesirable effects of tampering, shock, or vibration, as well as salt air, humidity, fungus, corrosive atmosphere, sand and dust.



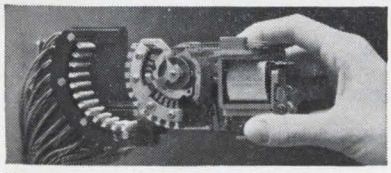
4 Custom-Designed Functional Sequence Control Units...

CLARE engineering can provide functional assemblies incorporating such features as variable time delay pulse generators. Combining stepping switches with solid state (for time delay and pulse generation) and relays (for switch-over between stepper levels), these assemblies expand the capabilities of Clare Stepping Switches.



Typical Clare-designed sequential switching unit: 104 point sequence scanner. Solid State pulse generator, driving 10-level, 52-point stepping switch, provides predetermined time interval at each position—and pulse repetition rate from 6 per second to 6 per minute.

5 Easy Installation with New Plug-in Connector for Type 211 Stepping Switches



Faster, easier assembly and replacement. Connector contacts, crimped to lead wires, snap into connector frame. Plated contact areas (tin or gold over nickel) for contact reliability.

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Group 05N6,
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CLARE®
relays and related control components

You are looking at an exact-size photograph of a new kind of precision laboratory recorder—the new Lockheed 417C.

It's the only laboratory instrument of its type that is truly portable.

In the lab it operates from 110V AC—and outperforms all but the most sophisticated and costly rack jobs.

In the field it gives the precision and capability of a large, fixed installation recorder—yet weighs only 25 pounds including its own built-in rechargeable battery.

You can even tuck it under an airplane seat on trips. Its price is small, too—as little as $7,000.

The new 417C is built by the same engineers who design Lockheed ultra-precision, low-power recorders for space and undersea use.

Exclusive, rugged, low-mass differential

capstan drive assures precision operation under vibration in any position. Other features:

Simplified transport mechanism
Phaselock servo motor control
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Up to 7 tracks, FM or Direct in any combination (IRIG compatible)
Power consumption only 6 watts
Battery, AC or DC powered

Weighs only 25 pounds including battery

For a free specification folder on the Lockheed 417C recorder/reproducer, write on company letterhead to Mr. Bernard Mayer, Lockheed Electronics Company, National Road, Edison, N. J.

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Over 30 input couplers allow the conditioning of virtually any input signal, so you can adapt the Dynograph Recorder to your changing requirements at very little cost.

This combination of reliability, accuracy and flexibility comes only with a Beckman Dynograph Recorder. For more information contact your local Offner Division Sales Engineering Representative, or write for Data File 722.

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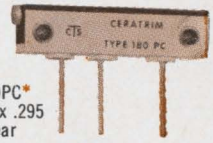

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Rectilinear

Series 170*
½" Square

Series 171*
½" Square

Series 660PC
⅜" dia., single turn

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locking bushing

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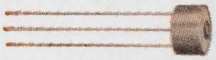

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½" dia., knob operated,
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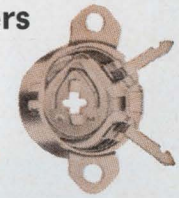

Series 112*
¾" dia., single turn

Series XPC110
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Series P115*
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Series 115
¾" dia., single turn

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spiral infinite resolution

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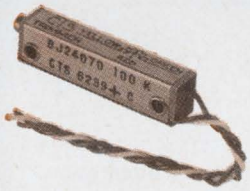

Series C140*
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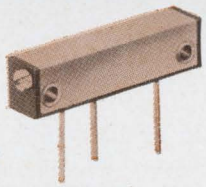
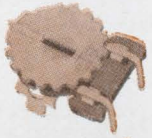
Rectilinear



Series C140PC*
1¼" x .325 x .295
Rectilinear

Series 220*
7/16" x ½" single turn

Series 330
½" dia., single turn



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19/32" dia., knob operated,
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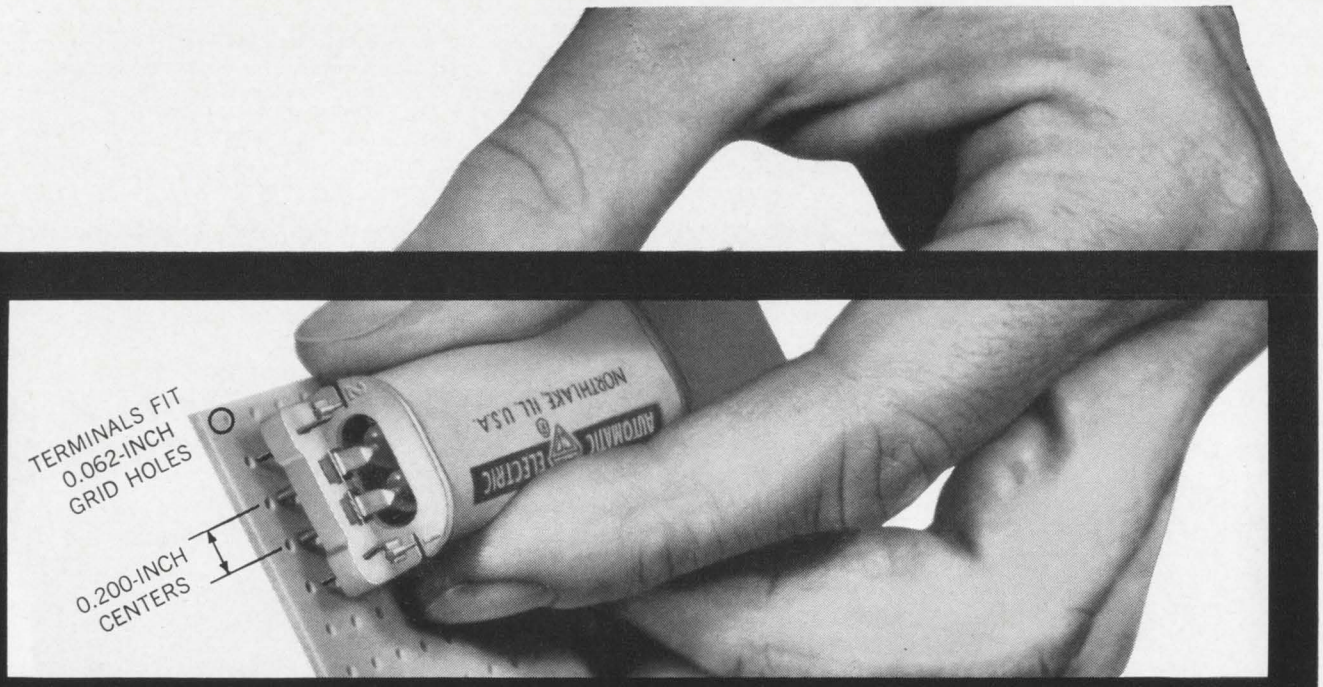

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That's because PC CORREEDS* are specifically designed for direct insertion into standardized grids. Terminals are located on multiples of 0.200-inch centers. And all terminals are designed to fit standard 0.062-inch holes; permit the use of small wiring pads. Standardized terminal size and spacing also allow for greater packaging density.

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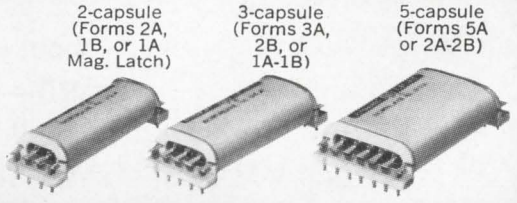
For the full facts on how these new AE Printed-Circuit Correeds meet the requirements of modern electronic circuitry, write to the Director, Electronic Control Equipment Sales, Automatic Electric, Northlake, Illinois 60164.



*Patent applied for.

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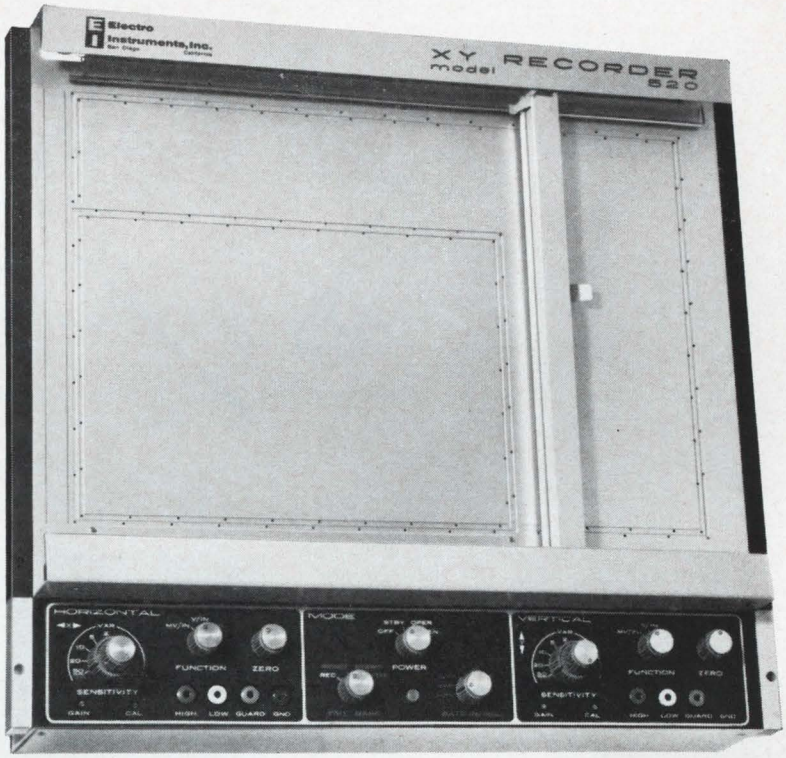

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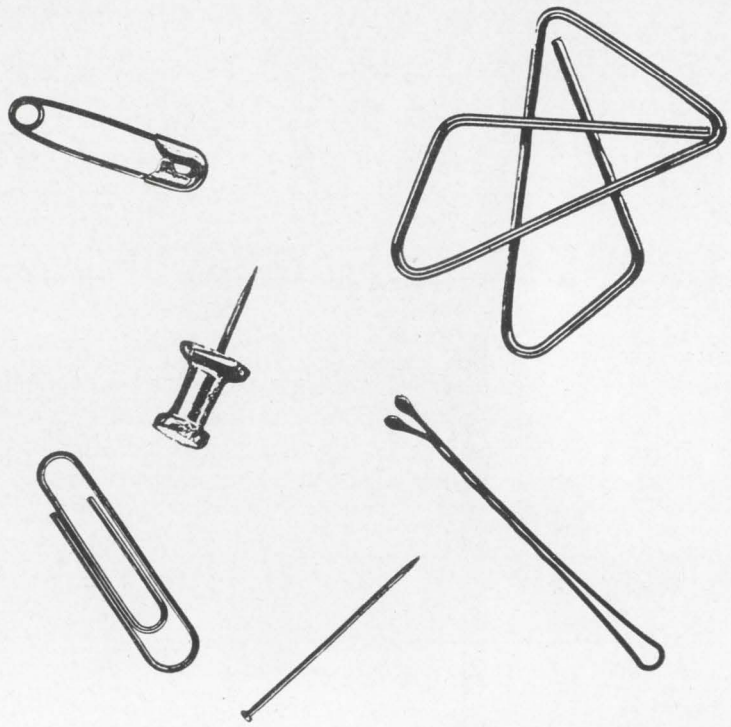

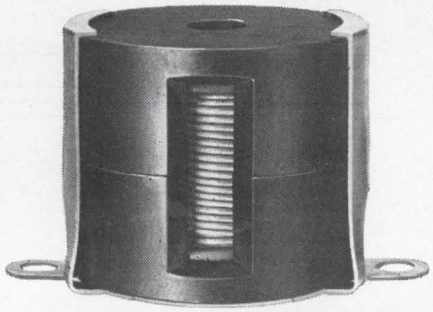

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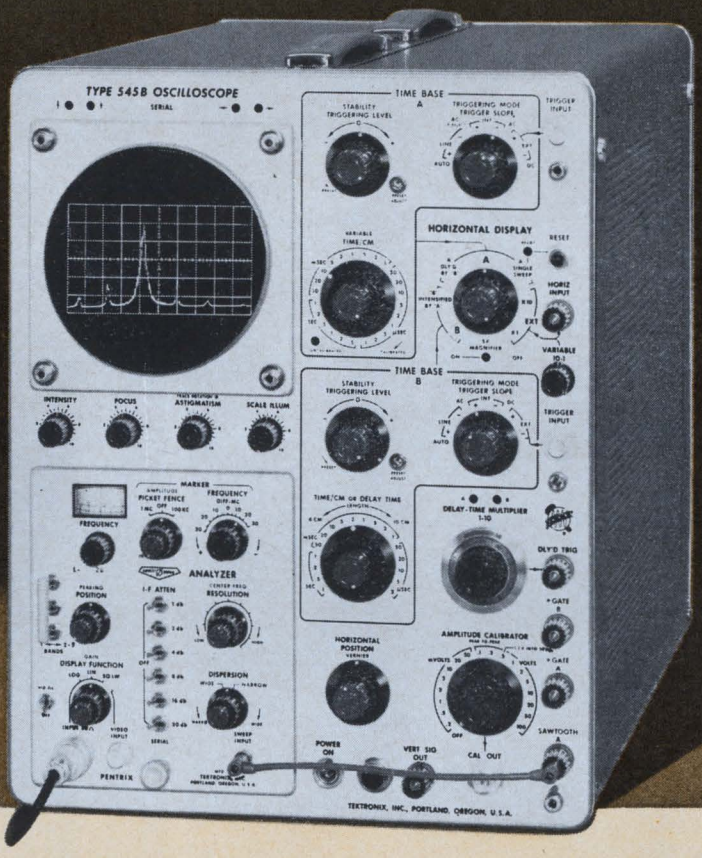

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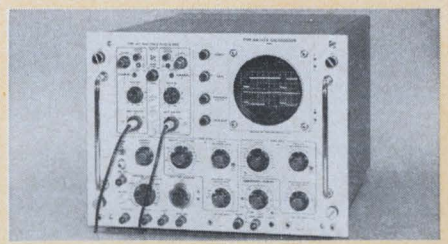

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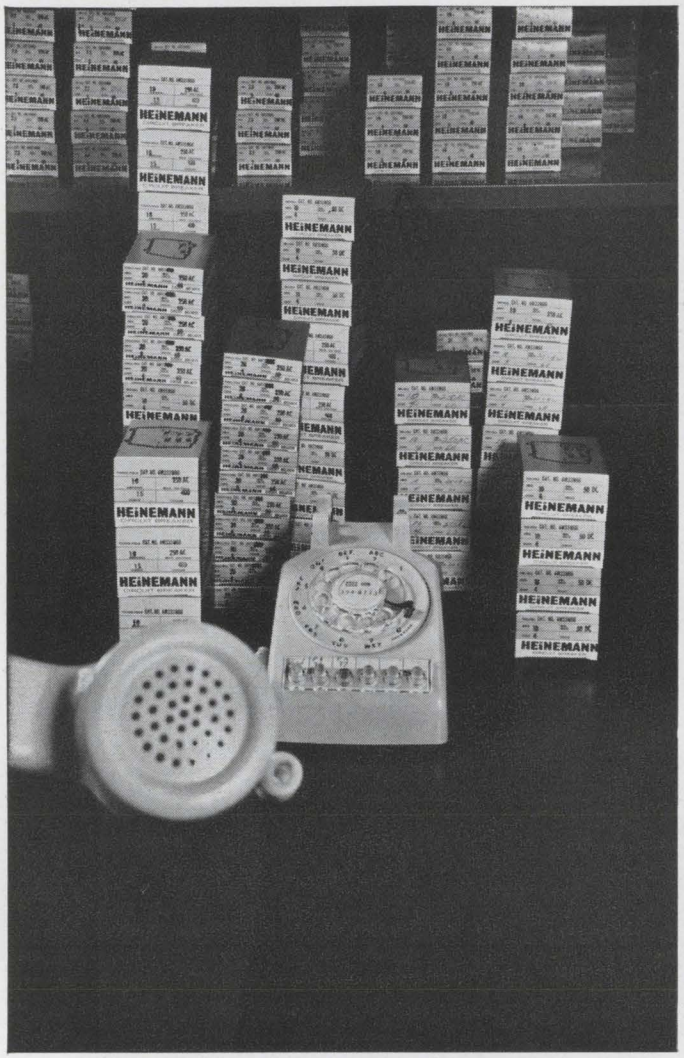

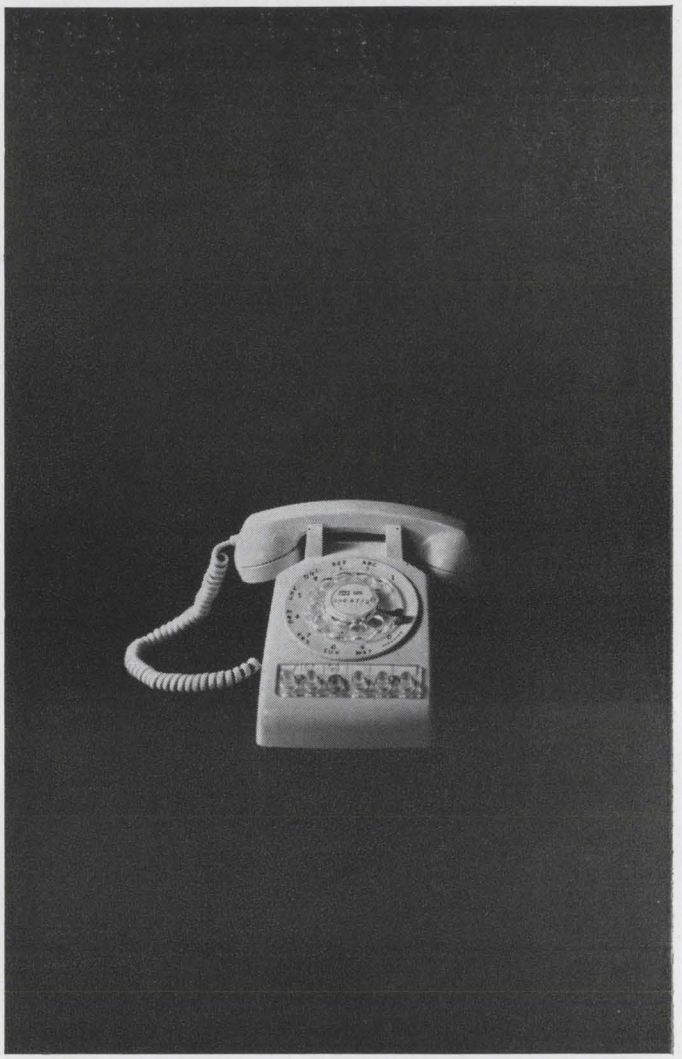

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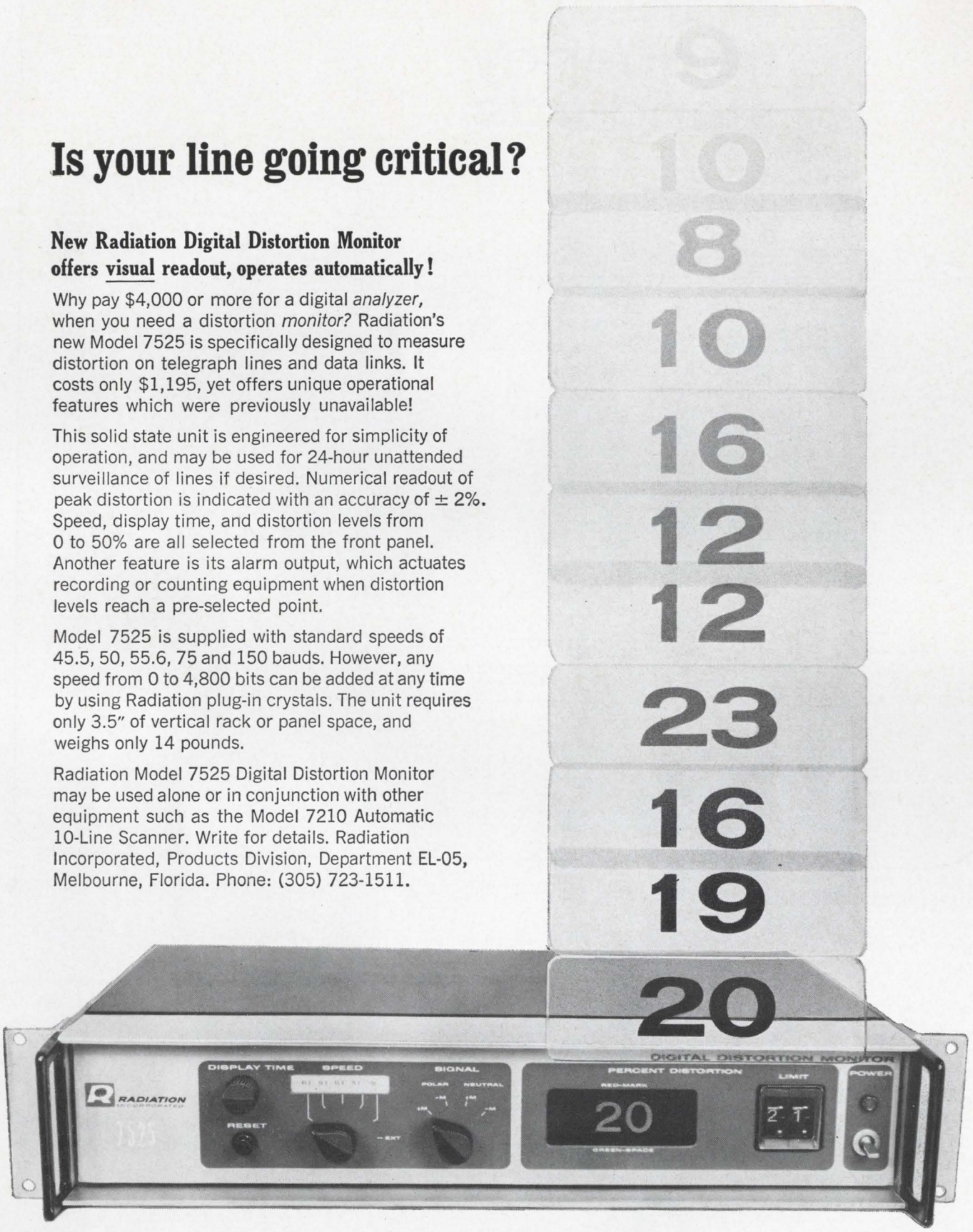
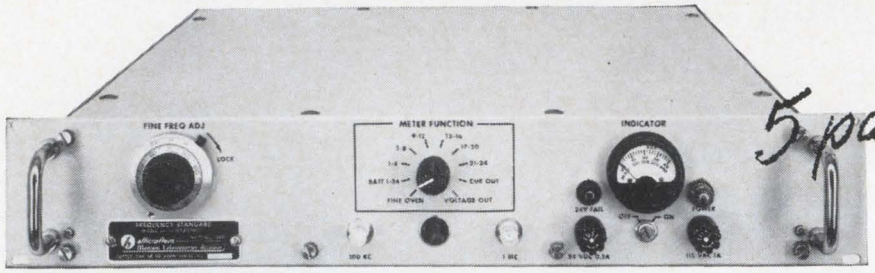


RADIATION INCORPORATED

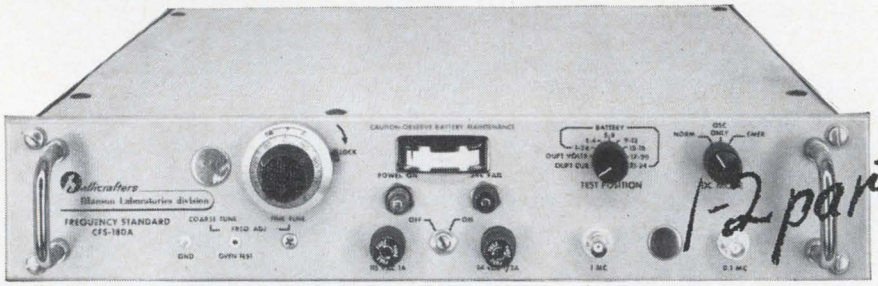
Circle 51 on reader service card 51

manson frequency standards



5 parts in 10^{11}/day

CFS-250A



1-2 parts in 10^{10}/day

CFS-180A

	CFS-180A	CFS-250A
Stability (Aging Rate)	1 to 2 parts in 10^{10} per day.	5 parts in 10^{11} per day.
Output Frequencies	1 Mc and 100 Kc.	1 Mc and 100 Kc.
*Optional Output Frequencies	5 Mc and spectrally pure 5 Mc.	5 Mc and spectrally pure 5 Mc.
Input Power (Power Supply self-contained)	115 V AC, 50-400 cps.	115 V AC, 50-400 cps.
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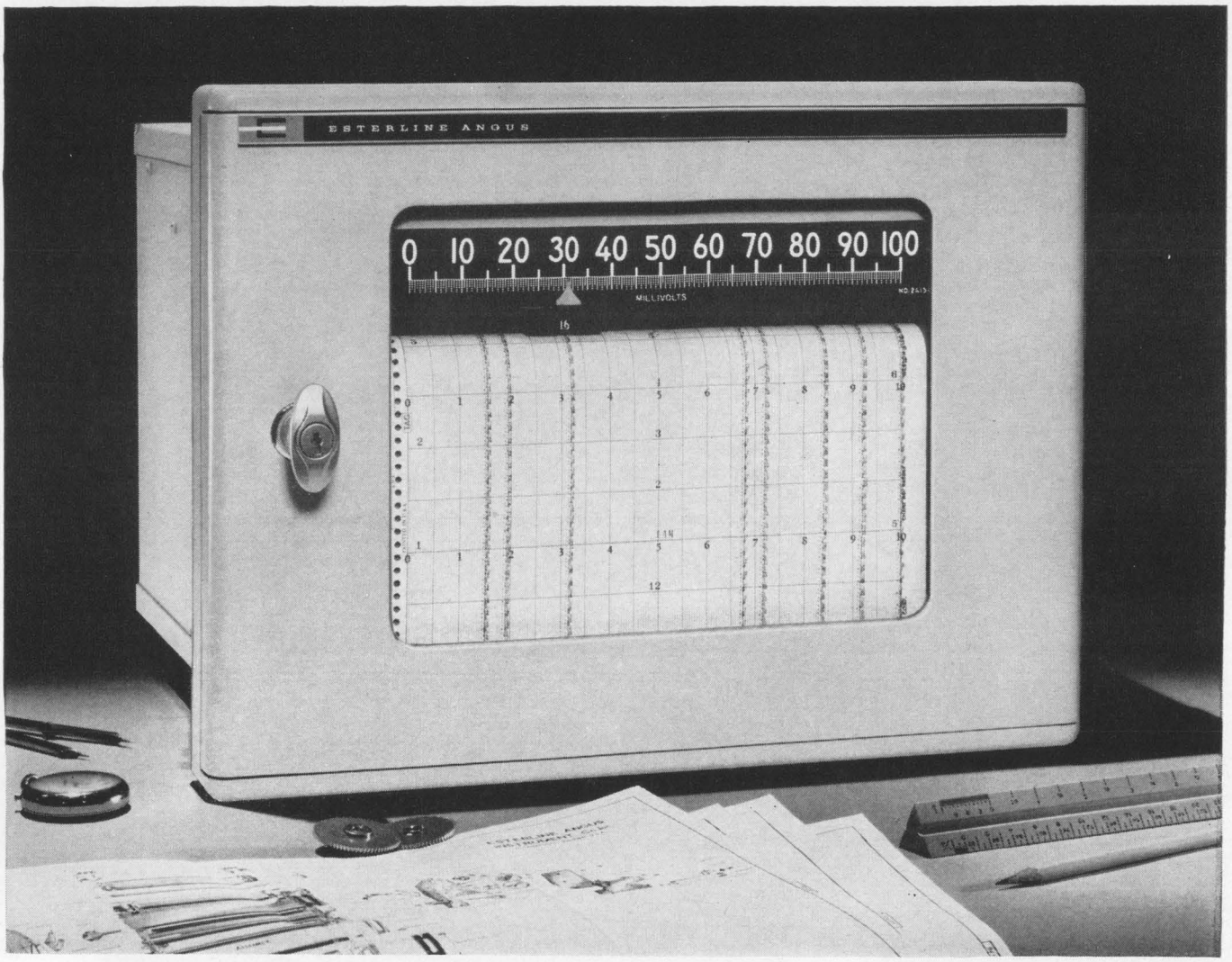

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Technical Articles

A new look at coaxial cavities for varactor multipliers: page 56

The coaxial cavity is usually pictured as a bulky piece of hardware used primarily in big radar and microwave systems. Yet a coaxial cavity multiplier can be designed as small as any other kind and it has some decided advantages: a better match of input and output impedances, and rejection of undesirable frequencies.

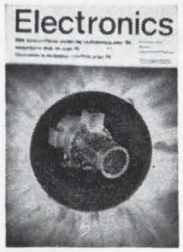
Light-pulse system shrinks high-voltage protection device: page 71

Light emitted by a diode is transmitted by fiber optics in this system, which protects utility transmission lines from overloads. The small device called the Traser replaces bulky current transformers in one of the first industrial applications of optoelectronics.

Protecting digital transmissions with optical matched filters: page 76

In most scrambling techniques to protect military communications, the bottleneck is decoding. A new technique, using ultrasonic pulses to modify polarized light, can speed decoding by replacing magnetoresistive delay lines.

Television's toughest challenge: page 80



In outer space, unattended cameras have to survive many hazards. Weight limitations impose severe restrictions, but there is increasing demand for television on projects from weather satellites to interplanetary probes. For our cover, photographer Richard Saunders photographed an RCA tv camera designed for space applications. The background is a man-made eclipse of the sun, at the Hayden Planetarium in New York.

Coming May 31

- **Inductors for integrated circuits**
- **Ground stations for communication satellites**
- **Protecting electroexplosive devices**
- **From Japan, a startling new color-tv set**

A new look at coaxial cavities for varactor multipliers

Frequently dismissed as bulky and difficult to use, this construction can be designed easily into simple, compact circuits

By Gerald Schaffner

Motorola, Inc., Phoenix, Ariz.

Most microwave engineers picture a coaxial cavity construction as the bulky, cylindrical workhorse used in radar and other microwave systems. They decide, quickly and erroneously, that it's too cumbersome to design easily and compactly into a varactor multiplier. Contrary to this popular misconception, coaxial cavity multipliers can be readily designed as small as any others.

In a varactor multiplier circuit, the varactor is usually mounted in parallel with the source and load, and the multiplier is designed so that only the input, output and idler currents flow through the varactor. This allows the best match of input and output impedances, and rejection of undesirable frequencies. A detailed discussion of these principles has been published.[1]

Two basic kinds of varactor can be used with the multipliers described in this article: conventional abrupt-junction, and large-area step-recovery junction.[1, 2] The step-recovery diode has higher power capabilities—more than 10 watts at 2,000 megacycles per second.

The author

Gerald Schaffner is manager of the microwave applications department at Motorola, Inc. He has a doctorate in electrical engineering. Since joining Motorola, Inc. in 1957 he has worked on microwave instrumentation, and on development of parametric amplifier and varactor circuitry. Before joining Motorola, Inc., he was with the electronics division of the Stewart-Warner Corp.

Although it is usually cylindrical, coaxial cavity construction can also consist of rectangular lines in square or rectangular enclosures, or air-dielectric striplines. The techniques involve any shielded transmission-line resonant circuit that uses a dielectric medium principally of air, and that sustains only transverse electric and magnetic fields.

Principles of cavity design

Transmission-line cavities[3, 4, 5] are merely resonant lines with open and/or short-circuit terminations. The points at which resonance occurs can be determined from a study of the lossless line-input impedance or admittance equations. These equations are:

$$Z_{in} = Z_o \frac{Z_L + jZ_o \tan \frac{2\pi fl}{v_c}}{Z_o + jZ_L \tan \frac{2\pi fl}{v_c}} \quad (1)$$

$$Y_{in} = Y_o \frac{Y_L + jY_o \tan \frac{2\pi fl}{v_c}}{Y_o + jY_L \tan \frac{2\pi fl}{v_c}} \quad (2)$$

where Z_{in}, Y_{in} = transmission line input impedance and admittance, respectively; Z_L, Y_L = transmission line load impedance and admittance, respectively; Z_o, Y_o = transmission line characteristic impedance, and admittance, respectively; θ = electrical length of transmission line; f = frequency; l = physical line length; v_c = velocity of propagation along line.

Equation (2) is especially useful in cavity design and will be employed in this discussion.

Cavities may utilize open or short-circuited lines,

or both. The multiplier design discussed here uses shorted lines. This permits simplification of Eq. (2) since, with a short-circuited line, $Y_L = \infty$. Therefore $Y_{in} = -jY_o \text{ Ctn } \theta$ (3)

For $\theta = \pi/2, 3\pi/2$, etc., Y_{in} is zero; this is equivalent to parallel resonance. For $\theta = \pi, 2\pi$, etc., Y_{in} is infinite; this is equivalent to series resonance. The most desirable mode of operation is with $\theta = \pi/2$ because this allows the shortest possible structure.

Transmission lines can use several geometries. Cross sections of three popular configurations are shown at the right along with equations for their characteristic admittances. These configurations are coaxial cylinder, circular cylinder in a square enclosure, and circular cylinder between two parallel planes. If the center conductor of the last-mentioned configuration has a rectangular cross-section, the geometry becomes stripline, and the conductor's characteristic admittance can be obtained from published curves.[6]

With each of the lines, only the transverse electric and magnetic field mode should be excited; excitation of the waveguide mode must be avoided. If it is not avoided, the transmission line equation must be altered. Higher transverse magnetic or transverse electric modes can be avoided if the average perimeter surrounding the center conductor is less than one-half the wavelength. Care in coupling into the transmission line structure is also helpful in preventing higher modes.

Some ways to use it

A cross section of a coaxial cavity is shown at the right, illustrating various ways of either exciting the cavity or extracting power. Both probe and loop coupling are shown, as well as direct coupling into the center conductor. The cavity consists of a section of coaxial line whose center conductor is shorted to the outer conductor and is normally one-quarter wavelength long at the resonant frequency. The coupling used can modify the resonant cavity length. For example, probe or capacitance coupling reduces the required length of the center conductor, while loop coupling increases it. Each of the three coupling methods may be used in cavity multipliers. Their use will be described later with the reasons for a specific choice.

Cavities for multiplier circuits are useful in impedance matching. A rule of thumb is that the tighter the coupling (that is, the bigger the loop or the closer the probe to the open end of the center conductor) the lower the impedance. Therefore, for transforming impedance to a higher value, the output coupling should be tighter than the input, and the opposite applies for stepping down impedance. The exact calculation of the required degree of coupling is difficult because of the complex geometry associated with the cavity, but the general impedance transformation relationship given above is useful in cavity design and optimization. A qualitative and quantitative study of this coupling has been made at Harvard University.[4]

COAXIAL CYLINDERS

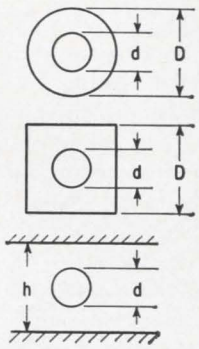
$$Y_0 = \frac{\sqrt{\epsilon}}{138 \log (D/d)}$$

CYLINDER IN SQUARE ENCLOSURE

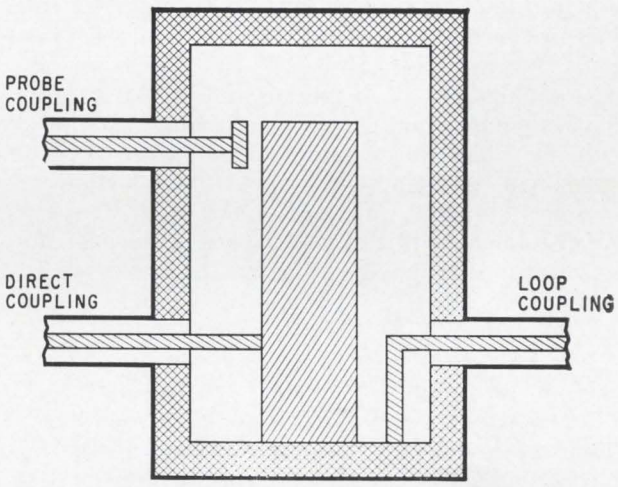
$$Y_0 = \frac{\sqrt{\epsilon}}{138 \log (D/d) + 3.54}$$

CYLINDER BETWEEN TWO PARALLEL GROUND PLATES

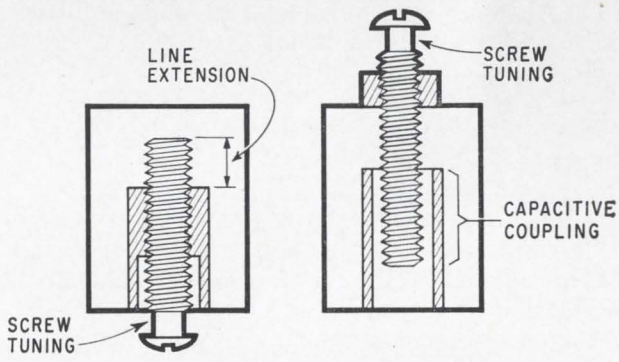
$$Y_0 = \frac{\sqrt{\epsilon}}{138 \log (4h/\pi d)}$$



Three transmission line geometries. The characteristic admittance formula for each geometry is shown to the left of the geometry.



Coaxial cavity illustrating three types of coupling. Probes couple to the electric field, loops to the magnetic field, and direct coupling is achieved by connecting directly to the cavity center conductor.



Two cavity-tuning methods. At left, tuning is accomplished by extending the center conductor. At right, resonant frequency is varied by changing capacitor loading on the center conductor.

Another advantage of this structure is the ease with which cavity resonance can be changed or tuned. Generally two methods are used for tuning: physically changing the center conductor length, and loading the open end of the transmission line with capacitance to ground. As shown at the right, both methods use threaded tuning pistons. How-

ever, if several cavities are being tuned simultaneously or if the tuning is motor-driven it may be desirable to use smooth pistons, with finger contacts replacing the threaded contacts.

The calculation of resonant frequency by the line-extension method is complicated by end capacitance, caused by lines of flux from the tuning screw to the top of the cavity, and the change in characteristic admittance between the fixed and movable parts of the center conductor. End capacitance is usually estimated to be 0.5 picofarad if a minimum spacing of one-fourth inch spacing is maintained between the center conductor and the cavity end capacitance. For closer spacing, a higher value capacitance should be assumed. The change of characteristic admittance (or impedance) is more difficult to handle because Eq. 3 is not valid for this type of construction, and the more general equation (2) is complex. However, for approximation, use of equation (3) is permissible because more than adequate tuning range is usually achieved with an extendable center conductor.

Resonant frequency with capacitance loading or tuning is obtained by equating the tuner's capacitive reactance with the inductive reactance of the shorted transmission line, this may be expressed as:

$$2\pi C_t = Y_o \operatorname{ctn} \frac{2\pi fl}{v_c} \tag{4}$$

where C_t = tuning capacitance.

For capacitance tuning, the center conductor should be hollow so the tuning piston and the inside of the center conductor form a coaxial capacitor. The equation for capacitance is then:

$$C_t = \frac{0.242\epsilon_r L_t}{\log (b/a)} \text{ in picofarads} \tag{5}$$

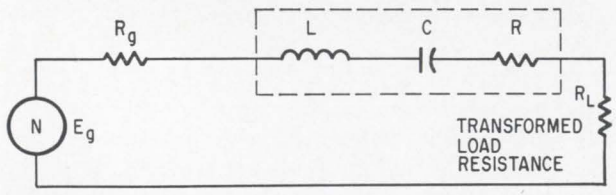
where ϵ_r is the relative dielectric constant,

L_t = distance in centimeters the tuning piston extends into the hollow conductor,

b = inside diameter of the hollow tube,

a = outside diameter of the tuning screw.

Another consideration in designing the cavity is loaded and unloaded Q. The insertion loss is a function of the ratio of unloaded-to-loaded Q. Expressions are given below for unloaded Q, loaded Q, and insertion loss assuming a series-resonant equivalent circuit. The series resonant equivalent circuit shown below is valid if the point of reference is a current maximum point on the input line. A parallel resonant equivalent circuit is used if a voltage maximum is the reference.



Equivalent circuit for a two-port cavity as seen at a current maximum point in the input line. Dashed box contains the equivalent cavity parameters. Source resistance is represented by R_g.

For a series-resonant equivalent circuit, unloaded Q is defined as

$$Q_U = \frac{2\pi fL_s}{R} \tag{6}$$

where L_s = equivalent cavity inductance

R = equivalent series resistance due to cavity losses.

Loaded Q is expressed by:

$$Q_L = \frac{2\pi fL_s}{R + R_g + R_L} \tag{7}$$

where R_g = source resistance and R_L = load resistance transformed to the reference point.

A more thorough discussion of these equations has been published by C. G. Montgomery et. al.[7]

Insertion loss, L, is defined as the ratio of power available, P_A, to power output, P_o. At resonance,

$$L = \frac{P_A}{P_o} = \frac{E_g^2/4R_g}{\dfrac{E_g^2 R_L}{(R_g + R_L + R)^2}} = \frac{(R_g + R_L + R)^2}{4R_g R_L} \tag{8}$$

For matched conditions, $R_g = R_L$; therefore equation (8) simplifies to:

$$L = \frac{(2R_g + R)^2}{4R_g^2} = \left(1 + \frac{R}{2R_g}\right)^2 \tag{9}$$

Since, for matched conditions

$$\frac{Q_U}{Q_L} - 1 = \frac{R + R_g + R_L}{R} - 1 = \frac{2R_g}{R}$$

Therefore, when source and load are matched,

$$L = \left(\frac{1}{1 - Q_L Q_U}\right)^2 \tag{10}$$

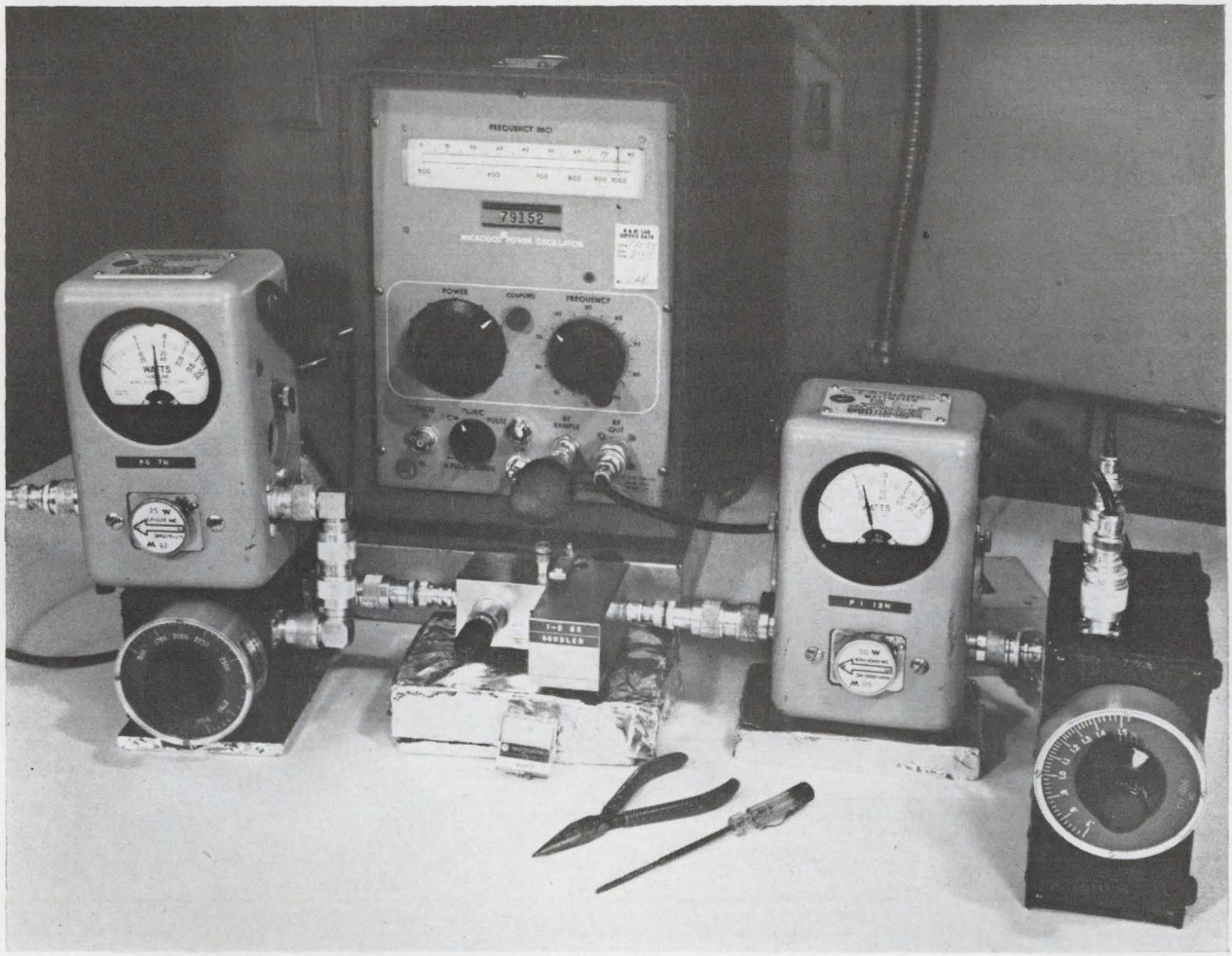
For low insertion loss, Q_L/Q_U should be as small as possible. This requires heavy coupling to source and load, and minimization of cavity losses.

It has been determined[8] that the highest value of Q_U occurs with a characteristic admittance of Y_o = 0.013 mhos (Z_o = 77 ohms). However, Q_U is not critically dependent on Y_o and cavities having values of Y_o from 0.01 to 0.02 mhos should work out well in multiplier design.

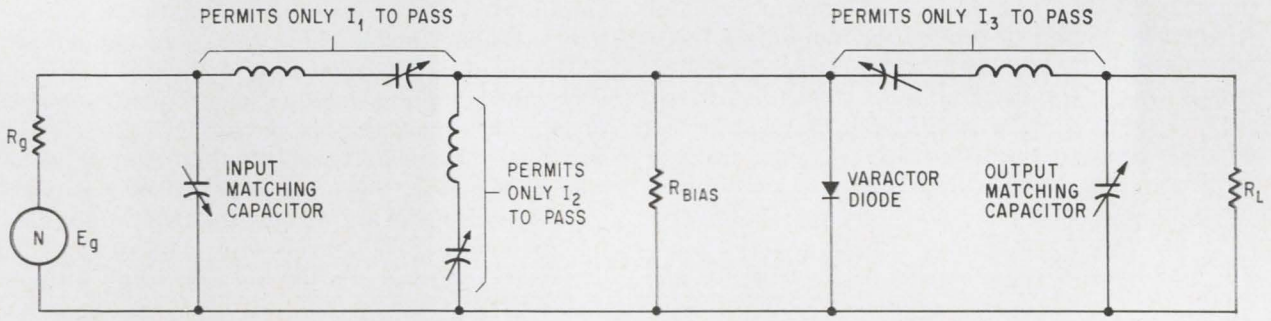
Multiplier design

The basic problems of multiplier design are to establish, and if possible, separate current paths for the needed frequencies, reject unwanted frequencies, match impedance for minimum conversion loss, and provide a mechanical structure to dissipate heat internally generated and to withstand a specified environment. At low frequencies using lumped circuits, the design is straightforward because functions can be separated as shown in the top circuit on the next page. Filters or resonant circuits are adjacent to the varactor, and separation of signal frequencies and impedance matching are possible with little interaction.

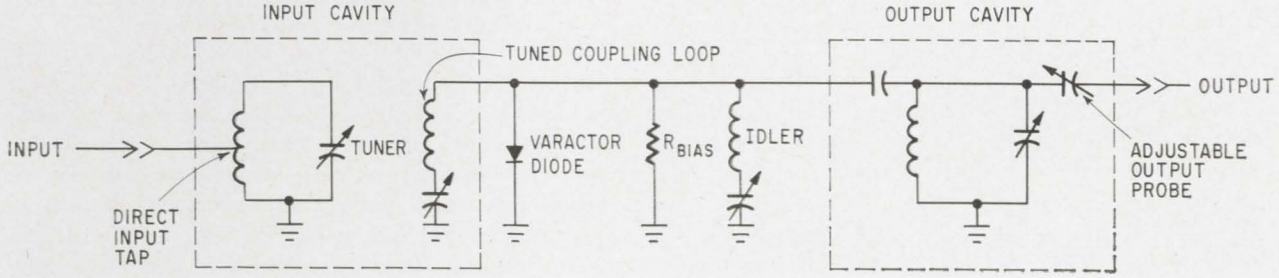
However, as the frequency increases, the electrical length of the interconnections increases. The effects of the varactor's parasitic reactances also



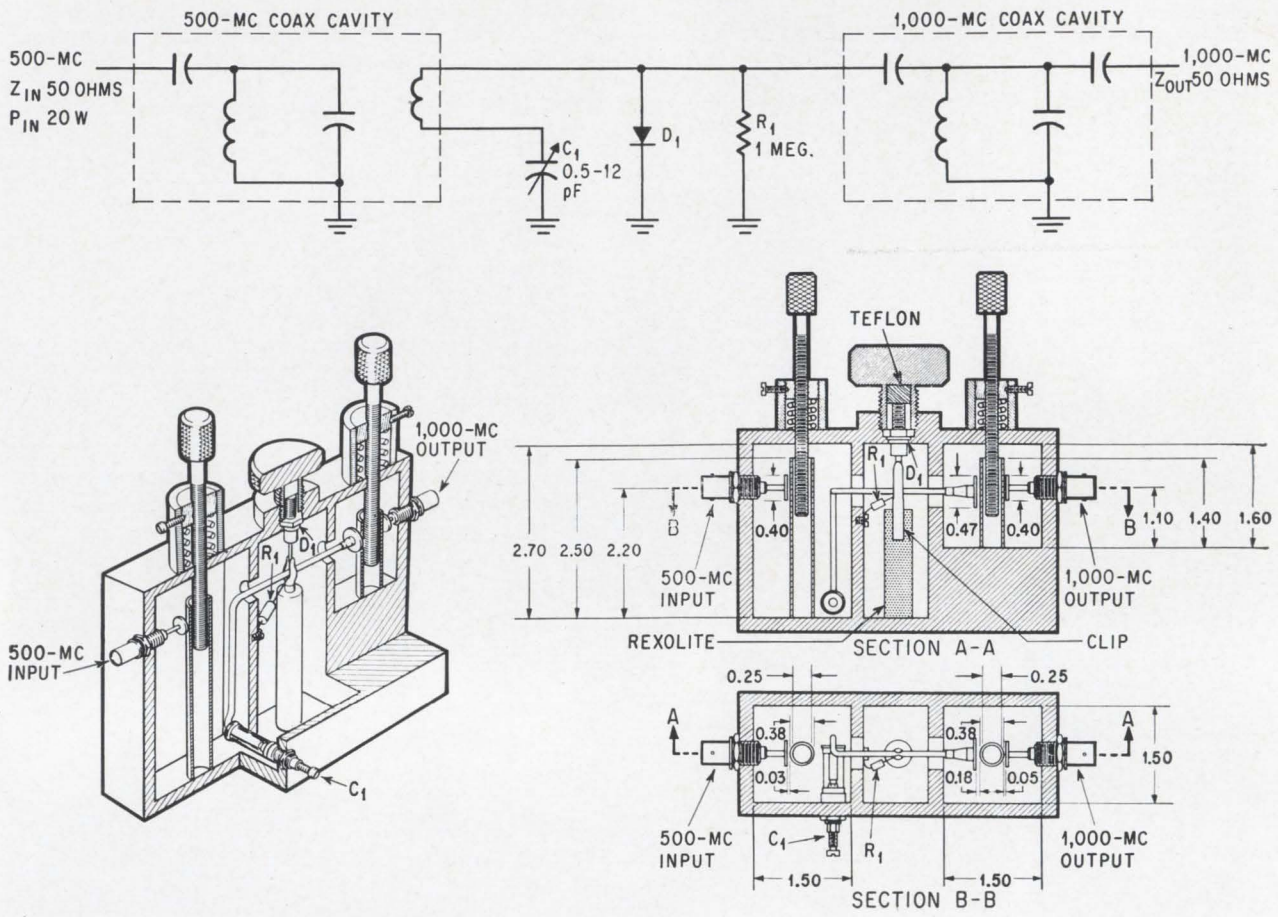
Test arrangement for 1-to-2-Gc doubler includes a wattmeter, at left, indicating the input power of 12 watts; a power oscillator set at 1 Gc; and another wattmeter, at right, showing the power output level of 7 watts at 2 Gc.



Lumped circuit multiplier showing input and output filtering and matching circuits, idler circuit, self bias and shunt-mounted varactor. I_1 is input current. I_2 is idler current. I_3 represents the output current.



Cavity multiplier with tuned coupling loop in input cavity and adjustable probe in output cavity. This multiplier is similar to the lumped circuit multiplier except the input and output filter and matching circuits have been replaced by cavities.



Harmonic doubler (500-to-1,000 Mc) circuit used for evaluation of varactor. When a 1N4388 varactor diode is used with 20-watt input at 500 Mc, typical output at 1,000 Mc is 12 watts.

increase, and it becomes difficult to separate frequencies without interaction. Moreover, at high frequencies, lumped resonances no longer make adequate filters, and distributed circuits—such as cavities—must be used.

In designing cavity multipliers, it is important to place the frequency-separating cavities as close to the varactor as possible to minimize interactions. Interactions arise when undesirable resonances occur too close to a desired frequency. Excessive transmission-line lengths between varactor and cavity often result in such resonances. For example, the input circuit can present a high admittance to the output frequency tending to short circuit the output. Fortunately, there are coupling techniques that minimize interaction. When these are used, along with compact circuitry to limit the length of transmission lines, satisfactory cavity-multiplier designs can be achieved.

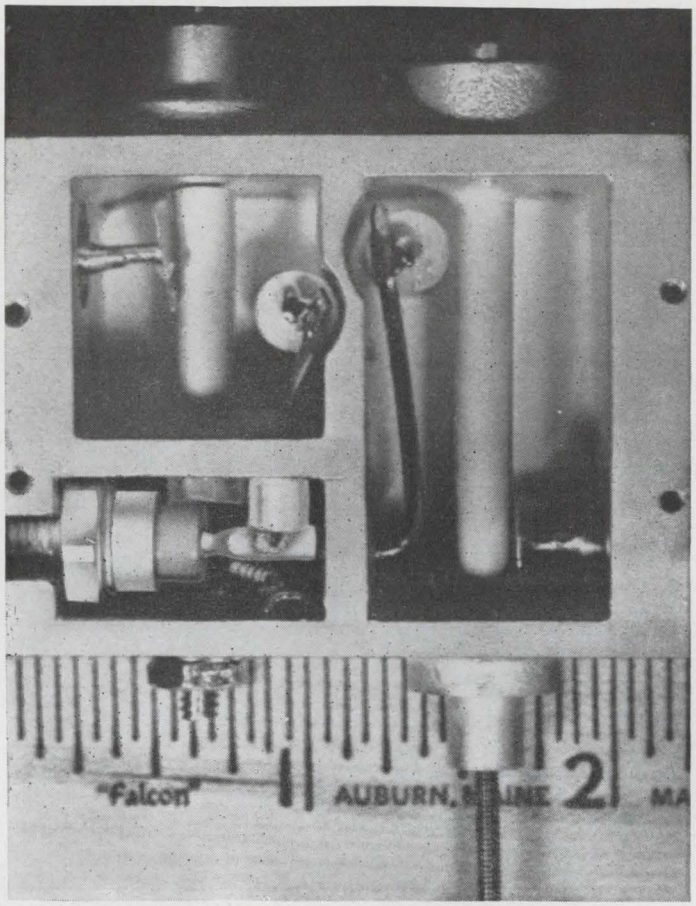
The recommended approach to cavity multiplier design is shown in the bottom circuit of the previous page. The multiplier consists of input and output cavities, both of which are coupled to the varactor. If multiplication higher than two is desired, one or more idler circuits are placed across the shunt-mounted varactor. The idler circuit is a series-resonant circuit, usually designed to double the frequency of its input current. For idler frequencies up to 2,000 megacycles, lumped circuits can be used and self-resonant operation with certain available tunable capacitors is recommended.

The input cavity consists of a shorted transmission line, either adjustable in length or capacitively tuned. The input to this cavity is a direct tap, shown on the previous page (bottom circuit), or an adjustable probe. Since input impedance of high-power varactor devices is low, relatively tight coupling is needed. The correct tap point, usually determined empirically, is the one providing little or no reflected power.

Proper coupling of the input cavity to the varactor is important because this coupling performs several functions. Not only must it provide the proper impedance match to the varactor, it must also block the idler and ouput frequencies.

It has been found, especially with doublers and triplers, that a short loop terminated by a tunable capacitor at the shorted end of the cavity works well. In effect, this is a tuned loop giving extra selectivity at the input. To prevent loss of idler or output frequency energy, the electrical length of the transmission line from the varactor to the capacitor tuning the loop should be less than one-quarter wavelength at the output frequency.

Probe coupling from varactor to the output cavity is suitable because the coupling reactance is



Miniature 500-to-1000-Mc doubler. With a 1N4388, outputs are obtainable to 10 watts.

high at the lower input or idler frequencies; thus, the probe and output cavity blocks these frequencies. Also, the probe may be changed easily. When the multiplier is aligned, the varactor's output coupling should be adjusted for minimum conversion loss.

The output cavity also consists of a shorted transmission line, tuned either by changing the length of the line or by capacitance loading. Output coupling to this cavity is best made by an adjustable probe. This can be accomplished with a bulkhead connector with a plate soldered onto one end. This type of output coupling is easily adjusted for minimum conversion loss.

The spurious output level of —30 decibels, typically obtained from a single cavity, is often insufficient for specific system requirements. Adding a bandpass filter or cascading additional cavities will provide additional rejection.

Many different varactor types can be operated in a single cavity multiplier with relatively few changes. This is because it is easy to tune and match the various types of devices, and even to interchange abrupt-junction varactors with those that exhibit step-recovery due to charge storage. The design examples to be discussed utilize step-recovery diodes. In some cases, however, abrupt-junction devices are compared with step-recovery diodes, and these results will also be discussed.

Doubler from 500 to 1,000 Mc

The cavity multiplier principles presented here may be applied to a variety of cavity designs. The first two to be discussed are 500 Mc to 1,000 Mc doublers. More details are given with the second design example because it leads to a more compact structure.

The design on the opposite page is used mainly to test 1N4388 varactors at high power levels. This circuit can easily handle 20 watts input at 500 Mc and provide a typical output of 12 watts at 1,000.

This multiplier design offers ease of tuning, matching, replacement of varactor diodes, good thermal properties and high efficiency.

The input cavity is capacitively tuned by moving a screw into the hollow center conductor. Since a low-resistance ground for the tuning screw must be maintained, oil or grease cannot be used on the bearing surface. Although an elaborate finger-contact arrangement can be used, it is simpler to use a spring-loaded tuning screw. In this way, continuous metal-to-metal contact between the tuning screw and the cavity wall is maintained. If the cavity walls are aluminum, it is recommended that an insert such as a Helicoil, be used to prevent thread wear.

To prevent galling or wear of the tuning screw's threads, the screw should be fabricated from a hard material such as beryllium copper. Gold plating of both cavity and tuning screw helps to prevent galling and tarnishing. This cavity's input port has an adjustable probe, whose end is only 0.03 inch from the center conductor. This arrangement provides tight coupling. The need for tight input coupling is created by the low impedance of the varactor, which is also tightly coupled to the input cavity by the tuned coupling loop. A suitable capacitor to tune the loop is a Johanson JMC1801, which has a guaranteed Q of 2,000 at 100 Mc. The JMC1801, or the miniature JMC2950, are both usable for input loops up to 1,000 Mc.

A low thermal-resistance path is provided for the varactor by pressing the flange against the housing. Similar results have been obtained by using a nut on the varactor study to clamp to the housing. Although the mounting shown is for a Jedec DO-4 package, it is easily modified for cartridge or pill packages while still maintaining the compression holding principle.

Bias is provided through a resistor from the varactor to ground. Satisfactory efficiency is provided if the resistor is greater than 0.1 megohm.

The output cavity is similar to the input cavity except for the probe coupling to the varactor. However, tuned-loop coupling has also been used with satisfactory results, as will be shown for a miniature 500 Mc- to 1,000-Mc doubler.

Miniature doubler 500 to 1,000 Mc

A photograph of a 500-Mc to 1,000-Mc doubler is shown above. A 10-step design procedure for

this doubler follows:

1. Select the cavity geometry. A cylinder in a square enclosure is often a good choice because the two multiplier cavities and the varactor holder can conveniently be placed inside one rectangular housing, which is easy to mount. Also, the lumped tuning capacitors and varactor holder can be mounted easily onto the rectangular housing. The use of circular cylinders for center conductors facilitates characteristic admittance calculations.

2. Where space is at a premium, the cavity cross-sectional dimensions D and d, shown in the top right diagram on page 57 are usually selected first. The ratio D/d is selected to provide the characteristic impedance of about 77 ohms ($Y_o = 0.013$ mhos). Use of the characteristic admittance equation shown on page 57 for cylinder-in-square construction, and $Y_o = 0.013$ mhos, yields $D/d = 3.1$.

However, a slightly higher impedance allows a shorter cavity. Therefore, a D/d ratio of 4 is selected, which gives Z_0 of 86 ohms ($Y_o = 0.0116$ mhos). Dimension D should be the practical minimum, being limited in this case by the size of the tuning capacitor on the loop coupling the varactor. The tuning capacitor has to fit between the center conductor and the outside wall. With D = 0.75" and d = 0.190", the JMC2950 capacitor can be placed in the cavity.

3. To keep the 500-Mc input cavity short, select the electrical length of the center conductor in the vicinity of 20°; since 1 wavelength = 60 centimeters, $l = (20°/360°) \times 60 = 3.3$ cm.

If this length is too short, the required tuning capacitor would be too large to fit within the allotted space.

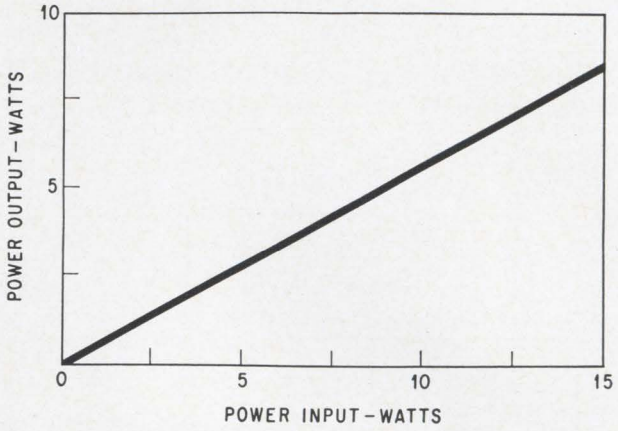
4. Calculate the input cavity's tuning capacitance by using equation (4), as follows:

$$C_T = \frac{0.0116}{2\pi 500 \times 10^6} \text{ ctn } 20° = 10.2 \text{ pf}$$

where $Y_o = 0.0116$
$f = 500 \times 10^6$ cps
$2\pi fl/V_C = 20°$

A large end-effect capacitance of 2 pf is assumed because the open end of the center conductor is placed near the housing top wall. This leaves 8.2 pf to be applied by the cavity tuner.

5. In designing the tuner, select a screw size to fit into the hollow center conductor while leaving enough wall thickness to accommodate a dielectric tuning sleve. The dielectric tuning sleeve is used to guide the tuning screw and increase the capacitance per unit length of the tuner. Some low-loss materials that can be used are Teflon, Rexolite and polystyrene. Rexolite was selected for this design because it is easier to machine and has better mechanical stability than Teflon. With a 2-56 tuning screw having an outside diameter of 0.086-inch (dimension a in equation 5) and a dielectric wall thickness of 0.030 inch, the inside diameter of the hollow tube, b, is 0.086" + 2 × 0.030, or 0.146 inch. This leaves the thickness of the conductor wall equal to (0.190 — 0.146)/2 inch,



Power input plotted against power output without tuning for miniature 500-to-1,000 Mc doubler.

or 0.022 inch which is adequate for a physical line length l of 3.3 centimeters or 1.3 inch. From equation 5, the tuning length

$$L_T = \frac{8.2 \log (0.146/0.086)}{0.242 \times 2.5}$$

$= 3.1$ cm (1.22 inch)

where $C_T = 8.2$ pf
$\epsilon_r = 2.5$ for rexolite
$a = 0.086$ inch
$b = 0.147$ inch

This tuning length is possible with the dimensions selected.

6. In the output cavity, determine the allowable tuning length by mechanical considerations and available space. The output cavities must share the available length with the varactor. A scaled layout drawing is suggested at this point. From such a layout drawing, a 1,000-Mc cavity 2.15 centimeters long, or 0.85 inch is selected. This length represents the multiplier length (1.58 inch set by the input cavity length) minus the varactor width, required clearances, and the multiplier wall width. If the cross-section is the same as the 500-Mc cavity (D = .75 inch, d = .190 inch) and a physical length of 2.15 cm is used, the electrical center conductor length is 26°.

7. The required output cavity tuning capacitor is

$$C_T = \frac{0.0116}{2\pi 1000 \times 10^6} \text{ ctn } 26° = 3.8 \text{ pf}$$

assuming an end capacity of 2 pf, the required tuning length is

$$L_t = \frac{1.8 \log_{10} 0.146/0.086}{0.242 \times 2.5} = 0.68 \text{ cm}$$

which is reasonable, considering that the available length within the output cavity for the center conductor is 2.15 cm.

8. The calculated dimensions are approximate because the reflected coupling reactances have a considerable effect on cavity tuning. Loop coupling raises resonant frequency; capacitance coupling lowers it. The capacitors have appreciable series

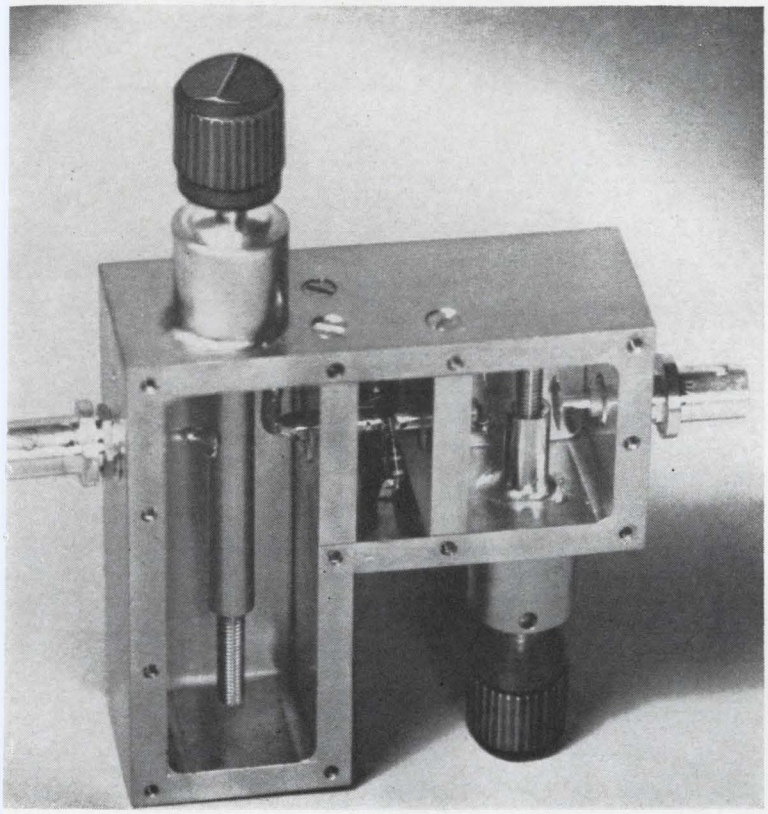


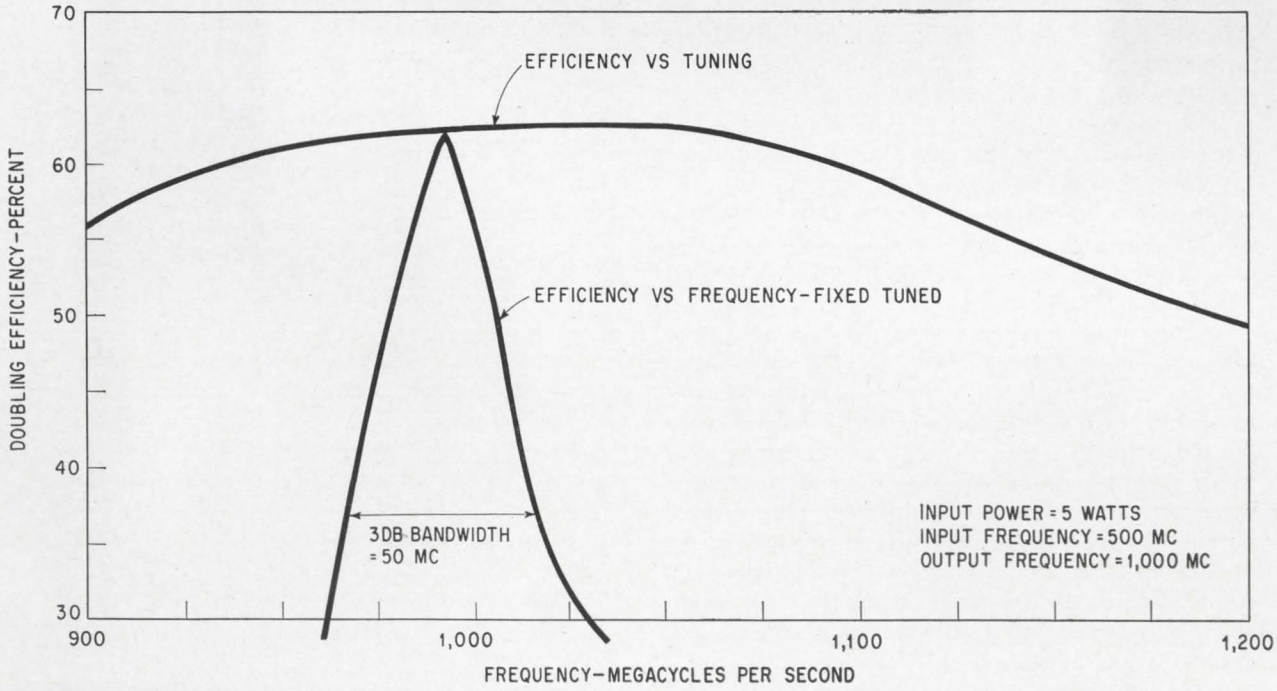
Photo of a 1,000-to-2,000-cavity doubler of a 1,000-to-2,000-cavity doubler using MV1808 varactor. Power outputs up to 7.5 watts may be obtained with this multiplier.

inductance; therefore the length of the loops tied to the capacitor must be shorter than might be expected if the lowest resonant mode of operation is to be achieved.

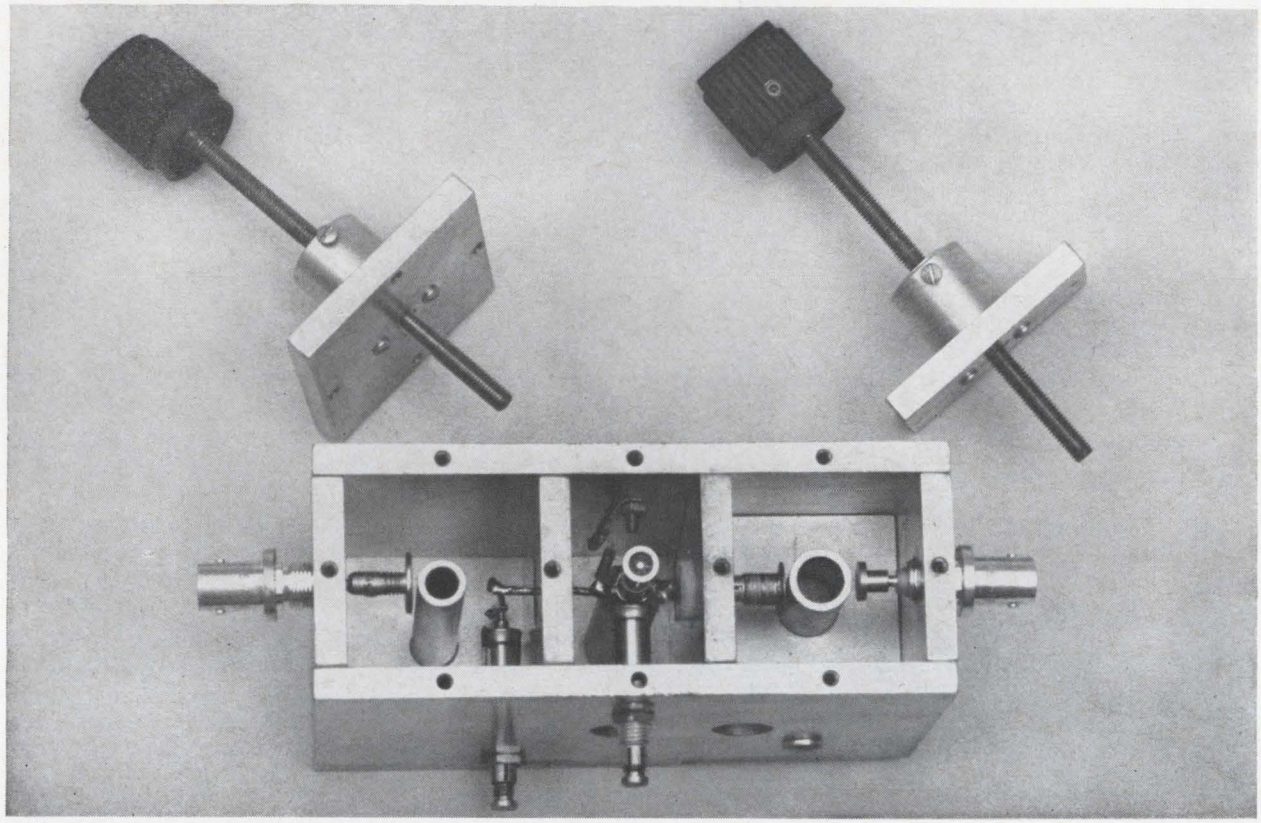
9. If a tuning range is required, the calculations should be made near the lowest needed frequency after assuring that the cavity length and end capacitance are resonant at a frequency considerably higher than necessary. With the tuning method used in this design, a 20% tuning range is easily achieved.

10. The doubler is fabricated from aluminum plates to make it small, light and rugged. These plates are assembled in place and the entire structure dip-brazed to provide a low loss microwave structure. A removable side plate is used for access to the doubler; this plate has closely spaced screws to prevent loss by radiation through gaps between the side plate and the cavity walls. To prevent erratic tuning, tension is maintained on the 2-56 tuning screws by spring loading. Also, to prevent galling of the threads, beryllium-copper screws are used. Everything but the tuning screws is gold-plated to reduce skin resistance and provide a tarnish-resistent surface.

The performance of this miniature doubler is summarized in the curve on page 62, showing the linearity of the output-input response, and in the curve below showing both the tuning range and fixed tuned bandwidth. With an input up to 15 watts, the response is almost linear, indicating a satisfactory circuit for amplitude modulation. Tuning range is 900 Mc to 1,150 megacycles, and the fixed tuned bandwidth is about 5% at 1 gigacycle. Power output is 8.6 watts with a 15-watt input, which compares favorably with the power



Efficiency versus frequency for 5-watt input to the miniature 500-to-1,000-Mc doubler. Responses with and without retuning are shown.



A 500-to-1,500-Mc tripler similar to the 50-to-1,000-Mc harmonic doubler shown on page 60. Typical tripling efficiency is 53% for a 5-watt input.

output of 9 watts obtained with a larger test fixture. The circuit also has excellent spurious rejection characteristics with all spurious emissions at least 31 decibels below the desired output.

1,000-Mc-to-2,000-Mc doubler

The design philosophy for a doubler from 1,000 Mc to 2,000 Mc is an extension of approach used to 500-Mc-to-1,000-Mc doubler except that more attention is paid to circuit layout. Because of the higher frequencies involved, shorter interconnections are necessary to prevent the interactions discussed earlier. A photograph of this 1,000-Mc-to-2,000-Mc doubler is shown on page 63. There are several differences between this doubler and those previously discussed. Its cavities are tuned by changing the center conductor length, direct tapping to the center conductor is used on the input, the coupling loop to the varactor is shorter, and a pill varactor is used rather than a stud mounted device.

Both abrupt-junction and step-recovery varactors have been used with this multiplier. The abrupt-junction varactor (MV1864A) has a 6-pf capacitance at −4 volts and a cutoff frequency between 100 Gc and 150 Gc. With a 5-watt input the conversion efficiency is 60%. Using an MV1808 step-recovery varactor, also having a 6-pf capacitance, the efficiency is 60% with a 12-watt input.

If suitable idler circuits are added, cavity multipliers also make excellent triplers. Up to 2,000 Mc, commercially available capacitors such as the JMC1801 or JMC2950 are satisfactory in idler circuits. With these capacitors, line length between the varactor and the idler capacitor terminal is kept to a minimum. Above, 2,000 Mc, idler circuits can be made from capacitively terminated transmission lines.

A 500-Mc-to-1,500-Mc tripler design is shown above. The dimensions are roughly the same as the first 500-Mc-to-1,000-Mc doubler discussed except that the output cavity is shorter and the idler capacitor is attached to the varactor holder. The varactors used in this circuit are the MV1864A abrupt junction type and the MV1808 step-recovery type. Both achieve 53% efficiency with a 5-watt input.

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2. P. Penfield, Jr., and R.P. Rafuse, Varactor Applications, MIT Press, 1962.
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4. Harvard University, Radio Research Laboratory Staff, Very High Frequency Techniques, Chapter 28, McGraw-Hill, 1947.
5. A. Kiriloff, "Designing cavities in the 500-Mc range," Electronic Design, Feb. 15, 1961, pp. 180-183.
6. The 1964 Microwave Engineers Handbook, Horizon House, Dedham, Mass., pp. 85-88.
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8. Harvard University, ibid, p. 770.

Suppressing noise at the connector

Tiny ceramic dielectric and ferrite filter, built around a connector contact pin, reduces interference

By Edwin Rowlands and Michael P. Noonan

ITT Cannon Electric, a division of International Telephone and Telegraph Corp., Los Angeles

When radio frequency interference distorts the picture during a television program, it's irritating. When it affects the trajectory of a missile or blacks out communication signals, it can be disastrous.

There are estimates that as much as 5% of the total sales revenue of the electronics industry is spent on eliminating unwanted signals. The growing number and increasing sensitivity of electronic devices and equipment in areas controlled by the government—military, space, communications—has led to more than 20 different federal specifications concerned with the suppression of radio frequency interference.

Engineers have a number of ways of filtering out unwanted electrical impulses that come out of, or enter, the black box at the points of interconnection. But these methods usually involve additional components and labor. Now a small ceramic filter, built around a connector contact pin, will suppress rfi with no extra wiring and little additional weight.

The filter pin connector, developed by ITT Cannon Electric Inc., a division of International Telephone and Telegraph Corp. with the assistance of Erie Technological Products, Inc., can be used for whatever contacts are desired

Kinds of disruption

Radio frequency interference falls into two broad categories—natural or man-made. Some of the natural sources of rfi are galactic noise, atmospheric noise, precipitation noise and corona noise.

Interference originating from natural causes usually consists of random noise spread over a broad band of frequencies varying greatly in amplitude with time and location.

Man-made sources of rfi fall into broadband or narrow-band categories. Broadband rfi can be completely random or may have some periodicity.

Narrow-band rfi is typified by the output harmonics from a radar or other high-power transmitter. Interference from such a source may cover a wide range of frequencies, but the energy distribution with frequency is generally sharply defined.

In electronic equipment systems, rfi can come from the three main sources: conducted source (like a lead entering a box); ground-loop coupling (two circuits having a common impedance between two ground points), or radiated field from nearby circuits (electrostatic or inductive coupling between two leads close together).

In many cases, the emitted energy radiates from connecting lines and harnesses that link a system composed of several black boxes. Connectors to suppress rfi are usually at the exit or entry points.

Many equipment applications require the simul-

The authors

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Michael P. Noonan has contributed a number of articles on connector developments to trade journals in the industry. He attended Dartmouth College and has a graduate degree from the University of Southern California.

taneous operation of extremely sensitive devices in the presence of ultrahigh-power radiated fields. A typical example is operation of a receiver with sensitivity of 0.001 microwatt close to a transmitter with a megawatt of output power. This situation represents a power difference of 150 decibels and so requires at least this degree of isolation between the devices through the use of appropriate electrical filters.

Filter types

Filters can be classified in two categories, reactive and absorptive. Purely reactive filters tend to reflect the unwanted signal back toward the source. They do not absorb the signal to any extent. Examples of these are inductor-capacitor types. They are usually non-lossy devices. Absorptive type filters present a resistance to high-frequency signals and tend to convert the undesired energy to heat. Because they incorporate certain lossy elements, they are in effect energy converters.

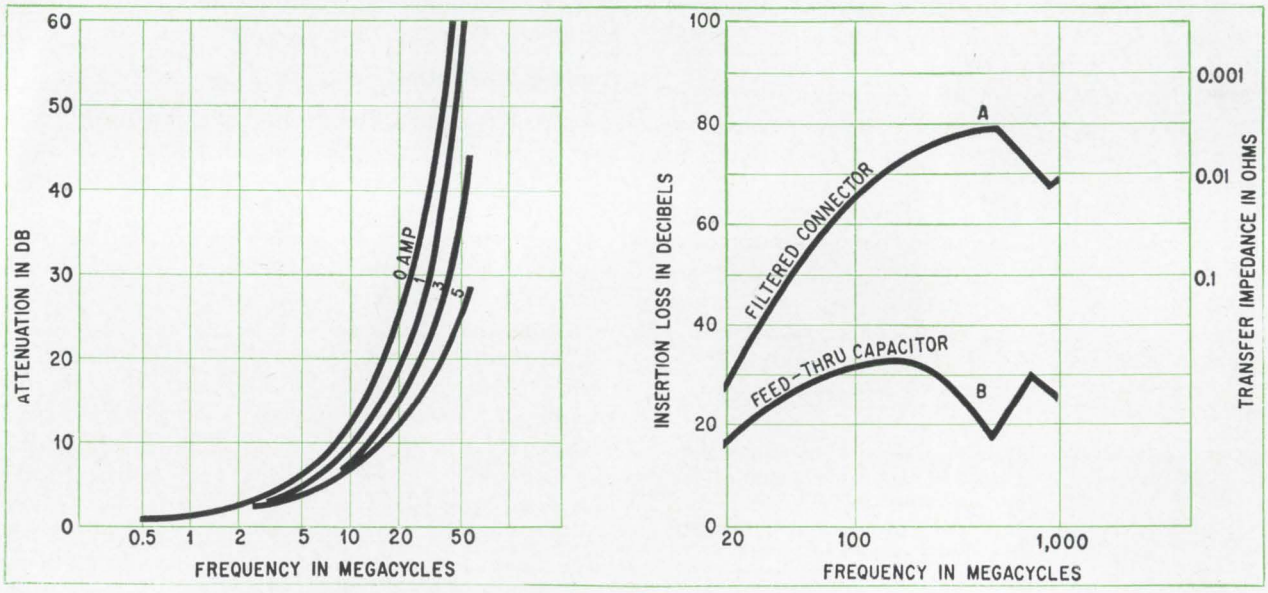
Filters can also be classified by function—low pass, high pass, band pass and band elimination.

Filters for cut-off frequencies up to approximately 100 megacycles usually comprise inductors, wire-wound coils, and capacitors. However, at higher cut-off frequencies these two elements become so small they are generally realized in various forms of coaxial or waveguide transmission lines. For example, changing the conductor diameter ratio in a coaxial line may have an inductive or capacitive effect depending upon the direction of change. Low-pass coaxial filters have been made by designers in a flexible coaxial form for cut-off frequencies of 500 Mc and higher. These combine the flexible nature of coaxial cable with the filter action, thus providing a dual function of a cable and filter.

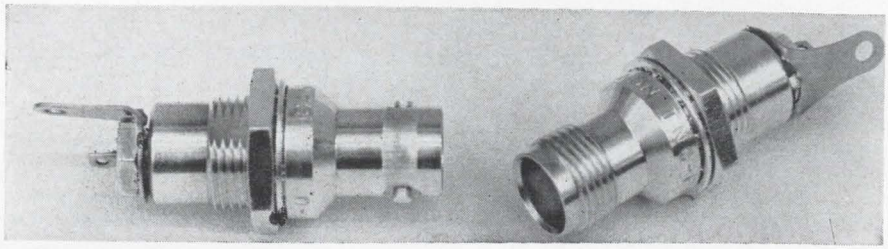
Undesirable signals can also be reduced by converting the electrical energy in the signal to heat energy. This conversion is accomplished by incorporating into filters certain materials that are lossy, or resistive. Pure resistors are not particularly frequency-sensitive. Fortunately, there are resistive materials such as ferrites that are frequency-sensitive and can be used effectively in filters.

Network filter

One of the connector filters that has been developed is a three-terminal network that operates as a low-pass filter. The filter consists of a pin contact with ceramic capacitors and ferrite material assembled to the contact. The filters are installed on the pin half of the connector and each filtered connector has a conventional contact layout and shell, differing from an ordinary connector only in that the pin half of the insert is slightly elongated in the rear. The filter contacts, capacitors, inductors and ferrites, are incorporated in four different connector series.



Attenuation vs frequency at different direct current bias levels (left) for pin filter. Comparison between filtered connector and feed-through capacitor (right).



Type BNC (left) and TNC (right) connectors with filters are used to connect small coaxial cables. The connectors can be used to filter out sparkplug, generator or fluorescent hash besides preventing interference from uhf and microwave signals.

In these filters, the ferrite performs two functions. It surrounds the contact and increases the effective inductance of that portion of the conductor. It also has a lossy or resistive effect as the frequency increases. Thus resistive and reactive effects are combined in these filters. The capacitor is made in two sections and is attached to the contact on either side of the ferrite sleeve.

Measured characteristics

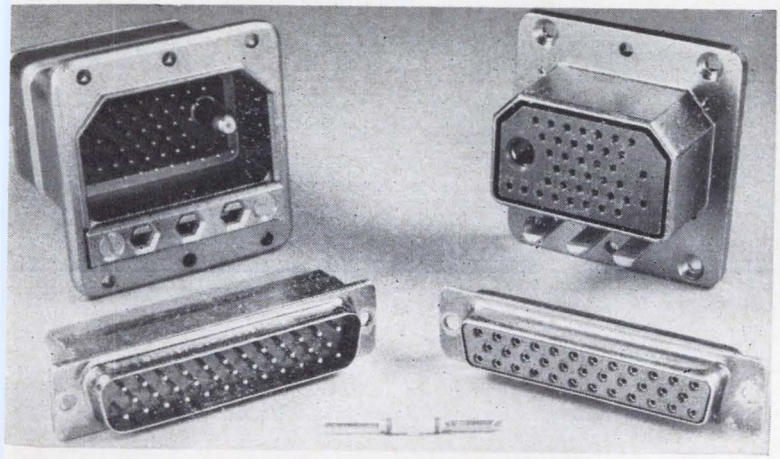
The graphs on page 66 represent the performance of the filtered connector pin compared to a conventional feed-through capacitor of approximately the same size. At point A on the graph at right, the filtered contact or pin has an insertion loss of 78 db. At the same frequency, a representative conventional feed-through capacitor has an insertion loss of 24 decibels, represented by point B. The filter, therefore, is over 500 times more effective at the same frequency.

While the filter reduces or eliminates the unwanted signal, it must not reduce the wanted signal usually in d-c control lines or a-c power lines operating at 60 or 400 cps. It must, therefore, offer low impedance at these frequencies. The graphs clearly indicate that the resistance and low frequency impedance of the filtered connector pin has little effect at frequencies below 1 megacycle, and therefore meets this requirement.

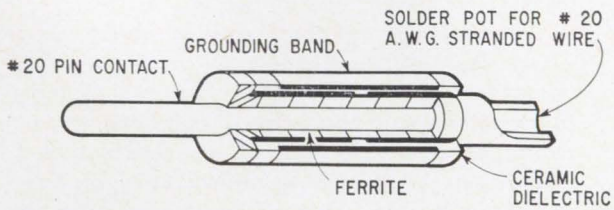
Attenuation measurements were made in accordance with MIL standard 200A, which calls for measurement in a 50-ohm system. However, in many applications, an impedance other than 50 ohms will exist. Often then, the results in actual usage can be even better than the test results. Specific characteristics of a typical filter are shown in the table above.

Characteristics of a filter contact

Minimum attenuation	15 db at 12 Mc 35 db at 30 Mc 50 db at 60 Mc 50 db (min) from 100 Mc to 2,000 Mc, over the temperature range from −55°C to 125°C
Capacitance	2,500 pf (guaranteed min) at 1 kc
Working voltage	200 v d-c, or 100 v a-c at 400 cycles
Dielectric strength	600 v d-c for 1 second (50 ma max charging current)
Operating temperature range	−55°C to 125°C
Insulation resistance	10K megohms min at 500 v d-c
D-C resistance	0.01 ohm maximum
D-C and low frequency current	5 amperes maximum (with some reduction of filter action)
R-F current	0.25 ampere maximum
Life test	1,000 hours at 400 v d-c at 85°C After life insulation resistance exceeds 1,000 megohms
Moisture resistance	Method 106A of MIL Std. 202C After test the insulation resistance still exceeds 1,000 megohms



Individual filter pin (bottom center) used in both the upper type DPX rack and panel connectors and the type D subminiature connectors below them.



Partial sectional view of the filter contact showing how the ferrite filter and ceramic dielectric capacitor surround the pin.

Interchangeable contacts

A few other manufacturers offer filter devices, some for specific, others for general application. Coaxial filter connectors have only recently been introduced elsewhere.

In the new designs, filter contacts, insulated contacts and grounded contacts are interchangeable and may be inserted in any one of the available cavities in the insulated body inserts.

With a pin half filtered, the configuration of the socket half of the connector is identical to that of a standard unfiltered unit. The only difference is in the subminiature connector series, where greater contact-to-contact spacing is required. The filter contact concept can be applied to both circular and rectangular connectors.

Other components, such as diodes, capacitors, resistors or inductors, have been built into connectors similar to the filter type described. These connectors are still under development.

Circuit design

Designer's casebook

Designer's casebook is a regular feature in Electronics. Readers are invited to submit novel circuit ideas, packaging schemes, or other unusual solutions to design problems. Descriptions should be short. We'll pay $50 for each item published.

Feedback system detects 1% amplitude difference

By P. H. Howard

International Business Machines Corp., Rochester, Minn.

To compare small differences in low voltage levels without a complex switching circuit and high gain precision-matched amplifiers, an inexpensive feedback system may be used. It distinguishes 1% amplitude differences in low voltage signals even though the gains of the amplifiers vary by as much as 20%.

One possible application of such a system is in a character recognition device which operates by passing light through a written character so a silicon solar cell can convert the transmitted light energy into an electrical amplitude signal. The feedback system then compares this amplitude signal with standard signals to identify the character.

A more common method would be to use voltage amplifiers in an n-way switching circuit, but that would require amplifying differences of millivolts by a factor of 5,000 and restricting variations in the gain between any two amplifiers to less than 1.0%.

The system shown in the block diagram on page 69 can compare any of n input voltages with amplitudes up to 10 millivolts and determine which is the greatest within 0.1 mv.

In the switching block, the most negative of the voltages, E_{max}, is the largest of the signals E_1, E_2, . . . E_n. In that channel where E_{max} is greater than E_{ref}, the transistor conducts, producing an output signal. In all other channels, the transistors are biased off by the voltage generated across the common emitter resistor R_k.

The feedback signal e_f is a function of E_{max}: $e_f = E_{max} - E_{ref}$ for $E_{max} > E_{ref}$ and $e_f = 0$ for $E_{max} \leq E_{ref}$.

If E_1 is the largest and E_2 the next largest of the input signal amplitudes, than $E_1 = E_{max}$, $E_1 > E_{ref}$ and therefore

$$e_f = E_1 - E_{ref} \quad (1)$$

Some fraction γ of this feedback signal is subtracted from each input before amplification, and from the block diagram

$$E_1 = G_1(e_1 - \gamma e_f)$$
$$E_2 = G_2(e_2 - \gamma e_f)$$

Equation (1) is introduced into each of these equations yielding

$$E_1 = G_1[e_1 - \gamma(E_1 - E_{ref})] \quad (2)$$
$$E_2 = G_2[e_2 - \gamma(E_1 - E_{ref})] \quad (3)$$

Equation (2) is solved for E_1 and the result is inserted in equation (3) to obtain an expression for E_2 independent of E_1. The difference between E_1 and E_2 can then be expressed as

$$E_1 - E_2 = \left(\frac{1}{1+\gamma G_1}\right) \times [G_1e_1 - G_2e_2 + \gamma E_{ref}(G_1 - G_2) + \gamma G_1G_2(e_1 - e_2)] \quad (4)$$

Since E_1 is greater than E_2, $e_1 > e_2$, and the last term of equation (4) above must be positive. To show that $(e_1 - e_2)$ is the most dominant term, the expression is rewritten

$$E_1 - E_2 = G_1e_1\left(\frac{1+\gamma G_2}{1+\gamma G_1}\right) - G_2e_2 + \frac{\gamma G_1 E_{ref}\left(1 - \frac{G_2}{G_1}\right)}{1+\gamma G_1} \quad (5)$$

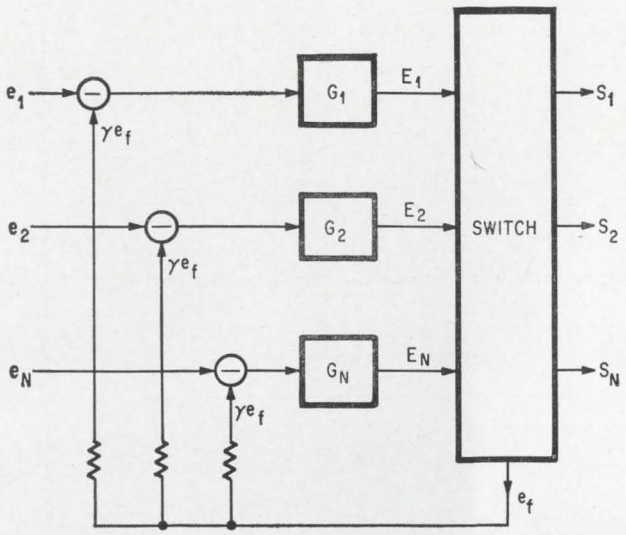
Usually, $\gamma G_1 >> 1$ and $\gamma G_2 >> 1$, and the expression above reduces to

$$E_1 - E_2 \cong G_2(e_1 - e_2) + E_{ref}\left(1 - \frac{G_2}{G_1}\right).$$

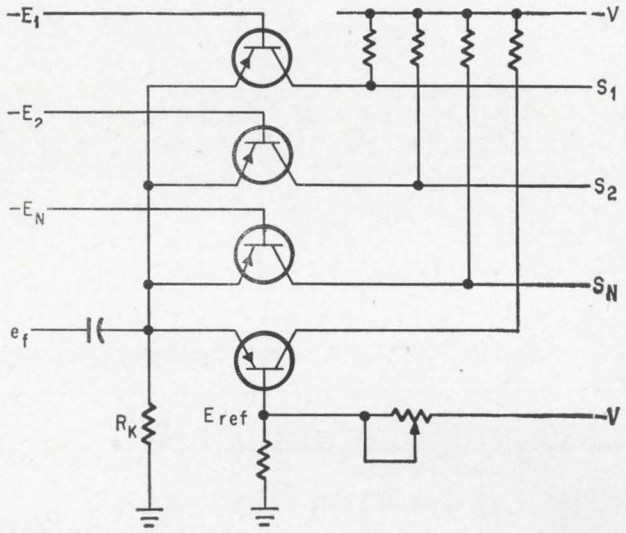
And from this equation, it is apparent that if G_1 and G_2 are fixed and approximately equal, the difference in the switching inputs is directly proportional to the difference in system input voltages. If the gains are not equal, make E_{ref} very small to reduce the significance of this inequality.

The voltage feedback ratio γ should be made large to stabilize the system response when the amplifier gains are unequal. However, γ must also be small enough to minimize coupling between the amplifier inputs. A value of $\gamma = 0.01$ satisfied both conditions in the circuit shown at right, top.

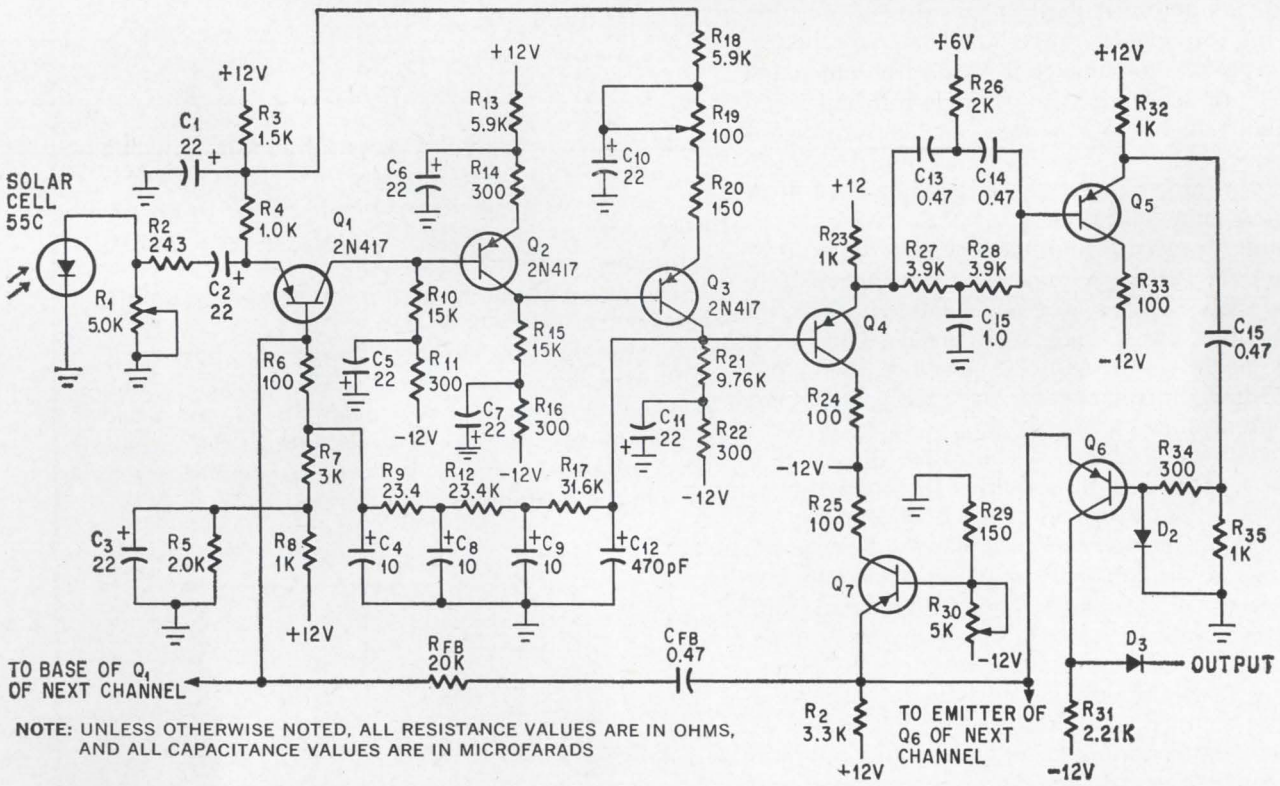
The voltage E_{ref} establishes a threshold prevent-



Negative feedback permits detection of pulse amplitude differences as low as 1%, even though the individual amplifier gains may vary by as much as 20%. System compares any of n input voltages with amplitudes up to 10 millivolts and determines the largest within 0.1 mv.



Selector switch provides voltage feedback ratio that must satisfy two conditions—it must be high enough to stabilize the system and at the same time low enough to minimize stray coupling from adjacent channels. For this system, $\gamma = 0.01$ satisfied both requirements.



NOTE: UNLESS OTHERWISE NOTED, ALL RESISTANCE VALUES ARE IN OHMS, AND ALL CAPACITANCE VALUES ARE IN MICROFARADS

One channel of solar cell signal amplifier and a section of of the switching block, built for an experimental character recognition device. Transistors Q_1 through Q_7 may be any pnp alloy switching types, and for diodes D_2 and D_3, any low-current germanium type may be used.

ing noise voltages from producing output signals. Voltage at the emitters of the transistors in the switching circuit will be approximately equal to E_{ref} because negative feedback occurs when any of the input voltages exceeds this voltage.

The circuit diagram shows one channel of a solar

cell signal amplifier and a portion of the switching block used in an experimental character recognition device. The voltage amplifier section consists of a common base input stage followed by two common emitter stages utilizing two forms of feedback for d-c stabilization. The three-stage low-pass R-C feedback loop from the collector of Q_3 to the base of Q_1 yields low frequency roll-off characteristics. The other feedback element is R_3 common to the emitter circuits of Q_1 and Q_3. The notch filter between Q_4 and Q_5 suppresses 120 cps ripple.

Transistors Q_6 and Q_7 are part of the switching block; Q_7 establishes E_{ref}. The emitter of Q_6 is tied to the common load resistor R_2, as are the emitters of the Q_6 transistors in each recognition channel. Similarly, the base of each Q_1 transistor is tied to the common feedback resistor R_{fb}. Transistor Q_7 is common for all recognition channels.

Cascode amplifier stabilized by reducing internal feedback

By Michael D. Wood

Ferranti Ltd., Manchester, England

The cascode amplifier does not need neutralization in the high-frequency range. In the circuit below, two transistors are connected so that the mismatch between the high output impedance of a grounded emitter and the low input impedance of a grounded base reduces the internal feedback, and the input and output impedances are independent of load and source impedance.

In single transistor amplifiers where the emitter is grounded, the capacitance of the collector-base junction (C_{ob}) causes internal feedback that becomes significant at high frequencies. This feedback is negative. It reduces amplifier gain, and causes input impedance to vary with load, and output impedance to vary as source impedance.

It is common practice to neutralize the internal negative feedback with a positive feedback that is external to the transistor. But neutralization is often a tedious process requiring many adjustments.

The isolation between input and output impedances of the cascode is important when multistage amplifiers are aligned, because the tuning of one stage does not affect the other stages. Moreover, the cascode amplifier gain is greater than the gain of a neutralized single transistor grounded-emitter amplifier with the same stability.

Although resistor R_4 acts as a source impedance of the d-c power supply for both transistors, the a-c signal from the Q_1 collector enters the low impedance of Q_2 emitter (12 ohms at 2 ma) rather than R (1,000 ohms). Thus, the signal is effectively decoupled from the d-c supply line. Connecting the L-C tuned circuit directly to ground increases decoupling.

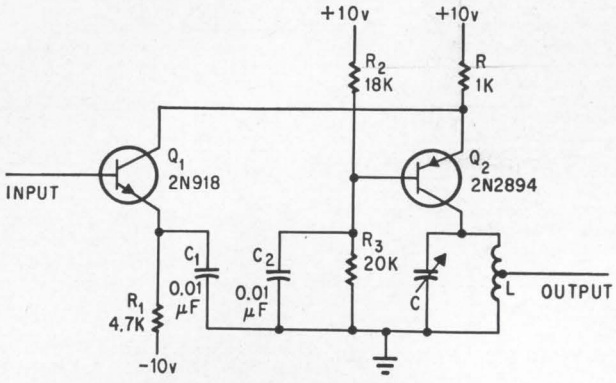
R-f signals flowing around loops formed by decoupling circuits often defeat their purpose and can be a major source of feedback. Such loops must be very small. But the cascode amplifier allows an open layout without giving rise to instability.

Because the Q_1 emitter is returned to a negative supply, its base can be coupled directly to the output of a previous stage, which is at ground potential. This eliminates the coupling capacitor and greatly reduces the circuit recovery time after an overload. By varying the current through Q_1, the amplifier gain can be controlled, without varying the total current drawn from the positive supply. This eases the output voltage regulation requirements of the power supply.

The upper frequency range is limited by the high-frequency capability of pnp transistors, which is currently about 600 megacycles. It is possible to connect a pair of back-to-back diodes from the base of Q_1 to the collector of Q_2, making a nonsaturating, self-limiting amplifier.

The pnp and npn transistors in a cascode circuit need not be a matched pair.

A six-stage, 80-Mc logarithmic amplifier was built with this basic circuit. Although only one decoupling capacitor was used on the negative supply and two on the positive supply, the circuit was completely stable with no screening, even though the overall amplifier gain is 80 decibels.



Cascode amplifier is stable and has high gain without an external capacitor to neutralize the negative feedback effect of the collector-to-base junction.

Light pulse system shrinks high-voltage protection device

The light-emitting diode and optical fiber transmission have been incorporated into a system which can replace bulky current transformers

By Clifford H. Moulton

Consultant, Allis-Chalmers Mfg. Co., Portland, Ore.

A-c transmission line systems are expensive, and to protect them from short circuits due to faulty equipment or lightning-caused surges, utilities customarily install current monitors and circuit-breakers. The conventional protection method requires a current transformer; but as voltages get higher, the iron core of the transformer gets bigger—and so does its price tag. Now the gallium arsenide light-emitting diode has been incorporated into a system, called the Traser (see photo on page 73), that is more accurate, smaller and lighter and, at high and extra-high voltages, cheaper.

Further, the Traser will do anything the conventional protection device will do, but with a 20-fold increase in accuracy in high-current, short-circuit conditions. Current transformers are 10% in error at 20 to 30 times normal current. But instead of operating off line current, the Traser converts a voltage analog of that current into light pulses which are transmitted to ground stations. It maintains constant accuracy of ±0.3% from normal loads to full-fault conditions.

The Traser is particularly attractive for extra-high voltage (EHV) lines. Last December, the Federal Power Commission published a report that recommended connecting every utility system in the United States into one huge power pool, a step the utilities were already studying. With the network of EHV lines required for the pool, the Traser may prove to be the most economical form of protection. It presently approaches the $6,500 cost of a current transformer for a 230 kilovolt line; for 500 kv lines, which are already in use, a Traser costs $15,000 and a current transformer $44,000. And 700 kv lines are being planned.

Blasting the arc

The prime application of the system is as a precision current transducer to control air-blast circuit breakers, which are used in the 10 EHV systems

The author

After working for Tektronix, Inc., for 12 years, on oscilloscopic developments, C.H. Moulton decided to become a full-time consultant. In addition to his work for the Allis-Chalmers Mfg. Co. extra-high voltage laboratory at Portland, Oregon, he is a consultant on a NASA contract to the University of Oregon's School of Opthalmology.

D-c possibilities

Conventional oil- or gas-filled current transformers are presently measuring current in extra-high voltage and high voltage a-c transmission systems and probably will continue to do so in the range of 230 kilovolts and below. But the a-c Traser can fulfill operating requirements in most EHV cases at a lower cost; and in addition, EHV d-c transmission is now under study.

Utilities planners have shown interest in the ability of the Traser to monitor d-c high voltage transmission lines directly, with the same accuracy and reliability as for a-c lines.

Only laboratory tests have been conducted so far on the d-c applications of the Traser. There are no d-c EHV systems in operation in the United States now; the first, the 500 kv Northwest-Southwest power pool, will begin operating in 1968.

D-c Traser units are at present limited to measuring the current levels produced by leakage and corona and are aiding in engineering development of d-c systems.

now operating in the United States. When a line short occurs, the Traser immediately senses the fault and operates the circuit breaker. As the contacts break, an air valve opens, allowing a blast of air to extinguish the arc and prevent damage to the contact points. Thus the booster transformers are protected from burning up.

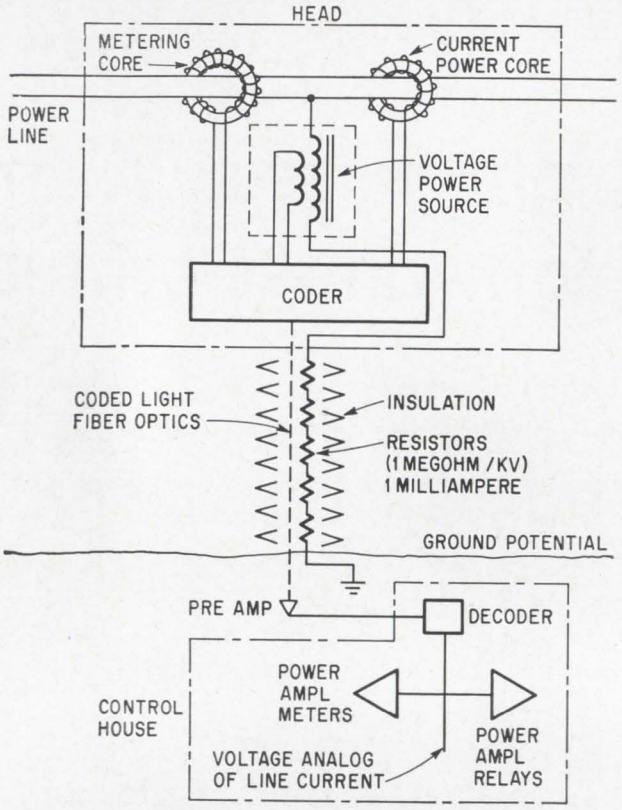
Current into voltage

Current is converted into its voltage analog by a small doughnut-shaped iron-core transformer placed around the transmission line or bus (see diagram at right). The transformer is grounded to the line to relieve the Traser of any need for dielectric protection between the line and the electronic coder.

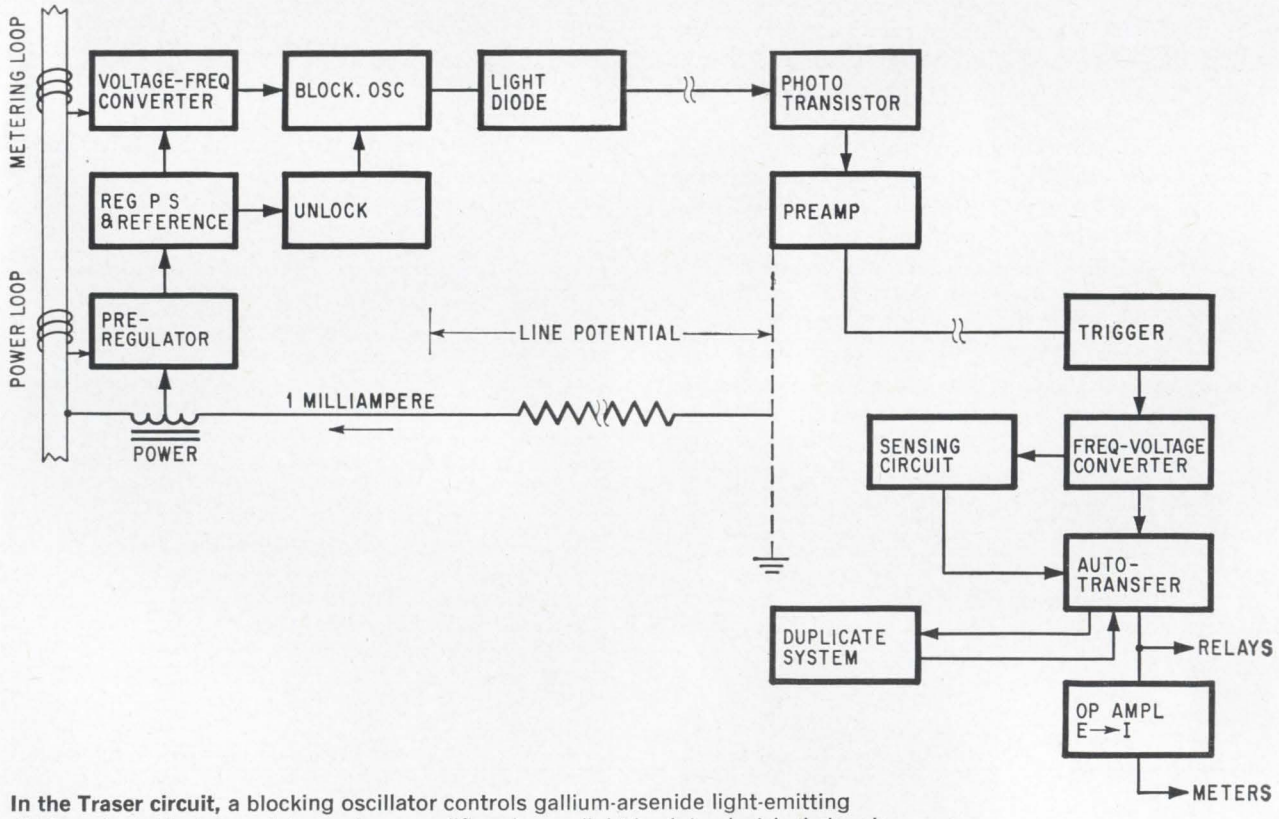
The coder draws only a few watts from the line, where a conventional current transformer would use from 10 to 100 watts. The metering transformer's core is about two inches in cross-section, accommodates power lines or buses up to six inches in diameter, and will monitor peak currents up to 120,000 amperes. A conventional transformer doing the same job would need several hundred pounds of core iron.

Taking a pulse

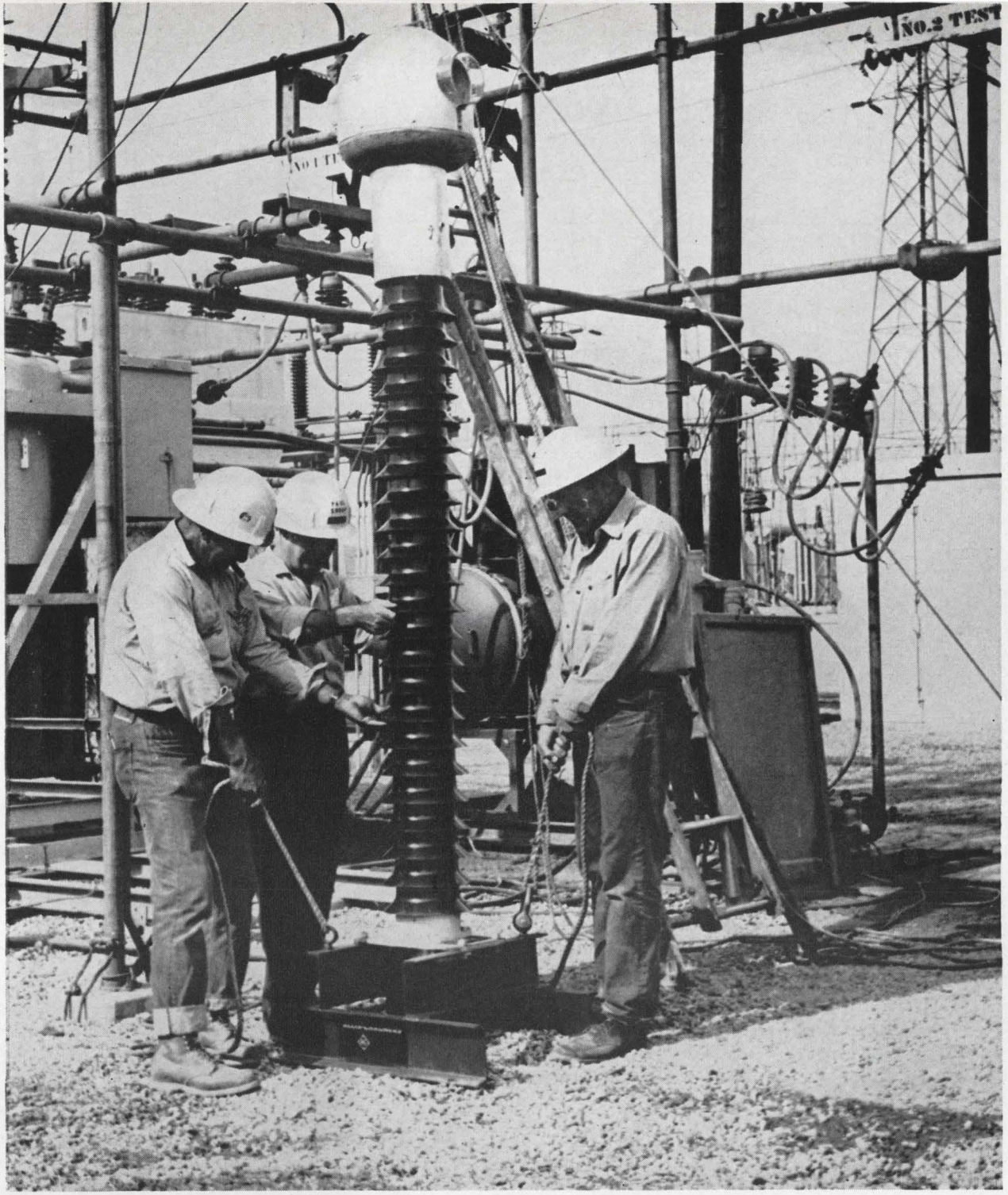
A gallium arsenide diode, selected for reliability, life expectancy, drive power, and speed of response, is used in converting the voltage analog into frequency-modulated light pulses. The pulses, at a wavelength of approximately 9,000 angstroms, are



The Traser system. Analog voltage is picked up from power line by metering coil. Either current or voltage can be used to run electronics. Pulsed light signals are sent through a fiber optic conductor to the ground and used to activate meters or circuit-breaker relays.



In the Traser circuit, a blocking oscillator controls gallium-arsenide light-emitting diode output. Phototransistor and preamplifier change light back to electrical signals. Autotransfer will bypass faulty output circuits to meters and relays.



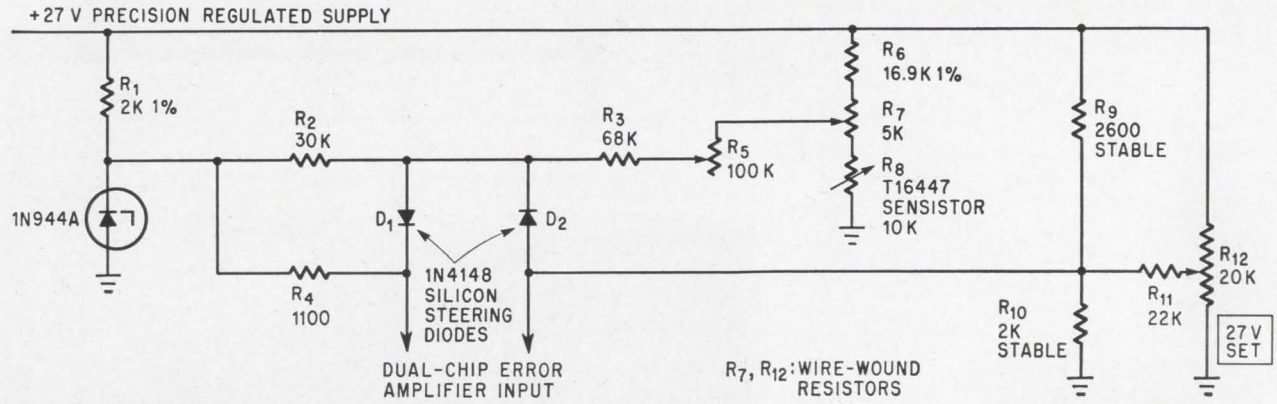
Workmen installing a Traser at the Southern California Edison Company in Los Angeles for prototype tests. Unit takes half the space of the current transformer it replaces and weighs one-tenth as much.

transmitted through optical fibers to a phototransistor and a preamplifier at the base of the insulator, which is grounded. Here the light pulses are converted into electrical pulses and transmitted through a triaxial cable to a central control room, where the signal voltage is decoded into a proportionate value of the line current and fed to an ammeter or used to energize relays which operate circuit breakers.

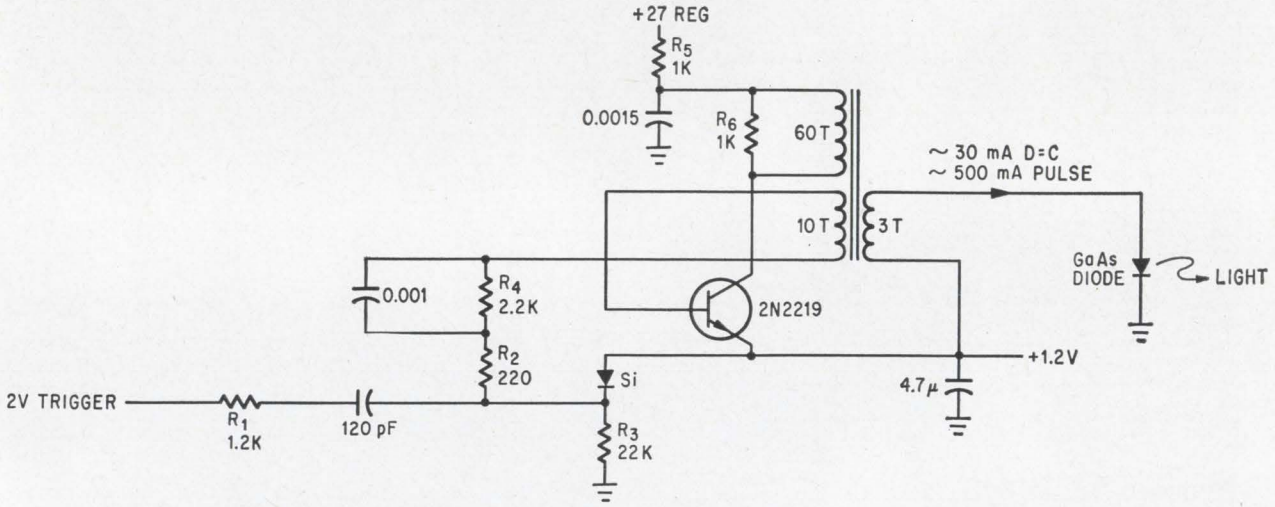
Double source

There are two methods of energizing the coder electronics. One uses a small current transformer, which will furnish the necessary power under either faulty or normal operating conditions. This source provides full coder output in about 0.5 millisecond; since the entire Traser system operates in approximately 1.5 milliseconds, or 1/10th of an a-c cycle, the relaying equipment has more than enough time to detect the current surge during the first current peak. The second method uses another transformer, built into the Traser, that forms a path to ground through a high resistance. Even with no load on the line, operating power is supplied through the second path to ground.

During a short circuit, for example, voltage



Temperature compensation circuit for the zener diode supplies the reference voltage to regulate the coder's power supply.



Light diode is driven by blocking oscillator. Triple-winding transformer gives highest output pulses for lowest power-supply drain.

falls below the operating level of the Traser; but the current source helps to maintain operation.

The voltage from the metering loop feeds into a voltage-to-frequency converter of conventional design (see system diagram above). An unlock circuit allows coder output to pass to the light-emitting diode only when the coder's regulated supply voltage maintains a constant of 27.00 volts. This circuit, a transistorized Schmitt trigger, decides when the unregulated voltage from the power loop is high enough to assure proper regulator action, allowing a blocking oscillator to receive triggers from the converter. After unlocking, it drains a load of 6 milliamperes from the 27-volt regulated power supply.

Zener reference

The regulated voltage is derived from a temperature-compensated zener diode reference. The diode is a 1N944A, rated at 11.7 volts. The reference voltage is compared to the 27-volt output by a dual-chip transistor that acts as an error amplifier. In the diagram at the top of the page, R_{12} is a 20,000-ohm wire-wound potentiometer that sets the supply voltage at 27.00 volts. If the output voltage varies, the voltage at the junction of R_9 and R_{10} will not match the voltage from the zener diode. The error amplifier will then cause the power supply to return to the correct value.

Down the glass path

When the blocking oscillator is triggered (see circuit on page 72) its output controls the pulses from the light-emitting diode. Since the Traser operates in the pulse mode, light level changes, caused by varying temperatures, do not affect the accuracy of the measurement.

The signal path for the light pulses is a 12-foot long conductor consisting of many glass fibers. Each fiber has an optically pure glass core with an outer layer of less refractive glass.

Optical fibers are inherently interference-free and 100% secure. The fiber bundle can be immersed in oil, tar or other contaminants without affecting light transmission. The bundle is also an excellent dielectric between the coder and the decoding unit.

The fiber bundles can be run over complex paths like electrical wiring. There are so many fibers that if one is broken, the transmission efficiency is unaffected.

The optical pulses are received by a phototransistor, whose output is a one-microampere pulse. At the preamplifier, the signal level is raised to 10 milliamperes and fed into a 75-ohm triaxial cable that runs to the central control room.

Protection at central control

The pulses from the preamp are fed into a one-shot multivibrator that controls the input to the frequency-to-voltage converter, or decoder. This is an integrating operational amplifier. The analog voltage can then be used to operate the coils of protective relays or converted to current and read out on an ammeter.

For 100% system protection, each Traser installation is fully duplicated. If a coder pulse is not received at the control room within 0.1 millisecond after the last pulse, a time-interval sensing circuit immediately triggers an automatic-transfer network that sounds an alarm to summon a control room attendant and switches its output lines to the other Traser system.

The calibration constant of the coder is 1 ampere to 5 kilocycles; the decoder constant is 5 kc to 2.5 volts. Calibration is accomplished by adjusting precision feedback resistors in the coder and decoder. Phase response of the output signal to the line current is adjusted in the same manner.

For greater reliability, if a duplex decoder setup is used, a comparison amplifier in each of the redundant decoders activates an alarm if either channel changes calibration.

Temperature compensation

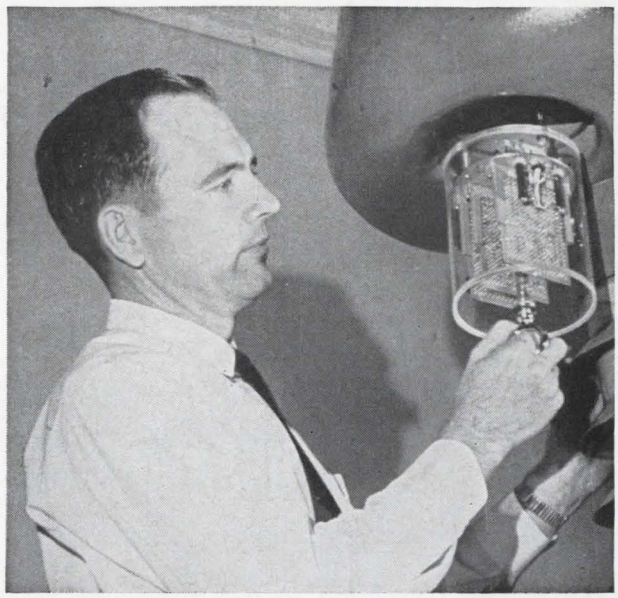
The zener diode was chosen to minimize error due to temperature variation, but ambient temperature changes over the expected range of from about −55°C to +75°C could result in error greater than 0.1%.

The 1N944A diode has a peak output voltage at between −15°C and +65°C. Normally, the output falls quite sharply at the high and low extremes. A unique temperature-correcting circuit compensates for residual zener voltage variations and reduces the voltage error by another factor of 10. The technique is known as end-compensation. A temperature-sensitive TI6447 silicon resistor (sensistor) generates a voltage, in the 6- to 13-volt range, that rises with temperature.

The reference for the voltage corrections comes from the zener diode across a divider consisting of resistors R_2 and R_3 in series. Output impedance of the divider is about 25,000 ohms, to which is added the end-compensation potentiometer R_5.

When the temperature increases, current flows through R_8, R_5, R_3 and D_1, through R_4 and the zener to ground to correct the reference voltage back to the mid-range value.

When the temperature is low, the current through R_8, R_5 and R_3 is steered by D_2 to the divider composed of R_9 and R_{10} that assures full output voltage of 27.00, even though the zener terminal voltage is low. With this correction technique, a constant output voltage will be produced over a large temperature range.



Plugging coder electronics into the head of a Traser system prior to prototype testing. Heavy magnetic shielding surrounds encoder unit to assure that passage of line current and resulting magnetic fields do not affect coder output accuracy appreciably.

Reliability and accuracy

The coder unit, with a 2700-volt input, has operated with ±0.1% accuracy in laboratory tests from —100° to 250°F. This is an extremely severe temperature test, 50% greater than the worst limits expected in the field. The Traser is rated from —65° to 165°F. This range is within the reference zener diode ratings and should afford less than 0.1% measuring errors in the coder under regular service conditions. There is very little heat generated within the unit itself.

The system is designed to withstand 120,000 ampere lightning current surges or 85,000 amperes asymetrical offset (term for the amount a sinusoidal wave is displaced from its normally symmetrical position around a zero current axis by introducing a direct current onto an a-c system; this occurs during a short-circuit on an a-c power system).

Severe atmospheric contaminations are restricted from entering the corona shield assembly by O-ring seals at all points of separation. Interchangeable plug-in units reduce replacement time.

The fiber optic system is secure against interference. Coder units are enclosed within heavy magnetic shields to assure that passage of line current and resulting magnetic fields do not change the coder's output accuracy by more than 0.01%.

The effects of vibrations in the mechanical structure and of stray radio and radar signals of severe strength have been taken into account in design and will be continually reevaluated. Carrier current signals on the line often have power levels measured in hundreds of watts; these signals and the Traser will not interfere with each other.

Protecting digital transmissions with optical matched filters

New system, using ultrasonic pulses to modify polarized light, may speed military decoding and foil jammers by replacing slower magnetoresistive delay lines

By Victor R. Latorre
University of California

Military messages are often transmitted as high-speed digital streams. To preserve secrecy and reduce the effects of jamming, they are frequently encoded by spread spectrum—chopping the data into small segments at the transmitter and reassembling it with a decoding mask at the receiver. This forces a jammer to disperse his energy over a wide band of frequencies, thereby reducing his chance of interfering with the data flow.

It's easy to encode a message this way, but decoding is slow because it usually requires the use of matched filters that employ lumped-constant or magnetorestrictive delay lines. Decoding also requires identical antijam codes at the transmitter and receiver.

Recent studies indicate that decoding may be sped up with an optical technique, using ultrasonic pulses to change the characteristics of polarized light. The optical method performs the job of electronic delay lines, abstracting energy from the digital stream according to a predetermined pattern and rejecting any jamming pulses that an enemy may have added. The method is already capable of providing up to 30 decibels of protection to data transmitted at 30,000 bits per second.

So far, work with optical delay lines has been confined to fixed-logic filters, but the technique can be extended to the design of filters employing pseudo-random logic. Such devices would immunize the communication system against so-called intelligent jammers that recognize a fixed coding pattern and then attack it.

Eluding jammers

Digital communication systems are frequently encoded by spread spectrum, in which the information bits that normally require a certain bandwidth, B_1, are chopped up into smaller bits, the transmission of which now requires a much broader bandwidth, B_2. The relationship of the two bandwidths is approximated by $B_2 = nB_1$. In this expression, n is the number of sub-bits per information bit. When voice, graphic or alphanumeric data is transmitted in this manner, a potential jammer who does not know the pattern or antijamming code into which each information bit is expanded must spread his interfering energy throughout a larger bandwidth. This requires him to use more radiated power to jam a broad-spectrum message than one that is transmitted in the clear. The ratio—or degree of jamming protection—is approximately equal to n.

A major problem with a system that uses fixed logic for its antijamming code is the fact that an intelligent jammer can quickly learn the code and jam it according to that pattern. When the same pattern is used to subcode every mark, and when only one other is used to subcode each space, the

The author

Victor R. Latorre received his doctorate in electrical engineering from the University of Arizona in 1960. Prior to joining the staff at the University of California as associate professor in engineering at the Davis Campus he was a research specialist in the aerospace division of the Boeing Co. in Seattle, Wash.

The work described was performed while the author was employed by the Boeing Co.

jammer can record this sequence and play it back. This procedure jams the receiver by causing it to decode all marks or all spaces for as long as the jammer produces approximately the same power in the receiving antenna as does the desired signal.

Changing the code

Changing the antijam code for every information bit or so eliminates vulnerability to repeat-jamming —one kind of intelligent jamming. In many cases a long code is generated, and a small portion of it subcodes each information bit into n antijam bits. Because these codes are generated by devices of finite size, such as feedback registers, they eventually repeat themselves every m antijam bits or every k information bits, where m = nk.

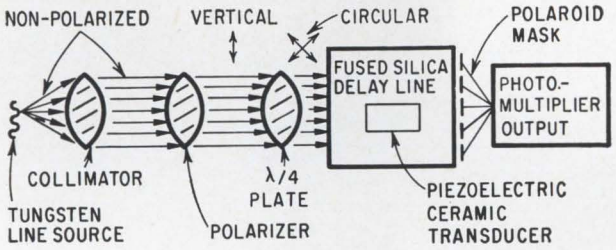
A particularly useful code for this purpose is the pseudo-random type, which is difficult to predict. The term pseudo-random refers to the logic used in the code generation. Purely random codes are not used because they would include long sequences of similar bits.

Fixed logic lines

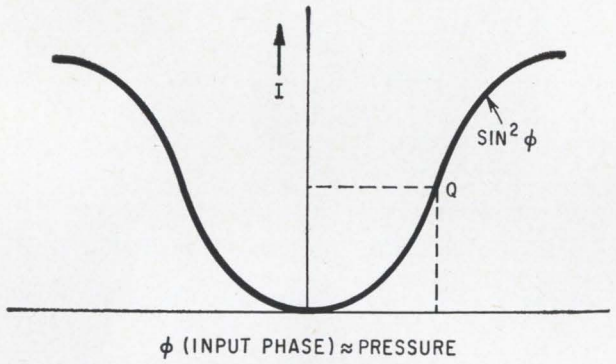
A typical delay-line arrangement is shown in the block diagram below. Its main feature is a 127-tap glass delay line, built by the Electronic Products division of the Corning Glass Works for the Boeing Co., and capable of handling 10-megacycle antijam subcodes. The data rate possible with this line is approximately 80 kilocycles per second.

The line is excited at one end by acoustical signals that are derived from the data. These signals cause the glass line to become optically birefringent or doubly refracting. A tungsten metal light source provides light energy with the proper spectral characteristics. The nonpolarized output is collimated and then vertically polarized. The resulting light, vertically polarized, is then sent through a quarter-wave plate that circularly polarizes it. The plate is a doubly refracting crystal, cut so there is no deviation of incident light rays.

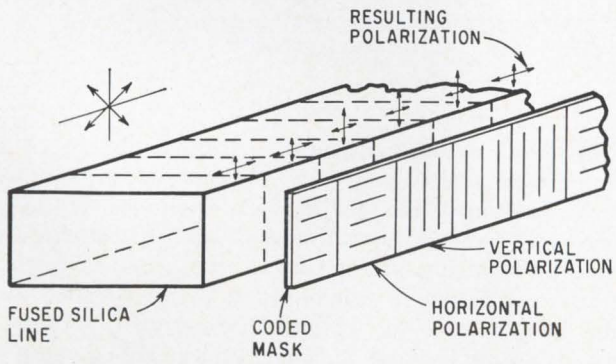
The ordinary and extraordinary waves travel at



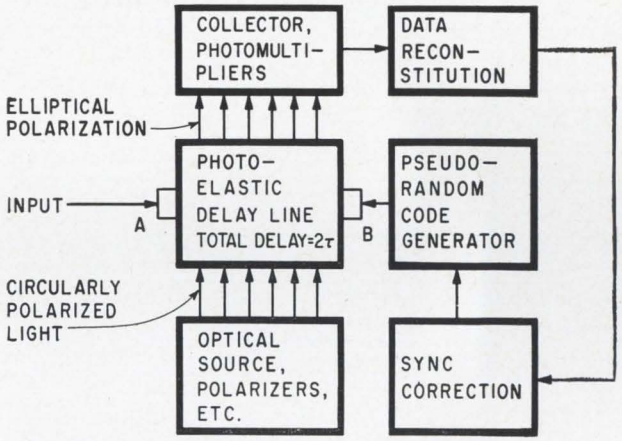
Light from tungsten source is circularly polarized before it passes through fused-silica delay line whose optical characteristics can be changed by ultrasonic signals from a ceramic transducer. Predetermined patterns that pass through a polarity-selective mask energize an output phototube



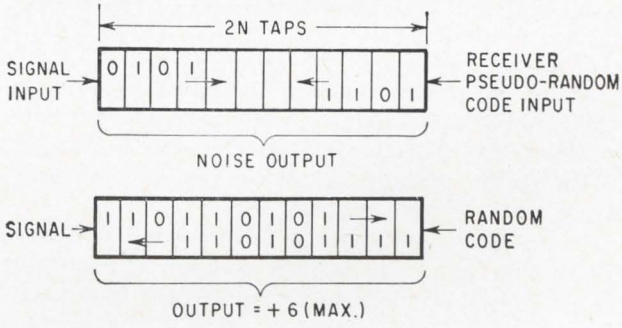
Intensity of light output from photoelastic delay line is plotted against input phase shift caused by acoustical pressure. Operation is centered on point Q near the flattest part of the curve.



Patterns of vertically and horizontally polarized light, resulting from changes in the optical characteristics of a fused silica delay line, can be matched by the pattern of a coded mask to produce light signals.

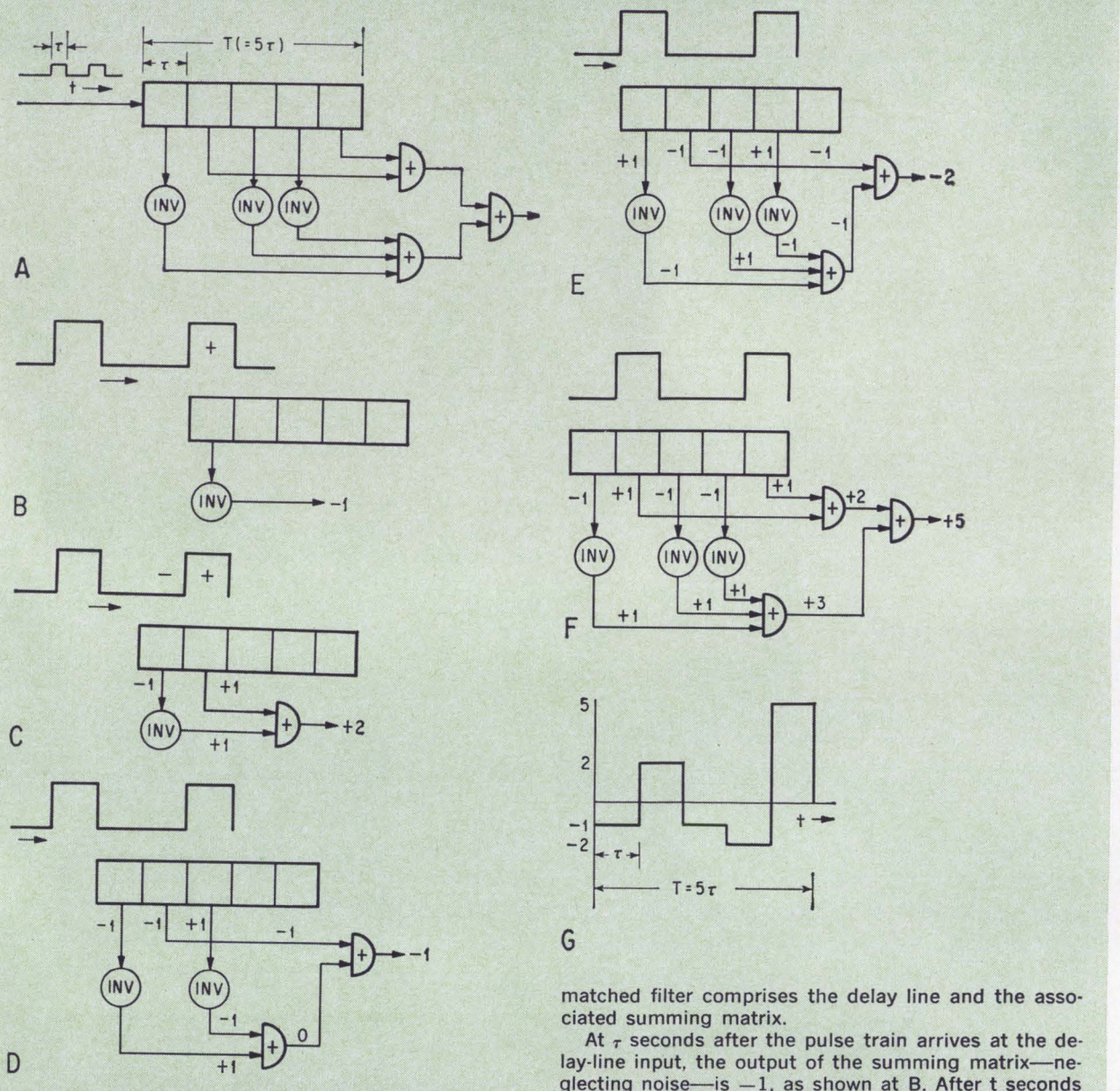


When pseudo-random variable code is employed, photoelastic delay line receives incoming signal from transducer A and pseudo-random code through transducer B. The photomultipliers receive signals when the overlap is additive.



Simplified illustration of a representative signal and random code before correlation (top) and after correlation (bottom).

Correlation with delay-line matched filter



This five-tap delay line employs fixed coding and a demodulated incoming signal. For this article, taps are actually optical slits. It is assumed that the information bit has been subcoded by five antijam bits to produce a process gain of five to one or 7 decibels. The pulse train's progress can be followed tap by tap (A through G) as it proceeds down the delay line. The matched filter comprises the delay line and the associated summing matrix.

At τ seconds after the pulse train arrives at the delay-line input, the output of the summing matrix—neglecting noise—is −1, as shown at B. After t seconds more it is + 2, as shown in C.

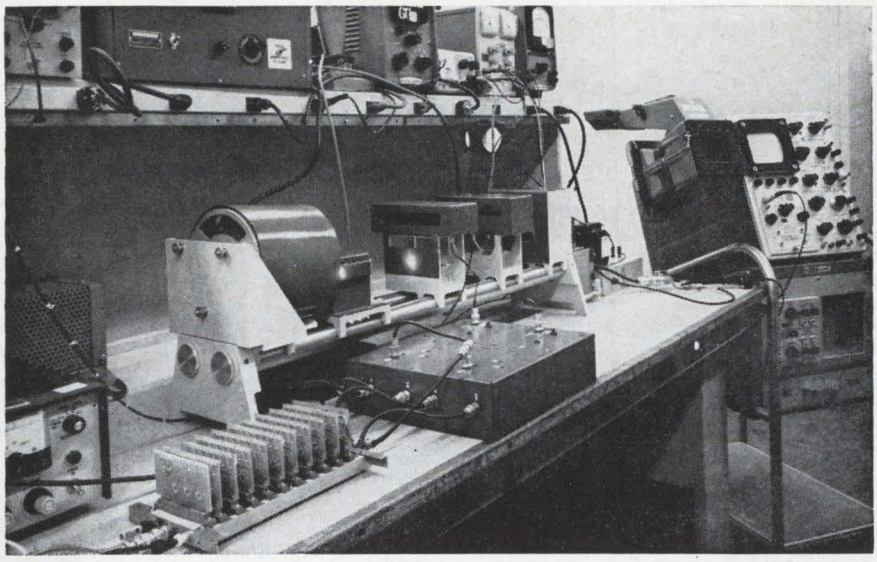
By the end of three pulses, in 3τ seconds the output is −1 as shown at D. For four pulses the output is −2; at the end of 5 τ seconds, or one information bit, the output of the filter matched to the wave illustrated is a maximum at +5, shown at F.

This process is plotted at G; the simplified example omits noise and assumes immediate shifting.

different velocities and are exactly one-quarter wavelength out of phase at the output of the plate. In effect, the quarter-wave plate results in biasing of the entire system, as illustrated by the curve above.

By operating at point Q, positive and negative changes in phase (acoustical pressure) cause approximately linear increases or decreases in output-light intensity.

The glass delay line is excited at one end by acoustical signals that cause it to become birefringent. This optical characteristic transforms circularly polarized light into elliptically polarized light, the major axis of the ellipse being varied according to the acoustical signal train exciting the line. By inserting an analyzer of the proper orientation—one having a transmission plane parallel to the long axis of the ellipse—the intensity of the receiver light is kept at a maximum. When many such optical analyzers are arranged in a definite sequence, the over-all intensity of received light becomes a maximum when the proper sequence of



Laboratory test setup showing logic circuits for delay line (lower left) and optical system with light source at right of optical bench.

acoustically generated stresses is present.

The output light is elliptically polarized if there is no acoustical deformation of the line. Thus it is possible to use a mask consisting of properly oriented analyzers—on the output. The mask's code corresponds to the correct slit polarization.

The mask arrangement is shown above. The mask, in conjunction with the photocell that linearly adds the light energy from each slit, can be considered the second half of the matched filter—the tap-summing matrix.

Variable logic lines

The foregoing discussion applies to fixed-logic lines, but the general principles can be extended to systems that use variable logic. The block figure above illustartes a scheme that can be used with pseudo-random codes and will not require synchronization to within a sub-bit. Additional details are given in the panel.

The length of the delay line is equal to twice the duration of an information bit and contains twice the number of required slits, or taps, spaced a sub-bit (antijam bit) apart. The incoming signal excites transducer A, and the output of the pseudo-random code generator in the receiver excites transducer B. The resulting acoustical waves travel toward one another and overlap continually after some initial time duration. This movement is illustrated in the diagram above.

From this diagram, it is evident that each block of n bits of the pseudo-random code generated in the receiver must be the conjugate, or time-reversal, of the corresponding information block of the transmitted pseudo-random code. One way to achieve this condition is to use identical pseudo-random generators and start the one in the receiver one full information bit earlier than that in the transmitter. From this code block, the desired conjugate code is produced to excite transducer B at approximately the same time as the transmitted code is being received at transducer A.

The major advantage of this system is that close synchronization is not necessary. Synchronization need be maintained only to within the period of one information bit. Generally this requirement also applies to systems other than those employing photoelastic-type delay-line matched filters.

High-rate correlation

If matched-filter detection is desired for spread-spectrum digital data at rates considerably in excess of those already considered, another class of ultrasonic delay line can be employed. Its correlation process is the same, in that the incoming digital data excites the delay line's input transducer.

If the ultrasonic wave's frequency is higher than about five megacycles, the line appears to act as an optical diffraction grating in which a series of diffraction patterns formed at the focal plane of the lens results from white-light input. The ultrasonic frequency is shifted, thereby changing the optical characteristics of the line; these images in turn will shift. If a particular image is selected and two slits are made in the screen, keying the incoming wave by a frequency shift will cause the diffracted light to pass through one slit or the other. This technique forms the basis of a fixed-logic diffraction-type ultrasonic delay-line matched filter. The mask in this case comprises a coded series of tiny, thin prisms.

To avoid the problems inherent in military use of fixed-logic delay-line matched filters, a scheme similar to that described in the preceding section is used. Tests are in progress on this type of device, in which the input and conjugate of the locally generated pseudo-random code stream pass in opposite directions through an ultrasonic line that is two information bits long.

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Television's toughest challenge

In outer space, unattended cameras must survive many hazards and restrictions on size and weight, and still produce clear pictures almost in the dark

By Max H. Mesner

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Television cameras that operate in outer space bear little resemblance to their cousins housed comfortably in earthbound broadcasting studios.

The instruments that photograph the moon from Ranger spacecraft and the earth from Nimbus and other satellites go unattended in cramped locations. They must withstand such hazards as launch, with its shock, vibrations and acceleration; and solar heat and radiation, intensified by the absence of atmosphere in space. They must be lightweight, consume little power, and produce high resolution at low light levels.

Vidicon: the first image sensor

The first tv cameras in space used vidicons as image sensors. Recently, other sensors have found their way into space applications. These will be discussed after the vidicon is described.

A vidicon's most important characteristics are its storage capacity, sensitivity, resolution, shading, gamma—slope of its transfer curve, brightness vs. response—microphonics, erasure of residual image, dark current, generation of spurious coherent signals such as those caused by spots on the photoconductor or mesh, and signal from the mesh. Especially important is its behavior as a function of temperature, particularly as related to sensitivity and to dark current.

The author

Max H. Mesner is manager of tv cameras for the Radio Corp. of America's Astro-Electronics division. He was responsible for the tv camera systems on the Tiros weather satellite and has directed development of miniaturized cameras for Nimbus, Ranger, Apollo, Tigris and the Orbiting Astronomical Observatory. He holds 14 patents.

Many space missions operate at low light level. During a landing on the moon in lunar twilight, or where the source of illumination may only be light reflected from earth, observations will require high sensitivity. This is also true in televising the interior of spacecraft and in making cloud-cover observations at high latitudes or in earth twilight.

Even if ample illumination is available, a sensitive sensor permits the use of slower lenses that are smaller, lighter and easier to mount. Where image motion requires the use of a shutter to prevent blurring, high sensitivity permits the use of a faster shutter. The typical response curve for a slow-scan photoconductor of antimony sulfide-oxysulfide illustrates its behavior as a function of integrated illumination expressed in foot-candle-seconds. A system-tradeoff analysis must consider these factors.

Good picture rendition demands maximum resolution for esthetic as well as for geometric reasons. The Nimbus weather satellite used 800 scanning lines; the horizontal resolution response was 10% to 20% for 800 tv lines. The Ranger 9 moon probe achieved a similar resolving power both horizontally and vertically with 1,132 scanning lines. The Tiros weather satellite, which uses a half-inch vidicon, has system requirements for 500 scanning lines.

In slow-scan operation, the slower the readout the lower will be the signal level, but dark current and spurious effects related to photoconductor irregularities remain unattenuated at the lower scanning speed. Because of this difference in attenuation, the effects of dark current and of variations in dark current often become a design constraint. The problem is more severe in space applications than in commercial tv because shading is more detrimental to an instrumentation system than to one used in entertainment.

Besides photoconductor variations, another cause of shading is improper beam landing. To minimize this, the beam's trajectory is controlled by carefully

The 6 tv cameras used in the Ranger 9 spacecraft are checked out by engineers. Two wide-angle and four narrow-angle cameras were used.

adjusting the alignment fields and shaping the focusing and deflection fields to maintain a beam-landing angle that is perpendicular to the photoconductive surface.

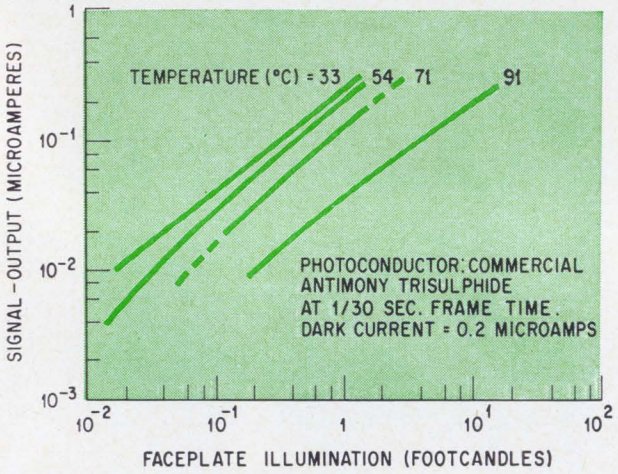
The dark current, larger than the signal, manifests itself as a strong pulse that occurs during vidicon blanking. This must be clipped prior to entering the transmitter modulator, so that the useful signal will be the major portion of the transmitted signal; in this way, the signal-to-noise ratio at the receiver is maintained at an optimum value.

Geometric reticle

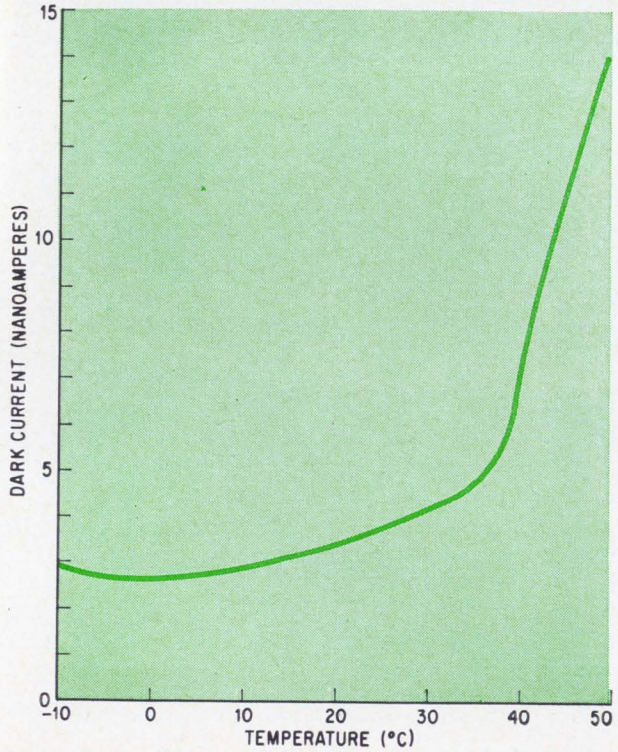
Television cameras that are used for mapping, weather observation and optical instrumentation employ a geometric reticle that is evaporated onto the photoconductor. This reticle is a metal evaporation on the inside of the tube, marking off only the intersections of a grid. It is in the same plane in which the image will be focused.

Reticles are made when the tube is manufactured, by masking the tube's faceplate and evaporating through the mask. The line on the tube may be 0.5 to 2 mils thick.

In Tiros, weather forecasters must plot position and movement of cloud and storm areas with respect to land masses. Accurately placed reticles, with a geometric relation to the earth's image, permit these measurements without placing unnecessary requirements on the scanning system's linearity and stability.



Effect of four temperature values on vidicon sensitivity. Maximum sensitivity is important in space tv cameras.



Effect of temperature on vidicon dark currents, which often becomes a design constraint.

Choosing a photoconductor

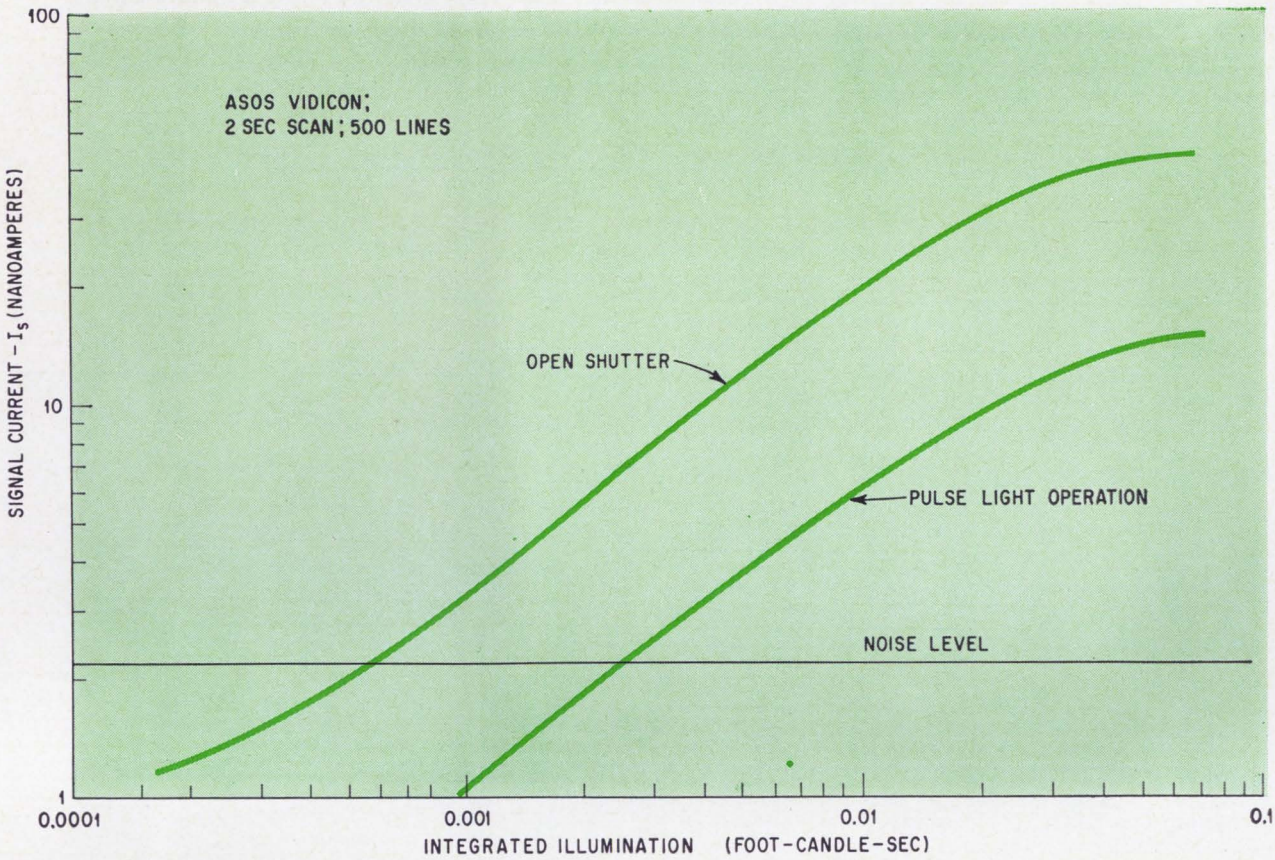
When building a camera that uses a vidicon, the choice of a photoconductor material is important. The material must match the requirements of the space mission. Four factors determine the choice: the decision whether to use pulsed light and subsequent image storage or to portray continuous motion with an unshuttered lens; length of frame time; sensitivity requirements; and the techniques available for image erasure to prevent double exposure from a residual image.

The need for image storage is usually determined by the frame time. The principal reason for using slow-scan tv is to reduce the information rate of a given resolution. The use of a narrower bandwidth improves the system's signal-to-noise ratio because it is inversely proportional to the square root of the bandwidth. This allows comparable reduction in power, which permits reduction in payload weight. The four tables that accompany this article include frame-times, scanning-line specifications, bandwidths and exposure times for several space-borne tv systems being built. They provide a basis for determining system tradeoffs.

Where pulsed light is to be used, the photoconductor is required to store the charge pattern that represents the image while the frame is read out.

Since the photoconductor's response is not instantaneous, motion results in image smear. To overcome this, the image is immobilized as in film photography. Pulsed light is provided by the use of either a shutter or a flashing light. The shutter time used in the Tiros cameras is 1½ milliseconds, made short with respect to the satellite's spin rate of 10 revolutions per minute to minimize smear. In the wheel-type operation of Tiros 9, the shutter time is synchronized with the spin rate. The longer exposure of 40 milliseconds in Nimbus is possible because the spacecraft is stabilized without rotation. Thus it is necessary only to immobilize the linear orbital motion with respect to the earth.

The principal photoconductor materials available are antimony trisulfide (variations of which are used in commercial vidicons), antimony sulfide-



Typical response curve for a slow-scan antimony sulfide-oxysulfide photoconductor shows its behavior as a function of integrated illumination expressed in foot-candle-seconds.

oxysulfide (ASOS), selenium and selenium compounds, and lead oxide. For slow-scan operation with pulsed light at frame times between 0.2 and 10 seconds, the ASOS surface developed by the Radio Corp. of America has been used most often, principally because of its high sensitivity and adequate performance over the range of the spacecraft's temperature variations, and its remarkable resistance to burns resulting from raster scanning and from excessive illumination.

ASOS has one major disadvantage; the storage qualities that make it acceptable at slow-scan rates make it impractical for use at commercial tv rates. It also required development of evaporation techniques to prevent spots and blemishes.

Selenium photoconductors have good slow-scan characteristics and operate satisfactorily under pulsed-light conditions. The problem with this material is that it deteriorates at temperatures greater than 35°C. The Westinghouse Electric Corp., the General Electrodynamics Corp. and RCA have been experimenting with selenium compounds possessing good slow-scan performance with sensitivity approaching that of ASOS, in search of a compound in which the temperature may exceed 35°C.

Lead-oxide surfaces have been evaporated by Philips Gloeilampenfabrieken, N. V., of the Netherlands, but their sensor, known as Plumbicon, has not been thoroughly evaluated for slow-scan operation.

Some projects require a frame rate slower than commercial tv but faster than the average slow-scan system. An example is the camera inside the Apollo spacecraft scheduled to go to the moon. The astronauts will be observed within the spacecraft in real time, but bandwidth-power constraints prevent the use of standard 30-frame-per-second rates. Instead, the frame time selected is 0.1 second. The 10-frame-per-second rate will be scan-converted on the ground to make the pictures adaptable to commercial tv, allowing the public at home to watch the astronauts on their journey to the moon. At 10 frames per second it is possible to employ the commercial type of vidicon that uses antimony trisulfide.

Long-storage photoconductors

Where the scene illumination is very low and no image motion exists, integration of the light-induced charge can be used to build up a stronger signal. This approach is taken in the cameras for stellar viewing. The photoconductor charges are built up for one second or more to reach a sufficiently high level for a good signal-to-noise ratio. This is done in the cameras being built and tested for the Grumman Aircraft Engineering Corp. for the Orbiting Astronomical Observatory, in which tv is part of the attitude-control system. It is possible to expose a star image for one second and build up charge signal (as collected by a commer-

Cameras for spacecraft monitoring

Program	Echo II & Centaur	Mercury	Saturn I SA-5, 6, 7	Vostok	Voskhod I	Apollo Command Module
Government agency	NASA	NASA Manned Spacecraft Center	NASA	USSR	USSR	NASA Manned Spacecraft Center
Camera developer	Lear Siegler	Lear Siegler	Marshall Space Flight Center	No information	No information	RCA Astro-Electronics Div.
Date	1962	1961	1964	1962	1964	Est. 1970
Sensor type	1-inch hybrid vidicon	1-inch²hybrid vidicon	1-inch hybrid vidicon	No information	No information	1-inch hybrid vidicon
Scan-line number	525	525	525	No information	No information *Com. tv rates	312
Resolution elements (tv lines)	350 x 500	350 x 500	350 x 500	No information	No information	220 x 300
Frame time (Seconds)	1/30	1/30	1/30	*More than 1/30 sec	*Est. 1/30 sec	0.1
Band-width	4 to 8 Mc	4 Mc	4 Mc	No information	*Est. 2 Mc	500 kc
Dynamic range (Foot-candle-seconds)	No information	No information	No information	No information	No information	0.008 to 30
Scene brightness (Foot-lamberts)	*11,000	No information	8,000–9,000	No information *Est. 100–300	No information *Est. 100–500	0.3 to 480
Exposure time (milliseconds)	Open lens	Open lens	Open lens	Open lens	Open lens	Open lens
Unit wt. (pounds)	7.3	7.3	11¾	No information	No information	4.5

* Typical data furnished by author
# Strobe light used on Centaur fuel tank

cially available lens) to a sufficiently high level to observe star intensities as dim as fifth magnitude whose brightness is about as low as the eye can perceive. Both the ASOS surface and selenium are adaptable to this program.

For applications that require longer frame times or storage for more than 10 seconds, it is desirable to employ a storage-type vidicon. The automatic picture-transmission system (APT) in Nimbus and Tiros 8, uses a dielectric storage technique where the charge pattern is transferred to a polystyrene layer that stores the signal for great lengths of time. The APT system readout takes 200 seconds, permitting an 800-line tv picture to be transmitted with a bandwidth of only 1,600 cycles per second.

Erasing a residual image

The importance of erasing a residual image depends upon the sequence of operation. In Tiros, a picture is taken every 30 seconds, with 15 scans produced in the period between pictures; this allows enough time for thorough erasure of the image. An erasure technique is required in cameras that have a short time between pictures, since the first scan removes only about 40% to 50% of the charge pattern on the ASOS surface.

It is desirable to find a vidicon photo surface that permits a higher percentage of erasure. This would permit a better erasure for each scan. Some selenium compounds have exhibited promising behavior in this respect, encouraging further laboratory research.

Special techniques for camera operation have been developed to erase images with fewer scans. The procedure requires a properly sequenced series of discrete actions that include flooding the photo-

Astronomical cameras

Program	Stratoscope	Celoscope	Orbiting Astronomical Observatory	Tigris	Advanced Orbiting Solar Observatory
Contract agency	Princeton University	Smithsonian Astrophysical Observatory (Harvard)	NASA Goddard Space Flight Center	NASA	NASA
Camera developer	RCA Laboratories	Electro-Mechanical Research	RCA Astro-Electronics Division (Grumman)	RCA Astro-Electronics Division (Cornell U)	Ball Brothers Research Co.
Date	1959–64	1965 est.	1965	1965	1968
Sensor type	1-inch vidicon 3-inch image-orthicon	2-inch uvicon	1-inch electrostatic vidicon	3-inch image orthicon	photo-multiplier
Scan-line number	500	No information	350	500	No information *800
Resolution elements (tv lines)	350 x 400	No information	245 x 350	350 x 500	No information *720
Frame time (Seconds)	1 (Vid) 1/20 (IO)	No information	1	2	No information
Bandwidth	200 kc (Vid) 2 Mc (IO)	No information	60 kc	60 kc	No information *240 cps
Exposure time (Milliseconds)	2 (IO) Open lens (IO)	No information	Open lens	Open lens	Open lens
Sensitivity	12th magnitude star (IO)	No information	2nd to 5th magnitude star	Up to 12th magnitude star	0.75×10^{-2} ft-c
Spectrum	Visible	Ultraviolet	Visible	Visible	Visible
Unit wt. (pounds)	15 (Vid) 50 (IO)	No information	17 plus 4 lb. lens	40	No information

INR—Information not received
* Typical data furnished by author

conductor with light, accompanied by electrode switching and fast scanning. The level of the remaining charge pattern is low enough to produce a residual image whose intensity is negligible compared with the new picture's. In most cases this residual image is reduced to less than 5% the intensity of the original picture readout. As much as 10% can be tolerated. This technique was employed on cameras for Nimbus and Ranger.

Image orthicon: a sensitive sensor

The image orthicon is about 1,000 times more sensitive than a vidicon. The image orthicon is more complex in the adjustment of electrode potentials, and has more stringent requirements for holding temperature variations to a tighter tolerance. In addition, the types available are larger and more difficult to mount in a light, rugged package.

The entry of this highly sensitive sensor into the space field has been delayed by these problems and by the unavailability until recently of an image orthicon readily usable at slow-scan rates. Such cameras are now being designed, and permit slow-scan operation and storage integration without resorting to sensor cooling. Both the three-inch and the newer two-inch image orthicons, which are included in space plans, permit the reproduction of scenes in very dim illumination. Applications include the observation of cloud cover in moonlight and of starlight and lunar scenes in light reflected from the earth.

By employing charge-pattern integration for several seconds, it becomes practical to observe stationary scenes or fixed star patterns of low intensity with an image orthicon. RCA has employed this technique in the Tigris program, in which strong

Cameras for observing weather from earth orbit

Program	Vanguard	Tiros 1–9	Nimbus AVCS	Nimbus APT System	Tiros Operational Satellite
Government agency	Army Signal Corps	NASA Goddard Space Flight Center	NASA Goddard Space Flight Center	NASA Goddard Space Flight Center	NASA Goddard Space Flight Center
Camera developer	Army Signal Corps Research and Development Laboratory	RCA Astro-Electronics Division	RCA Astro-Electronics Division	RCA Astro-Electronics Division	RCA Astro-Electronics Division
Date	1959	1960–63	1964	1964	1965
Sensor type	Photo-cells	½-inch vidicon	1-inch vidicon	1-inch storage vidicon	1-inch vidicon and storage vidicon
Scan-line number	Less than 25	500	800	800	800
Resolution elements	**	350 x 400	550 x 800	550 x 700	550 x 800 550 x 700
Frame-time (Seconds)	**	2	6.5	200	6.5 200
Band-width	No information	62 kc	60 kc	1.6 kc	60 kc 1.6 kc
Dynamic range in Foot-candle-sec)	No information	0.01–1	0.004 to 0.4	0.01 to 0.7	0.004–0.4 0.01–0.7
Scene brightness (Foot-lamberts)	10,000	8,500	11,800	11,800	11,800
Exposure time (Milliseconds)	Open lenses	1.5	40	40	1.5
Unit wt. (pounds)	No information	6 to 10	18	20	Est. 13

** Depends on satellite spin

signals from 10th- to 12th-magnitude stars have been obtained, and in which zodiacal light has been observed with illumination levels dropping as low as 5×10^{-8} foot-candles.

The problems that face the designer of the image orthicon camera, compared with those of the simpler vidicon camera, include more precise control of electrode voltages and focus field, better thermal control of the camera package, more complex mechanical structure to support the sensor in the space environment, better isolation against shock and vibration, high power-deflection drivers, and provision for packaging a high voltage power supply. None of these requirements is beyond the state of the art.

Two other sensors

Two other sensors that nearly compete with the image orthicon in sensitivity are the image-intensifier vidicon and the secondary emission conductivity sensor (SEC tube).

The image intensifier is a small unit that can be mounted in front of the vidicon faceplate. The intensifier contains a photocathode from which an electron pattern is accelerated sufficiently to excite the phosphor with the same image pattern. It is coupled optically with the vidicon's faceplate. The light amplification obtained by the intensifier may be in the range of 50 to 100 times per stage, increasing the sensitivity proportionally. While this results in a sensitivity that is somewhat lower than the three-inch image orthicon's light sensitivity, it is similar to that of the two-inch image orthicon. The intensifier, combined with the one-inch vidicon, can be enclosed in a volume only slightly greater than that required for the vidicon and somewhat

Cameras on lunar and deep space probes

Program	Ranger 3	Rangers 7, 8, 9	Surveyor	Mariner 4	Apollo (LEM)
Government agency	NASA JPL	NASA JPL	NASA JPL	NASA JPL	NASA Manned Spacecraft Center
Camera developer	RCA Astro-Electronics Division	RCA Astro-Electronics Division	Hughes Aircraft Co.	JPL	Westinghouse
Date	1962	1965	Est. 1966	1964 launch	Est. 1970
Sensor type	1-inch electrostatic vidicon	1-inch vidicon	1-inch hybrid	1-inch electrostatic vidicon	SEC sensor
Scan-line number	200	283 x 1132	No information	200	312
Resolution elements	140 x 200	1,000 x 1,000	220 x 220	140 x 140	220 x 290
Frame time (seconds)	10	0.25 2.5	3.6	24 (playback-8.33 hr.)	0.1
Band-width	2 kc	200 kc	No information	5 kc video (playback-4.17 cps)	500 kc
Dynamic Range (Foot-candle-seconds)	0.01 to 1.0	0.003–0.3 0.004–0.7	No information	64:1 ratio	*4×10^{-6} to 4×10^{-4}
Scene brightness (Foot-lamberts)	2400	350 to 1,650	50 to 2,600	No information *1,000	0.007
Exposure time (Milliseconds)	20	2 and 5	No information	200	Open lens
Unit wt (pounds)	7 (less lens)	17	No information	No information	No information

INR—Information not received

* Typical data furnished by the author

less than that needed for any member of the orthicon family.

The SEC sensor investigated by Westinghouse, RCA and other companies employs a photocathode and an image section in which electrons bombard a sandwich-like target. As the electrons penetrate the porous material they release secondary electrons, producing a gain in electron charge. The target surface is a material of high resistivity, within which the amplified charge pattern is stored until scanned by the beam from the electron gun. These sensors have been used with excellent results on low-light scenes.

An effort is being made to reduce the size for more spaceborne applications.

The graph at the right shows the relative sensitivities of the vidicon, intensifier vidicon, image orthicon and the SEC sensor.

A further step toward greater sensitivity is the development of the image-intensifier orthicon, which permits tv by starlight. Laboratory models are still large, however, and incompatible with the requirements of a small lightweight spaceborne camera. That limits its utilization to missions that can accommodate a large package until miniaturized versions are developed.

The space environment

The environment of space imposes several constraints on the design of camera systems. Environmental factors that require special attention are vibration, shock and acceleration during launch; temperature variations in a vacuum, and radiation.

Vibration and thermal effects pose the greatest constraint on the design of tv cameras for space.

Vibration is felt mostly in the area of the image

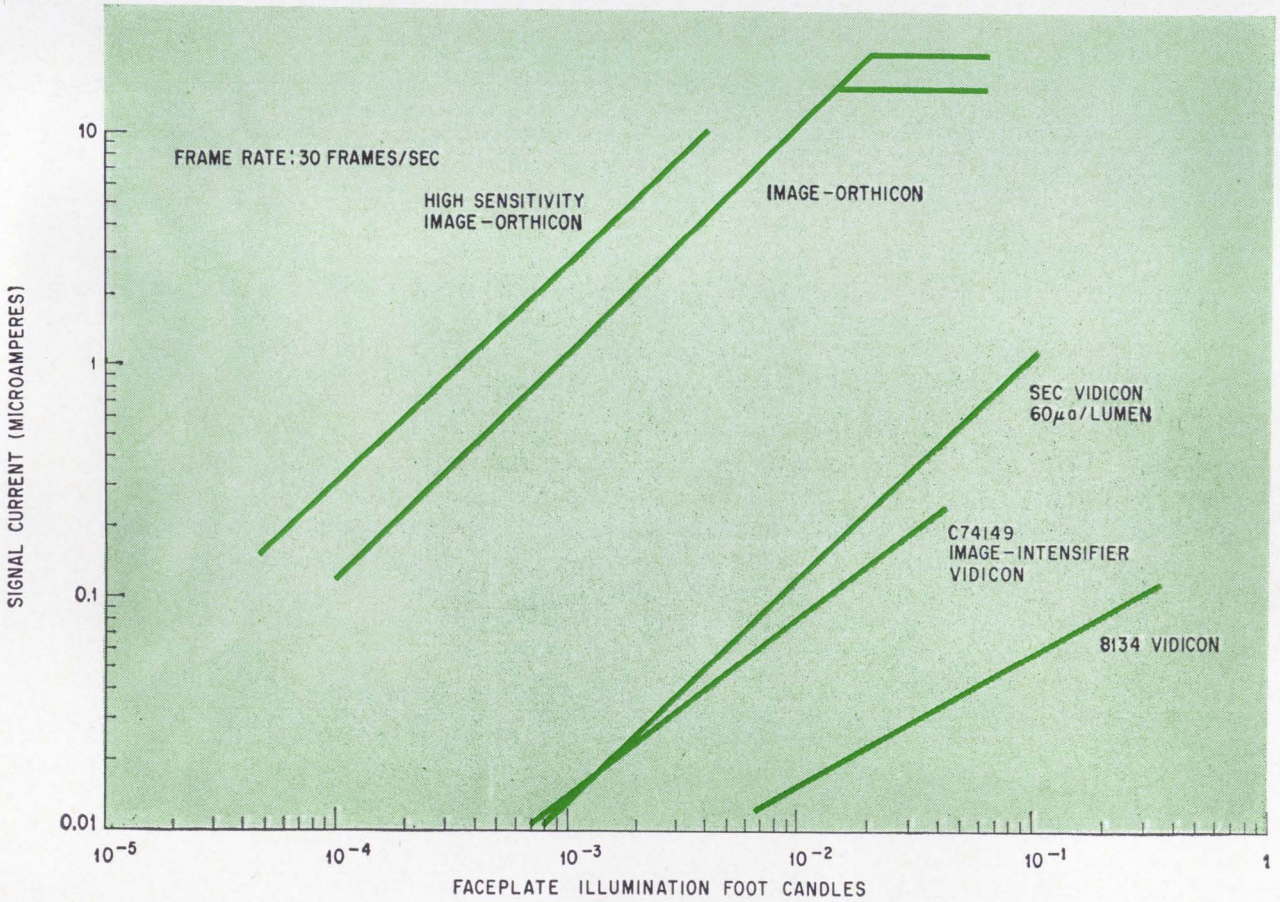
sensor. Precautions include ruggedized design of the tube, stiffening of elements to raise the resonant frequencies above about 700 cycles per second, and a sensor support providing an isolator-damper. The filament element must be made as rugged as possible.

Extensive effort has been expended on the design of the vidicon mesh and its suspension. This fine mesh, placed close to the photoconductor, is subjected to vibration similar to that experienced in a drumhead. The vibrating mesh close to the photoconductor provides an electrostatic microphone, resulting in microphonics appearing in the picture as bars and a fine grain pattern. Vibration and shock may also cause loose particles to fall upon the photoconductor or the mesh and create spots in the picture. To alleviate this problem, special traps between the glass bulb and the gun catch the particles. Extra cleanliness is necessary during manufacture of the tube to minimize the loose particles in the tube envelope.

The mission requirements determine whether the camera must only survive launch or whether it is also to take pictures during launch, as required in the Apollo missions. In either case, the vidicon must be mounted securely so that the position of the image plane will not be shifted during environmental stress. The most effective mounting method employs a fiberglass tube in which the vidicon is suspended in a silastic compound. The fiberglass tube may be clamped tightly, holding the vidicon securely in its proper position without placing unnecessary stress on the glass. A shock-absorbing material also provides a certain degree of vibration absorption, which reduces the microphonic problem.

Where the picture is to be transmitted during the vibration of a launching, a specially designed isolator attenuates vibration frequencies between 600 and 2,000 cycles, where internal resonance occurs within the tube. In the Apollo camera, the random vibration of nine times the acceleration of gravity was applied to the camera housing without causing a significant disturbance from microphonics in the resulting picture.

While the vidicon or other image sensor presents the greatest problem as far as vibration environment is concerned, care must also be taken in all other components. One design that has been highly satisfactory provides a flat mechanical frame, with a central shelf to which the circuit boards are connected. This shelf is rigid enough to cause the resonant frequencies in its structure to be much higher in frequency than the vibration inputs from



Relative sensitivities of available image sensors. Image-intensifier vidicon and secondary emission conductivity sensor compete with image orthicon in sensitivity.

Smile, Moon Maid—you're on tv

APT camera system on Nimbus 1 and Tiros 9 operates with inexpensive receiving stations on the ground to provide local cloud-cover pictures

Television is a useful tool in space. Rangers 7, 8 and 9 transmitted 17,259 high-resolution tv photographs of the moon. Television pictures from weather satellites—over 450,000 from Tiros and 27,000 from Nimbus—have given the first warnings of almost every tropical storm and hurricane since 1960. Live pictures have been transmitted of Soviet cosmonauts circling the earth in Vostok and Voskhod spaceships. And on July 14 of this year, United States scientists expect to receive 22 television pictures of Mars from the Mariner 4 spacecraft.

Future space missions will utilize solid state television transmitters and image sensors, large multiple arrays of ground antennas, and perhaps even laser communication systems.

Weather and mapping

Tiros 1 carried the first tv camera into space on April 1, 1960. Since then, Tiros satellites have observed the weather with scarcely a break. Tiros 9, latest in the series, rolls about its polar orbit like a cartwheel, continuing to send tv data to earth despite loss of one camera. Just around the bend is the Weather Bureau's Tiros Operational Satellite system (TOS), which next year will tie new weather satellites into an advanced computerized weather reporting system.

TOS will make use of an Automatic Picture Transmission system (APT) which was used successfully on Tiros 8, orbited Dec. 21, 1963, and on Nimbus 1, orbited last August 28. The high resolution wide angle APT system continuously photographs areas of the earth and its cloud cover. Pictures are transmitted directly to ground stations in a 2.0-kilocycle bandwidth.

The APT system uses a one-inch storage vidicon; a polystyrene insulating layer permits an image to be stored for a relatively long period with subsequent slow-scan readout.

Nimbus 1 carried an Advanced Vidicon Camera System (AVCS) as well as APT. The AVCS television system recorded worldwide weather data for later readout over a central ground station. The satellite lost power Sept. 23; but while it was operational, Nimbus transmitted even better pictures than Tiros.

Lunar and space probes

The Soviet Lunik 3, launched Oct. 4, 1959, sent pictures of the far side of the moon for about 40 minutes. Lunik took pictures some 40,000 miles from the moon, exposed and developed them on board, and used a film scanner in a long time readout for transmission to earth.

Ranger 9, last and most sophisticated in that series, carried six cameras using one-inch-diameter vidicons. On March 24 it took about 6,000 pictures; 200 of them were converted for network television circuits. A converter was used for the first time to change Ranger's slow-scan pictures, employing 1,132 lines per frame, into the commercial 525 lines per frame.

Mariner 4, launched last Nov. 28, is to begin taking pictures of Mars when it is about 5,500 miles from the planet on July 14. The spacecraft's cameras use a 200-line system with a long time readout; a digital transmission system will send each picture in about eight hours. By 1970, more powerful transmitters and antennas are expected to cut this time down to about one minute.

Future Voyager spacecraft will carry advanced tv systems to Mars in 1971. In the more immediate future, the first Surveyor, to be sent to the moon this fall, will carry two television cameras. One will scan the lunar surface, the other will send pictures of an arm of the spacecraft sampling the moon's crust.

Lunar orbiters will also take tv pictures of the moon beginning next year. These spacecraft will send pictures from as low as 28 miles above the surface for use in making detailed maps. They will use a film processor system in which a CBS Laboratories line screen kinescope scans the film and provides high resolution pictures.

Monitoring spaceflights

Both the U.S. and the Soviet Union have used tv for monitoring spacecraft and astronauts. Television pictures of Cosmonaut Alexei Leonov floating outside his spacecraft were transmitted at 25 frames per second and 625 lines per picture. The previous Voskhod, last October, transmitted 10 frames per second and 400 lines per picture. Earlier manned flights provided slow-scan pictures which were scan converted to permit observation on network tv.

Television has also been used on U.S. space flights. A camera built by Lear Siegler, Inc., observed Astronaut Gordon Cooper during the 22-orbit flight of Faith 7 on May 15, 1963. The National Aeronautics and Space Administration says it does not plan to use television to monitor Gemini missions.

Cameras are being developed by the Radio Corp. of America for the Apollo command module. Using vidicons in a $4\frac{1}{2}$-pound package, they will provide 10-frame-per-second pictures of the astronauts, the earth and the moon; the pictures will be scan-converted on the ground for home tv.

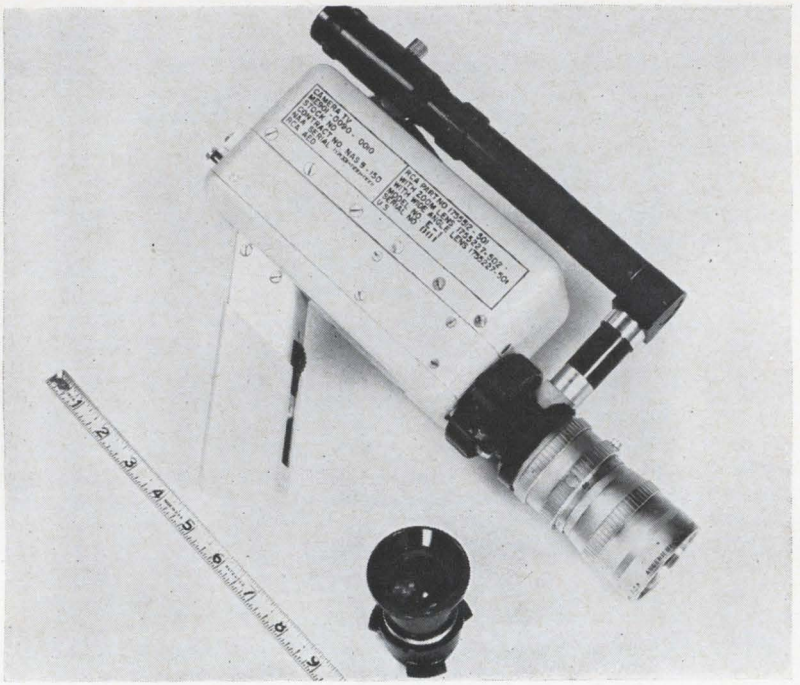
A larger television camera is being developed for the lunar excursion module (LEM), which is to land the astronauts on the moon. The camera will also transmit 10-frame-per-second pictures of the astronauts; these pictures will be scan-converted for viewing on earth in real time. Generally similar to the command-module camera, the LEM camera is designed to take pictures in light reflected by the earth. It will also include a system of passive temperature control to withstand direct sunlight in space.

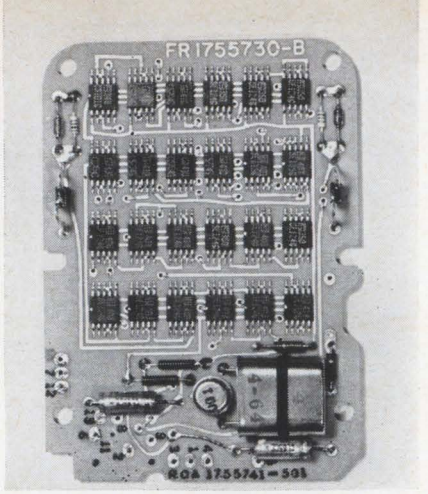
Orbiting observatories

Television cameras on Orbiting Astronomical Observatories (OAO) will observe the spacecraft's position relative to stars at the time astronomical observations are made. The next OAO is scheduled late this year.

RCA has built cameras for the Tigris project, which use an image orthicon for observing the faint glow from gaseous regions of interplanetary space. These cameras provide integration over several seconds, and their sensitivity permits 12th-magnitude stars to be observed. The cameras will be operated from a rocket fired into a trajectory above the atmosphere.

Cameras for the high-altitude balloon in the Stratoscope project have furnished television guidance for pointing astronomical telescopes suspended from the balloon. Earlier Stratoscope cameras employed a one inch vidicon. The later ones use a three inch image orthicon. This produces a television picture of sufficient resolution and picture quality to direct the powerful telescope accurately by remote control.





Apollo camera's circuitry is about 80% integrated circuits of the digital type or hybrid chips adaptable to analog circuit techniques.

Apollo camera built by RCA has synchronization generator circuits that use digital modules and operational amplifiers that are available as off-the-shelf components. This simplifies component replacement by astronauts during Apollo moon trip.

the spacecraft. The design prevents the occurrence of component-vibration problems.

Another advantage of this design is that conformal coating of components mounted on the boards, and spot potting of heavier components and cables, secures components tightly to the board, preventing damage from vibration. At the same time, the design makes components readily available for replacement if repair of the circuit boards becomes necessary due to accidents in testing.

The thermal environment, aggravated by the fact that the equipment is in a vacuum, presents a serious problem in the design of tv equipment for spacecraft. It is assumed that the power consumption and the power dissipation of various components has been reduced to a minimum; however, certain components require heat sinks. Because radiation provides the only ultimate release of thermal energy in the vacuum environment, conduction must be provided to the radiation planes. Convection can be employed for this purpose only if the unit is pressurized.

The design for the thermal environment may be aided by the use of passive thermal controls. This is important in the spacecraft design. To prevent the circuits from being sensitive to thermal change, liberal use of feedback on all transistor circuits is important, as is the use of balanced circuits. Thermal-compensating circuits to minimize temperature drift provide high reliability and minimum susceptibility to thermal changes.

Silicon transistors are used almost exclusively to achieve the reliability that is necessary in unattended cameras. Stringent quality controls are necessary.

Stability of materials in the space environment must be studied. It is important to identify and trace sources of all component materials and to undertake reliability studies in conjunction with a worst-case circuit analysis. An initial step is to derate all parts thermally by a factor of 10, and electrically by a factor of two, with preconditioning, before applying them to circuit boards. Circuits providing automatic adjustment lend themselves best to unattended operation.

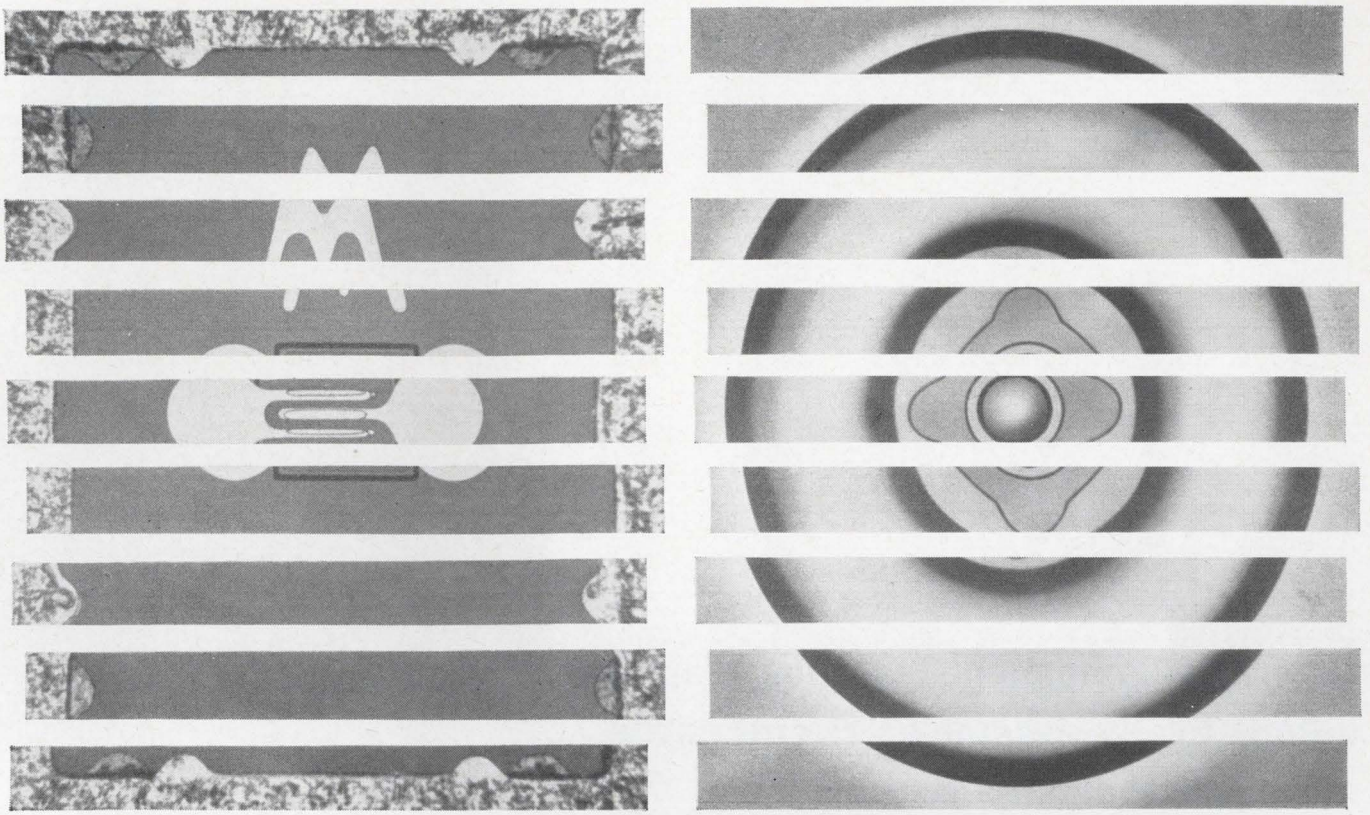
Smaller and smaller

Space and weight restrictions require miniaturization of components. Cord-wood construction is adaptable to high-density packaging and provides a three-dimensional casing.

Integrated circuits in various forms are used in the construction of space-borne cameras. These are highly reliable and capable of high-density packaging, permitting reduction of volume and weight of the circuit components to one-seventh, and sometimes one-tenth, of that resulting from the use of conventional circuits.

In the Apollo cameras, about 80% of the circuitry was built either with integrated circuits of the digital type or with hybrid chips adaptable to analog circuit techniques. Synchronization generator circuits use digital modules as well as operational amplifiers that are available as off-the-shelf components. These components make replacement easy by providing a throw-away module package. Another technique is the use of active components to eliminate large-bypass capacitors and to reduce volume and cost of the package.

No single camera system incorporates the best refinements for all purposes. Each system represents trade-offs of weight, power, sensitivity, and resolution that permit compromises in one area to achieve benefits in another. The result is a design that adequately meets system requirements.



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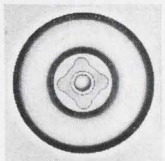
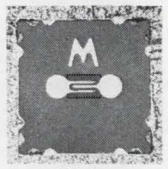


4-Pointed Star† Mesa



3-Finger Microconnection

Two new transistor fabrication processes — the Annular* microconnection construction which yields *passivated germanium devices* and the Selective Metal Etch* technique — make it possible for Motorola to design new germanium transistor geometries with improved performance for virtually any high-frequency amplifier or switching application requirement. Two of these geometries are shown at left.

What does this new design freedom mean to you? In addition to higher frequency and lower noise performance, you also get:

- **specified collector-emitter breakdown voltage as high as −20 Vdc I_C @ −2 mAdc, I_B @ 0;**
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- **a specified collector-base time constant of 6 psec max;**
- **minimum parameter trade-offs.**

In fact, these new transistors can do virtually anything their conventional germanium striped or silicon counterparts can do . . . only better, in most cases.

They're presently available off-the-shelf as PNP epitaxial amplifiers in Motorola's 4-lead (grounded case for shielding) TO-18 package.

For superior performance in your applications requiring high-gain, low-noise, FM-RF, TV-RF, mixer, "S" and "L" band operation, investigate these new devices today! Consult your nearest Motorola representative or write for data sheets to: Box 955, Phoenix, Arizona 85001, Dept. 50, or in Europe: Motorola, Wembley, Middlesex, Empire Way, York House, England.

*Patents pending †Trademark of Motorola Inc.

UNIT	f_T (mc)	NF @ f
2N3783	800 min	2.2 db max @ 200 mc 6.5 db max @ 1000 mc
2N3784	700 min	2.5 db max @ 200 mc
2N3785	700 min	2.9 db max @ 200 mc
MM2503	1000 min	3 db max @ 200 mc

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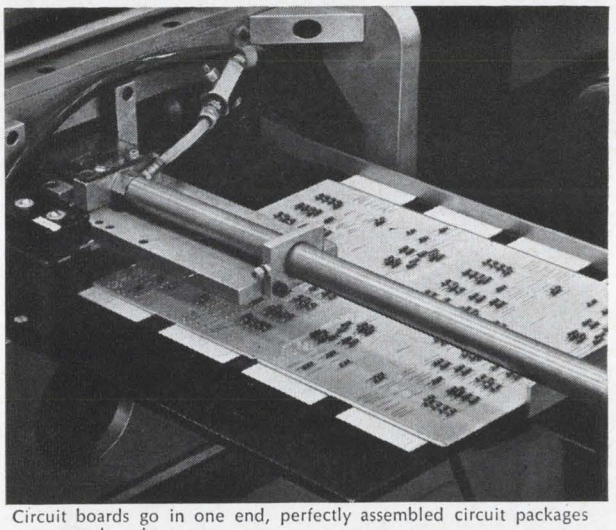

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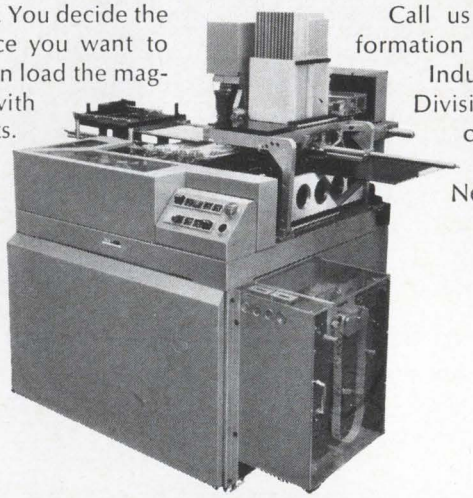

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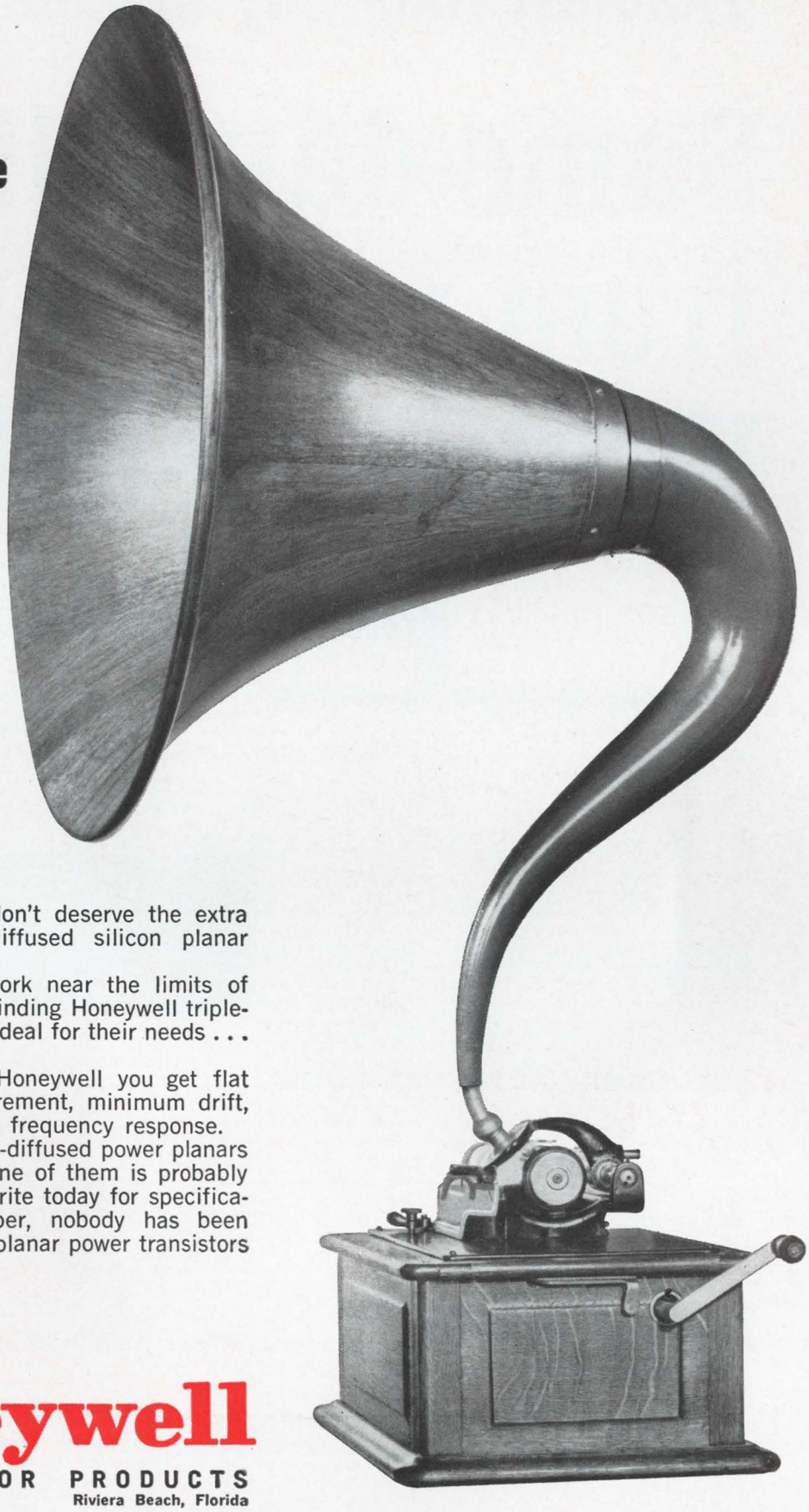

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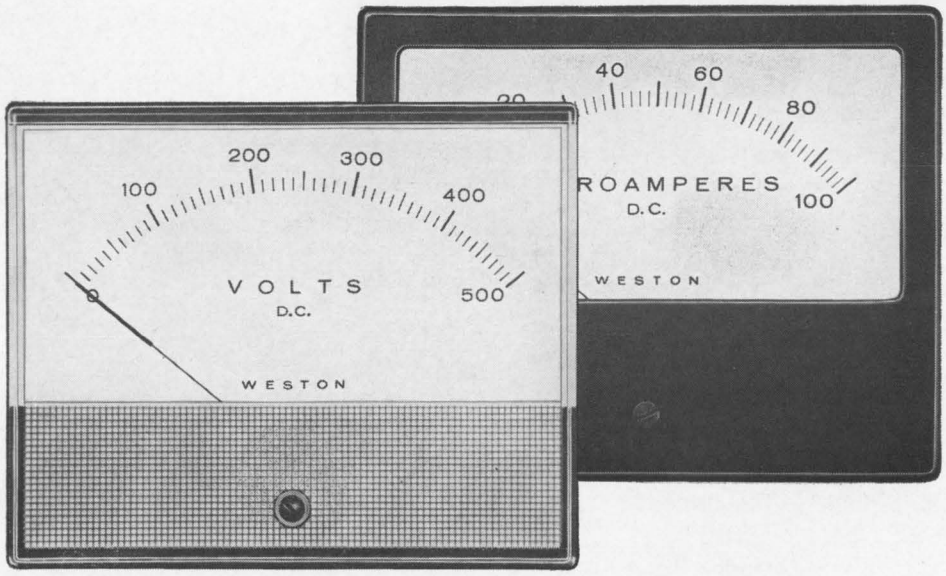

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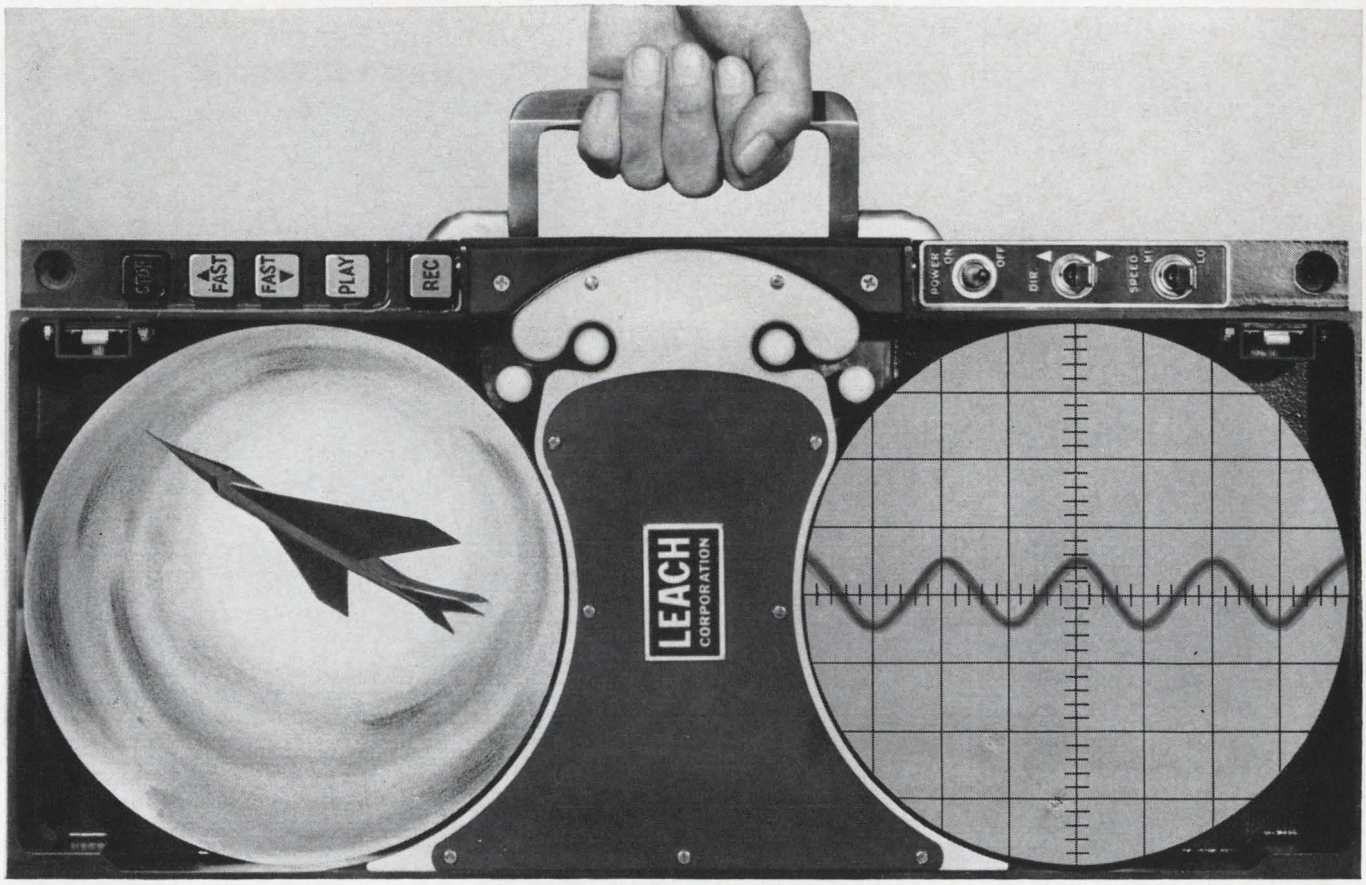

This Tape Recorder/Reproducer is Reliability With a Handle

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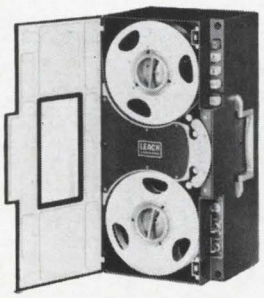
For further information on the MTR-3200 Tape Recorder/Reproducer write to:



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MT-200 Series Actual Size

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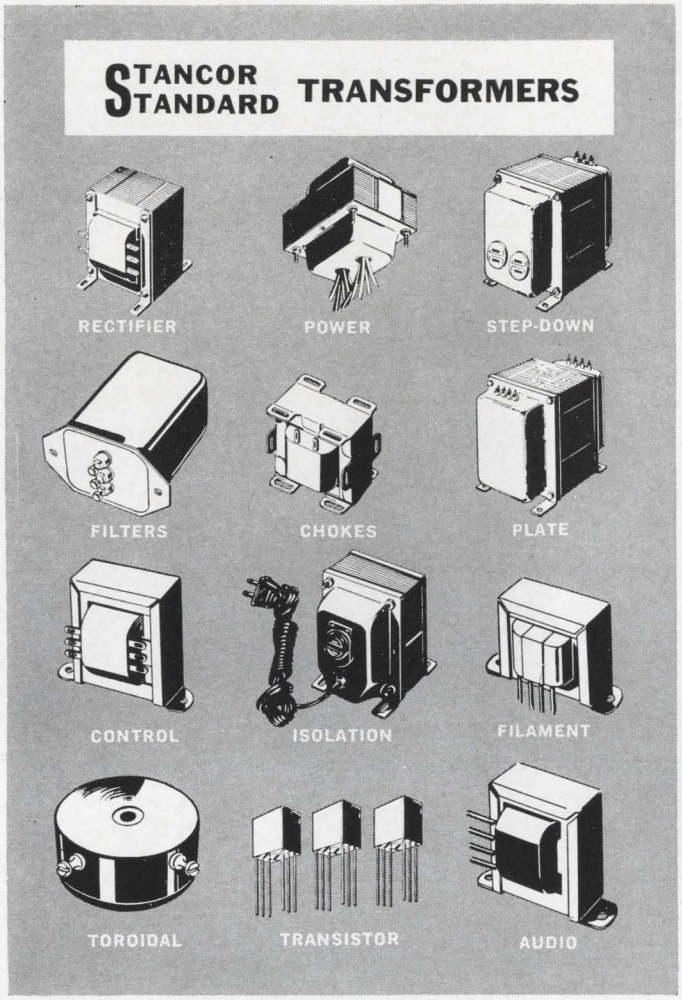

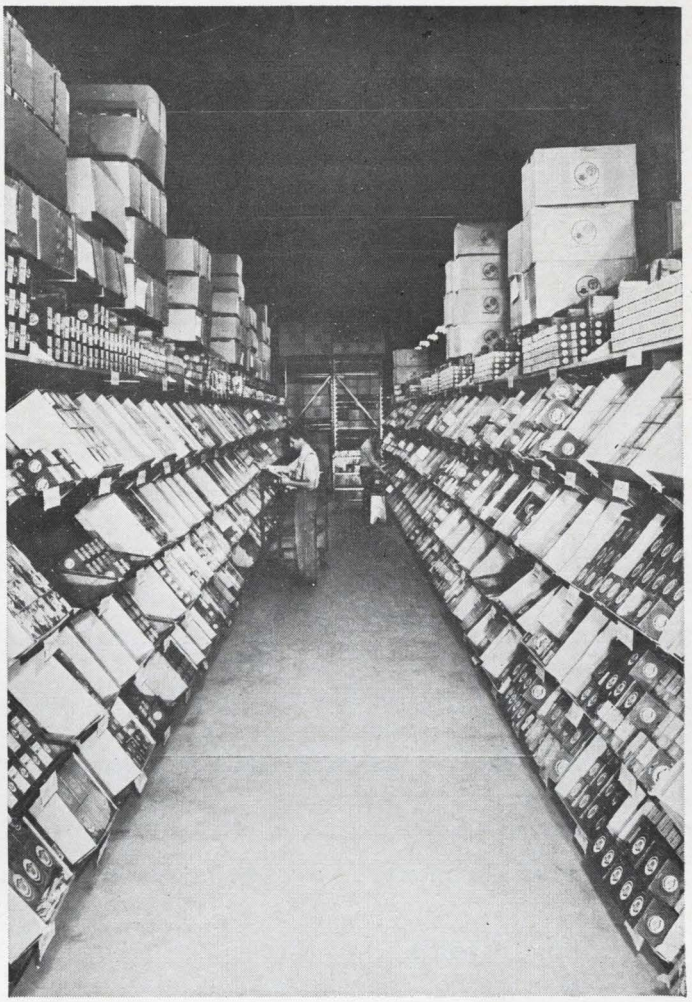

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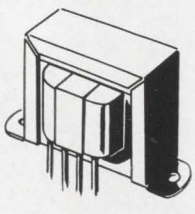

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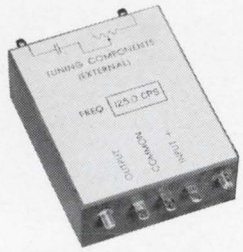

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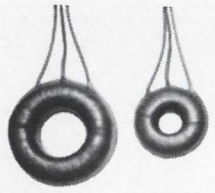

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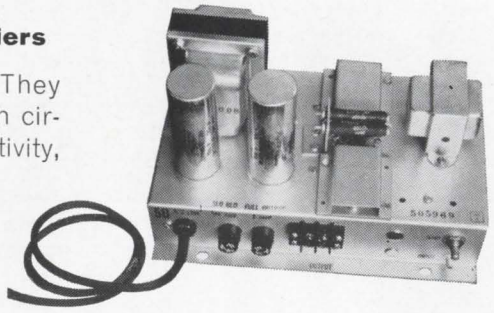

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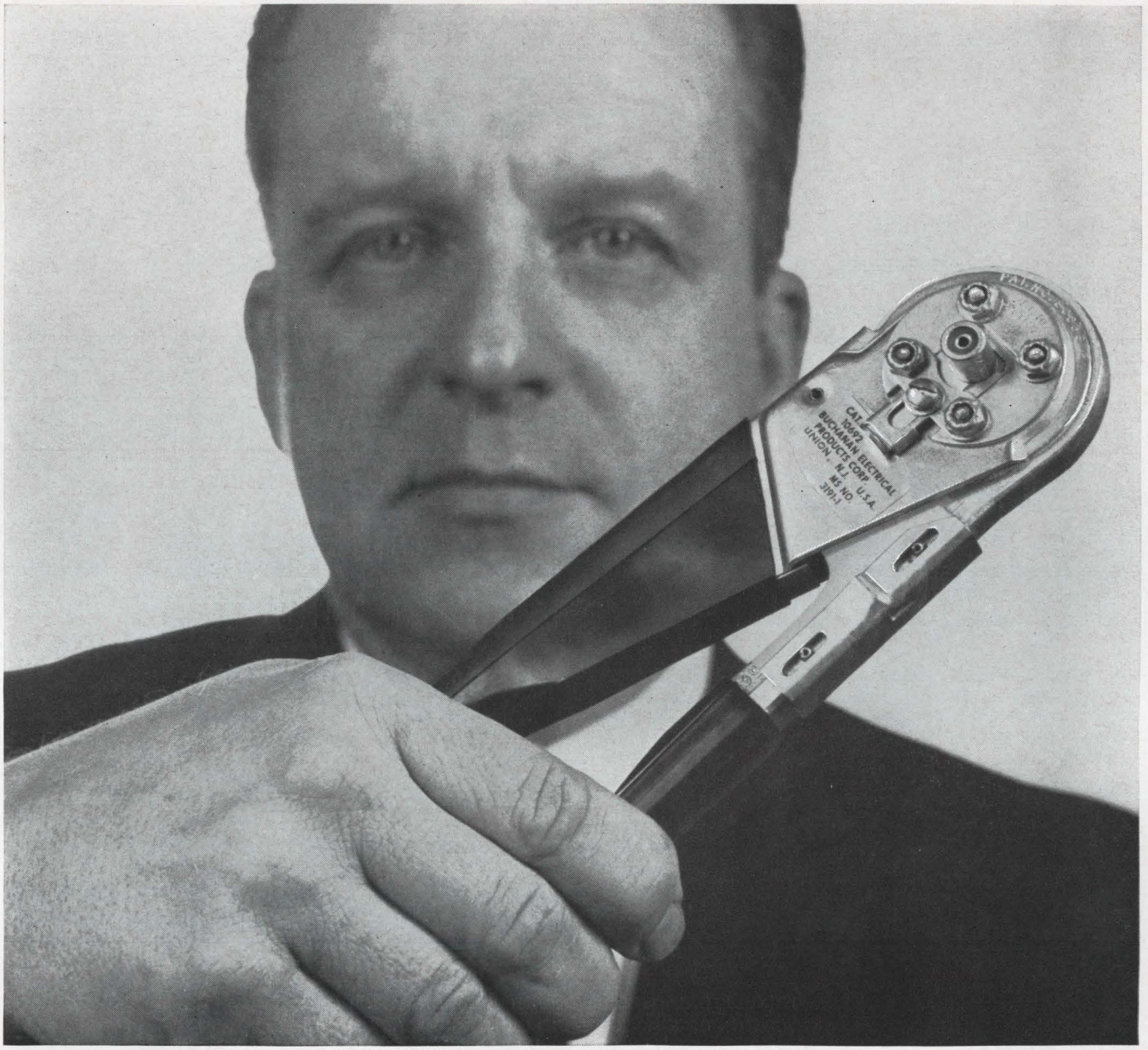

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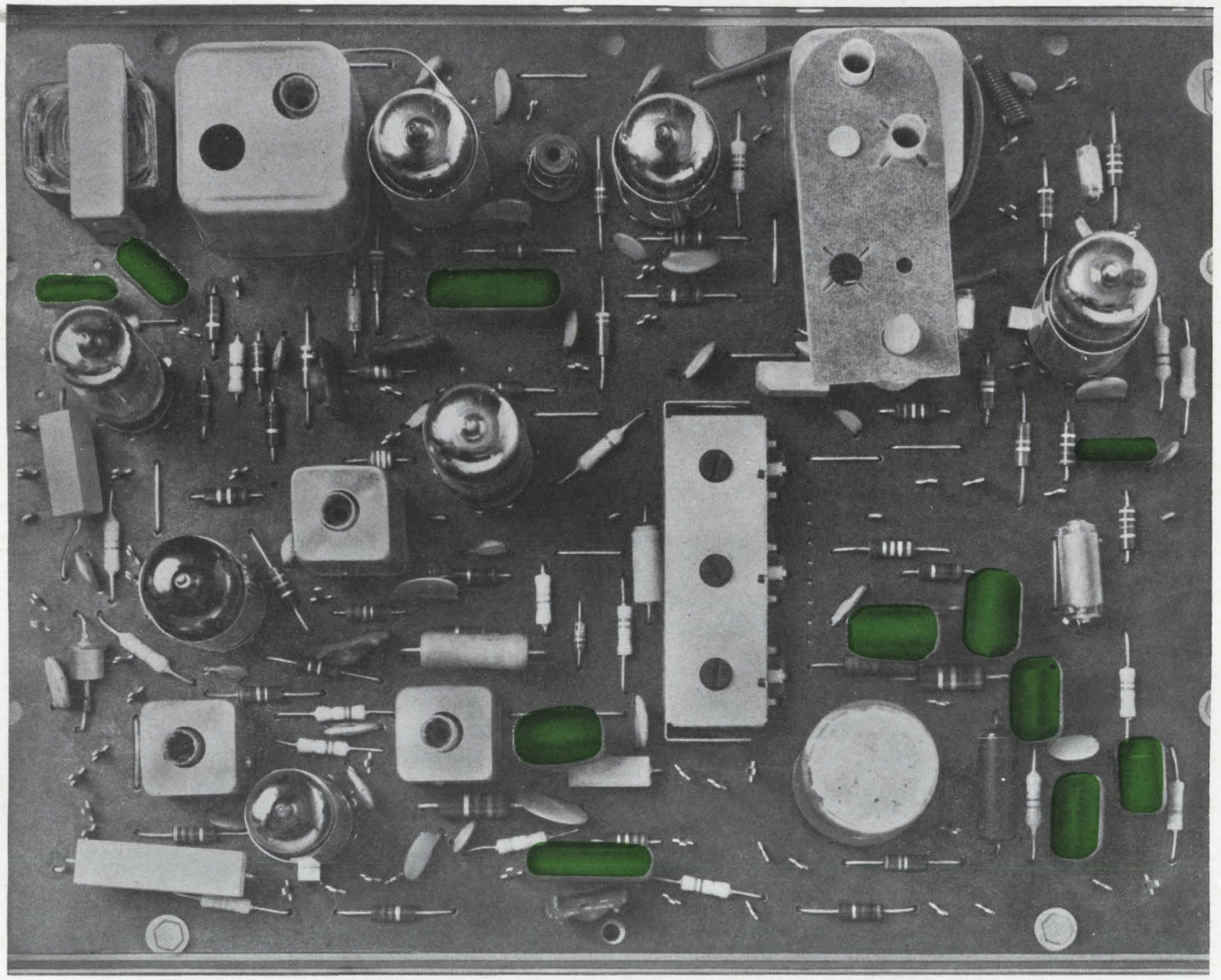

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Probing the News

Military electronics

Radar for the GI in the field

Small sets have already proved their worth in Vietnam, but present units have drawbacks. A new generation is on the way

By W.J. Evanzia
Avionics Editor

Darkness works for the enemy in Vietnam. Guerrilla forces, moving quietly at night through the jungle they know so well, can neutralize American superiority in weapons with the tactic of surprise. To guard against such attacks, both the Army and the Marine Corps are investigating devices for "illuminating" a defense perimeter at night. Sonic wave detectors, light intensification devices, television, infrared sensors, and radar have been tried; so far, radar has worked best. Though it is chiefly thought of as a long-range tool, radar has been remarkably handy in Vietnam for spotting a man stepping into a jungle clearing, or approaching a forward post [Electronics, March 22, p. 18]. Radar and an experienced operator have even detected a man crawling through grass.

I. Operational radar

Three field perimeter surveillance radar units are in use today. They all employ pulse doppler. Target indication is by audio tone —though one of them also has a visual scope presentation.

All three radars do a good job, but each is limited.

- The AN/PPS-4, the Army's best medium-range (8,000 meters) surveillance sensor, is seven years old. The Sperry Gyroscope Co., a Sperry Rand Corp. subsidiary which developed and built the unit, has since modified it. When it was first built, it used vacuum tubes and was powered by a gasoline generator almost as noisy as a burglar alarm; transistors have now replaced the tubes and a battery has ousted the generator.

The PPS-4 weighs approximately 140 pounds—too much for one man to carry. Since it does not present the target visually, but only by a doppler tone, it is limited to one target at a time. The operator must rotate the antenna manually, and the battery must be recharged every eight hours.

- The AN/TPS-25, the Army's long-range (20,000 meters) surveillance radar, is also seven years old. Though it has been modified slightly, it still uses vacuum tubes,

The remotely operated AN/PPS-5 is scheduled to replace the PPS-4 as the Army's front line surveillance radar.

The AN/PPS-6, now under development by the Army Electronics Command for the Marine Corp, can be hand carried into battle.

is powered by a gasoline generator, and must be scanned manually.

The unit weighs about 300 pounds, and five men are needed to carry it. The TPS-25 does provide visual presentation of the target, in addition to the audio tone. The visual presentation, however, is limited; the display is an "A" scope, which shows target size and range. Bearing must be obtained by checking the position of the antenna. The "A" scope also has no target retention capability. Once the antenna has moved past the target, the signal disappears. The Army may improve the unit by equipping it with a "B" scope, which shows all targets in the area scanned and indicates bearing.

The TPS-25 was developed by the Hazeltine Corp.

- The AN/TPS-21, a long-range (20,000 meters) unit built by the Admiral Corp. for the Marines, is not as old as the other two radars —the Marines first tested it in 1960 —but it weighs 250 pounds, it uses tubes and a gasoline generator, and it has no visual display.

The TPS-21 does scan automatically and can change beamwidth for different phases of its operation.

The Marines have used the TPS-21 successfully in Vietnam, and elsewhere; but they, like the Army, want still better gear.

II. In the works

A new generation of field surveillance radar, consisting of three units, is being developed by the Army. All three radars are lighter, smaller and more versatile than the present units. Displays will be clearer, circuit refinements will cut down on power consumption, and better signal processing will provide better target definition.

- The AN/PPS-5 will replace the PPS-4 to become the Army's new medium-range field radar. Now undergoing test and evaluation, the PPS-5 is closest of the three new radars to becoming operational. It should be ready for the field by 1968.

The PPS-5, built by the Airborne Instrument division of Cuttler Hammer, Inc., weighs less than 100 pounds. It can be dropped into a battlefield by parachute or carried in by three men. A remote unit permits the antenna to be placed on a hilltop while the operator controls the set from a foxhole 50 feet away.

Double mode. The remote unit will operate in two modes: a normal radar mode in which all targets, both stationary and moving, are shown, and a moving target indicator mode in which all background clutter is filtered out.

In either mode, targets are presented at the remote unit on "A" and "B" scopes, as well as audibly by doppler tone. The set can detect a walking man at 3,000 meters and a moving vehicle at 5,000 meters.

The unit is fully transistorized except for the magnetron and local oscillator tube. It automatically scans various preset sectors of 30, 60, 90 or 120 degrees. Countermeasures have been built in to make the set relatively jamproof.

Target resolution is better in the PPS-5 because of its 1.0 degree beamwidth. The PPS-4's beam is 6.6 degrees wide.

- The AN/PPS-6, now being tested by the Marines, is the first field radar light enough to be carried and operated by one man. It weighs about 10 pounds, and uses conventional solid state, discrete transistor circuits. A target is indicated by the usual doppler tone, and range can be read off a meter.

The radar is for short-range use (2,000 meters) to help troops patrol the forward battle areas. It was developed by the Army Electronic Command Laboratories, at Fort Monmouth, N. J. A more rugged version is being built now by the General Instrument Corp.

- The AN/TPS-45 is also a short-range radar, more sophisticated than the PPS-6, that is now being developed for the Army.

The TPS-45 will be smaller, lighter and more rugged than the PPS-6. It will employ advanced transmission, signal processing and display techniques. It will use integrated circuits and power transistors. The General Dynamics Corp. is developing the radar.

III. Rifle-toted radar

A two-pound radar that can be attached to an automatic rifle is being developed by the Missile and Surface division of the Radio Corp. of America in Moorestown, N. J. Although it is only an experimental system and still in the breadboard stage, the Army and Marines are both interested.

The radar is a continuous-wave, pulsed doppler system that operates in the X band. RCA claims that the radar will have a useful range of 250 yards and will be able to identify animals, vehicles and people. Targets will be indicated by an audio tone.

The antenna will be a multichannel, solid state, phased-array system. Nine inches in diameter and one-half inch thick, it will be mounted below the rifle barrel.

Many of the integrated circuits

and microcomponents in the system will be potted in the back of the antenna, so that the antenna will be rigid and the components free from vibration and shock. The batteries which supply power to the radar can be carried in a belt clip. Power output of the radar is only 0.2 watt.

Miniaturizing sets and improving target resolution is only part of the goal of bettering field radar. Gen. Wallace Greene, the Marine Corps commandant, would like to have sets which process the information to provide a direct readout that does not have to be interpreted.

IV. Radar's limitations

Although radar has proven to be a good battlefield sensor, engineers know that it does have limitations. Claims by some producers that their gear can tell the difference between men with guns and men without guns, or between men and women, or mules and carts, are usually based on laboratory experiments. Men in the field rarely find their equipment to be so photographic.

Slow-moving targets (close to one mile an hour) often get lost in background noise, and targets faster than 35 mph aren't picked up. Wind sometimes causes branches and tall grass to look like people moving, although an experienced operator can usually tell the difference between the random motion caused by the wind and the steady movement made by a man.

Other sensors. To avoid drawbacks inherent in radar, most of which operates in the X or K bands, RCA is experimenting with sound waves. This would eliminate clutter caused by weather. The sonic wave, which is around 38 kilocycles, would be produced by an electromechanical transducer and collimated by a horn with a parabolic surface. RCA hopes to start testing a breadboard model in June.

Another important technique being studied by the Air Force and Navy as well as the Army is low light level television. General Electric Co. and RCA are both building systems that can see targets in light levels lower than 10^{-4} foot candles. When used in conjunction with radar, the combination may prove to be the best technique yet tried for positive perimeter control.

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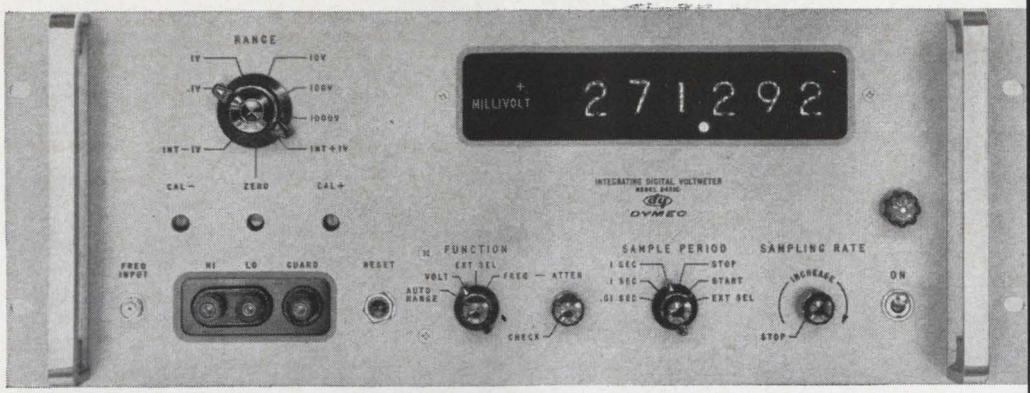

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Inertial navigation at a bargain price

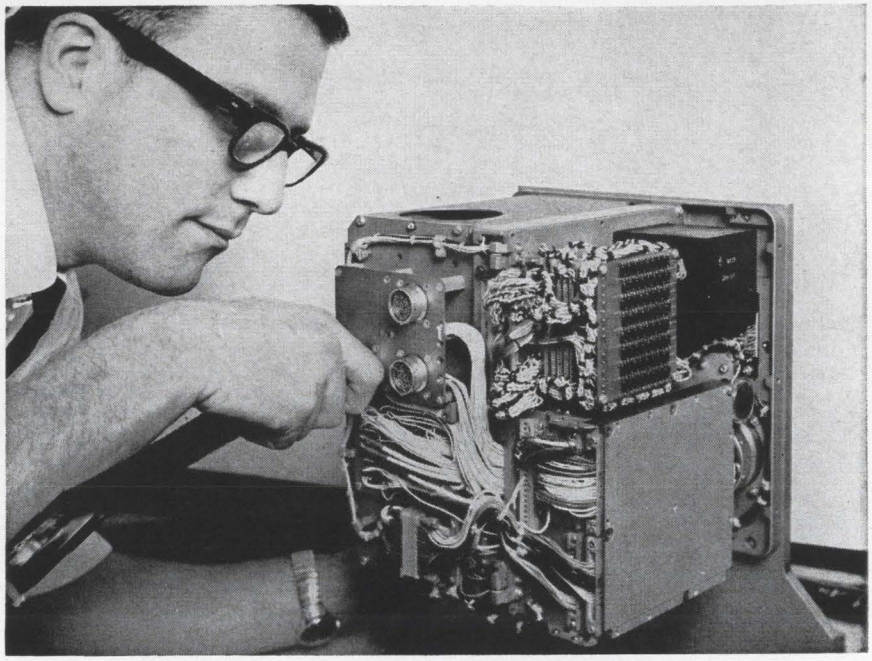
The Air Force is halfway through a program to build a highly reliable system that is simpler and less expensive than those now in use. It could be used by military planes or civilian airliners

By George Sideris

Senior Associate Editor

Inertial navigational systems are highly accurate, and by their self-contained nature jamproof and interference-free. But widespread use of such systems has been delayed because they are so complex, unreliable and costly. A small group of Air Force officers and engineers stationed at Holloman Air Force Base, in the New Mexico desert near Alamogordo, hopes to overcome those obstacles. Their goal: an inertial system with a bargain-basement price tag and Rolls-Royce performance. By stressing design simplicity, they hope to cut the cost per system from the current $75,000-$100,000 to only $25,000, and at the same time boost navigational accuracy to one mile per flight hour and reliability to 2,500 hours mean time between failures (mtbf).

The system would include a digital computer, associated analog circuitry, controls and display. The $25,000 price tag is based on the assumption that 200 systems will be produced at a rate of 20 a month, starting in January, 1967.



Breadbox-sized computer is prototype of the one that Nortronics will build for the Air Force's low-cost inertial navigation system. Memory and power supply are in the right-hand side of the instrument, logic in the left.

I. The Reichel program

Officially, the group at Holloman is named Detachment 1, Avionics Laboratory, Research and Technology Division, Air Force Systems Command, of Wright-Patterson AFB, Ohio. Informally, the work at Holloman is called the Reichel program, after its technical director, Wladimir A. Reichel, who died last winter.

The group's work, which began in July, 1963, is about half done. The design is set, evaluation of components has begun, and computer contracts will go out this month. Inertial sensors will be evaluated and flight tests made next year, after the sensors, the analog electronics, and the computer are assembled as a system.

Contracts for the computer will go to two companies: the Northrop Corp.'s Nortronics division and the Instrument division of Lear Siegler, Inc. Each will build a prototype, one of which will be chosen for the ultimate system.

To be built with about 500 integrated circuits, the computer is to cost only $6,000 to $10,000 yet is to have a reliability of 10,000 hours mtbf and computational accuracy as tight as 0.1 mile per flight hour. The only comparable reliability has been in systems designed for spacecraft intended for long missions.

II. Open to airlines

The system is not classified, and the project officers hope that it will be used in commercial as well as military aircraft. From the start, one of the program's goals has been to spur the electronics industry to lower costs of navigation systems while improving performance.

Industry has already made progress in paring down costs and raising performance. For example, Litton Systems Inc. expects to fly the first of a new series of inertial guidance systems, called the LN-15, next month. Prices, which will depend on system configuration, are estimated at from $35,000 to $50,-

000. Accuracy will be better than one mile per flight hour, and mtbf will be 1,000 to 1,500 hours. By comparison, Litton's LN-3 system, which is being produced for the F-104G, costs $75,000 to $85,000, and has an accuracy of two miles per flight hour and an mtbf of 200 hours. Both systems use analog computers.

Too expensive. While commercial airlines would like to use inertial systems for long-range flights, especially across oceans, most have shied away because of high cost. The exception is Pan American World Airways. Starting this summer, Pan Am will equip its fleet of 55 Boeing 707's with the SGN-10 system built by the Sperry Gyroscope Co. Each plane will carry two systems, for added accuracy and reliability. The SGN-10 has an accuracy of about 2 miles per flight hour and an mtbf of 940 hours. Pan Am will spend $12½ million for the equipment—about $100,000 per system.

The new Air Force system would not only cut costs but would be usable for many years. It's designed for worldwide flights, at speeds up to 2,200 knots and altitudes up to 80,000 feet.

III. Bucking the trend

If the Holloman design is to become a standard in military avionics, it will have to be so good that the military can't afford to turn it down. By making the digital computer part of the system, the Holloman group is bucking the trend toward the use of a central, general-purpose computer which would service various types of avionics systems in a plane. Such integrated avionics systems are being designed for military planes and have been proposed for the supersonic transport plane. A central computer is planned for the C-5A, the next-generation military transport plane [Electronics, April 5, p. 34].

There is still much dissention in the ranks of avionics designers over which approach is better. Centralizing weapons, navigation and control computations in a single computer is efficient, some say, but it also means putting all the eggs in one basket.

The Holloman group's job is to demonstrate that the traditional ap-

proach—self-contained systems—is better. Capt. James Cox, project officer, believes it is.

"We don't think we can get the combination of lowest cost and best reliability in a general-purpose computer," he says, "because they are larger and more complex than special-purpose computers. The most reliable computer is the simplest computer for the job."

IV. Competing designs

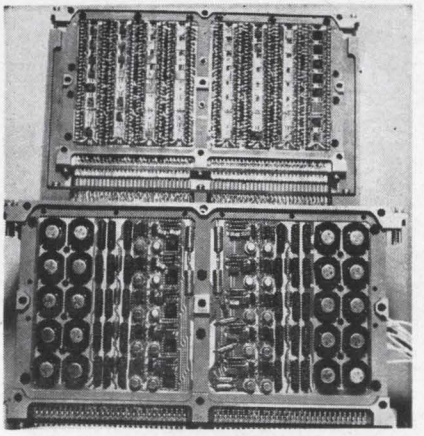
The Air Force has specified that the computer must handle the warmup, alignment, calibration and timing of the inertial components, and compute and display such navigational data as course, distance and time to any of four destinations, and the airplane's ground track and position. The computer must also locate malfunctions in any part of the system.

The computer's volume will be 500 cubic inches, it must weigh no more than 15 pounds and power consumption will be 50 watts. The total system will weigh 60 pounds, draw 350 watts, and have a volume of 2,650 cubic inches—just under 100 cubic feet.

Details of the final design of the computer are up to the contractor. Holloman does want the computer to be able to solve a set of unipolar equations developed by the Autonetics division of North American Aviation, Inc. These equations are more accurate for navigation near the earth's poles than the conventional two-pole equations are.

Nortronics. The computer that Nortronics is developing will be a modification of one called the Model 1050, built in prototype form last December. This computer can be used for airborne hyperbolic navigation, combat mapping, ordnance control and other military missions. Combined with inertial sensors, it is one of the systems that will be tested by the Missile Development Center, also at Holloman, for navigation of the F-111 fighter-bomber.

The basic 1050 has a random-access core memory of 1,024 20-bit words and a serial arithmetic section. Its clock rate is 250 kilocycles. The logic circuits are all integrated, and the memory is partially integrated. The entire computer has 632 integrated circuits and more than 1,000 discrete components.



Nortronics' logic board (top) is made by mounting circuits on etched-wiring sticks, then soldering contact fingers on the sticks into another etched circuit.

The calculated reliability is 9,000 hours mtbf.

Lear Siegler. This company's computer is based on the Divic, which was especially designed for navigational computation. Divic stands for Digital Variable Incremental Computer. Its arithmetic section is unique—organized to solve trigonometric problems as fast as most computers can solve simple multiplication problems. The Holloman version will solve 33 navigation problems a second, operating at a clock rate of 3 to 4 Mc.

Divic was developed last year under another name, the Hyperbolic Coordinate Converter, for the Federal Aviation Agency's program to automate Loran C navigation in aircraft. Loran is a hyperbolic radio-navigation system, but the computer can also solve the unipolar inertial-navigation equations without modification. Programs will be permanently stored in a core-rope memory, a type also used in the Polaris missile and Apollo spacecraft navigation computers. The read-write memory will be ferrite. Less than 500 integrated circuit packages will be used in the Holloman version.

Gyros. A number of inertial components are now being evaluated. Among the gyros are the Autonetics G-10, Litton's Vibrarotor, the Conductron Corp.'s RGG-1, and the Gyroflex made by the Kearfott division of General Precision, Inc.

These gyros were picked by Holloman because of the simplicity of their construction. Each of the gyros will sense motion in two of the three orthogonal axes. Only two

gyros need be used, instead of three as in some systems. Also being evaluated are low-cost gimbals, among them Sperry's SGN-10.

V. Long-range goals

An objective of the Holloman group is to improve the system until it eventually achieves a reliability of 25,000 hours mtbf—equivalent to the total useful life of the system now being built.

The group thinks that one of the keys to such phenomenal reliability will be a source of continuous power, wholly contained within the inertial assembly. This would eliminate dependency on the aircraft's generators—an unstable source of power—and it would also eliminate most of the slip rings now used to deliver power to the inertial components. Also, it would allow the gyros to be run continuously, ending the need to warm them up before each flight.

The power source proposed is a nuclear generator, similar to the Snap type of radioisotope generators being developed by the Atomic Energy Commission. The AEC is interested in developing one for Holloman, but estimates it would take two or three years.

Computer on a slice. New integrated circuits are also being researched as part of the program. Autonetics is developing the analog circuits that will marry the inertial sensors to the rest of the system. These include the servo, amplifier and power-supply regulator circuits.

Although Holloman plans to use conventional integrated circuits, packaged two or four to a flatpack, the computer logic may eventually be made of a few highly complex monolithic circuits, or arrays of circuits on a single crystal of silicon.

The Molecular Electronics Branch of the Avionics Laboratory at Wright-Patterson AFB is eyeing the Holloman computer as a candidate for the Air Force's first "computer on a slice."

The groundwork for such a possibility is being laid in several contracts for research on single-crystal arrays. Researchers expect that such arrays will greatly improve the reliability of systems made with integrated circuits by eliminating most connections between circuits.

A practical application of the arrays would be in a small, mass-produced computer, such as the one being developed for Holloman.

Contracts

The Pentagon tries life-cycle procurement

A single company will be prime contractor for the C-5A transport's development, production and maintenance

By Herbert W. Cheshire

Washington News Bureau

To that vast lexicon of jargon peculiar to the Pentagon, add the phrases "life-cycle costs" and "total package procurement." They are key terms in a new purchasing philosophy that promises to have a major impact on defense contractors.

In considering new military systems, Defense Department officials are thinking increasingly in terms of lifetime costs, rather than the

price tags systems bear for any given phase. They are taking into account the full cost range that begins with development, builds up with production and continues with the maintenance and logistical support necessary to keep a system in operation. Any they want to buy a single package.

This is a new concept, and its implications are far-reaching. Heretofore, winning contractors for major systems have been those bidding low on development only, with little consideration for costs over the long pull. Under the new philosophy, a contractor with high development costs and low production and maintenance estimates could win the award.

I. First test

The new philosophy is about to be given a practical test on a huge scale. The Air Force will buy the whole life cycle of the C-5A transport plane at one time. The winning contractor will not only develop the plane, which will be the largest in the world, but will produce it, and provide spare parts and ground support equipment for its full life.

If the procedure proves successful in the case of the C-5A, other systems will be bought in this way.

II. Competition in every phase

Defense officials believe total package buying will cut over-all

Robert H. Charles, assistant secretary of the Air Force, feels very strongly that development and production should be treated as a single package.

costs. When a contractor wins a development contract, he is almost sure to get the production contracts later. This leads to a single-source, negotiated contract for production. Thus, competition has been present only in the development phase, which generally accounts for only 25% of the total cost of a system. Total package procurement would provide competition on 100% of the money spent on the system during its entire life cycle—though there would be only one competitive round. Robert H. Charles, the assistant secretary of the Air Force and its procurement chief, feels very strongly that development and production should be treated as a single package. Charles thinks the program will:

- Prevent "buying in," a contractor practice of bidding unrealistically low on development in the expectation of recouping losses on the noncompetitive production contract that follows.
- Deter developers from making extravagant promises of how the finished product will perform, and force them to tighten design discipline for economical production, product reliability and ease of maintenance.
- Spur prime contractors to obtain components and supplies from the most efficient source. In principle, the program should lead to less in-house work by primes and more subcontracting. And where subcontracting is used, the prime will be under greater pressure to resort to competitive bidding to keep his costs down.

III. Impact on electronics

This first total package contract will, of course, not go to an electronics company but to an airframe company. The contenders are the Lockheed Aircraft Corp., Boeing Co. and Douglas Aircraft Co.'s team—North American Aviation, Inc. and the Martin Co.

Eventually, though, electronics companies will get prime contracts under the new program, Charles says. Life-cycle contracts will be awarded for big electronic systems and for subsystems developed independently of the total system. The contract for the Mark II integrated avionics package for the F-111 fighter-bomber may be a total package contract.

C-5A's subsystems

Subcontracts for electronic subsystems for the C-5A will be awarded in September, a month after the prime contract is scheduled to be signed. The awards will be numerous and will represent a great deal of money. The prime contract, for 58 operational planes, will be in the neighborhood of $2.2 billion. The Air Force will take an option to buy up to 200 planes.

Because the C-5A will operate over a long range—more than 5,000 miles—and in remote areas, it will need an inertial navigation system. To support brush-fire wars, it will need terrain-avoidance radar for low-level flying and all-weather takeoff and landing equipment, and it must be capable of making accurate air drops without visual reference to the ground or dependence on ground signaling equipment. It will have station-keeping equipment to permit formation flying in all-weather conditions, and an on-board maintenance and checkout system for the avionics package. Communications equipment will be off-the-shelf long- and short-range radio.

The only projects not elegible are those in which major state-of-the-art advances are involved. In such cases, a contractor would find it impossible to bid realistically on production costs, lacking fairly firm estimates on development costs.

IV. Technical transfusion

The contract for the C-5A will be of the fixed price-incentive type. Under this plan, the government shares with the contractor any costs above, or savings below, the competitively established target price. The more the contractor holds down costs, the greater his profit will be.

Less palatable to companies competing for proposals is the concept known as "technical transfusion." Under this plan, the Air Force can take the best features of the losers' proposals and incorporate them into the winning design.

The transfer is supposed to cover only those design features developed with government funds, and not proprietary features. Industry fears, however, that the transfer might run over into equipment that had not been directly funded by the government.

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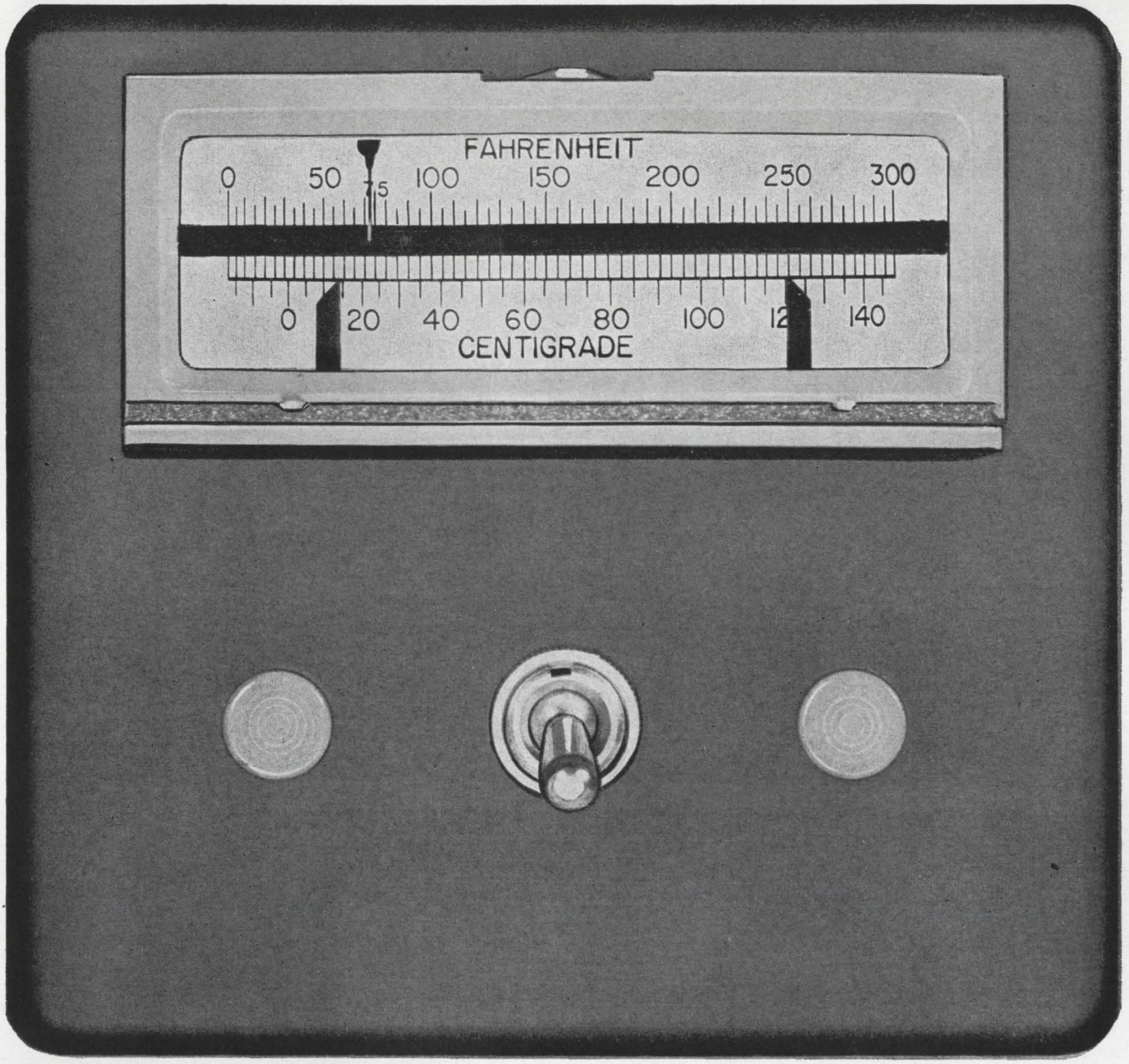

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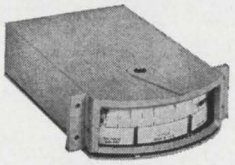
TEMPERATURE CONTROLLERS—STANDARD FEATURES • 300°-3000°F Ranges • Electrical Cold Junction Compensation • T/C Resistance Balance Bridge • T/C Break Protection • Fail Safe Operation • Heavy Duty Load Relays • Taut Band • Fahrenheit/Centigrade Scales • From $195.00 List



28VDC Series
Meter Relays
From $145.00

DON'T LIMIT US TO TEMPERATURE CONTROL! STANDARD CONTROLS AVAILABLE FOR:
• DC Microamps • DC Millivolts • AC-DC Amperes • Watts • Phase Angle • Vars.
• From $185.00 List • Liberal Quantity Discount Schedule • OEM Pricing Available.

Write for Catalog C-164 **THE HICKOK ELECTRICAL INSTRUMENT CO.**
10527 Dupont Avenue, Cleveland, Ohio 44108
Represented in Canada by Stark Electronics, Ajax, Ontario • Internationally by Hughes International, Culver City, California

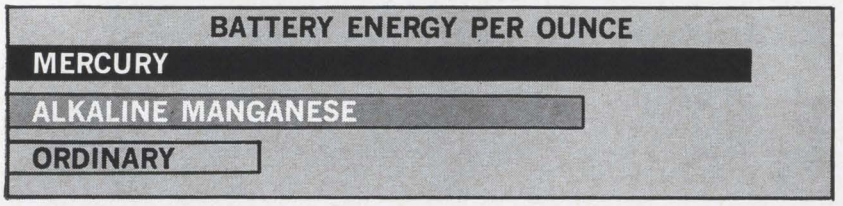
Design For Sales Appeal

...with Mallory high energy batteries

Greater convenience

Getting maximum hours of service before batteries need changing is a major factor in creating convenience of a battery powered product.

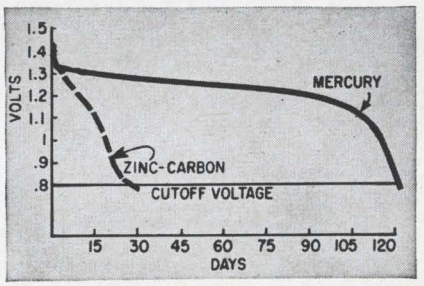
Mallory high energy batteries reduce battery changing to a minimum. Size for size, Mallory batteries offer the longest life, and most reliable operation of any commercially available batteries. Mallory Mercury Batteries for electronic circuits have about four times more energy per unit volume than ordinary batteries . . . last correspondingly longer, and hold their capacity for years when left idle. Mallory Alkaline Manganese Batteries, for heavy-duty usage, have about three times more energy than conventional batteries.



Mallory Mercury Batteries cut battery changes because of higher energy content.

Higher stability

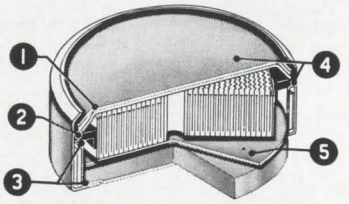
Mallory Mercury Batteries have the unique property of staying exactly at the same voltage throughout long life. So exactly is their output that they are often used as laboratory voltage standards. This stability makes them especially useful in electronic watches, instruments and electric eye cameras, where you need accurate voltage to obtain correct operation.



Typical load-life performance of Mallory Mercury Batteries. Note how voltage stays steady until battery capacity is nearly depleted.

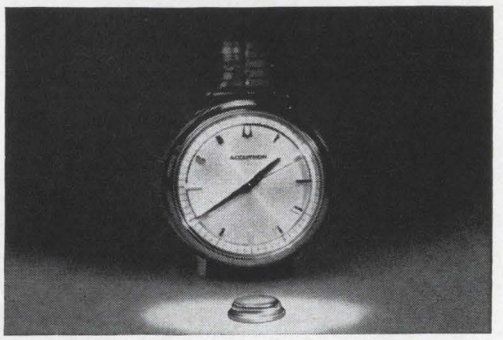
Low-temperature reliability

Most batteries lose capacity in cold weather, because chemical action slows down as temperature drops. We've overcome this problem with the Wound Anode Mercury Battery. Its special construction gives larger anode area and lower internal impedance. Result: capacity at freezing and sub-freezing temperatures is improved by a factor of 6 to 12 times over our pellet anode mercury system. At 32°F, it has 94% of its capacity at 68°F; at +15°F, 46%; and at −10°F, 10%. Cells with capacities of 400 to 13,000 milliampere-hours are available.



1. Double top seal
2. Sealing grommet
3. Self-venting structure
4. Non-corroding metal structure
5. Long-Life barrier

Leading Battery Powered Products Use Mallory Batteries



The Accutron® timepiece, by Bulova, only electronic wrist timepiece, runs for well over a year on a tiny Mallory Mercury Cell especially designed to give excellent reliability on low-current service. Highly precise, stable voltage of this cell is essential to its exceptional accuracy of timekeeping. Mallory makes a broad line of energy cells for self-powered watches and clocks.

Western Electric electronic artificial larynx gives new voice to patients whose larynx has been paralyzed or removed. High-energy Mallory Mercury Batteries power the transistorized sound-producing circuit, give longest possible life between battery replacements.

Mallory Batteries cost more, but they're worth more because of the superior performance they give your product. For a consultation on your specific requirements, write or call Mallory Battery Company, a division of P. R. Mallory & Co. Inc., Tarrytown, New York.

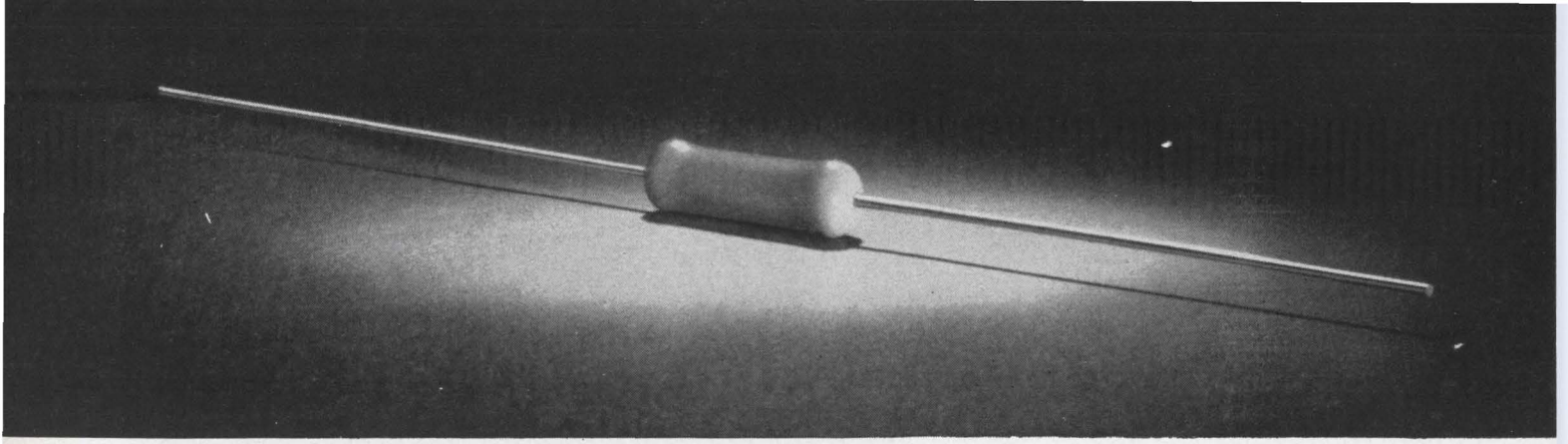
MALLORY

RESISTOR PROVING GROUND: RELIABILITY TESTING

Resistors are run under the most difficult operating conditions they might be expected to meet. Even after 1,000 hours under load, Stackpole resistors are well within the limitations of MIL-R-11 specs. This exemplifies the continual rigid testing that creates resistors of the highest quality and dependability.

Other tests are conducted to determine temperature/resistance characteristics. Perhaps you'd like to discuss this or other tests with us. Write or call: Don Kirkpatrick, Manager-Engineering, Electronic Components Division, Stackpole Carbon Company, St. Marys, Pa. Phone 814 834-1521. TWX 814 826-4808.

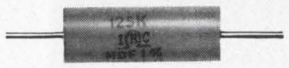
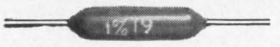
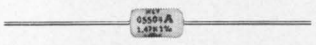
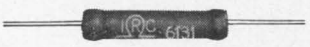
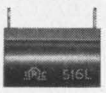
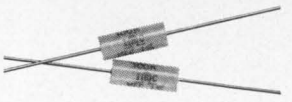
STACKPOLE
ELECTRONIC COMPONENTS DIVISION



If you can find one resistor that's best for all precision applications

...buy it

We don't think you will.
That's why we make all these different types... can recommend without bias.

 **MOLDED DEPOSITED CARBON** Low cost, most popular MIL-R-10509	 **COATED DEPOSITED CARBON** Industry's first precision film, MIL-R-10509	 **MOLDED METAL FILM** Best MIL-R-10509 performance, hi-rel option	 **COATED METAL FILM** Smallest size resistor for MIL-R-10509
 **ULTRA RELIABILITY METAL FILM** MIL-R-38101, Minuteman .0001%/1000 hr.	 **HIGH RELIABILITY METAL FILM** MIL-R-55182, 4 sizes, glass-hermetic	 **LOW COST METAL FILM** 100 ppm T.C. Molded or coated types	 **MINIATURE METAL FILM** Saves space, 1/20 watt, 1% tolerance
 **PRECISION POWER WIREWOUND** Miniature, ½ to 15 watts, 25 ppm T.C.	 **ENCAPSULATED WIREWOUND** MIL-R-93, humidity and shock resistant	 **UNENCAPSULATED WIREWOUND** Instrument grade, low cost Wirewound stability	 **MATCHED METAL FILM** Matched to 3 ppm T.C. and/or .02% tolerance

Write for Precision Resistor Selection Chart... complete data in handy 11" x 17" size.

IRC®

INTERNATIONAL RESISTANCE COMPANY

PHILADELPHIA, PA. 19108

Circle 118 on reader service card

Socket for flatpack integrated circuits

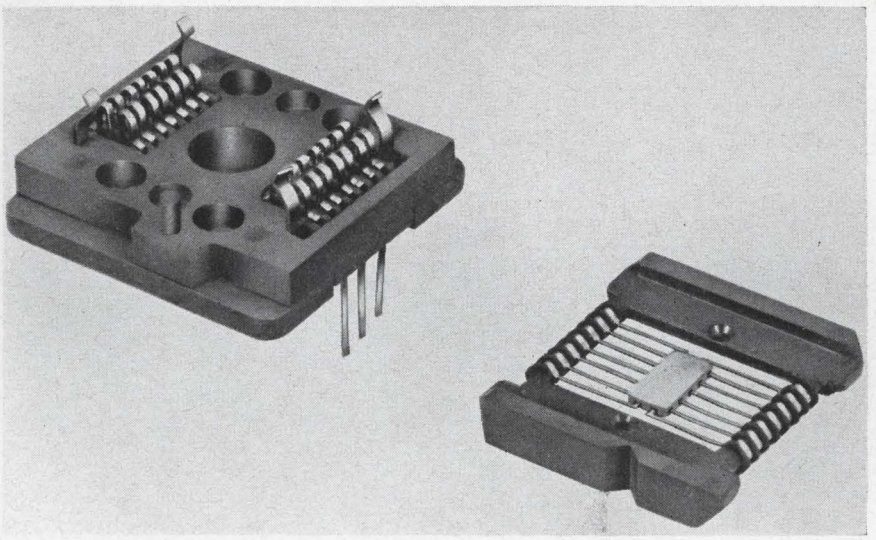
Semiconductor networks can be plugged in quickly and easily for testing circuits or components with TI connector

A user of flatpack semiconductor networks who wants to test his purchase or try it out in a test circuit has a tedious job if he must solder or weld to test, then unsolder or cut the leads to remove the flatpack. Metals and Controls, Inc., a division of Texas Instruments Incorporated, has lightened his task with a connector which is essentially a socket that can be installed permanently in the test circuit, prototype or production systems. It holds the flatpack with a spring device: in effect, you plug the flatpack in to test, then unplug it when the test is over.

The connector, known as the Mech Pack, mates only with the protective frame carrier used by TI to ship its ¼ in. by ⅛ in. 14-lead flat package semiconductor networks. The Mech Pack has its own leads, which are soldered to the rest of the system. The frame is notched so that it can be held by a spring.

The only contact between flatpack and connector is at the lead points. The contact spring acts like the divided contact in a card connector, and two contacts can be made to each lead independently, if desired. With the springs in place, more precise test measurements can be made on an inspection line for sophisticated systems.

Overall height of the network plus the connector is 0.400 in., which permits direct replacement on discrete component cards in systems which have card spacings down to 0.500 inch. The length and width of the connector were selected so that one can be placed against another either vertically or horizontally. Contact legs on abutting connectors are spaced in multiples of 0.050 inch. There is an 0.250 inch hole through the connector to facilitate air movement over the semiconductor network, or to provide a mount for a heat sink.



Connector, left, accepts protective frame assembly, right, that carries flatpack. Device permits plug-in and operation of semiconductor networks, allows rapid and easy testing of networks, and is suitable for production packaging onto printed circuit cards.

The preferred technique for interconnecting networks packaged in the flatpack configuration is to weld the leads that emerge radially from the device to a printed circuit board, though some users choose soldering. Users requiring maximum packaging density and highest reliability will probably choose welding as their production packaging technique, and use the Mech Pack connector as a prototype tool and test socket for incoming inspection of devices.

The new Mech Pack connector sells for less than $1 a unit when ordered in quantities of 50,000. Single connectors can be purchased retail through distributors at $4.70 each.

Specifications

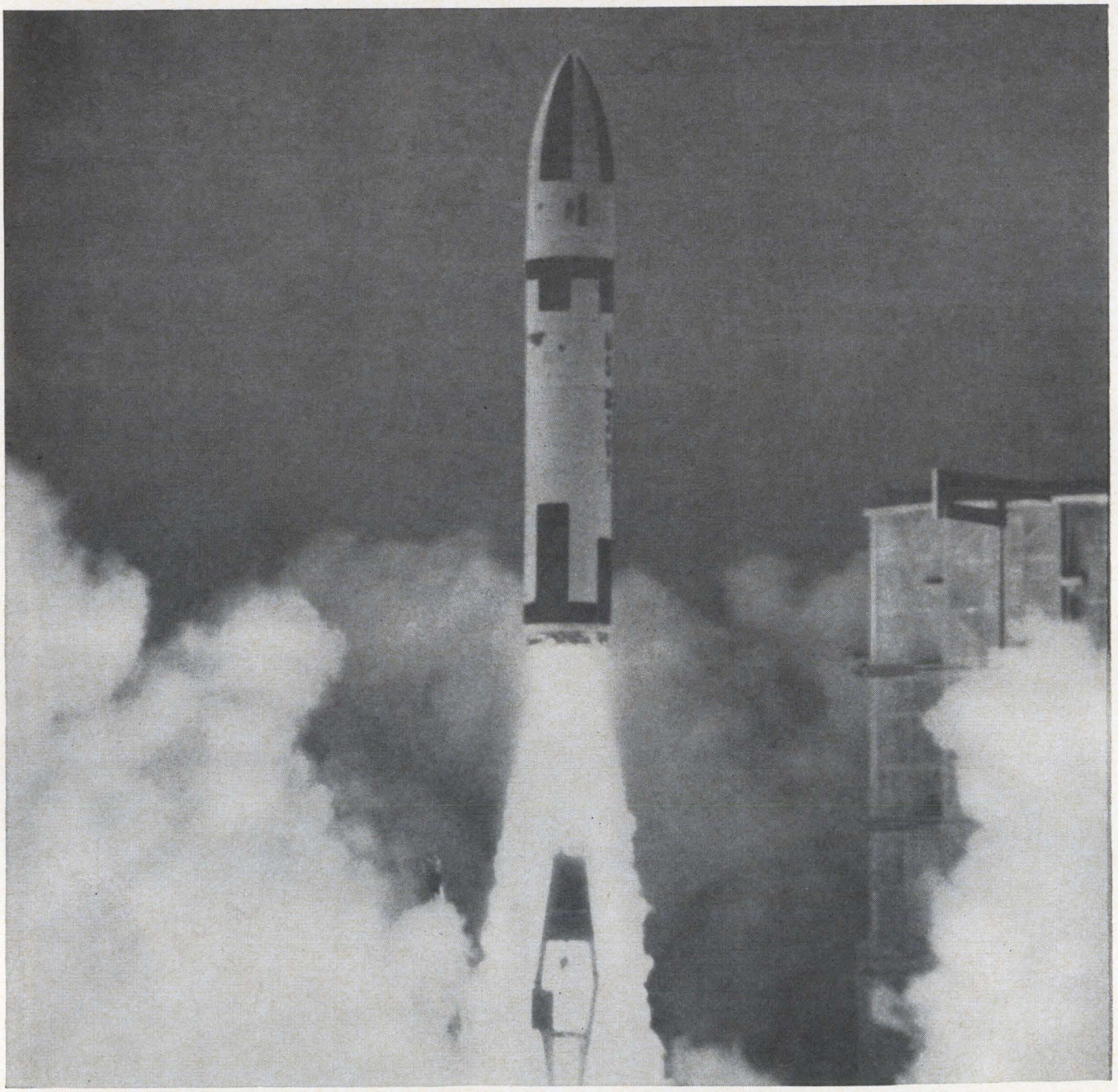
Contacts	gold-plated beryllium copper
Retention springs	nickel-plated steel
Body material	glass-filled alkyd
Operating temperature	–65 deg C to 150 deg C
Overall dimensions, with network in place	0.950 x 0.950 x 0.400 inch

Metals & Controls Inc., a division of Texas Instruments Incorporated, 34 Forest Street, Attleboro, Mass.
Circle **349** on reader service card

Transistor amplifier features low noise

A tiny transistor amplifier operates in the 225- to 400-Mc range. In this frequency band, the model TQO-2002-S features a low noise figure of only 4 db with a gain of 20 db. It also features a 1-db compression from linearity occurring at a power output of 0 db, with a gain ripple of less than ±1.5 db. Excluding connectors, the new amplifier is only 3½ by 1¾ by 1 in. It is suitable for retrofitting existing telemetry receivers operating in this portion of the frequency spectrum. The TQO-2002-S is designed to meet MIL specs; delivery, 45 to 60 days.

Micro State Electronics Corp., 152 Floral Ave., Murray Hill, N.J.
Circle **350** on reader service card



ENGELHARD silver-copper silicon alloy used by Wah Chang to assure superior thermal conductivity for Polaris jet nozzle

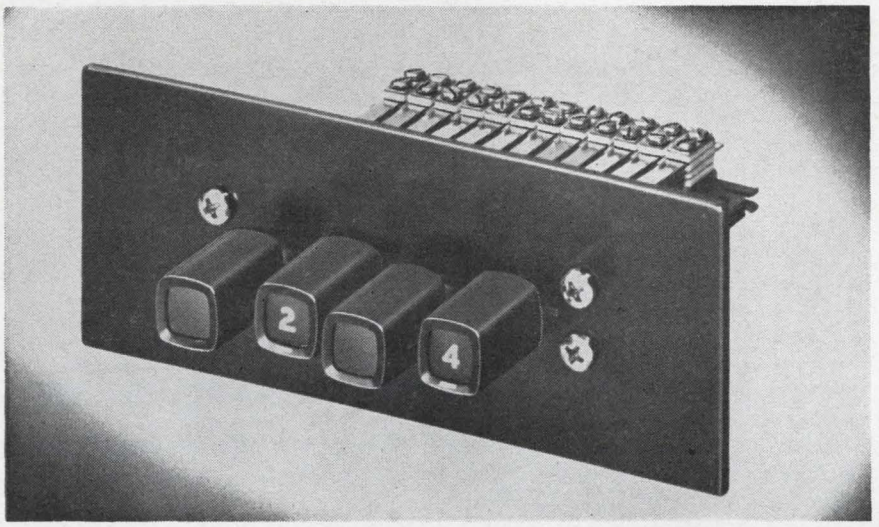
One of the keys to the successful launching of a ballistic missile is the complete reliability of its many components. The Wah Chang Corporation, Albany, Oregon, producers and fabricators of metallic elements such as tungsten, molybdenum and columbium, used Engelhard silver-copper silicon alloy to infiltrate the large tungsten segments used in the jet nozzle of the Navy's Polaris A-3 Fleet Ballistic Missile. The jet nozzle is one of the many vital components of the solid propellant rocket engine, developed and produced by the Aerojet-General Corporation, Sacramento, California.

Wah Chang credits the high chemical purity and excellent corrosion resistance of Engelhard silver-copper silicon as two of the factors in assuring the superior thermal conductivity and long life of the jet nozzle.

Engelhard, long one of the world's leading fabricators and refiners of precious and semi-precious metals, supplies them in pure form, alloyed with base metals, or custom-fabricated to meet exacting specifications. If you have a problem involving the industrial use of precious and semi-precious metals, why not consult Engelhard first, the company that is working wonders with the wonder-working metals. An experienced staff of metallurgical specialists will be glad to help you select the material best suited to your requirements. For details, write to our Technical Service Department.

187 A

Push button lights up without bulb or power



No external power is needed to make a push button devised by Switchcraft, Inc., light up. The button has an internal illuminator that fluoresces when exposed to the ambient light. The face of the button is a translucent screen marked with a letter or number; pushing the button brings the screen against the illuminator, which is on a disk in the body of the button, and the screen lights up.

The display requires some external light to be effective, and will not glow in the dark. But since switches incorporating the glow button have no complicated wiring and no power supplies, they can be made for about half the cost of ordinary illuminated switches.

The push button was developed to fill the need of one of Switchcraft's regular customers who wanted a control panel with a large number of push-button switches, and visible indication of the actuated buttons. Because of a limited budget, as well as the impracticality of dealing with lamp-heat dissipation, electrical wiring, and power supply, standard illuminated buttons couldn't be used. The Glo-Button was the answer.

Switchcraft uses Glo-Buttons in its model 7000 switches, and model 8000 and 35000 Multi-Switches. The buttons can be incorporated in other switches having plunger action with a maximum fall back of one-sixteenth of an inch.

Switchcraft sees a big market for the glow buttons in control panels, instruments, industrial controls, computers, and other applications calling for positive push-button control, as well as displays where no switching is involved.

The new Glo-Button, X-Series, sells for about 40 cents each when ordered in lots of 1,000. List price for single item is $1.25.

Specifications

Mounts to 0.050-inch x 0.187-inch plungers	
Shell and body	molded black plastic
Illuminator	fluorescent orange-red
Screen	translucent plastic
Compression springs	tinned wire
Eyelets	brass

Switchcraft, Inc., 5555 N. Elston Ave., Chicago, Ill. **[351]**

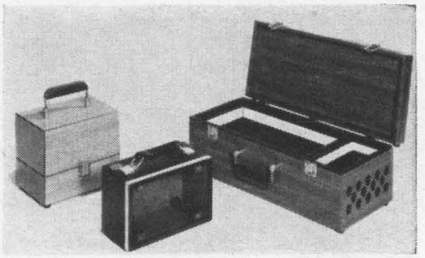
Miniature capacitors cased in aluminum

Aluminum-encased electrolytic capacitors are designed for the low-voltage and small-size requirements of transistorized circuitry. All-welded construction and plastic insulated aluminum bodies of the

New Components

Arcolytic type ME capacitors provide increased ruggedness and resistance to environmental conditions. Corrosion and electrolyte leakage are eliminated. Electrically, they exhibit low leakage and maintain extended shelf life without deterioration. Operating temperature range is −30° to +85°C. Capacitance value, working voltage and case size are printed on each unit.
Arco Electronics, Inc., a subsidiary of Loral Corp., Community Drive, Great Neck, N.Y. **[352]**

Formica cases protect precision instruments



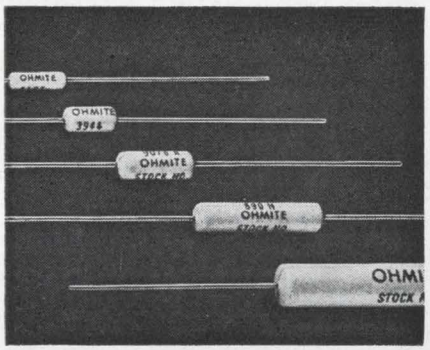
Ruggedized formica cases now protect quality precision instruments. The manufacturer says they are strong because $\frac{1}{16}$-in. Formica is laminated to a mahogany core with waterproof epoxy resins, bonded under heat and pressure. The cases can be designed in any size or shape with any desired cutouts, partitions, panel seats, panel mounts or hardware, without die or set-up charges either on sample units or on production orders, according to the producer. Light in weight, durable, resistant to moisture and dust, these cases have passed Navy shipboard requirement tests.
W.A. Miller Co., Oquossoc, Maine 04964. **[353]**

Wirewound pot has half-inch diameter

A wirewound potentiometer of ½-in. diameter is in production. The single-turn model 140 is available in standard resistance ranges from 50 ohms to 50,000 ohms with a linearity of ±1.0%. Power rating

is 2 w at 40°C ambient and operating temperature range is −55° to +125°C. The model 140 bushing mount has terminals mounted on the rear for optimum packaging density and a new type mechanical stop design to provide high stop-strength. A unique wiper design is said to assure positive contact under severe conditions of shock and vibration as described under MIL-STD-202B, still providing long rotational life and low torque characteristics. A servo ballbearing mount, designated the model 142, is also available. It has continuous rotation and a starting torque of only 0.075 oz.-in. max. The price, in 1 to 9 pieces, is $9 for the model 140 and $17.50 for the model 142. Spectrol Electronics Corp., 1704 S. Del-Mar Ave., San Gabriel, Calif. **[354]**

Axial-lead resistors have molded coating



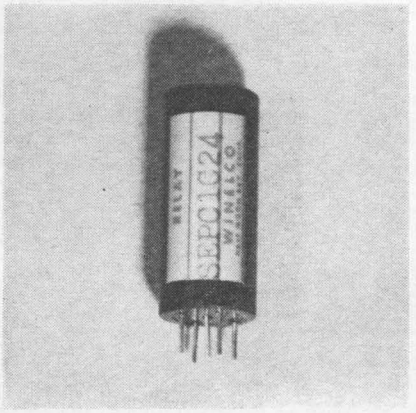
Series 99 resistors are now stocked for immediate shipment in five sizes —1½, 2¼, 3¼, 5 and 11 watts. Tolerance is ±5%. A considerable selection of stock values is offered. For example, the 11-w size is stocked in 146 different resistance values from 1.0 to 51,000 ohms. Series 99 are said to be the first resistors to have a molded vitreous enamel coating due to a new, company-engineered, ceramics technique. The thicker, more uniform coating that results, provides several benefits. A 1,000-v a-c insulation is guaranteed by the uniformly molded thickness. Precise shape facilitates use in automated assembly, or in clipped mounting where a heat sink advantage allows sizable wattage increases. It withstands very high temperature (1,500°F) without deformation or loss of markings. It resists chipping

New Components

and breaking, particularly where leads enter resistor body. Vitrified markings resist powerful organic solvents, abrading, and high temperatures.

Ohmite Mfg. Co., 3646 Howard St., Skokie, Ill., 60076. **[355]**

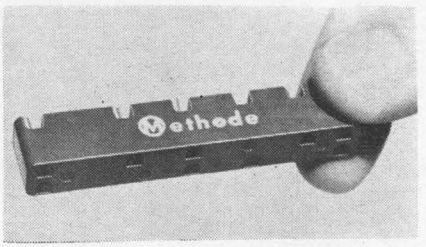
Reed relays occupy small space



Type SEPC reed relays are designed for printed-circuit board mounting. The relay is a single-end unit requiring little more space than a transistor; it is 0.437 in. in diameter and 1.00 in. high, and is available with form A, B or C contacts. Coil voltages are 6, 12 or 24 v d-c. Contact ratings of form A and B is 10 w or 0.5 amp; form C is 3 w or 0.25 amp. Contacts are hermetically sealed in glass. Magnetic shielding is available if required.

Win-Elco, 799 Main St., Half Moon Bay, San Mateo County, Calif. **[356]**

Bussing connector mounts on p-c boards

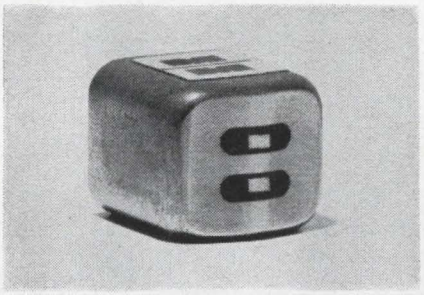


A nine-contact bussing connector is being offered for mounting on p-c boards. Model TB-809 WS is

expected to find application in communications, data acquisition and transmission equipment. It mounts on any p-c board up to $\frac{3}{32}$ in. thick through standard 0.051 diameter holes. The connector is suitable for dip or wave soldering. Jumper bars are available for bussing between any pair of contacts. The contacts are formed of beryllium copper, electro-tinned. Insulation material is glass-filled diallyl phthalate. Contacts are easily identified by molded-in numbers on the body of the connector. The body also has barriers to prevent voltage breakdown between terminals. The p-c board bussing connector measures 2⅜ in. long by 0.340 in. wide by $\frac{7}{16}$ in. high, not including terminals. Price is 75 cents each in production quantities. Delivery is in four weeks.

Methode Electronics, Inc., 7447 W. Wilson Ave., Chicago, Ill., 60631. **[357]**

Laminated head resists tape wear



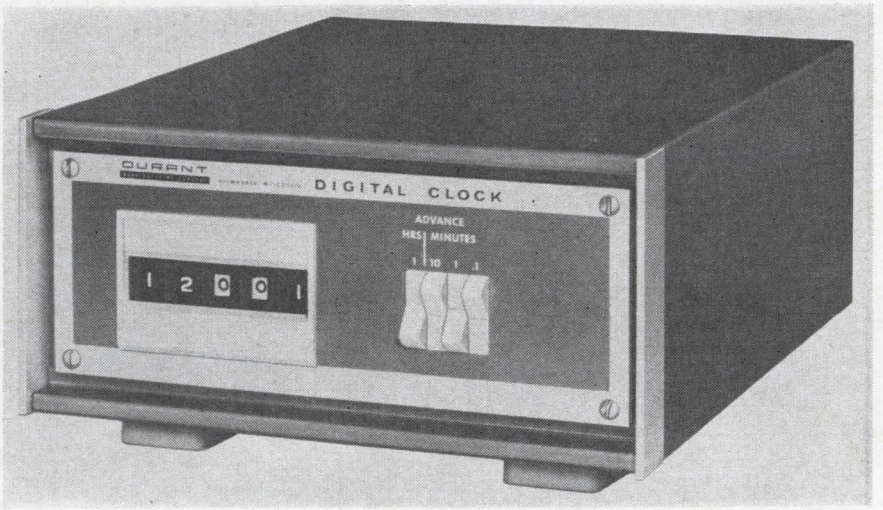
The first of a broad line of laminated tape recorder heads, the four-track stereo 5NP-300, has extended frequency response and is for both professional and home use. Faced with a glass-filled composition, the new head offers superior tape wear resistance—as much as five times that of conventional metal or Bakelite faced heads, according to the manufacturer.

The 5NP-300 has a hyperbolic face, which permits proper tape contact without the use of pressure pads. Mounting is available in side or rear stud mount, with or without shielded leads. Available in a wide range of impedances, the 5NP-300 is suitable for almost all tape recorders.

Michigan Magnetics, Vermontville, Mich., 49096. **[358]**

New Instruments

Digital clock offers accuracy at low cost



For many industrial controls, a digital clock is needed to provide synchronizing and timing pulses. An all-electronic unit can provide these functions with great precision and a high degree of versatility, but at a rather high cost.

The Durant Manufacturing Co., long a producer of industrial counting equipment, felt that many industrial processes did not require the extreme accuracy or very high speed of the electronic unit. For situations where economy is the overriding consideration and where the accuracy of the line frequency used as the timing source is sufficient, Durant has introduced the model 59026-420 digital clock.

The clock is designed for data reduction systems or batch controlling operations where timed mixing is important; as an aid to computing piece rates in all production processes, and for all types of data or material handling where a time base is required. The clock is constructed using the Durant Unipulser, a single-decade, high-speed electromechanical counter.

The clock is available in configurations in hours and minutes or in hours, tenths, hundredths and thousandths of hours. Each digit has an isolated 11-line readout, which is terminated at a connector at the rear of the chassis. The remote electrical readout can be made available to computers, printers and controls. Each clock has provisions for a readout command which keeps the digits from advancing while the readout is in progress. An internal memory stores any time pulse initiated during a readout period to prevent readout ambiguity, and enters it in the time recording decades upon completion of the readout.

The clock is available with or without an internal time base generator; if one is included, it can operate either from a 50- or 60-cps source. The line frequency is used as the timing source and elapsed time accuracy is dependent upon this frequency. Individual time pulse repetition accuracy is 5 milliseconds, with nonaccumulative error. External time base generators, which will have their own associated timing errors, can be used, but should consist of a contact closure device, electronic switching circuit or a voltage pulse source with compatible ground circuit.

The clock can be easily modified for special applications. It is available for bench top placement or may be supplied with a 19-inch rack mount adapter plate. On the front panel are manual switches to reset each of the digits.

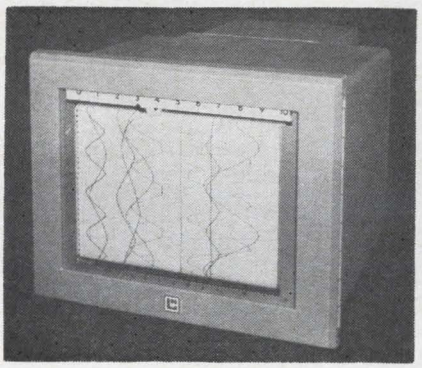
Specifications

Elapsed time	24 hours
Number of digits	4 or 5 (standard)
Power input	115/230 volts, either 50 or 60 cps, 15 watts

Pulse repetition	5 milliseconds
Size	10½ x 4-11/16 x 12⅝ inches (for desk top mounting)
Price	$405 for model 59025-420, illustrated
Availability	(incl. time base generator) 4 weeks

Durant Mfg. Co. 622 N. Cass St. Milwaukee, Wis. **[381]**

Multipoint recorder shows curves in color



This graphic recorder can plot 12 different curves in different colors. To add to the versatility of the device, the recorder prints dots with a numbered dot printed periodically to assure that cross-over or closely spaced records are clearly readable. The Speedomax W multipoint instrument can record 2, 3, 4, 6 or 12 points and can be easily converted to different speeds. Other features available include one to six alarms either common to all points or commutated, dual chart speeds, time-stamped charts and fluorescent illumination of scale and chart. Basic accuracy is ±0.3% of electrical span. The instrument offers a large chart in a small space—chart width is 9⅞ in. in a case measuring 15 in. wide and 12 in. high. Price is $1,260 for the basic recorder with 6 to 10 weeks delivery.

Leeds & Northrup Co., 4901 Stenton Ave., Philadelphia, 44, Pa. **[382]**

Automatic integrator plugs into scope

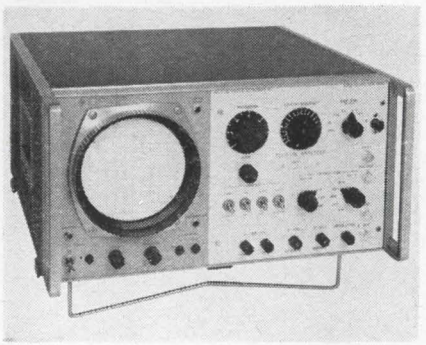
Model 2430 automatic area integrator, when plugged into the Lumatron model 120 sampling oscilloscope, measures the area under a selected portion of a waveform displayed on one channel of the oscilloscope. A front panel meter reads in square centimeters of dis-

New Instruments

play; it can represent from microseconds to picoseconds of time and from millivolts to volts of amplitude depending on the oscilloscope settings. An analog output is also available for readout on a digital voltmeter. Applications include integration of high-frequency waveforms, measurement of stored charge in diodes and transistors, flux measurements in fast memory cores and thin films, hysteresis loop display at high frequencies, and impulse bandwidth measurements. To indicate the portion of the waveform being integrated, a time-zone pulse is displayed on the second channel of the dual channel oscilloscope. The leading edge of the pulse indicates the start of integration and the width indicates the time over which integration takes place. Both the start and stop of integration may be continuously varied to cover the full screen width. Actual time duration in nanoseconds depends on the sweep speed setting of the oscilloscope.

General Applied Science Laboratories Inc., Merrick and Stewart Avenues, Westbury, N.Y. [383]

Spectrum analyzers plug into 140A scope

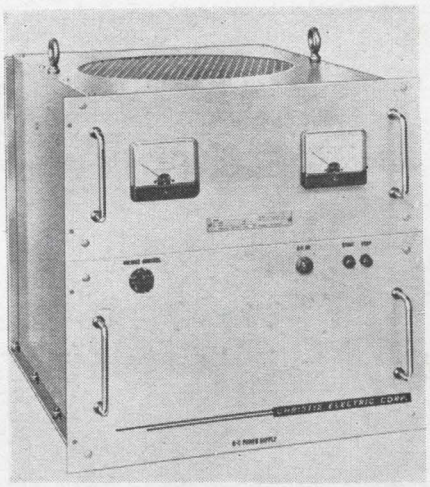


The PSA-030 series low-frequency spectrum analyzers plug into the Hewlett-Packard type 140A oscilloscope. Units contain their own internal sweep generator as well as vertical and horizontal deflection amplifiers. Models PSA-031, PSA-032 and PSA-033 have center frequency ranges of 10 cps to 20 kc; 35 cps to 100 kc; and 150 cps to 500 kc, respectively. Their disper-

sion and resolution bandwidths are: 100 cps to 6 kc and 10 cps to 100 cps; 500 cps to 30 kc and 35 cps to 250 cps; and 2.5 kc to 150 kc and 150 cps to 2 kc, respectively. All three models have a sensitivity of 85 μv per cm deflection; a dynamic range of 60 db, minimum; both linear and 40 db log displays; 80 db input attenuator; 60 db i-f attenuation; and sweep rates of from 5 scans per sec to 50 sec per scan. Aside from the normal tuning mode, a full scan or search mode is provided in which the entire band is displayed. Models PSA-031, -032 and -033 are priced at $760, $830 and $850 respectively.

Nelson-Ross Electronics, Inc., 5-05 Burns Ave., Hicksville, N.Y., 11801. **[384]**

D-c power supplies feature low ripple

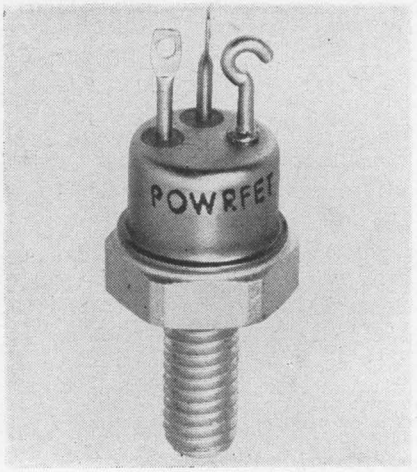


A line of scr-regulated, d-c power supplies is announced. The E series is said to be the first line of 0-36 v d-c power supplies up to 600 amps offered as standard, catalog equipment. The units operate from either 220 or 440 ± 10% v a-c, 3-phase, 60 cycle a-c input and have a continuously variable d-c voltage range of 0-36 v d-c. They are rated 75, 150, 300 and 600 amps continuous duty, with very good overload capabilities. Maximum d-c voltage ripple is less than 100 mv peak-to-peak. All units are available with both voltage and current regulation, plus many other optional features. They can be furnished to MIL-Specs, including rfi.

Christie Electric Corp., 3410 W. 67th St., Los Angeles, Calif., 90043. **[385]**

New Semiconductors

Power FETs rated at up to 9 watts



Four power field-effect transistors called Powrfets, with dissipation ratings of from 3.6 to 9 watts, have been made available by Crystalonics, Inc. Although power FET's have been produced in Europe, Crystalonics, Inc. is the first American company to announce commercially available units.

The Crystalonics silicon n-channel devices are general purpose types. Applications include current limiting, high-power switching, and power amplification.

The company hopes the power FET's will capture some of the present market for low-current silicon controlled rectifiers. If they do, the high-current scr market is the next target.

Crystalonics' chief engineer, Joel Cohen, says "These are single-chip devices, but we can also deliver a ten-chip device which can handle ten amperes. If the interest is there, we should have the capability to supply a 100-ampere device within two years."

The four junction FET's are of planar epitaxial construction and have input resistances greater than 100 megohms. The units are expected to be considerably more radiation-resistant than comparable conventional junction transistors; the radiation sensitivity of the devices is currently being tested.

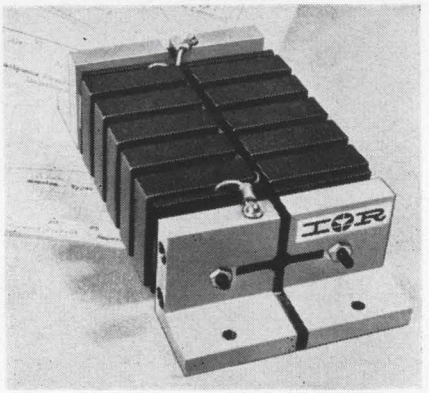
The power FETs provide useful power gain up to 70 Mc with cutoff frequencies up to 500 Mc. Prices start at $42.75 for the CD600 in sample quantities.

Specifications

Maximum drain-to-source voltage	
CD600, CD602	20 volts
CD601, CD603	30 volts
Drain-to-source current, I_{DSS}, at V_{DS} = 15v, V_{GS} = 0	
CD600, CD601	60-180 ma
CD602, CD603	100-300 ma
Transconductance, g_m, at V_{DS} = 15v. V_{GS} = 0	
CD600, CD601	10,000—30,000 μmhos
CD602, CD603	20,000—60,000 μmhos
Dissipation at 25°C	
CD600	3.6 watts
CD601	5.4 watts
CD602	6.0 watts
CD603	9.0 watts
Typical on-resistance	40 ohms
Typical gate-to-drain capacitance	10 picofarads

Crystalonics, Inc., 147 Sherman St., Cambridge, Mass. **[371]**

Rectifier columns are compact and rugged



Ultracompact and low-priced silicon rectifier columns are available with up to 160 kv peak reverse voltage (prv) and 8.5 amps average. The columns are suitable for laser pump supplies, radar modulators, broadcast transmitters, atomic particle research and other applications requiring rugged, compact, medium-current, high-voltage rectifiers.

Higher-density packaging enables the new columns to handle 5 kva per cubic inch compared with 2.5 kva with the established line. A bonus is this compact design's ability to withstand 15 G

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Compare Value

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S	0-500	0-200 MA	2.0%	400.00
Electro RB-500	0-500	0-250 MA	0.03%	395.00

Compare Features

High Voltage Output: 0-500 VDC.
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Ripple: 5MV, RMS maximum.
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2% D' Arsonval Meters: Dual scale . . . 0-500V/0-150V. 0-250 MA
Separate AC, DC Switches.
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Wherever precisely regulated DC power is a must, the EPL RB-500 fills the bill economically. Engineered and built for heavy-duty production testing; electronic circuitry development and design in industry, laboratories and schools.

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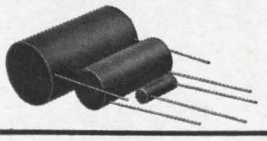
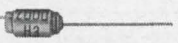
Capacitance, 20 pF to 600,000 pF; capacitance tolerance from ±0.3% to ±20%; temperature coefficient, N100 and N150 ±50 PPM/°C; Voltage, 33 VDCW to 1000 VDCW.



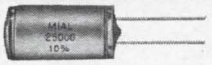
MIAL 602
High Reliability Precision Type

MIAL 603
Printed Circuit Mounting—
High Reliability Precision Type

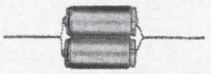


MIAL 610
Sub-Miniature

MIAL 611
General Purpose N150

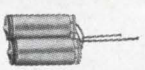


MIAL 612
Printed Circuit Board Mounting

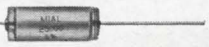


MIAL 613
Axial-Lead Close Tolerance

MIAL 614
Radial Lead Close Tolerance



MIAL 615
End Lead Close Tolerance



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New Semiconductors

vibration in all three axes for 30 minutes at each resonant frequency when tested according to MIL-T-5422E.

These rectifier columns are made with encapsulated modules consisting of four diodes per module. Each diode is shunted by an appropriate resistance-capacitance network to insure equal division of working prv and transient voltage spikes due to commutation and other causes. Normal delivery is 30 days. Pricing is according to voltage and current required.

International Rectifier Corp., 233 Kansas St., El Segundo, Calif. **[372]**

Uhf transistor comes in silicon package

The first of a series of medium- and high-power uhf transistors has been introduced—a six-watt-output, 400-Mc oscillator/power amplifier unit. Type PT 4690 operates from a 28-v source with typical 400-Mc efficiency of 40%. It is housed in a silicone molded package featuring low profile and four axial leads, with isolated collector and stud-mounting. It is suitable for use in stages following the company's new 1.5-watt, 400-Mc high-gain PT3502 oscillator/driver. When operated at 250 Mc, the PT4690 has a power output of 8 w, 8 db gain and 70% efficiency. At the 100 level the new transistor is priced at $37.50. Evaluation quantities are available from factory stock.

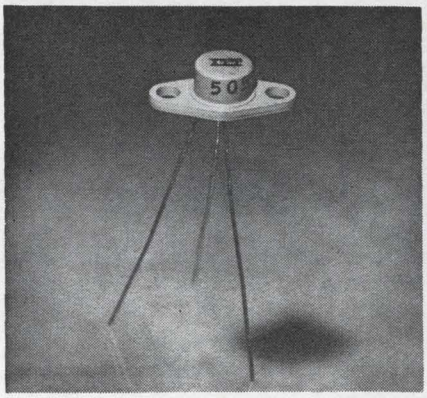
TRW Semiconductors, Inc., 14520 Aviation Blvd., Lawndale, Calif. 90260. **[373]**

Silicon capacitors are voltage-variable

New silicon, voltage-variable capacitors have a minimum Q of 300 at 50 Mc over a capacitance range of 15 to 47 pf. Piv to 40 v and guaranteed low leakage current are offered. The devices are useful in the 400 Mc to 2,500 Mc region for high-frequency tuning, frequency multipliers, and higher frequency modulation. They are furnished in

a DO-7 glass package, and are available in 5%, 10%, or 20% tolerances. Price is $19 to $25 in 100 lots; delivery, stock to 30 days.
Eastron Corp., 25 Locust St., Haverhill, Mass. **[374]**

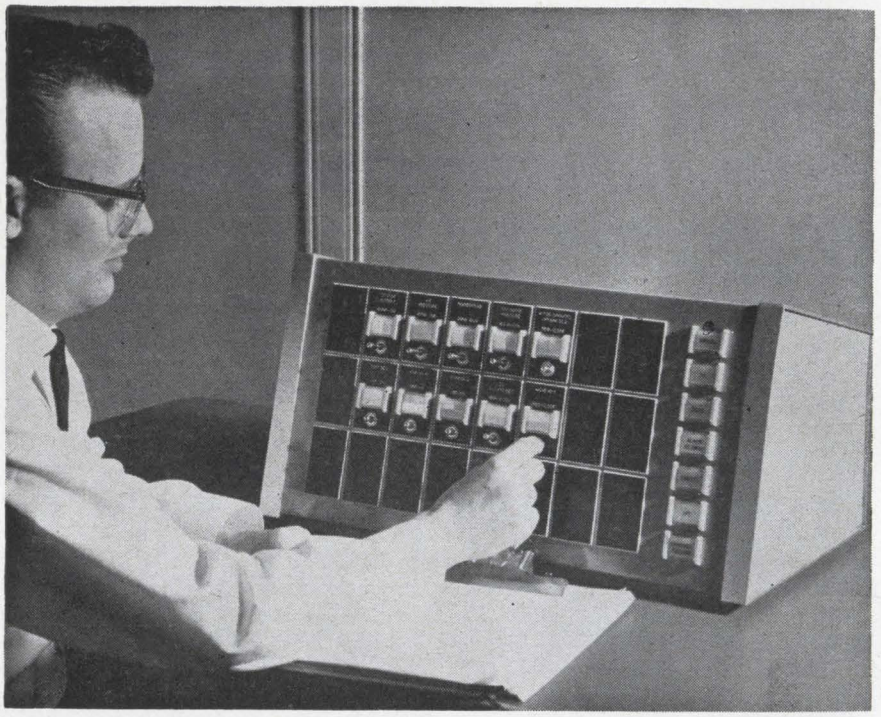
H-f power transistors for r-f amplifier use



Two new diffused silicon power transistors of the epitaxial type offer up to 5-w output at 150 Mc. Both npn devices, the transistors are intended for use as high-gain Class B and C r-f amplifiers in the 100-400 Mc range. Designated the 3TE250 (illustrated) and 3TE260, these devices feature an emitter electrically connected to the case, providing higher gain than previous types, and are thus ideally suited for use as grounded emitter amplifiers where power gain is an important consideration. This concept also makes possible lower feedback between the input and output of the transistors. The 3TE250 is capable of 5 w r-f power output at 150 Mc, 3 w at 250 Mc, and 2 w at 400 Mc. The lower power 3TE260 produces 1-w output at 150 Mc. The high-power 3TE250, packaged in a JEDEC TO-37 case, produces up to 5 w in a circuit with a collector-emitter voltage of 28 v. Gain in the same circuit is more than 11 db at 150 Mc. The lower power 3TE260, in the TO-5 configuration, is capable of 11 db gain at 150 Mc in a 28-v d-c power circuit. Prices for the 3TE250 are $35 for 1 to 99, $28 for 100 or more; for the 3TE260, $15 and $12 respectively, for the same quantities.
ITT Semiconductor, 1801 Page Mill Road, Palo Alto, Calif. **[375]**

New Subassemblies and Systems

Remote control system is small, inexpensive



Dispatcher's console of Automatic Electric's new Conitel 10 remote control system, for small control applications requiring up to 24 controlled devices in one location.

Conitel 10 will open or close remote valves or switches—and remember which it did last—quickly and inexpensively. This willing slave is a small industrial remote control system that derives its name from the words "**Con**trol, digi**t**al, **el**ectronic". It has two bigger brothers, the Conitel 100 and the Conitel 1000; all three are made by the Automatic Electric Co., a subsidiary of the General Telephone and Electronics Corp.

Conitel 10 is intended for a relatively small number of devices—up to 24—at a single location. The maker claims its speed and reliability match those of much larger systems.

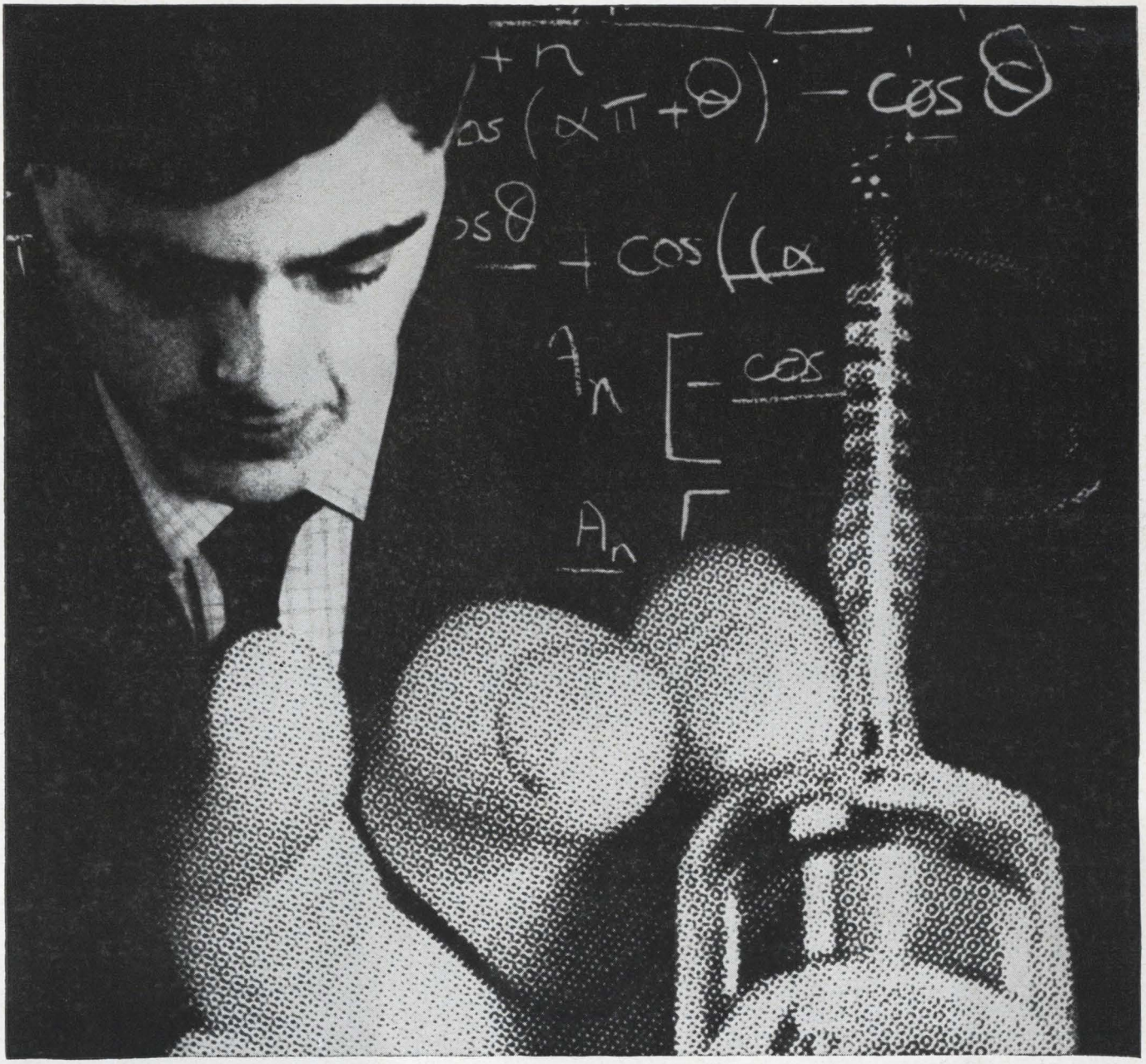
An industrial control system of this type, according to Len Mitchell, an Automatic Electric engineer associated with the project, must provide accurate, timely data at a remote point. This requires detection of any errors in communication between the master station and the remote point, and the avoidance of any action based on erroneous information.

To attain this goal, AE adopted an established technique for data transmission. The code consists of long or short pulses on a wire, or of bursts of two different frequencies corresponding to the positive and negative pulse levels when a carrier current or microwave link is used.

The system is designed for bang-bang control—that is, it supervises and controls switches which may be on or off, valves that may be open or closed, motors that may be stopped or started, and so on. Partial actuation, or "jogging," of a device capable of intermediate states, such as a valve which may be gradually opened, is possible if the controlled variable is the time of actuation of a device rather than the actuation itself. Jogging is also possible with an optional incremental control.

Mitchell says that one Conitel 10 system is installed and working on a pipeline at the present time, and more than 30 have been ordered for installation by pipeline operators, electrical utilities, and others.

The memory in the Conitel 10 consists of an array of Correeds,



the product is only part of the deal

The ultimate design of the most complex electronic apparatus may well be determined by one special component. It may be a magnetron, a visual display tube or a transistor; but whatever it is the design engineer must choose from many alternatives and equivalents. How does he make his choice? Not by specifications and measurements alone. Equally important are the supplier's research and applications know-how, technical data and assistance and his willingness to share problems before and after the products have been purchased.

This is the kind of support that Mullard gives, and much of it stems from Mullard research.

Scientists at the Mullard Research Laboratories are engaged on fundamental and target investigations in almost every field of electronics. They work in close co-operation with the applications and development engineers at Mullard factories and independently collaborate with universities and government departments.

If we are not serving your Company already, please let us know if we can help you.

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New Subassemblies

AE's highly reliable glass-encapsulated contacts. It stores the last report from the remote station and displays the status in the form of lights on the dispatcher's console. The dispatcher can initiate any control sequence from the console, and can request a supervisory sequence to verify the system status. If all is well, the scan should not turn any console lights on or off.

The system is quiescent—that is, it is inactive except during a control or supervisory sequence. This minimizes power requirements and extends the life of the system.

The system is assembled from standard AE subassemblies which are available as off-the-shelf items. Thus the production of the system is quick and inexpensive, once the details of the individual installations are worked out.

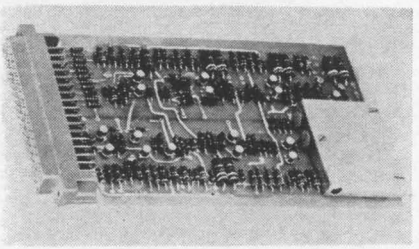
The price of the system is in the four-figure range. Output signals, physical size, and actual price depend on the particular application and on details such as the number of devices to be controlled and the kind of box or frame the system is to be packaged in.

Specifications

Capacity	Two to 24 devices
Remote stations	One
Master to remote	Any distance
Remote to device	On premises; e.g. approx. 100 ft.
Output signal	Timed pulse or d-c
Size	Varies with customer need
Availability	Six months or less

Automatic Electric Co., Northlake, Ill. [401]

High data rate serial memory system

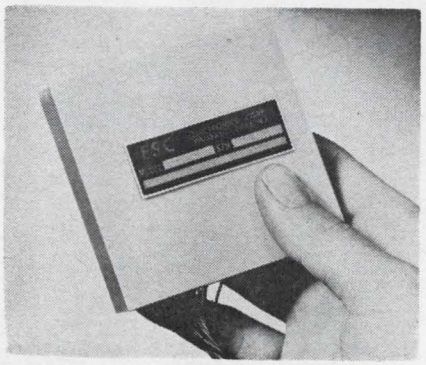


This serial memory system is completely packaged on a 7½ in. by 4½ in. p-c card which allows simple connection to card racks

through a 35-pin Elco Varicon connector. The series 5000 offers a maximum bit rate of 10 Mc RZ or NRZ with total capacity up to 20,000 bits, depending on bit rate and delay. Delay lines up to 1,000 μsec are mounted directly on the board. Longer delay lines may be either mounted on a common plate with the circuit board, or separated from it by as much as 3 ft. Inputs may be either RZ or NRZ mode. Either polarity logic may be used, and a choice is offered of trailing or leading edge clocking. Input signal may vary between 2.8 and 8 v without need for adjustment. All gating for serial memory operation is furnished, including an expandable input gate. The input circuitry is transient noise protected to allow operation under the most demanding conditions. Input signal-to-noise ratio may be as low as 2.5:1. Output voltage may be RZ or NRZ and of any level from 2.8 to 6 v, of either polarity. Complementary outputs are provided, capable of supplying and absorbing up to 25 ma and of driving up to 200 pf load capacitance. All semiconductor devices employed in the circuitry of the series 5000 units are silicon types.

Andersen Laboratories, Inc., 501 New Park Ave., West Hartford, Conn., 06110. [402]

Delay lines come in small package



Model 9671 is a miniaturized, iff transponder delay line enclosed in a silicone rubber package. It exhibits a delay-to-rise-time ratio of 50 to 1 for a 10.5-μsec delay. Taps are provided to a tolerance of ± 0.05 μsec, the delay impedance is 750 ohms, and pulse attenuation is less than 40%. Within the same

New Subassemblies

small 2¾ in. by 3 in. by ½ in. package there are two additional delay lines of 1.15 and 1.4 μsec delays. Impedance for these two sections is also 750 ohms and the pulse rise time for each is 0.2 μsec. The delay-line package is designed to be molded to a p-c board. Its operating temperature range is from −55°C to +105°C.

ESC Electronics Corp., 534 Bergen Blvd., Palisades Park, N.J. **[403]**

Variable delay line occupies 0.072 cu. in.

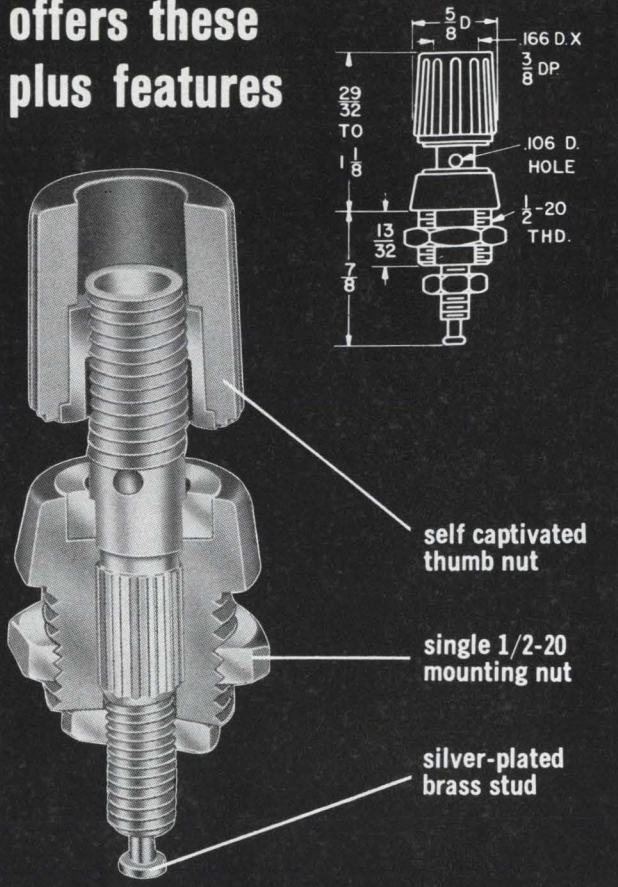
The V981 variable delay line with a volume of 0.072 cu in. is claimed to be the smallest unit of its type ever produced. Although designed for use as a trim delay in computer circuits, it has many potential uses in all digital and analog applications where time-coordination is critical. The unit is housed in a plastic case with a miniature seal "O" ring on the shaft and is constructed to meet military as well as commercial requirements. Four delay ranges are offered, from the -1 unit having a range of 3 to 25 nsec at an impedance of 1,000 ohms, to the -4 unit with a range of 5 to 100 nsec at an impedance of 50 ohms. Resolution of all units is less than 1/100, temperature coefficient less than 50 ppm per degree centigrade and attenuation less than 1 db. Price is $50, with discounts for larger quantities. Delivery is two to three weeks after receipt of order.

Computer Devices Corp., 6 W. 18th St., Huntington Sta., N.Y. 11746. **[404]**

NEW!

40 AMP. BINDING POST

offers these plus features



Here's a new compact, pre-assembled "6-way" binding post that's designed for fast, easy installation and high reliability! Designated the 111-300 Series, it's rated at 40 amps, with a voltage breakdown of 7,000 volts DC. Insulation resistance is greater than 200 megohms after MIL-T-5422B humidity test. Capacity to ⅛ inch panel is 3.5 pf. Mounts in ½ inch diameter circular hole, "D", or double flat hole—.422 across flats. Post is available in six standard colors to Federal Standard 595 for coded application. Molded of tough, low-loss polyamide; 6 methods of electrical connection; single ½-20 mounting nut; silver-plated brass stud; self captivated fluted thumb nut; circuit connection may be made at the solder terminal, or a lug may be slipped over the threaded portion of the stud and secured with a nut.

Also available—111-100 Series binding post, rated at 15 amps, with voltage breakdown of 8,000 volts DC.

NEW SET SCREW TYPE BANANA PLUG

Versatile . . . designed for wide variety of applications! Voltage breakdown: 10,000 volts DC. Capacity plug-to-plug: 1.3 mmf. Current carrying capacity: 15 amps. Available in 10 colors for coded applications.

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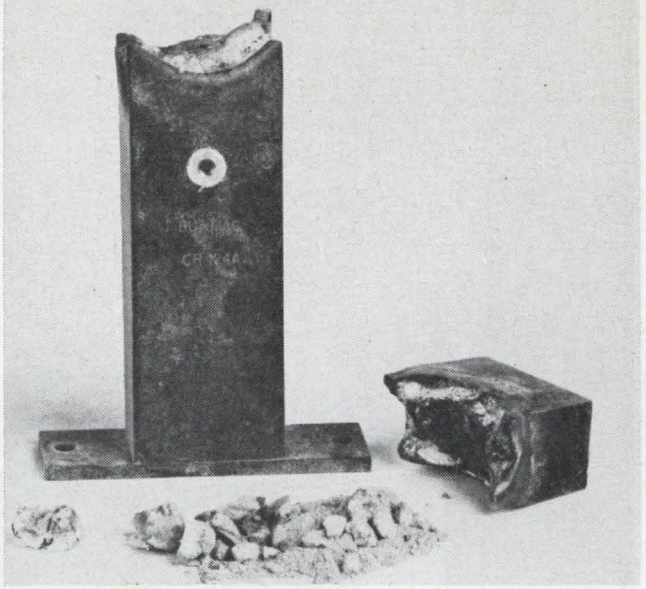


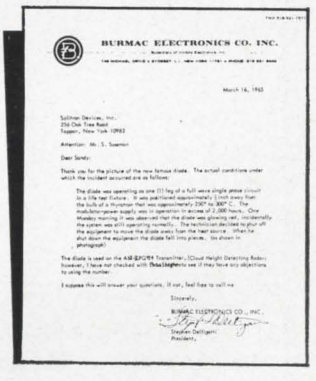
24,000 PIV Silicon Rectifier Operates Far Beyond Specs

The illustrated letter, written to Solitron Devices, Inc., by Stephen Delligatti, President of Burmac Electronics Co., Inc., contains this description of what happened to the diode shown above.

"Thank you for the picture of the now famous diode. The actual conditions under which the incident occurred are as follows:

"The diode was operating as one (1) leg of a full wave single phase circuit in a life test fixture. It was positioned approximately ½ inch away from the bulb of a thyratron that was approximately 250° to 300°C. The modulator-power supply was in operation in excess of 2,000 hours. One Monday morning, it was observed that the diode was GLOWING RED, incidentally the SYSTEM WAS STILL OPERATING NORMALLY. The technician decided to shut off the equipment to move the diode away from the heat source. When he shut down the equipment, the diode fell into pieces."

Solitron doesn't recommend operation of its diodes at glowing red temperatures, but this incident does prove that Solitron's high voltage silicon rectifiers, as well as their other high-quality semiconductors, will withstand maximum abuse in the equipment for which they were specified. High voltage units are available up to 120,000 PIV per block, many for off-the-shelf delivery. Also custom designed units available to over 500,000 PIV. Our Application Staff will be happy to recommend, design, and ship custom units within 1 week.



BURMAC ELECTRONICS CO. INC.

March 16, 1960

Solitron Devices, Inc.
256 Oak Tree Road
Tappan, New York 10983

Attention: Mr. S. Suozzo

Dear Sandy:

Thank you for the picture of the now famous diode. The actual conditions under which the incident occurred are as follows:

The diode was operating as one (1) leg of a full wave single phase circuit in a life test fixture. It was positioned approximately ½ inch away from the bulb of a thyratron that was approximately 250° to 300° C. The modulator-power supply was in operation in excess of 2,000 hours. One Monday morning it was observed that the diode was glowing red, incidentally the system was still operating normally. The technician decided to shut off the equipment to move the diode away from the heat source. When he shut down the equipment the diode fell into pieces, as shown in photograph.

The diode is used on the All-Epoxy Transmitter-Closed Height Detecting Radar; however, I have not checked with Raytheon to see if they have any objections to using the number.

I suppose this will answer your questions. If not, feel free to call me.

Sincerely,

BURMAC ELECTRONICS CO., INC.

Stephen Delligatti
President

Solitron DEVICES, INC.

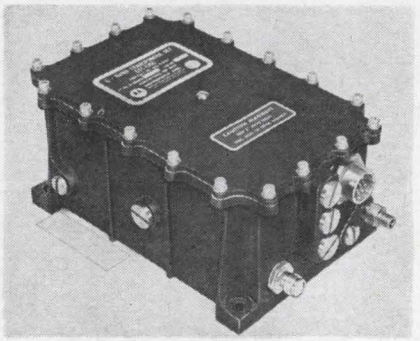
Leader in Solid-State High Voltage Rectifiers, Temperature Compensated Zeners, Voltage Variable Capacitors, and Random/White Noise Components.

256 Oak Tree Road • Tappan, New York 10983 • 914-359-5050

Circle 139 on reader service card

New Microwave

Radar transponder meets tough NASA spec



A solidstate, superheterodyne C-band transponder has been developed by the Military Electronics division of Motorola, Inc. The National Aeronautics and Space Administration wanted a device which would incorporate the high-performance characteristics of the standard Motorola transponders SST-102A and SST-131—both of which had been evaluated and successfully flown on Saturn. But the agency considered it necessary that equipment for use on man-rated vehicles, such as the Saturn, be designed and constructed in strict accordance with NASA standards. The result was the SST-135C, which Motorola calls a general purpose transponder. Now in production, the unit is intended for use with such precision tracking radars as AN/FPS-16, AN/MPS-25, AN/MPS-26, AN/FPQ-6, and AN/TPQ-18. It will meet the severe environmental conditions experienced in both liquid and solid fuel rockets, missiles, and space vehicles, and will operate within specifications at 85°C, 24G and vibration of up to 2,000 cycles per second.

A major element of the SST-135C is an integrated r-f head, comprising a ferrite circulator-duplexer, a three-cavity preselector, a mixer, and a local oscillator. The head provides improved performance under severe environmental stresses, such as shock and vibration. A linear logarithmic receiver with special video circuitry provides a transponder delay stability of less than 0.05 μsec variation with signal level changes from 0 to —62 decibels above 1 milliwatt, without a requirement for any form of automatic gain control. Six telemetry outputs provide data of antenna vswr, received signal level, input and output pulse repetition frequency, and transponder temperature. Special features, such as command decoder circuitry, coded replies for telemetry, or a solid state local oscillator, are available.

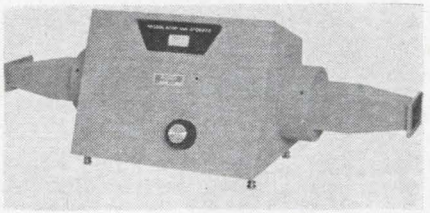
Limited quantities of the SST-135C are now being produced. Off-the-shelf delivery will be possible by July. Prices will depend on the number ordered.

Specifications

Output power	700 watts
Input power	24 to 30v d-c
Power drain	0.9 amp at 1000 pps 0.7 amp standby
Tuning range	5400 to 5900 Mc
Sensitivity	—65 dbm under all specified environments
Recovery time	50 μsec maximum
Delay variation with signal level	50 nsec max from —62 dbm to 0 dbm
Size	6.6 x 4.6 x 3.6 inches
Weight	5.6 pounds

Military Electronics division of Motorola, Inc., Western Center, 8201 East McDowell Road, Scottsdale, Ariz., 85251. [421]

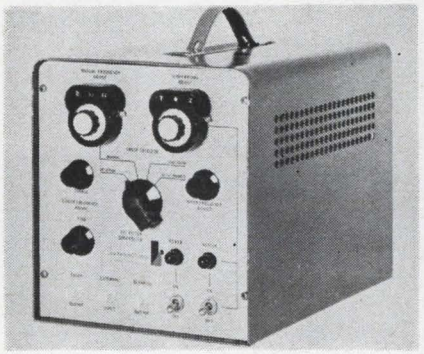
Rotary vane type precision attenuator



A direct-reading precision variable attenuator is announced for use over the frequency range of 3.3 to 4.9 Gc. The rotary vane type attenuator provides a precision calibrated attenuation range of 0 to 60 db over the frequency range with a maximum vswr of only 1.15. The instrument produces a highly stable attenuation characteristic which is independent of frequency and a precision steel tape mechanism is used to provide the attenuation readout. Model 2922 has been designed for minimum size configura-

tion and features a simple adjustment control. Average power capacity is 15 w; insertion loss, 1 db maximum; accuracy, ±2.0% or +0.1 db whichever is greater from 0 to 50 db; ±3.0% from 50 to 60 db. Price is $975 each.
Waveline Inc., Caldwell, N.J. **[422]**

YIG filter controller gives digital readout



A new YIG (yttrium-iron-garnet) filter controller has been developed for laboratory operation of standard YIG filters. Containing power supplies, a driver, and a temperature control unit, the device is capable of controlling any YIG filter that takes a unidirectional sweep. The controller provides sawtooth of 1 to 100 cps or sine wave sweep at 60 cps, as well as manual control of the resonant frequency of the filter. It will also accept external sweep inputs up to 100 cps and provide a sweep output for scope display of the band pass. A digital readout of the manual frequency and the temperature control adjustment is provided on the front panel of the equipment. The YIG filter controller weighs approximately 30 lb and measures 8¼ in. by 9½ in. by 13 in. Priced at $2,275 each in small quantities, the new units are available within 30 days.
Advanced Products Division of Loral Electronic Systems, 825 Bronx River Ave., Bronx, N.Y., 10472. **[423]**

Ferrite isolators cover 3 bands

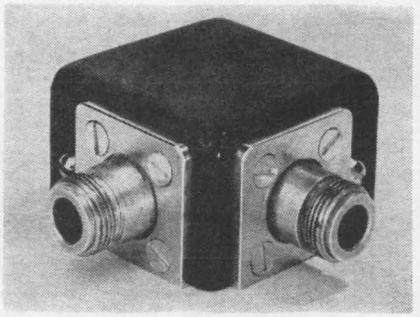
This range of ferrite isolators covers the following frequency bands: 5.925 to 6.425 Gc, 5.925 to 6.175 Gc, and 6.175 to 6.425 Gc. The CIC4 is a field displacement isolator with a

New Microwave

maximum forward loss of 0.35 db and a minimum reverse loss of 35 db. Vswr is 1.02:1. The CIC5 and CIC6 are resonance isolators with forward and reverse loss of 0.5 db minimum and 25 db maximum respectively. Both have a vswr of 1.06:1. The r-f connections on all three devices are waveguide 14. These devices are particularly suitable for use in broadband radio communication systems.

The M-O Valve Co. Ltd., a subsidiary of The General Electric Co. Ltd., Brook Green Works, London W.6, England. **[424]**

S-band YIG limiter protects crystals

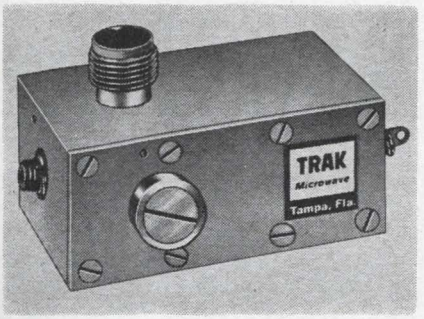


A new S-band YIG limiter has been developed for crystal protection and protection of tunnel diode amplifiers. Model LS-101 limiter has a limiting threshold of −10 dbm and can be provided either mechanically or electronically tuned over ±200 Mc centered at 2,800 Mc. Complete amplitude modulation suppression for modulation frequencies up to 500 kc is obtained over the entire bandwidth of the limiter, with a minimum of 20 Mc at limiting threshold. The inherent properties of YIG allow selective limiting of signals separated in frequency by as little as 0.5 Mc. Other features include a 30 db dynamic range and a 50 kc/°C temperature coefficient. Size is 1 in. by 2 in. by 2 in., exclusive of connectors, and the unit weighs from 6 to 10 oz depending on the connectors chosen. Strip line units can be supplied without connectors if plug-in capability is desired. Delivery is in 30 days.

Physical Electronics Corp., 1185 O'Brien Drive, Menlo Park, Calif. **[425]**

New Microwave

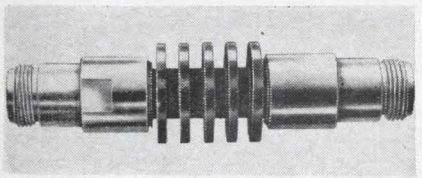
Microwave oscillator covers 3.1 to 3.4 Gc



Part number 9511-1007 is a new solid state oscillator at S-band with 300 Mc double-screw manual tuning range. Frequency is 3.1 to 3.4 Gc; power output, 15 mw minimum; power input requirement, 28 v d-c at 15 ma maximum. There is no spurious output in the frequency range. Frequency stability is 5 ppm/°C. Weighing 3 oz, the oscillator is approximately ⅞ in. square and 2 in. long.

Trak Microwave Corp., Tampa, Fla. **[426]**

Low-pass filters rated at 500 w

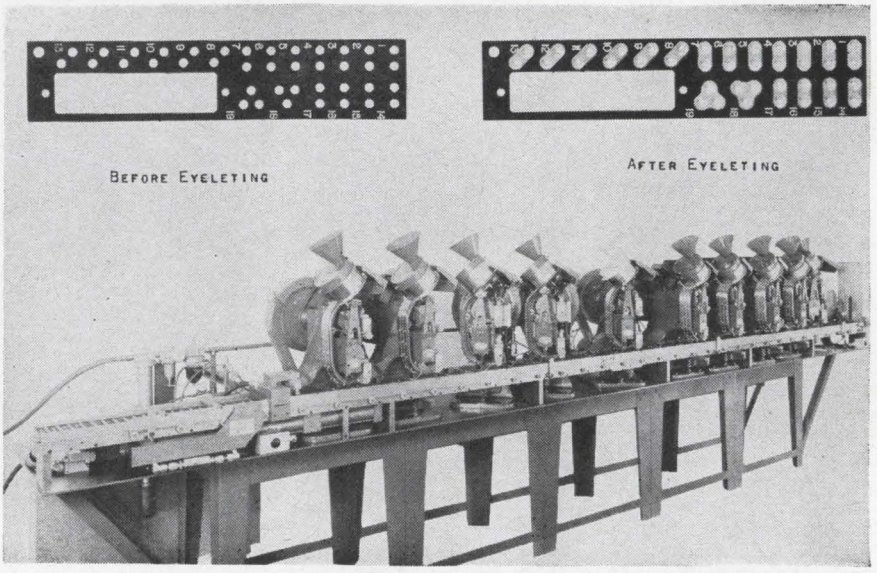


A line of high-power low-pass filters, conservatively rated at 500 w, has the same external dimensions as medium-power low-pass filters. Advanced materials combined with proven normalized prototype designs make this possible. Pass-band response is extremely flat, vswr and and insertion loss low, and stop band rejection is spurious-free to 6 times cutoff. Available with standard or special connectors, the filters easily withstand extreme shock and vibration as well as temperature and humidity changes.

Microtech Co., Cheshire, Conn. **[427]**

New Production Equipment

'Stitching' eyelets in terminal boards



Ten eyelet attaching devices are included in this machine, which can process 50,000 terminal boards a week. Scoops on top are for insertion of eyelets.

Producers of telephone, television and radio equipment need thousands of terminal boards, and every terminal board needs terminal eyelets. Putting in the eyelets can be time-consuming and costly—but the strange machine shown above does it quickly and cheaply. It can assemble 19 eyelets on each of 30 terminal boards every minute, and reject any board that has missing eyelets.

Developed by Edward Segal, Inc. of New York City, the machine accepts a blank board and attaches to it, in a prescribed pattern, 17 twin- and 2 triple-barrel eyelets.

When the bare board comes out of the feeder, an electric eye examines it for proper orientation, and the eyelets are inserted. At the end of the line, each eyelet on the board becomes part of a low voltage series circuit that tests for the presence of all the eyelets. A missing eyelet is indicated by an open circuit, and the board is rejected.

Only one operator is needed to load the empty boards into the stack feeder, replenish all the eyelet feeders, and generally supervise the operation.

The machine, known as the NR-ILT, consists of a magazine feed that delivers the blank terminal boards, a battery of 10 Edward Segal model NR eyelet attaching machines, a transfer device, the electrical inspection stations and a steel mounting stand. The complete unit is 18 feet long.

This unit is now the only one in existence; it cost $27,000 and is owned by a company that is already banging out 50,000 boards a week. Segal expects to build two more—one a possible companion for that machine.

The basic NR-ILT can be varied according to the installation. It can be altered to feed and set any type of eyelet, including eyelets of different dimensions and configurations. Any number of eyelet attaching machines and inspection devices can be included in the basic unit. Delivery time would be 12 to 14 weeks.

Edward Segal Inc., 132 Lafayette St., New York, N. Y. **[451]**

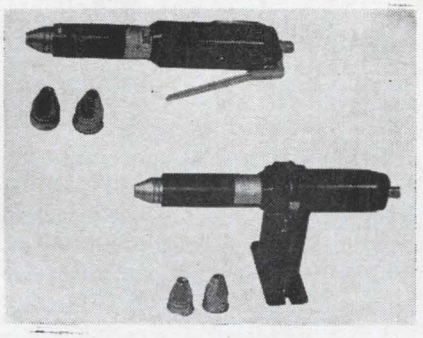
Ball bearings speed toroid winding

Model 700 toroid winder has a ball-bearing drive that rotates the shuttle at speeds up to 1800 turns per minute by either hand or foot controls. Interchangeable winding heads and shuttles offer more flexi-

bility than any other winding machine, according to the manufacturer. With a 4-in. winding head, core sizes range from 0.055 in. i-d to 2 in. o-d and 1¼ in. high. With a 6-in. winding head, $\frac{3}{16}$ in. i-d to 4 in. o-d and 2 in. high sizes may be wound. Sixteen sizes of easily removable precision shuttles permit a large variety of cores to be wound. With a 4-in. winding head, wire sizes from No. 26 to No. 50 Awg may be used. The 6-in. winding head will accommodate wire from No. 22 to No. 40 Awg. The entire core holder assembly may be moved back, forward, or sideways while the core is being wound, by a jockey stick positioner. The preset register and transistorized electronic counter guarantee accurate counting both for loading and for counting turns.

Gorman Machine Corp.. 480 So. Main St., Randolph, Mass. **[452]**

Pneumatic crimp tool has positive release

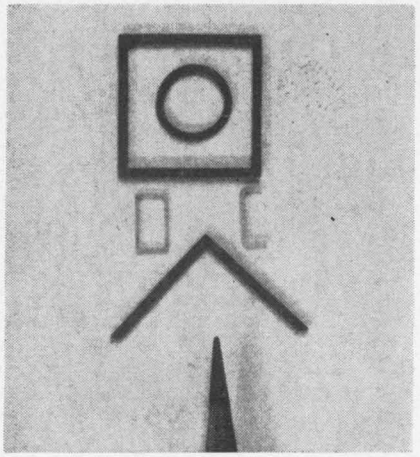


A portable, pneumatic crimp tool has been developed for terminating wires to the contacts of electrical connectors. Designated CPT, the tool operates with an air pressure of 80 to 120 psi, and has a positive stop and ratchet release to insure crimps of consistent depth. For stationary crimping, a bench-mounted model is available with a foot pedal. The crimp heads have four indentors, each with a double indent configuration. Standard size 20, 16, or 12 heads will crimp any contact designed to meet specification ME3190. Special heads can be supplied for most other contacts. Both the hand and foot models may be hand held, suspended over work areas, or mounted in a bench bracket.

ITT Cannon Electric, Inc., 3208 Humboldt St., Los Angeles, Calif. **[453]**

New Materials

Kovar sealing glasses flow easily



Flatpack frames sealed with new low-viscosity glass

Flatpack frames with a minimum of distortion can be produced with a family of Kovar sealing glasses with low viscosity and consequent better flow characteristics. These characteristics also provide improved control coverage of the connector pin area.

Fusite Corp. also claims much better results in sealing alumina to Kovar; though since the family is available in a variety of expansions, it is useful in a number of other combinations as well.

Specifications

Physical properties:	
Strain point	440°— 410°C
Annealing point	500°— 510°C
Softening point	685°— 720°C
Working point	990°—1115°C
Density (as smelted)	2.2—2.4 grams/cm^{-3}
Electrical properties:	
Volume resistivity (25°C at 50% RH)	10^{16} ohm-cm
Dielectric constant (1 kc, 25°)	5—8

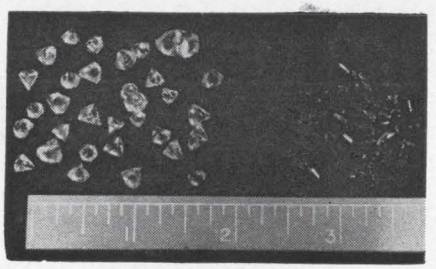
Fusite Corp., 6000 Fernview Ave., Cincinnati, Ohio, 45212. **[441]**

Coating improves hybrid microcircuits

A new ceramic platinum-gold coating has been developed for use where possible migration of silver-bearing compositions must be avoided. Type 5800 paste concentrate may be used as an electrical contact material and to form conductive patterns applicable to interconnections in hybrid microcircuitry or for resistor and capacitor terminations. The coating has a wide firing range from 500 to 800°C, and features excellent adhesion characteristics to ceramics and glass surfaces, including high alumina bodies, pyrex, quartz, steatite and barium titanate. Resistance of a 1-mil film is less than 0.1 ohm/sq. The concentrate is suitable for silk screening, and can be diluted for other applications. It is permanently solderable after firing. The use of noble metals imparts extreme stability and resistance to harmful environmental conditions. Type 5800 is available for less than $60 per troy ounce in production quantities.

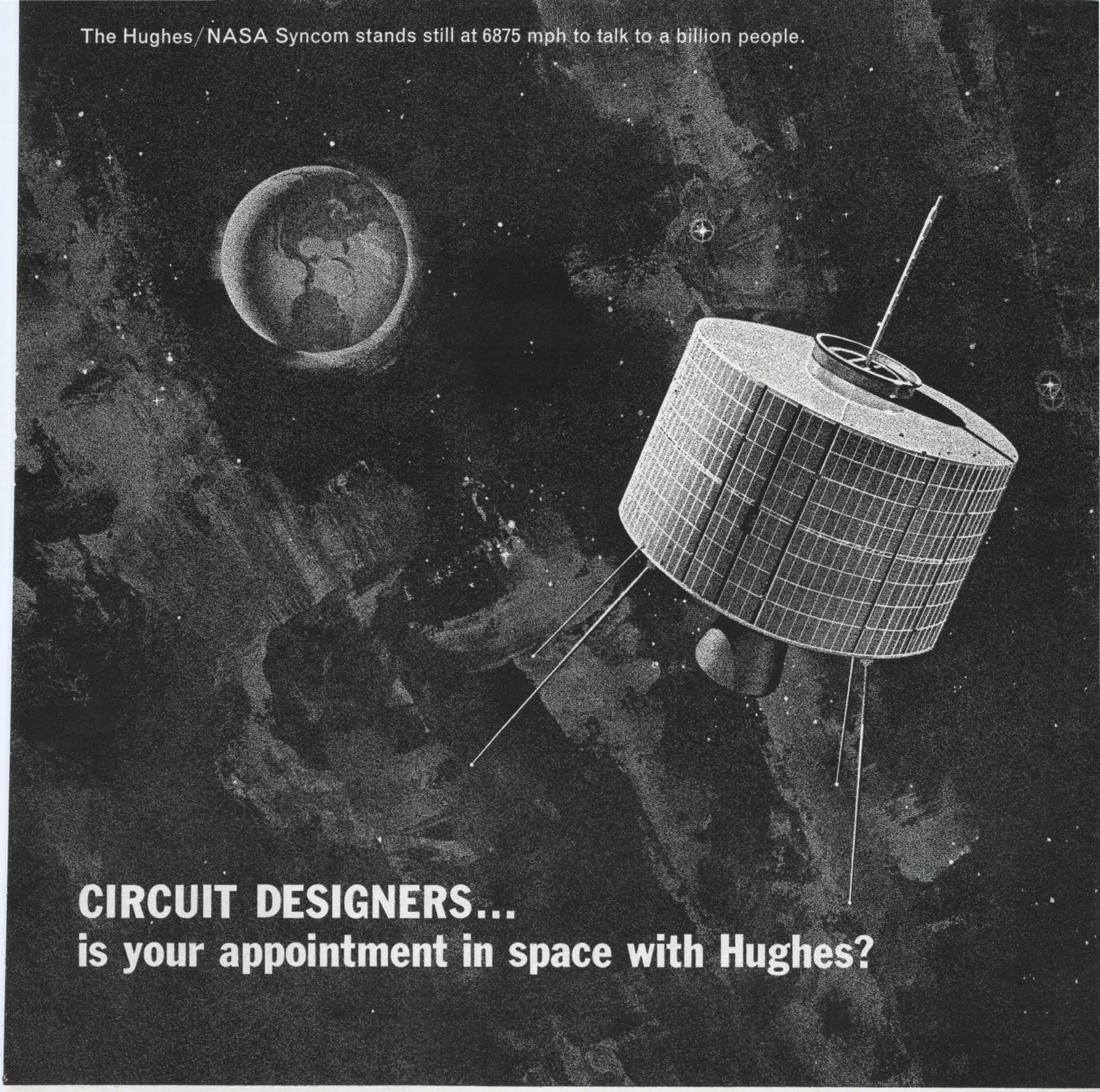
Electro-Science Laboratories, Inc., 1133 Arch St., Philadelphia, Pa., 19107. **[442]**

Three new types of single crystals



Three new single crystals are now being produced. Beryllium oxide (BeO) grown in hexagonal prismatic forms is available in nominal size, approximately 1 to 2 mm in diameter, and also in 3 to 4-mm sizes. Purity is 99.99%, not including a maximum of 1,000 ppm molybdenum. Beryllium silicate (Be_2 SiO_4) single crystal is offered in sizes of 1 to 5 mm in diameter, spherical in shape, and prismatic. Zirconium dioxide (ZrO_2) single crystal is available in sizes of 1 to 2 mm in diameter, and in angular crystals nearly cubic in form. Complete literature is available.

Electronic Space Products, Inc., 854 South Robertson Blvd., Los Angeles, Calif. 90035. **[443]**



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New Books

Electron tubes

Handbook of Electron Tube and Vacuum Techniques
Fred Rosebury
Addison-Wesley Publishing Co., Inc., 597 pp., $17.50

This handbook is a new version of the Tube Laboratory Manual, which was produced by the Research Laboratory of Electronics of the Massachusetts Institutte of Technology. However, this volume includes a considerable amount of new data and information.

The book begins with 148 pages of information on tube materials and tube design and then presents a 335-page glossary covering tube terms, definitions, materials and manufacturing processes.

The book is very well organized and edited; in fact it is a model reference book. Its definitions are well written, its illustrations are clear and easy to follow, and its organization is excellent.

Some of the areas covered in detail include cleaning of electron tubes and vacuum components; electroplating and stripping, heat-treating and brazing; induction heating: radio frequency heating; bombarding; glass-to-metal seals; and metal and ceramic bonding.

Liberal use of tables and charts adds greatly to the book's usefulness. More photographs would have been helpful, however.

If the glossary, which is very complete and written in encyclopedia form, were widely adopted, it could combat the current practice of many authors of coining their own terms when writing for technical journals.

There are more than 300 terms in the glossary, plus 120 tables, charts and illustrations. Each chapter includes a bibliography. Two indexes are supplied; by author and by subject.

Items listed in the glossary are freely referenced. In some cases, two or three pages are devoted to a glossary item.

Some of the material presented in this book should be of interest to engineers working in areas other than the electron tube field. For example, the material on vacuum techniques not only crosses other branches of science such as chemistry, metallurgy, gas dynamics and properties of materials, but also applies to many other areas of engineering. Material such as the discussion of heater design is for the most part limited to the vacuum tube engineer, however.

The author is the supervisor of the Electron Tube Laboratory of the Research Laboratory of Electronics at the Massachusetts Institute of Technology. He was cited by the government for his work during World War II at the MIT Radiation Laboratory.

Recently published

Radiative Recombination in Semiconductors, 7th Intenational Conference on the Physics of Semiconductors, Dunod, 296 pp., about $11.

Discharge Detection in High Voltage Equipment, F.H. Kreuger, American Elsevier Publishing Co., 223 pp., $12.

International Symposium on Electrical Accidents, International Occupational Safety and Health Information Centre (CIS), Geneva, Switzerland, 269 pp., $7.50.

The Nature of Induction Machines, Philip L. Alger, Gordon and Breach Science Publishers, 516 pp., $25.

Oriented Nuclei, Polarized Targets and Beams, J.M. Daniels, Academic Press, 278 pp., $9.

Data Smoothing and Prediction, R.B. Blackman, Addison-Wesley Publishing Co., 182 pp., $11.75.

Ceramic Acoustic Detectors, Alevtina Aleksandrovna Anan'eva, Consultants Bureau Enterprises, Inc., 122 pp., $22.50.

The Elements, Samuel Ruben, The Bobbs-Merrill Co. 114 pp., $1.95.

The Electronics of Materials, Samuel Ruben, The Bobbs-Merrill Co., 109 pp., $4.25.

Principles of Electron Tubes, James W. Gewartowski and Hugh A. Watson, D. Van Nostrand Co., 655 pp., $18.50.

The Goonhilly Project, F.J.D. Taylor, The Institution of Electrical Engineers, London, 152 pp., $8.40.

Electromagnetics in Space, Karl R. Spangenberg, editor, McGraw-Hill Book Co., 277 pp., $15.

In German

Stronversorgung, Siegfried W. Wagner, R.v.Decker's Verlag G. Schenck, Hamburg, 726 pp.

Programmierfibel, Theo Lutz and Voler Hauff, Telekosmos-Verlag, 228 pp.

In French

Le Calcul Analogique Par Courants Continus, M. Danloux-Dumesnils, Dunod, Paris, 279 pp.

Acoustique Sous-Marine, L. Guieysse and P. Sabathe, Dunod, Paris, 252 pp.

Technical Abstracts

Radiation Monitor

Radiotelemetry provides data on nuclear explosions

J.G. Nish, P.L. Phelps, G. Holliday, Lawrence Radiation Laboratory, University of California, Livermore.

Radiotelemetry provides a means for measuring the amount of radioactive material settling in a large area. It is useful where nuclear explosives are used for excavating large masses of earth, such as in Project Plowshare. The Lawrence Radiation Laboratory at the University of California has constructed a prototype system that monitors gamma radiation or other significant parameters at several remote locations. The data is collected almost instantaneously at a central recording station.

The system has several unique features, which are mostly related to the rough, isolated locations of the events being monitored. The prototype consists of a central data collector, two portable repeater stations, and ten remote sensors. The remote sensors may be increased in number tenfold and adapted to measurements other than gamma radiation.

The system must be highly portable. The central collection center is located in a trailer with self-contained power and air conditioning; the remote sensors and repeater stations are small enough so that ten can be carried in a single pick-up truck or flown by helicopter to the intended location.

Because the remote sensors will be placed in relatively inaccessible spots, they are designed to operate up to six weeks under all weather conditions, and have a wide dynamic range. Each of these stations consists of a gamma sensing unit, a battery pack and an electronic control unit. The gamma sensor is an ion-chamber/log-amplifier combination; the electronic control unit contains the telemetry receiver-transmitter, the command decoding circuits and a voltage-controlled oscillator.

System operation is either completely automatic or by external command.

Presented at the National Telemetering Conference, Houston, Texas, April 13-15.

Chemical probe

Measuring atom concentration profiles in the upper atmosphere

J. Greyson, R.T. Keen and R.B. Ingalls Atomics International, a division of North American Aviation, Inc. Canoga Park, Calif.

Freeze-dried polymer aerogels (called fluffs) are used as chemical probes for measuring nitrogen and oxygen atom concentrations in the upper atmosphere. Those described in this paper were designed to react to their environment on a one-to-one basis, producing long-lived paramagnetic species, or free radicals, which can be extremely accurately detected by an EPR (electron paramagnetic resonance) spectrometer.

Fluffs were prepared from a 1% solution of polystyrene in benzene frozen with liquid nitrogen. The solvent was pumped off, taking care to maintain the frozen state. The fluff was then dried by continued evacuation at about 60°C and mounted in an evacuated tube passing through a microwave generator cavity. Gas flow was started and allowed to continue for 15 to 30 minutes, at which time the microwave generator was turned on to provide the atom stream. The EPR spectrometer was used to monitor the rate of free radical formation in the polymer foam, the steady-state concentration of radicals, the concentration of atoms over the fluff, and any changes in the nature of the resonance spectrum obtained for the fluff as a function of time, atom concentration, and atom type. Spin concentrations were calculated by referring spectral intensities to a calibrated ruby standard permanently mounted in the spectrometer cavity.

Results indicated that the rate of loss of atoms from the system is equal to the rate of production of paramagnetic species in the fluff, which is, in turn, proportional to the concentrations of the reacting species. From the calculated rate constant, a half-life for atoms in contact with fluff is determined. The half-lives, along with some idea of the residence time of the atoms in fluff, provide an estimate of fluff-atom reaction efficiencies.

NEW from NYTRONICS

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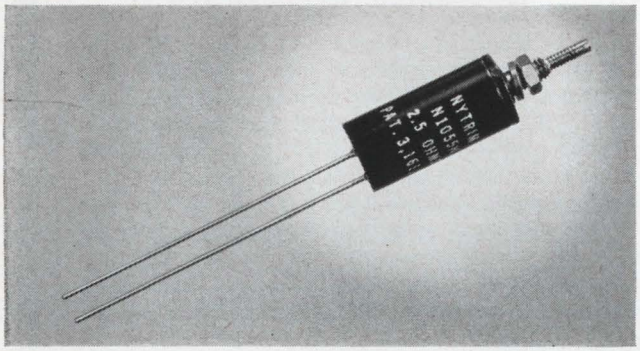

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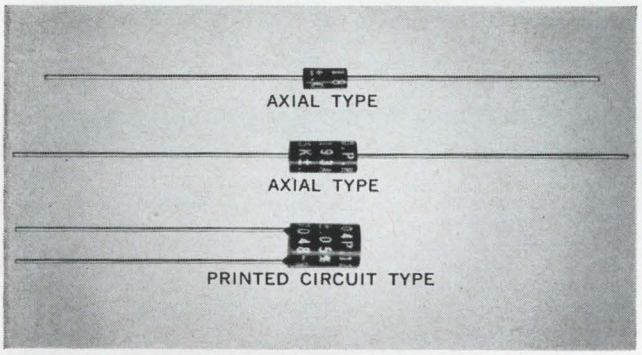

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- ★ 1.0 ohms to 6 megohms
- ★ Tolerance to .001%
- ★ Stability: to 10 PPM/year
- ★ HTC to 0.5 PPM/°C
- ★ Axial Size: ⅛" to ¾" diameter by ¼" to 2" in length.
- ★ Printed Circuit Size: ¼" to ½" diameter by 13/32" to 1" in length

For Complete Engineering Data Write Dept. E or Phone (201) 464-9300

NYTRONICS

550 Springfield Ave., Berkeley Heights, N. J.

Design Leaders — STANDARD Components to Meet CUSTOM Requirements

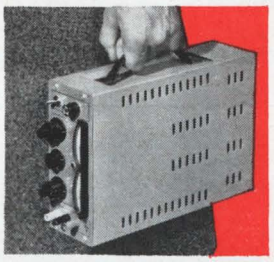
Circle 218 on reader service card

a remarkable

NEW POWER SUPPLY

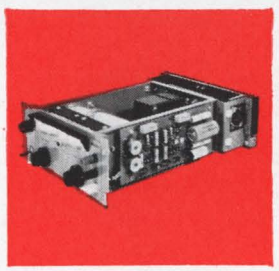
from Deltron

"DUET" twin amplifier controls voltage or current with automatic electronic crossover



Built-in handle makes it easy to carry the "Duet". It's about half the size of an average briefcase.

- ■ Dual output range: 0-40 V at 0.75 amp . . 0-20 V at 1.5 amps.
- ■ 0.01% regulation.
- ■ Ripple — less than 200 microvolts.
- ■ All specifications are *guaranteed* without any need for external programming resistors.
- ■ No overshoot on turn-on . . turn-off . . or power interruption in either voltage or current mode.
- ■ Automatic series and parallel operation without complicated connections.
- ■ Half-rack size . . permits rack mounting as singles or duals . . as well as portable use.
- ■ One free demonstration will prove the "DUET" superior in PERFORMANCE . . QUALITY . . and PRICE . . to any other on the market.



Examine for yourself the superior design, workmanship, and components in the "Duet".

16 *OTHER RP MODELS AVAILABLE IN A WIDE RANGE OF RATINGS*

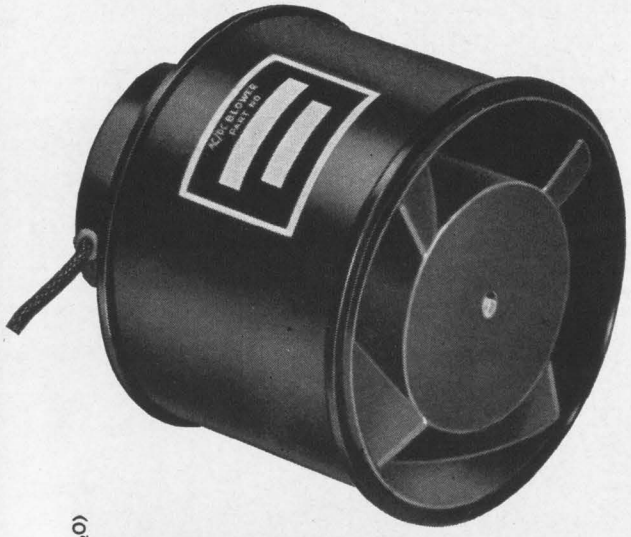
For more information . . or to arrange a demonstration, write to . .

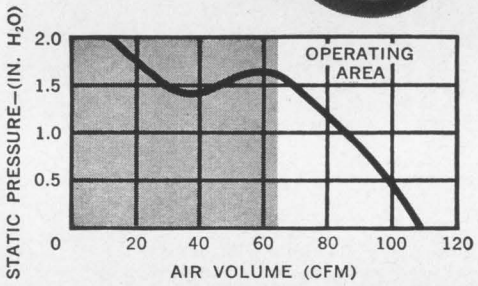
Deltron inc.

FOURTH AND CAMBRIA STREETS, PHILADELPHIA, PA. 19133
PHONE: (215) 739-1101 TWX: (215) 569-8686

Circle 151 on reader service card

3" dia. x 3¼" long, 16 ounces





NEW VANEAXIAL

AC/DC UNIVERSAL BLOWER

Globe's VAX-3-GN Universal Blower gives you 110 cfm. free air, with a design point of 68 cfm. at 1.5" H_2O—on **either** 115 v.d.c. or 115 v.a.c., 60 cycle power. Other voltages can be supplied. Nominal speed is 14,000 rpm.

You can standardize on this extremely versatile blower for ground support and commercial electronic cooling. It's designed to meet MIL specs, having passed shock and vibration per MIL-E-5272. Production tooling makes this blower economical. Prototypes can be in your hands tomorrow (telephone BA-2-3741 for part no. 19A908); production orders normally delivered in a short time.

Rugged mechanical protection is provided by the black anodized aluminum housing and propeller. Mount by clamping to servo ring at either end. Nominal life exceeds 1000 hours. Max. current is 0.47 amps at free air delivery. Request Bulletin GNB from Globe Industries, Inc., 1784 Stanley Avenue, Dayton 4, Ohio.

24 HOUR delivery on some units

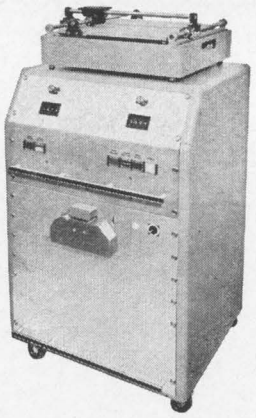
GLOBE

GLOBE INDUSTRIES, INC.

Circle 210 on reader service card

Automated Micro Positioner

for
welding
soldering
testing
drilling
abrading
inspection
insertion



Automate production of microminiature circuits and assemblies with Westgate's Universal Digital Micro Positioner. Complete systems automatically position and perform production operations from tape, computer or manual input. X-Y coordinates are located anywhere in the 10" x 10" working area with an accuracy of ±0.001" and repeatability of ±0.0005". Unit produces its own tapes without additional keyboard equipment. Bulletin DMP 3-65. Westgate Laboratory, Inc., Yellow Springs, O.

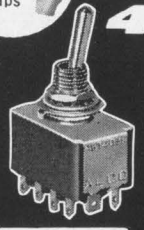
WESTGATE LABORATORY, INC.
a subsidiary of Arvin Industries, Inc.

THE WORLD'S FINEST
MINIATURE ALCOSWITCH
Available from these stocking distributors:

Alco Elec., Lawrence, Mass.
Almo, Philadelphia, Pa.
Arrow, Farmingdale, N. Y.
B & B Distr., Berkeley, Cal.
Colorvision, Reseda, Cal.
D & H Distr., Baltimore, Md.
Electric Switches, L.A., Cal.
Electronic Components of San Diego, Cal.
Fortune Elec., San Francisco
Goddard, W. Palm Beach, Fla.
Harrison Radio, N.Y., N.Y.
Harvey Radio, N.Y., N.Y.
Industribution, Oak Park, Ill.
Interstate Elec., Wichita, Kan.
Peninsula Elec. Supply, San Jose, Cal.
Radio Products, L.A., Cal.
Reliance Merchandising, Philadelphia, Pa.
Ed Warburg Co., L.A., Cal.
Wehle Elec., Buffalo, N.Y.
Wofford Elec., Houston, Tex.

Available with color coded caps

WORLD'S FIRST
MINIATURE 4PDT TOGGLE
UNITIZED BODY



- One-piece "unitized body" reduces parts, weight, size to a minimum for ultra-miniature space requirements.
- Supplied with miniature bat handles or plastic color-coded caps. Solid silver contacts and terminals.
- Insulation over 100 megs. Breakdown over 1000V. Over 80,000 on/off cycles.
- 4 PDT $4.85. Ask for O.E.M. quantity price schedule on complete line of ALCOSWITCH.

BODY SIZE
½" x ½" x 13/16"

ALCOSWITCH

SEND FOR FREE CATALOG
Lawrence, Mass. Dept. Q-50

Circle 152 on reader service card
Circle 211 on reader service card

Technical Abstracts

The most important characteristics in the use of fluffs as atmospheric probes seem to be the reaction efficiencies possible.

Presented at the Third Symposium on the Remote Sensing of Environment, Ann Arbor, Mich., Oct. 14-16, 1964.

Short-range telemetry

Transmitter for auto proving grounds
Marvin K. Stark,
Experimental Dept., General Motors Corp., Milford, Mich.

When running cars on the proving ground, it is often necessary to obtain data, such as shaft torque, gear tooth stress, and universal joint temperature, related to moving components of the test vehicle. In the past, it has been common practice to use slip rings or flexing wires to bring out electrical signals.

For tests repeated often, special assemblies have been developed, but often their use involves excessive wear and contamination. And for special testing, the construction of these assemblies is time-consuming and costly. A solution to this problem, developed at the General Motors proving ground, uses a short range telemetry system to transmit data using an r-f carrier.

The system uses a miniature transmitter which mounts directly on the moving part. The receiving antenna is mounted close by, on the vehicle. The short transmission path results in high signal levels.

Data from transducers such as strain gauge bridges is transmitted over the radio frequency carrier. Since it is necessary to include the steady-state value as well as the signal components, a subcarrier is used to modulate the r-f carrier.

The design of the unusual subcarrier circuit provides inherent stability and relatively high sensitivity, and is easily demodulated. Unlike most subcarrier circuits that use voltage-variable oscillators, this one contains two inductor-tunnel diode series.

Over-all sensitivity of the transmitter is maintained at ±2% from 40° to 300°F. through the use of silicon semiconductors and low temperature coefficient resistors.

Presented at the National Telemetering Conference, Houston, Texas, April 13-15, 1965.

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This Qualification Form is designed to help you advance in the electronics industry. It is unique and compact. Designed with the assistance of professional personnel management, it isolates specific experience in electronics and deals only in essential background information.

The advertisers listed here are seeking professional experience. Fill in the Qualification Form below.

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6. **Mail to: Classified Advertising Div., Electronics, Box 12, New York, N. Y. 10036.**

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GENERAL ELECTRIC CO. Apollo Support Dept. Daytona Beach, Fla. 32015	151*	3
GENERAL ELECTRIC CO. Heavy Military Electronics Dept. Syracuse, NY	148*	4
GENERAL ELECTRIC CO. Television Receiver Dept. Electronics Park Syracuse, NY	155	5
IBM CORP Hopewell Junction, NY	150*	6
LAWRENCE RADIATION LABORATORY Livermore, Calif.	150*	7
LOCKHEED MISSILES & SPACE CO. Sunnyvale, Calif.	138*	8
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* These advertisements appeared in the May 3 issue.

(cut here) **Electronics WEEKLY QUALIFICATION FORM FOR POSITIONS AVAILABLE** (cut here)

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Personal Background

NAME .....
HOME ADDRESS .....
CITY .....**ZONE**.....**STATE** .....
HOME TELEPHONE .....

Education

PROFESSIONAL DEGREE(S) .....
MAJOR(S) .....
UNIVERSITY .....
DATE(S) .....

FIELDS OF EXPERIENCE (Please Check)

5/17/65

- ☐ Aerospace
- ☐ Antennas
- ☐ ASW
- ☐ Circuits
- ☐ Communications
- ☐ Components
- ☐ Computers
- ☐ ECM
- ☐ Electron Tubes
- ☐ Engineering Writing
- ☐ Fire Control
- ☐ Human Factors
- ☐ Infrared
- ☐ Instrumentation
- ☐ Medicine
- ☐ Microwave
- ☐ Navigation
- ☐ Operations Research
- ☐ Optics
- ☐ Packaging
- ☐ Radar
- ☐ Radio—TV
- ☐ Simulators
- ☐ Solid State
- ☐ Telemetry
- ☐ Transformers
- ☐ Other .....
- ☐ .....
- ☐ .....
- ☐ .....

CATEGORY OF SPECIALIZATION

Please indicate number of months experience on proper lines.

	Technical Experience (Months)	Supervisory Experience (Months)
RESEARCH (pure, fundamental, basic)	.....	.....
RESEARCH (Applied)	.....	.....
SYSTEMS (New Concepts)	.....	.....
DEVELOPMENT (Model)	.....	.....
DESIGN (Product)	.....	.....
MANUFACTURING (Product)	.....	.....
FIELD (Service)	.....	.....
SALES (Proposals & Products)	.....	.....

CIRCLE KEY NUMBERS OF ABOVE COMPANIES' POSITIONS THAT INTEREST YOU

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

TV Receiver Openings in

CONSUMER ELECTRONICS MANUFACTURING

G.E.'s expanding Television Receiver Dept. announces these career openings at Electronics Park, Syracuse, N. Y.

PRODUCIBILITY ENGINEER to assure optimum new model design integration for manufacturability in keeping with functional specs. BSEE, IE or ME plus high-volume electronic assembly experience needed.

MFG. DEVELOPMENT ENGINEER for analysis, recommendation and implementation of new production equipment needs for new model runs. BSEE, ME or IE required plus experience in design of high-volume electronic assembly equipment.

QC ENGINEER for new model quality assurance. Assert quality principles in design, mfg., failure evaluation stages. BSEE plus TV QC or production experience.

TEST EQUIPMENT DESIGNER to plan, design, organize and give tech. direction for construction of electronic test equipment for TV manufacture. BSEE needed with experience in transistor and signal generation circuits; test equipment design knowledge.

ALSO . . . ELECTRICAL CIRCUIT DESIGNER for electrical components used in mass-produced TV sets. Needs BSEE plus experience in transistor or vacuum tube signal circuits.

WRITE, sending a resume of your experience to: Mr. M. H. FitzGibbons, Television Receiver Dept., Section 26, Electronics Park, Syracuse, N. Y.

(An Equal Opportunity Employer)

GENERAL ELECTRIC

E. E.'s
for FEE-PAID Positions
WRITE US FIRST!
Use our confidential application for professional, individualized service . . . a complete national technical employment agency.
ATOMIC PERSONNEL, INC.
Suite 1207L, 1518 Walnut St., Phila. 2, Pa.

POSITION VACANT

Communications Engineer—Excellent opportunity for advancement with large midwestern gas and electric company. B.S.E.E. required. Experience in a Utility Communications Section desirable but not necessary. Must be experienced in system design and operation of mobile radio systems and microwave networks. Should be familiar with carrier systems, utility relay practices, supervisory control and telemetric equipment. Will be responsible for all company communications systems. Salary open but commensurate with qualifications and experience. Send complete resume detailing experience, personal data, and salary requirements to P-6624, Electronics.

CLASSIFIED ADVERTISING
SEARCHLIGHT SECTION
BUSINESS OPPORTUNITIES
USED OR SURPLUS EQUIPMENT

Color DIAL TELEPHONES $10.95

Factory rebuilt Western Electric In white, beige, ivory, pink, green, or blue. If 4 prong plug is required add $2.00. Fully guaranteed. Write for free list. All shipments FOB.

Complete

SURPLUS SAVING CENTER
Dept. E-5135
Waymart, Pa.

CIRCLE 963 ON READER SERVICE CARD

COMPUTER LOGIC DESIGNERS

When it comes to space, UNIVAC systems are way out there.

Our Data Buffer Memory System in Mariner is now on its 350 million mile journey to Mars. This sophisticated little package weighs only 21 ounces. It contains two memories with 1320 data bits of storage per memory. Its job is to record and store what is "seen" by Mariner's TV cameras and make it available for subsequent radio transmission back to earth.

This system is just one example of UNIVAC-St. Paul's systems engineering and production proficiency in space and defense work. We are, in fact, more involved in this area than any other computer company.

For our staff — and for our computer logic designers in particular — this means constantly working with new techniques and devices on the edge of today's technological revolution spurred by the conquest of space. Our lab work right now is deeply involved with new connections and packaging techniques that go a long way to solve the systems problems of nanosecond logic circuits . . . new evaporated circuitry operating on low drive currents . . . techniques in overcoming radiation effects in space computer systems . . . real time data links . . . ground support and test recording devices.

Opportunities are open to logic designers whose pioneering spirit and technical knowledge matches our own. Assignments require a BS or MS degree to perform logical design of high speed digital equipment using solid state circuitry and the logical design of systems taking into account the interfaces between the central computer and its input-output equipment.

If you qualify, send a resume to Mr. R. K. Patterson, Employment Manager, Dept. E-17, UNIVAC Division of Sperry Rand Corp., Univac Park, St. Paul, Minn. 55116. An equal opportunity employer.

UNIVAC
DIVISION OF SPERRY RAND CORPORATION

SEEKING A LEADERSHIP POSITION ?

If so, one of these demanding descriptions may fit you

■ **SECTION MANAGER, TRANSMITTERS.** To direct aggressive development programs for UHF, high power and state-of-the-art miniaturized RF transmitters. He should have ten years of experience in the design and engineering supervision of military communications equipment: it should have given him personal drive, demonstrated leadership ability, unusual technical understanding and keen administrative insight.

■ **SENIOR STAFF ENGINEERS, RECEIVERS.** Leadership capability sufficient for immediate assumption of key roles in vigorous development programs for solid-state microminiature receivers. Positions require six to eight years of experience and in-depth knowledge of receiver design fundamentals.

■ **PROJECT ENGINEERS, SPACE INSTRUMENTATION.** Technical ability of the very highest order is required. Six to eight years of experience, preferably data handling, control, or analog instrumentation.

■ **MICROELECTRONICS SPECIALISTS.** Senior- and intermediate-level responsibilities in a rapidly expanding microminiaturization and thin-film program. Sound technical knowledge and demonstrated supervisory skill required.

If you qualify, there's a leadership position open for you at Electronic Communications, Inc. You can increase your professional rewards and personal satisfaction by contacting ECI today.

ECI has built a solid, successful reputation in airborne communications, multiplexing and space instrumentation. The Company offers pleasant living conditions and unusual educational and cultural opportunities in St. Petersburg, Florida. And it offers you a chance to participate in further growth through technological contribution. Call collect Duane Meyer (813) 347-1121, or send him your resume at ECI, Box 12248B, St. Petersburg, Florida 33733. (An equal opportunity employer.)

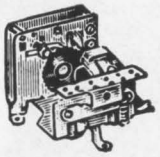
ECI
ELECTRONIC COMMUNICATIONS, INC.
St. Petersburg, Florida

GUARDIAN M120 SEQUENCE RATCHET

4 PDT stepper with 3 position switch operation, center position off. Contacts rated for 12.5 amps. 20 steps per sec. GUARDIAN 1R-M120-115: 115 VAC 4PDT, 12.5 amp contacts.
#R5626 .....7.00

GUARDIAN MC

A compact, continuous rotation, single circuit, 24-position stepping switch. Max. speed: 20 steps per second. $3\frac{1}{4}$" x 3" x $2\frac{3}{16}$"h, overall.



#R4815	6VAC	7.50
#R4828	24VAC	7.50
#R4845	115VAC	8.00
#R4865	6VDC	7.50
#R4816	24VDC	7.50
#R4829	48VDC	7.50
#R4846	110VDC	8.00

RELAYS BY UNIVERSAL

Highlighted here are just a few of over 2,000,000 in 20,000 different types in stock . . . Most makes. This permits immediate delivery of production quantities. We are equipped to assemble, adjust and test any type of relay.

Average shipment made within 48 hours.

Orders requiring coil and frame assembly, special testing or adjustment are shipped within one week to ten days.

Send for latest 60-page free illustrated catalog #E which describes the largest inventory of relays in the world.

"Satisfaction is on the other end of your telephone"

Universal RELAY CORP.

42 WHITE ST., NEW YORK 13, N. Y. • WAlker 5-6900

CIRCLE 951 ON READER SERVICE CARD

The BEST WAY:

- **TO BUY Surplus Electronics**.....
- **TO SELL YOUR Surplus Electronics**..

IF YOU INQUIRED about **Signal Generators,** we would send you a listing of 34 types: G.R.#1001A, H.P. #608B, etc. etc. up thru X-Band. But **Signal Generators** is only 1 of the **52 categories** by which we classify our tremendous stock of choice materiel. Turnover is too fast to keep up with a general catalog, but we keep category lists current . . . so please **tell us your specific needs!**

WE KEEP 3 FILES by category:
INVENTORY . . . WANTS . . . OTHERS HAVE

If your **WANTS** inquiry drops into a slot unmatched in the other 2 files, chances are that tomorrow it will be matched by a new card in one of the others.

SO if you HAVE MATERIAL, surplus to your needs, or want to update, tell us about it and price it . . . same as **we** price whatever **we** offer for sale . . . and we try to make our prices tempting. There may be a hole in our **inventory** or **wants** file that will absorb your material fast.

Write . . . Wire . . . Phone . . .

R. E. GOODHEART CO., INC.
P.O. Box 1220-E Beverly Hills, Calif. 90213
Area 213 Phones 272-5707, 276-9349.
Messages: 275-5342

CIRCLE 952 ON READER SERVICE CARD

PERFECT FOR ELECTRONICS!

Practically New
ONE STORY AIR COND.
65,000 SQ. FT.
MODERN PLANT • 16 ACRES
Bennettsville, S. C.

BINSWANGER
1420 Walnut St., Phila., Pa. 19102 • PE 5-0202

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TUBES & COMPONENT
FREE...CATALOG
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212-WAlker 5-7000 TWX-571-0484

CIRCLE 954 ON READER SERVICE CARD

★ HEWLETT PACKARD ★

80 pieces of laboratory equipment
VTVM's — Oscillators-counters-attenuators
send 25¢ for list and picture.
EASY-UP, INC.
2425 Bradley Road, Rockford, Ill.
or phone 877-5288 area code 815

CIRCLE 955 ON READER SERVICE CARD

COAXIAL CABLE

RG 213U (former RG 8U)
RG 215U (former RG10U)
RG 219U (former RG18U)

LARGE QUANTITIES— BELOW FACTORY COST

Other types available
Rigid—Flexible—Semi-flex
Call or write for listing

Sierra Western Electric Company
P. O. Box 4668
Oakland, California 94623
Telephone AC 415-832-3527

CIRCLE 956 ON READER SERVICE CARD

FREE Catalog

OF THE WORLD'S FINEST ELECTRONIC GOV'T SURPLUS BARGAINS

HUNDREDS OF TOP QUALITY ITEMS — Receivers, Transmitters, Microphones, Inverters, Power Supplies, Meters, Phones, Antennas, Indicators, Filters, Transformers, Amplifiers, Headsets, Converters, Control Boxes, Dynamotors, Test Equipment, Motors, Blowers, Cable, Keyers, Chokes, Handsets, Switches, etc., etc. Send for Free Catalog—Dept. E-5.

FAIR RADIO SALES
2133 ELIDA RD. • Box 1105 • LIMA, OHIO

CIRCLE 957 ON READER SERVICE CARD

HIGH-QUALITY
Commercial and Military
TEST EQUIPMENT

Hewlett-Packard, General Radio, Tektronix, Ballantine, Beckman, Daven, DuMont, Kepco, Lambda, etc.

We invite your inquiries.

ELECTRONICRAFT, Inc.
P. O. Box 13, Binghamton, N. Y. 13902
Phone: 607-724-5785

CIRCLE 958 ON READER SERVICE CARD

RADAR AUTO-TRACK & TELEMETRY ANTENNA PEDESTALS 3 & 10 CM. SCR 584 AUTOTRACK RADARS. M-33 RADAR TPS-1D SEARCH. APS-45 TPS-10D HT. FINDERS. WX RADARS. FPN-32GCA. APS-10 APS-15B APS-27 (AMTI) SEARCH. ■ ■ APN-102 DOPPLER. DOZENS MORE. CARCINOTRONS. PFN'S. .25-.5-1-2-3-6 MEGAWATT PULSE MODULATORS. CAVITIES. PULSE TRANSFORMERS. IF STRIPS. WAVEGUIDE. BENDS 200 MC. 1 KMC. 3 KMC. 6 KMC. 9 KMC. 24 KMC. RF PKGS.

RADIO RESEARCH INSTRUMENT CO.
550 5TH AVE., NEW YORK 36, N.Y. JU 6-4691

CIRCLE 959 ON READER SERVICE CARD

SEMICONDUCTORS
MAJOR BRANDS

INTERGRATED CIRCUITS • DIF. AMPS DARLINGTONS • POWER DIODES & TRANSISTORS • SPECIAL DEVICES
Write for Catalog S-1
SEMICONDUCTOR SALES OF CALIF.
1063 Perry Annex Whittier, Calif.
(213) 696-7544

CIRCLE 960 ON READER SERVICE CARD

free catalog
POTTING APPLICATORS
MANUAL AND DISPOSABLE
6cc 12cc 30cc
FOR POTTING, ENCAPSULATING, AND SEALING OF MINIATURE COMPONENTS
PHILIP FISHMAN COMPANY
7 CAMERON ST., WELLESLEY 81, MASSACHUSETTS

CIRCLE 961 ON READER SERVICE CARD

SMALL AD but BIG STOCK
of choice test equipment and surplus electronics
Higher Quality—Lower Costs
Get our advice on your problem
ENGINEERING ASSOCIATES
434 Patterson Road — Dayton 19, Ohio

CIRCLE 962 ON READER SERVICE CARD

New Literature

Microwave noise measurement. Spectra Electronics Inc., P.O. Box 85, Los Altos, Calif., 94023, has published a short form catalog illustrating and describing microwave noise measuring instruments.
Circle **461** on reader service card

Direct digital controller. Process Automation, division of E-A Industrial Corp., 2326 S. Cotner Ave., Los Angeles, Calif. An eight-page brochure describes the EA-101 direct digital controller. **[462]**

Digital voltmeter. Electronic Associates, Inc., Long Branch, N.J. Bulletin IC-64140 covers the series 6000-6001 digital voltmeters and the series 6101 digital volt-ohmmeter. **[463]**

Switching diodes. The Philco Corp., a subsidiary of Ford Motor Co., Lansdale, Pa., has issued a data sheet on the L4760-70 series switching diodes that are designed for use as high-speed microwave switches in K-band applications. **[464]**

Instruments and controls. API Instruments Co., Chesterland, Ohio. Bulletin 45 describes four categories of indicating and controlling instruments. **[465]**

Metalized ceramic terminals. Pekay Tool Co., 76 Woolsey St., Irvington 11, N.J. An engineering bulletin contains complete information specifications and dimensions on metalized ceramic housings for resistors, capacitors, diodes and coil components. **[466]**

Tropospheric scatter. Radio Engineering Laboratories, 29-01 Borden Ave., Long Island City, N.Y., 11101, has released a chart and accompanying colored map insert showing its tropospheric scatter equipment in systems throughout the world. **[467]**

Closed circuit tv monitors. Cohu Electronics, Inc., 5725 Kearny Villa Road, San Diego, Calif., 92112. Specifications and technical details on a complete line of high-resolution, closed-circuit television monitors are presented in technical data sheet 6-365. **[468]**

Portable anechoic chambers. The Eckel Corp., 155 Fawcett St., Cambridge, Mass., 02138, has issued an illustrated, four-page specifications booklet on portable anechoic chambers. **[469]**

Power supply. Nexus Research Laboratory, Inc., 480 Neponset St., Canton, Mass., 02021. A single-page bulletin describes the NPS-30, a reference grade regulator designed to supply power to a few amplifiers in small analog systems. **[470]**

Photomultiplier magnetic shields. Magnetic Shield Division Perfection Mica, Co., 1322 No. Elston Ave., Chicago, Ill., 60622. Data sheet 177 illustrates and describes various photomultiplier magnetic shields that can be shorter in length and yet give better protection from magnetic fields than shields previously available. **[471]**

Medical transducer. Scientific Advances, Inc., 1400 Holly Ave., Columbus, Ohio, 43212, has issued a data sheet on a subminiature medical transducer capable of measuring absolute pressures in the range of 26 to 35 inches of mercury with 100% overload capability (23 to 38 inches of Hg). **[472]**

Instrumentation amplifier. Epsco, Inc., 411 Providence Highway, Westwood, Mass. Technical bulletin 016504 covers the model ADS-95 isolated, wide bandwidth, differential d-c instrumentation amplifier. **[473]**

Insertion loss test set. Maury Microwave Corp., 10373 Mills Ave., Montclair, Calif., 91763, offers catalog D on the MT-100A, a dual-channel, d-c comparator insertion loss test set for extremely accurate measurements. **[474]**

Digital printers. Franklin Electronics, Inc., East Fourth St., Bridgeport, Pa., 19405. Bulletin 2050 describes the new series 1200 high-speed digital strip printers. **[475]**

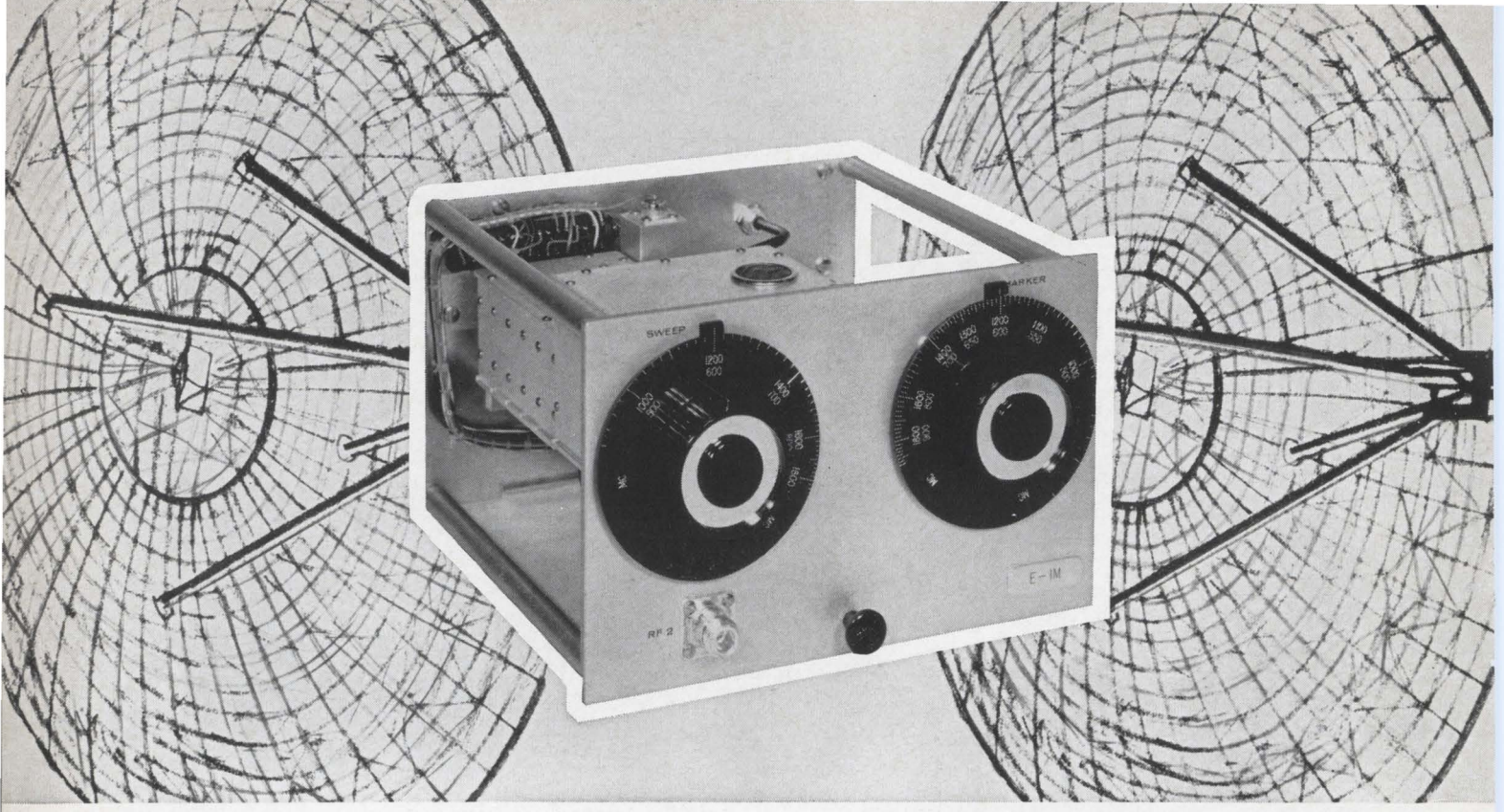
Analog building blocks. Nexus Research Laboratory, Inc., 480 Neponset St., Canton, Mass., 02021. "Building Blocks for Analog" is an 11-page catalog that fully covers a line of analog modules and instruments. **[476]**

D-c power supply modules. Dressen-Barnes Electronics Corp., 250 North Vinedo Ave., Pasadena, Calif., has issued a bulletin on 26 models of three series of unregulated d-c power supply modules. **[477]**

Microwave semiconductors. Microwave Associates, Inc., Northwest Industrial Park, Burlington, Mass., has released a 28-page catalog containing complete electrical and mechanical specifications for mixer and detector diodes, power varactors, p-i-n switching diodes, tunnel diodes and harmonic generator circuit characterized varactors. **[478]**

Laboratory recorders. Honeywell Inc., Wayne & Windrim Aves., Philadelphia, Pa., 19144. Two-page sheet S193-2 illustrates and describes ElectroniK 19 one- and two-pen strip chart lab recorders. **[479]**

Recorder/reproducer. Ampex Corp., 401 Broadway, Redwood City, Calif. Detailed description, features and specifications for the FR-900 5.5-Mc instrumentation recorder/reproducer are contained in brochure 2214. **[480]**



Three low-cost Telonic Plug-in Heads cover .4 to 3 Gc

SWEEP MICROWAVE FREQUENCIES

It's almost like a three-for-the-price-of-one sale. That's about the price difference between the Telonic microwave sweep oscillator heads and everyone else's. Yet, that's only where the savings begin. Because of the preciseness of these Telonic microwave plug-in oscillators, valuable checking time in laboratory and production lines is reduced to a minimum. On one of the plug-in models, the sweep oscillator tube cost is less than $5—a more than impressive saving when compared with approximately $1000 for a BWO. As for accuracy in frequency marking for units under test, an optional variable marker is available. The marker is a tuned oscillator which can be varied over the entire fundamental range of the sweep oscillator. Specific information, including price, on the three models are included within the chart below.

SPECIFICATIONS

	E-1 $750*		E-2 $995*		E-3 $995*	
TYPE	R.F.1	R.F.2	R.F.1	R.F.2	R.F.1	R.F.2
CENTER FREQUENCY	460-920 Mc	920-1840 Mc	600-1200 Mc	1200-2400 Mc	550-1000 Mc	1650-3000 Mc
SWEPT RANGE	435-970 Mc	870-1940 Mc	570-1250 Mc	1140-2500 Mc	530-1040 Mc	1590-3120 Mc
SWEEP WIDTH	0.02-10%		.02-10%		.02-8%	
OUTPUT-R.M.S. INTO 50 OHMS	Band 1- 1v r.m.s.	Band 2- 0.25v r.m.s.	Band 1- 1v r.m.s.	Band 2- .25v r.m.s.	Band 1- .75 r.m.s.	Band 2- .15v r.m.s.

The "E" Series microwave plug-in heads, as well as other models covering specific or broad frequencies between 20 cps. to 3,000 MC, are used in conjunction with the Telonic Sweep Signal control chassis, Model SM-2000.

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Circle 158 on reader service card

May 17, 1965

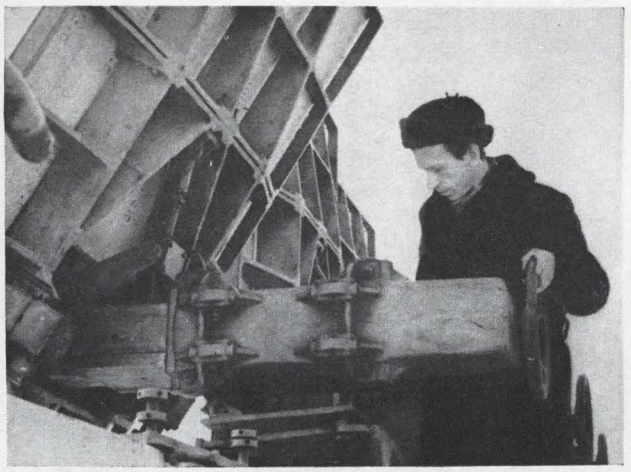
Electronics Abroad

Volume 38
Number 10

Soviet Union

International radio telescope

Soviet astronomers have informally proposed an international project to build a large radio telescope similar to the one at the Pulkovo Observatory near Lengingrad. Astronomers in the West indicate interest—especially in Britain, where a government-appointed committee has urged a $12-million program stressing sophisticated techniques rather than bigger and bigger dishes.



Segment of Pulkovo telescope is adjusted by Soviet technician. Each of the 90 elements must be adjusted individually.

The Pulkovo instrument offers good resolution—down to about 6 minutes of arc at wavelengths between 2 and 6 meters—without the cost of mammoth dishes or huge antenna arrays. It employs two antennas that form a highly accurate interferometer radio telescope. Their resolution is approximately equal to that of an antenna as wide as the space between the two, because an incoming wave's edges contain almost as much information as the entire wave.

Instruments record the incoming signals from each antenna. When the two resulting charts are compared, the direction of the radio source can be determined.

Two views. Its main reflector has a surface consisting of 90 rectangular elements, each 9.5 feet high; the reflector describes a parabolic torus—the shape generated by moving a parabolic contour over an arc of a circle whose center is on the parabola's axis. From above, the reflector's surface is parabolic; from the side, it is circular.

The parabola consists of adjustable elements 4.5 feet wide, each consisting of three steel plates. The outermost plates are angled slightly inward to approximate a section of spherical surface. When a reconstruction is completed late this year, Soviet astronomers say each element will consist of a single curved plate. This should increase the telescope's precision. Signals from the parabolic reflector are intercepted by a central mirror and directed into horn antennas, which feed into receivers.

This antenna scans the sky as the earth rotates on its axis; the other reflector is a steerable parabolic dish with a mesh surface that reduces wind resistance.

Checking on Mariner. As an indication of its precision, Pulkovo has measured the double radio source in the Cygnus A galaxy at 3.2 centimeters, and has corroborated the Mariner satellite's measurements of Venus's heat.

The Pulkovo instrument is not the Soviet's biggest. At Serpukhov, 65 miles south of Moscow, the Lebedev Physics Institute of Moscow is building a Mills cross-type instrument whose east-west arm is one kilometer (0.625 mile) long. The telescope occupies 21 acres.

Sky's the limit. The British committee says its program would result in sky-scanning facilities "unlikely to be surpassed elsewhere in the near future." It would concentrate most of its expenditures on two telescopes, for the radio astronomy centers at Manchester and Cambridge Universities.

At Manchester, Prof. Bernard Lovell operates Jodrell Bank, which contain the world's largest antenna that's completely steerable—a dish 250 feet in diameter. One proposal is to increase Jodrell Bank's resolving power with a large, steerable radio telescope.

Cambridge employs two antennas: a fixed unit 3,350 feet long, and a moveable one that can be placed 1,700 feet away. The Cambridge telescope's resolution is 1° of arc at 8 meters wavelength. A triple paraboloidal radio telescope is under construction at Cambridge; with this system, two fixed paraboloidal antennas 60 feet in diameter are used together with one mounted on rails. Using an aperture-synthesis approach similar to Pulkovo's, this telescope will produce a radio map of the sky equivalent in resolution to one that could be produced with a dish one mile in diameter.

Satellite shift

Lightning 1, the Soviet communications satellite, has been kicked into a higher orbit "to assure communication between Moscow and Vladivostok for longer periods, and at more convenient hours." The perigee was raised to 340 miles from 310; the apogee remains at

slightly under 25,000 miles.

The correction lengthens the experimental satellite's orbit period 12 minutes, to one revolution every 12 hours. The correction apparently was made to halt the satellite's drift westward.

The Russians have not yet replied to a French suggestion that Lightning 1 be used to relay color television signals from Paris to Moscow. Henri Peyroles, general manager of the Compagnie Française de Télévision (CFT), says he expects the Russians to accept the proposal. CFT owns rights to Secam, the French color-tv system.

France

Streamlining at GE

Ever since the General Electric Co. invested $43 million in the French Compagnie des Machines Bull 10 months ago, drastic changes have been expected. One occurred this month: 500 of Bull's 12,000 employees were laid of.

In Paris, company officials linked the move to preparations for switching from punched-tape to magnetic-tape computers. In New York, a GE spokesman attributed it to a streamlining effort. "Bull had three employees per unit sales," he said, "compared with less than two for IBM in France."

The layoffs cut across job categories: engineers, factory workers and marketing men. Nearly all those affected had worked on punched-card products, according to a Paris spokesman for Bull-General Electric.

Business is better. The company insists that business is good. First-quarter sales this year were up 26% from the 1964 period. Bull's principal product, the Gamma 10 computer, has been selling at a 40-a-month pace. But Bull seems committed to magnetic tape; a few weeks ago, in Italy, it introduced the Gamma 115, a tape machine it developed with Ing. C. Olivetti & Co. GE acquired Olivetti's data-processing operations last August.

Besides the French and Italian operations, GE's international computer division includes a facility in Phoenix, Ariz.

Great Britain

Electronic switching

Britain's telephone system is expected to start going electronic next year. British manufacturers are so sure of it that they are already staking a claim to the world market for small-capacity switching systems. They are quietly preparing to produce tens of millions of relays a year, starting with their own government's first big orders.

In 1962, a time-division multiplex exchange went into operation at Highgate Woods, London. It was the first result of cooperative research by five big companies and the General Post Office, which administers the phone service. The experimental exchange was found to be technically satisfactory but too expensive.

Companies that pool their research and patents with the Post Office are Associated Electrical Industries, Ltd., Automatic Telephone and Electric Co., Ericsson Telephones, Ltd., General Electric Co. of England, and Standard Telephones and Cables, Ltd., a subsidiary of the International Telephone and Telegraph Corp.

Time vs. space. Present research is concentrating on space-division multiplex, using reed relays as switching points. The most advanced systems seem to be the small-capacity exchanges being developed by Ericsson and GEC. Ericsson's system uses more matrices, allowing greater traffic-handling capacity; it also employs smaller relays.

Space division employs a separate wire path for each conversation. In time division, logic gates sample several conversations in rapid sequence, then switches connect pairs of telephones in sequence.

Ericsson's system makes more lines available to a subscriber, and is easier to control. Control circuits determine the routing and sequence of connections, and are sectionalized so that one unit can fail without putting the entire exchange out of service. The Post Office has ordered an Ericsson installation for 800 subscribers at Ambersgate in Derbyshire. GEC's system is still being tested by the Post Office at Leamington Spa.

Patents pooled. If present trials are successful, the Post Office will approve the Ericsson system for exchanges of up to 2,000 lines. When one system is approved, the other manufacturers will be allowed to produce it under the patent-pooling arrangement.

At Leighton Buzzard, 40 miles north of London, a larger system will soon be put to the test. It is being developed jointly by Associated Electrical Industries, STC and Automatic Telephone. A space-division multiplex system, it will serve 3,000 subscribers but is expandable to tens of thousands.

Where the buyers are

Britain's campaign to increase productivity and efficiency should also lead to increased profits for electronics companies in the United States. This is the conclusion of a market-testing program conducted by the U. S. Department of Commerce.

After a seven-month market study indicating a rich market for electronic instruments, machine tools and factory equipment, the Commerce Department sent its biggest exhibit ever to the International Engineering Exhibition in London. The theme of the American exhibit was industrial modernization; 80 companies participated.

The outlook. The market survey showed that recent moves by the British government, such as depreciation allowances, had already increased productivity in the metal, petroleum and chemical industries.

The survey expected increases in British imports of control equipment, predicted the 1968 figure will be $31 million, and said American

companies could grab 60% of these orders.

Sales of instruments and control systems in Britain should climb soon to over $200 million a year from $73.9 million in 1962, the U. S.-sponsored study added. U. S. companies now receive about 10% of this market.

The survey showed a strong lead in technology by U. S. companies, particularly makers of instrumentation for the military and space programs. It found British companies strong in development of sensors, controllers, flow convertors and electropneumatic convertors, but lacking a well-rounded line of instruments.

Products and prices. Many of the U. S. exhibitors learned that their equipment costs less than British counterparts. The Dynamics Research Corp., exhibiting in Europe for the first time, says the $160 price of its digital shaft encoder is dramatically lower than the price of British components with resolution comparable to DRC's 3,000 pulses per shaft revolution.

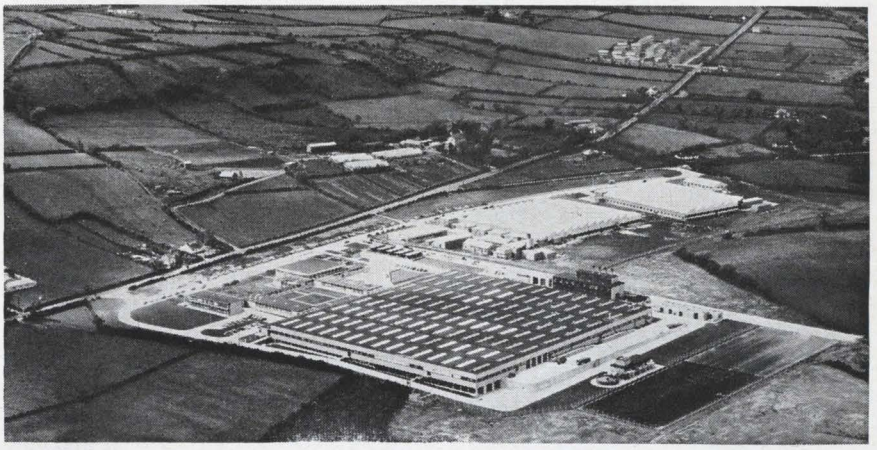
Pleasantly surprised was the Digital Equipment Corp., which sold more than 20 of its low-priced PDP-8 computers to British companies. The U. S. concern says one British customer has ordered one computer a week through 1965.

Low cost helped DIT-MCO, Inc., of Kansas City sell an automatic wiring tester that will check 15 miles of wire in the British-French Concorde supersonic jetliner. The tester, costing only $6,000, will check voltage, resistance and grounding conditions. In eight hours, including setting up and dismantling, it does the work of 200 million manual probe tests over 20,000 electrical terminations. Actual test time is only three hours.

Northern Ireland

Influx of industry

It's the "other" Ireland, the famous six counties that chose to keep their union with Britain rather than join Eire and independence; many people's knowledge of the country is confined to that single fact. Here's another: as a tax haven, an area of cheap labor and relatively high unemployment (6% to 9%), and as an aggressive seeker of manufacturing plants, Northern Ireland is rapidly becoming an industrial center.



New plant of Standard Telephones and Cables, Ltd., an ITT subsidiary, occupies 300,000 square feet in colorful rolling countryside of Northern Ireland. Company expects employment to climb to 2,500 when present expansion plans are completed. At lower right is a soccer field, adjacent to a sports pavilion.

Since World War II, the tiny land with 1.4 million people in 5,242 square miles—half the population of Connecticut in about the same area—has lured 180 concerns to its shores. A government development council in Belfast has representatives in London, Stuttgart and New York who plug the country's willingness to help new industry and its advantages of membership in the British Commonwealth and the European Free Trade Association, also its proximity to the Common Market.

Lure for electronics. Because of its position across the Irish Sea from England, Northern Ireland says it is an ideal base for electronics manufacturers, whose products are small and easy to transport, and of high value.

Companies seem to agree. Standard Telephone and Cables, Ltd., a British subsidiary of the International Telephone and Telegraph Corp., opened a 50,000-square-foot plant near Belfast in 1962, replaced it a year later with one six times as large that employs 1,700 people; and the company plans to expand further. Grundig GmbH of West Germany began making tape recorders in Northern Ireland in 1960, now employs 800 people, and is planning to double the size of its 78,000-square-foot plant. International Computers & Tabulators, Ltd., is keeping a 562,000-square-foot plant busy.

The latest entry is Centralab, Ltd., a joint venture of the Globe Union Co. of Milwaukee and Britain's NSF, Ltd., a member of the Simms Group. Centralab will begin making radio and tv components this summer at a temporary plant while its new 18,000-square-foot facility is being built. It expects to employ 70 persons by 1968.

Inducements. Shortly after the war, the largely autonomous government in Belfast took stock of its economic situation, and was unhappy with the tally sheet. It found high unemployment, industry concentrated on shipbuilding and linen weaving, and difficult accessibility.

It created the development council, planned improvements to the Port of Belfast and the nearby Aldergrove Airport, and enacted some of the most attractive and flexible systems in Europe for government assistance to new industrial plants.

The government offers ready-built factories, also housing, schools, churches and shopping centers. Early this month, the development council reported that 21 plants were under construction or

being planned for future owners.

Taxes are enacted in London for all of the United Kingdom, but Northern Ireland has added inducements. For example, under certain circumstances a company can write off investments against profits to the tune of 130% in its first year of operation. The government also offers capital grants or assistance in financing a new factory and equipment.

Since 1945, the development program has cost the government $237 million. But Northern Ireland considers this a good investment.

Japan

NC step by step

A simplified approach to numerical control of machine tools has enabled Fujitsu, Ltd., to offer a two-axis system for $3,400. Previously its least-expensive two-axis unit cost $6,000. The three-axis version is priced at $5,000, down from $8,500.

In the United States, the Superior Electric Co. announced a two-axis system early this year, priced starting at $4,800.

Because Fujitsu's Fanuc 260 positions one axis at a time, instead of two or three, it can use a single register and less circuitry than other numerical-control systems. Open-loop control simplifies installation since there's no need for feedback devices; the pulse motors are simply mounted onto the machine-tool frame and geared to each lead screw.

Open-loop operation. Fujitsu says both versions of Fanuc, an acronym for Fujitsu automatic numerical control, can perform all positioning operations as well as straight-line milling. A two-axis system can position a drill press or control a milling machine cutting horizontal surfaces. A third axis adds a capacity for programed depth control, permitting a milling machine to be used both on horizontal and vertical surfaces.

Fanuc 260 is built around Fujitsu's electrohydraulic pulse motors, which rotate 1.5° for each pulse from the driving circuit. The motors operate open-loop with no cumulative error. Their maximum response is 4,000 pulses a minute. With usual gearing, every pulse advances the workpiece 10 microns (393.7 microinches) along the tool axis.

No time lost. Controlling one axis at a time, rather than several at once, doesn't mean a slowdown, Fujitsu contends. The company concedes that Fanuc 260's positioning speed of 2,400 millimeters a minute is slower than the maximum for conventional numerical-control systems. But it says those systems lose time when slowing down to a final positioning speed and then creeping up to the programed positioning, whereas the Fujitsu system operates at maximum speed to within one millimeter of the destination.

While positioning one axis at a time restricts contouring to straight-line milling of horizontal or vertical surfaces, these operations account for 80% of all contouring operations, Fujitsu says. Of the remainder, about 15% are oblique and 5% are curved.

Tape input. Systems controlled by dials or pinboards usually allow only about 20 operations on each workpiece. The Fanuc 260 punched-tape input permits programs of almost limitless length. Tape is punched in a standard eight-hole code prescribed by the Electronic Industries Association of the U. S. The tape reader can handle 200 characters a minute.

The basic, no-frills Fanuc 260 can be adapted for specialized jobs with extra equipment.

West Germany

Untangling traffic

Next year, a British computer will try to do what the Munich police have failed to accomplish for a decade: shake out the tangle of trucks, cars, buses and streetcars that clogs the Bavarian capital's narrow streets. It will be Germany's first

truly computerized system for traffic control.

Initially, the plan will be confined to the bustling Karlsplatz, where traffic converges from six directions. A specialized computer, made by Elliott-Automation, Ltd., for $350,000, will select programs from a repertoire of 40 that control the timing of traffic lights.

Field reports. Every second, the computer will query each of 130 traffic detectors consisting of photoelectric cells, radar, and ultrasonic detectors. From this information, it will decide which program will permit each green light to stay on as long as possible without obstructing traffic too long in other directions. If the computer should fail, the lights would go back to the present system.

The computer's storage capacity is 8,192 words of 18 bits each. The memory consists of conventional ring-core storage elements. There are 256 signal inputs and 64 outputs.

Within the next few years, Munich traffic planners hope to extend the computer controls to other downtown streets.

Around the world

Italy. The International Business Machines Corp. will build a computer plant soon in Vimercate, near Milan. The facility will occupy 263,000 square feet and employ more than 1,200 workers to produce the Model 20, smallest unit in IBM's System 360 line. The company declines to disclose the cost.

Taiwan. The Republic of China has opened a "multimillion-dollar" microwave radio network. No cost has been given, but the Collins Radio Co. says its share of the project was about $9 million.

Lebanon. Telephone service has begun over Lebanon's first microwave communication link, 50 miles between Beirut and Tripoli. Installed by the General Telephone & Electronics Corp., the $250,000 system eliminates delays that had held up phone calls as much as five hours.

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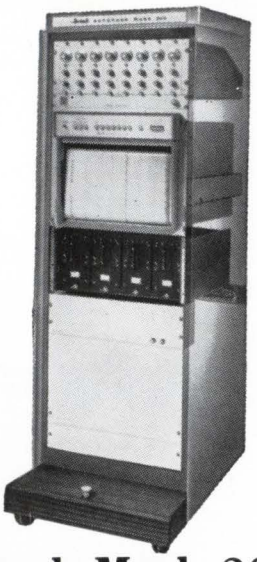

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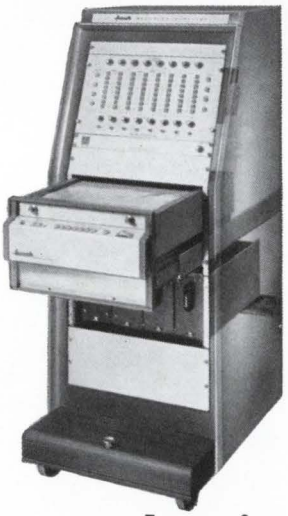

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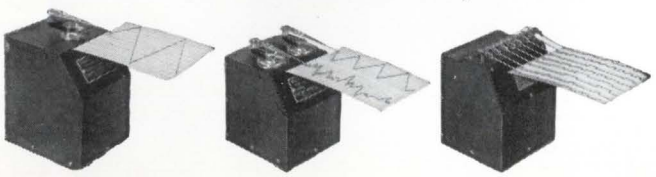

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