A McGraw-Hill Weekly 75 Cents May 31, 1963

electronics

SHORT PULSE, SHARP RETURN

New radar resolves three-inch range, p 36

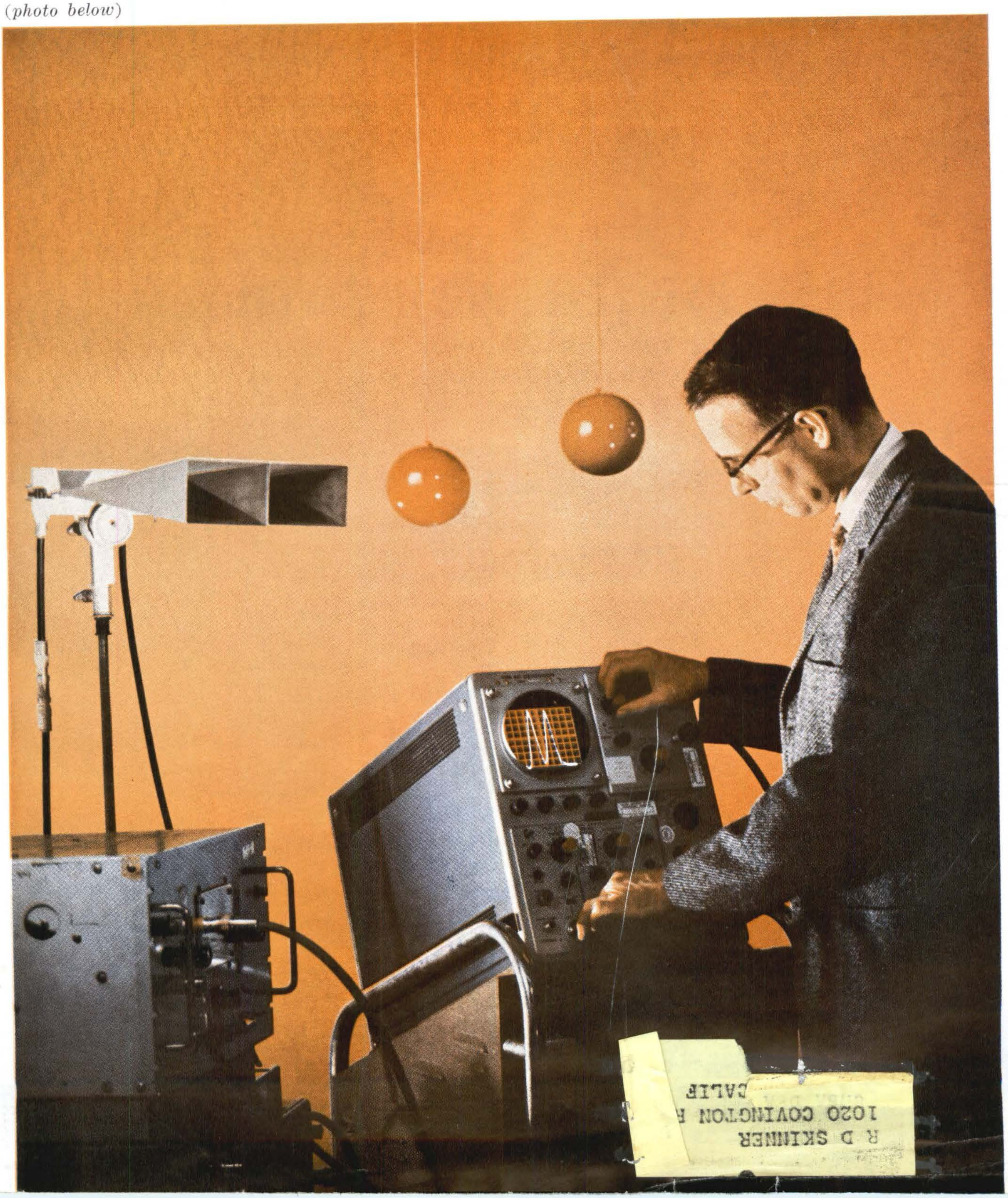
(photo below)

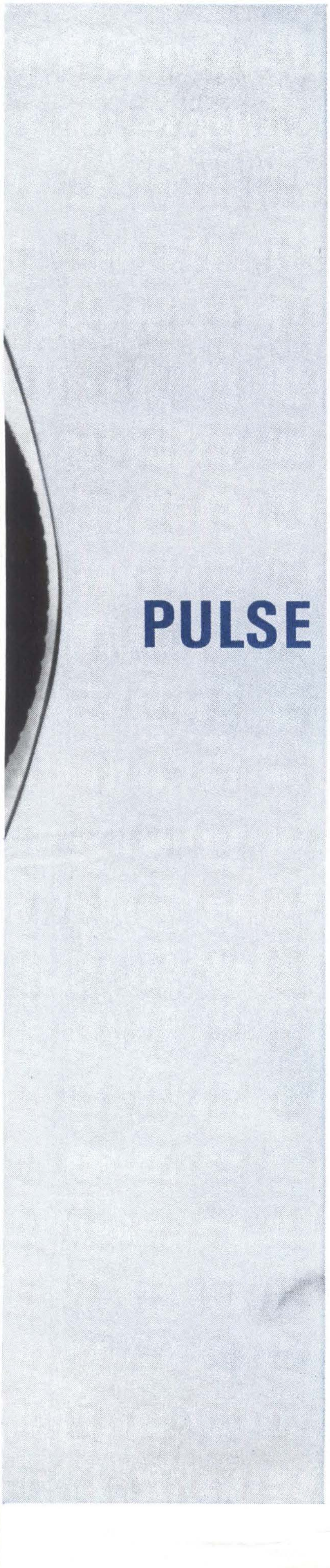
INTRODUCING THE NRE

Details on a new circuit component, p 21

FIXING CIRCUITS IN OUTER SPACE

Future satellites need not stay dead, p 12





SPECIFICATIONS

Source Impedance:	50 ohms on 50 v range and below
Pulse Shape:	RISE AND FALL TIME—Less than 13 nsec on 50 v range and below; typically less than 10 nsec for maximum vernier attenuation; typically 15 nsec on 100 v range
	PULSE AMPLITUDE—100 v into 50 ohms; calibrated attenuator to 0.2 v plus vernier
	POLARITY—Positive or negative
	LEADING AND TRAILING EDGE OVERSHOOT—Less than 5%
	PULSE TOP VARIATIONS—Less than 4%
	PULSE DROOP—Less than 5%
	PRESHOOT—Less than 2%
	PULSE WIDTH—0.05 μsec to 10 msec, continuously adjustable
Rep Rate Trigger and Timing:	INTERNAL—Repetition Rate: 10 cps to 1 mc, continuously adjustable; pushbutton for single pulse
	EXTERNAL—Repetition Rate: dc to 1 mc, controls allow selection of level and slope; sensitivity: greater than 1 v
	TRIGGER OUTPUT PULSE—Continuously adjustable 0 to 10 msec in advance or delay of output pulse; amplitude, 10 v into 1000 ohms; jitter less than 0.05%
	MAXIMUM DUTY CYCLE—100 v and 50 v range, 10%; 20 v range, 25%; 10 v range and below, 50%
Power:	115 or 230 v ±10%, 50 to 60 cps, 325 watts
Dimensions:	16¾" wide, 7¼" high, 18⅜" deep; hardware furnished for quick conversion to 7" x 19" rack mount, 16⅜" deep behind panel
Weight:	Net 35 lbs.
Price:	$875

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

PULSE POWER (100 v, 2 a into 50 ohms)

- **50-ohm source impedance**
- **Less than 15 nsec rise and fall times**
- **Positive and negative pulses, dc coupled**
- **Double pulse feature**
- **Pulse burst capability**

This new Hewlett-Packard pulse generator delivers positive or negative 100 volt 2 amp pulses into 50 ohms with rise times of 10 to 15 nanoseconds. What's more, it offers controlled pulse shape, external trigger slope and level selection and a 50-ohm source impedance for elimination of errors arising from reflections.

The high power output of the 214A is four times the power available from previous pulse generators. At output levels below 50 volts, the 214A has a matched source impedance of 50 ohms, eliminating error-producing reflections. Reflections from the circuit under test are absorbed in the 50-ohm source impedance, and the output pulse is always clean, even though the impedance of the circuit under test may be complex. At reduced output levels the duty cycle may be as high as 50%, ideal for square wave testing.

Pulse repetition rate is continuously adjustable to 1 mc, and pulse characteristics are carefully controlled. Pulse rate, width and delay jitter are kept to a minimum to assure accurate, dependable test results.

The 214A offers an extremely wide range of trigger syncing for triggering on external signals. It will trigger on external signals as small as 1 volt peak, either polarity, and slope and level may be selected so that triggering occurs at a given point on the trigger waveform. The instrument also provides a trigger output for use in synchronizing external equipment.

The pulse generator may be gated on, to provide bursts of pulses, and a double pulse feature is provided for pulse resolution tests of amplifiers and memory cores.

Ask your Hewlett-Packard representative for a demonstration on your bench.

8437

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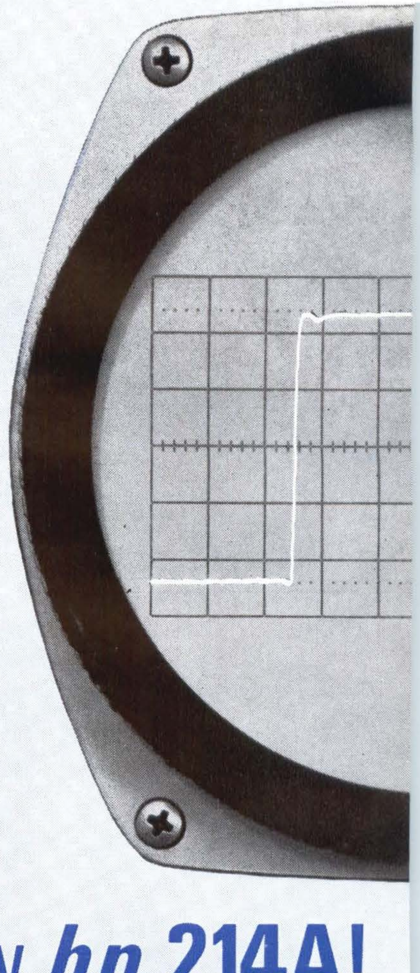
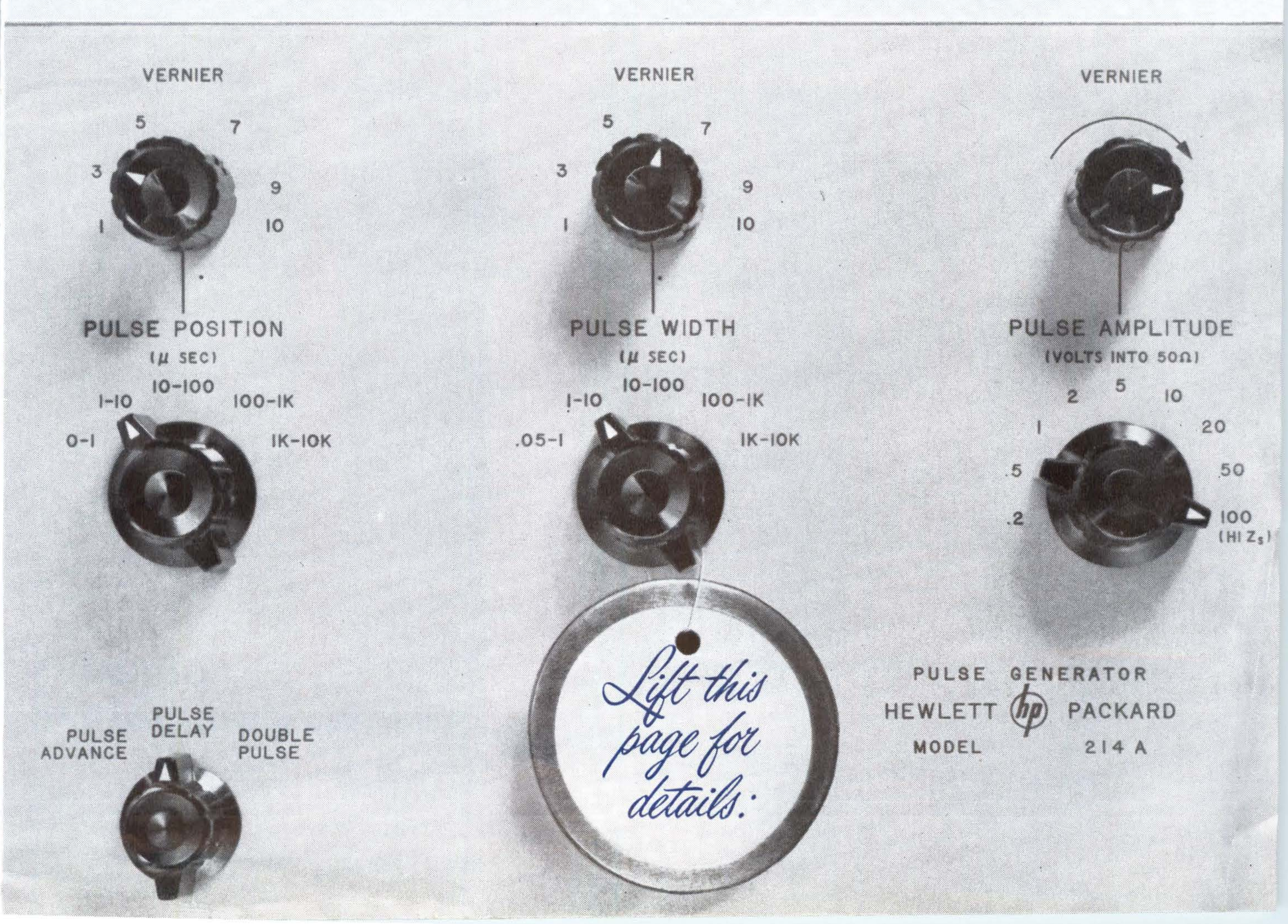
CIRCLE 900 ON READER SERVICE CARD

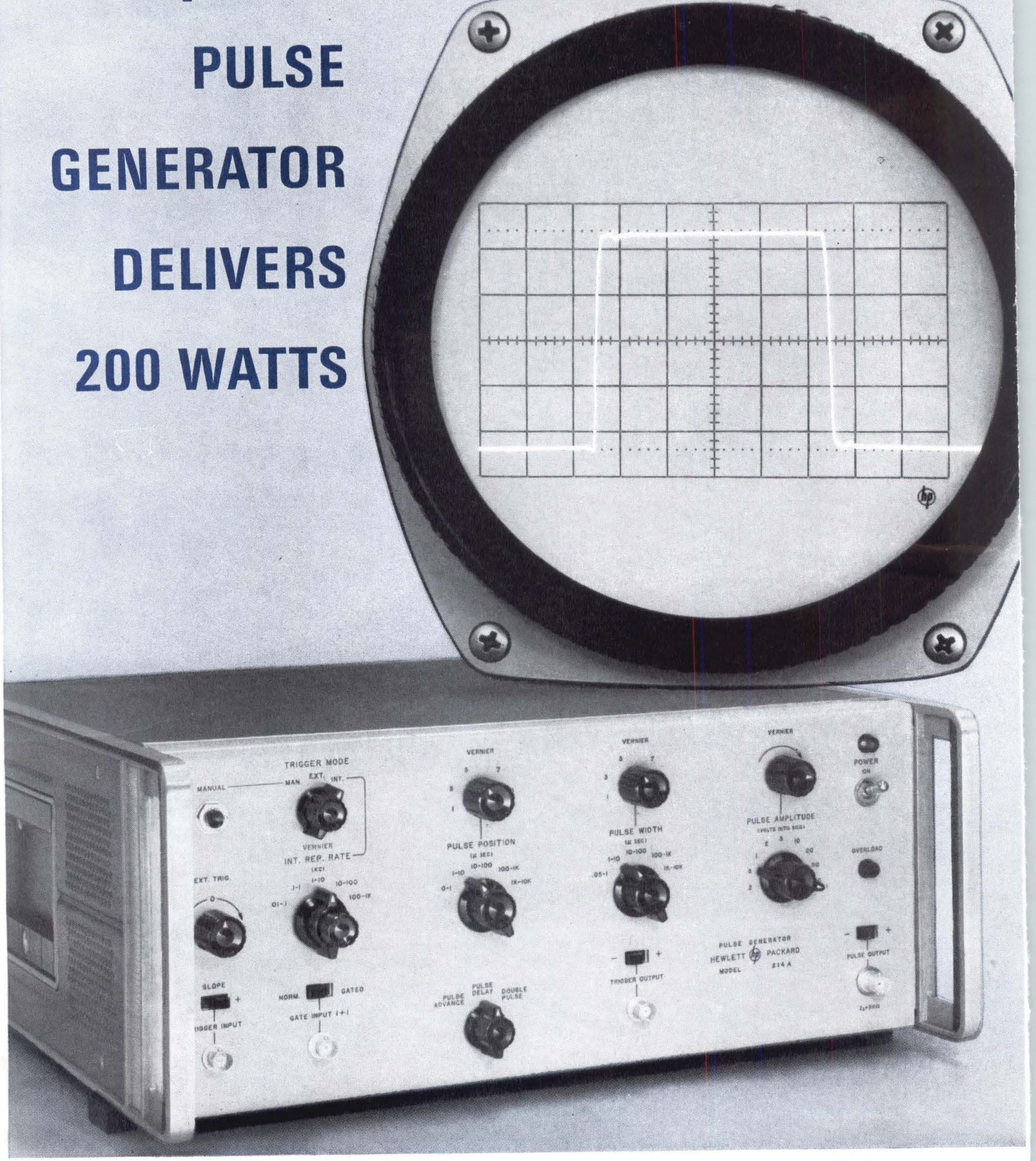


POWER PACKED PULSES 200 WATT!

PULSE POWER from the new *hp* 214A!



hp 214A PULSE GENERATOR DELIVERS 200 WATTS



May 31, 1963

electronics

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Contents Continued

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CONTENTS Continued

DEPARTMENTS

Information: The Whole Picture

A WELCOME CONTRIBUTION to better understanding of scientific and technical communications problems—both in and out of government—and of steps that can be taken to meet those problems — —

That's what President Kennedy says in his foreword to the so-called Weinburg report, "Science, Government and Information," by the President's Science Advisory Committee.

However, the report concentrates on only three phases of the technical information transfer: professional society journals, abstract services and information centers. In these areas, the report makes some good suggestions.

But the report fails to present the whole picture. Worse, it almost ignores a prime mover of fresh technical information—the commercial technical magazine.

Information centers, abstract services and professional journals are essential, but they are most useful if you know, in general, what you are looking for. The scientist or engineer must frame his questions to the information center. When he subscribes to a specialized abstract service, or when he joins a professional society or group he has in effect zeroed in on a field of interest.

The user must know what he wants. And this is where these services fall short. They do not create the desire to know and they tend to confine the mind of the scientist or engineer within the range of his specialty.

What is missing is the cross fertilization of knowledge that has so often been responsible for scientific and technical innovation.

We submit that the commercial technical publication is an essential vehicle. A good commercial technical magazine creates broad interest by continually stressing the novel and useful, and by reporting on new technical needs. It invites interest and readership by its varied contents, layout and presentation. Thus, it brings important related scientific and engineering work to the attention of many who might otherwise have missed that work.

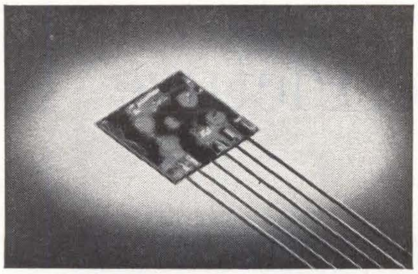
Commercial magazines form an essential link in the chain of information transfer—as indeed also do hard-cover textbooks at the other end of the spectrum.

Unlike the professional journal, abstract service or information center, the commercial technical magazine does not require direct or indirect monetary support from government, as the Weinburg report recommends for those three classes of information services.

However, the government and the scientific community should acknowledge formally and constructively the value of good commercial technical magazines as an essential and perhaps the first step in the information-transfer chain and do everything possible to encourage the flow of technical information to such publications.

Specifically, when the technical magazine editor requests information on new developments from a government or industry source, unnecessary military or proprietary secrecy should be removed. Engineers and scientists should be encouraged to disclose the results and significance of their work to qualified technical reporters without fear of reprisals such as being denied publication of their full article in a professional journal.

The transfer of information is a many-faceted process. Let's not concentrate so much attention on so few parts that we interrupt the smooth functioning of the whole system.



COMMENT

Outer Coupling Capacitor

In *Components and Materials* for Jan. 18 (p 62), J. M. Rollett describes a crude but effective means for providing d-c isolation in the outer of coaxial line circuits. This suffers from a serious resonance due to lead length which occurs at 50-100 Mc.

A useful technique for overcoming this has been tried in these laboratories. It consists of lapping the flanges and separating them by a thin PTFE film. Using the size of flange mentioned in the article (1.125 inches diameter with 0.625-inch diameter hole in the middle) and ¼ thou. film, the capacitance so formed is 1,500 pf. Low-frequency performance is as in Rollett's article, except the frequency scale is multiplied by 10. If the size of the flanges is not limited by other equipment, an increase by a factor of 3.16 would produce a capacitance of 0.015 μf, this giving the same low-frequency performance as in the article.

High-frequency limitation is when the radial length of the flange is longer than ¼ λ; at this dimension it looks like a short circuit giving perfect coupling. The device certainly operates at frequencies in excess of this; that is, greater than 6.8 Gc for the 1.125-inch flange or 2 Gc for the 3.5-inch flange.

S. S. HARTLEY
M. K. MCPHUN
Central Electricity Research Laboratories
Leatherhead, Surrey
England

Author Rollett replies:

Mr. Hartley and Mr. McPhun describe two components, one of small diameter (1.125 in.) for higher frequencies, and one of large diameter (3.6 in.) for lower frequencies.

For higher frequencies, outer coupling capacitors are available commercially, for example Microlab type HR 51, with vswr 1.2 maximum between 500 Mc and 10 Gc; it therefore seems pointless to construct them.

For lower frequencies, the component described by the readers suffers from these disadvantages: (a) large diameter (3.6 in.) would make it extremely cumbersome in normal work, and impossible to use in the situation described in the fifth paragraph of my article; (b) the difficulties of construction using a large area of ¼ thou. PTFE are considerable, if not prohibitive; (c) the fragility of the film would make the component unlikely to stand up to normal laboratory usage —useful components should withstand being plugged together and unplugged many thousands of times without mishap.

Thus, the readers' low-frequency component is too large, too hard to make and too fragile to be practical. In contrast, the component described in my article is small, easy to make and very robust; moreover, such components have been in use for over two years in three different research establishments!

J. M. ROLLETT
Government Post Office
London, England

Readers Hartley and McPhun comment:

The conflict between Mr. Rollett and ourselves appears to lie in the difference of application. We are using tunnel diodes at about 500 Mc and require low vswr over a wide bandwidth. This is of course just at the changeover frequency from Mr. Rollett's coupler to the Microlab version, and necessitates a different design.

Obviously we agree that for Mr. Rollett's specialized application, our device is too large, but we take issue with him when he says it is "too hard to make and too fragile to handle." We arranged for our workshops to make one of a mechanical form suitable for Mr. Rollett's work using ordinary workshop techniques, but putting the PTFE film in place in the laboratory away from steel dust, etc. The unit was complete within an afternoon and has stood up to deliberate rough handling.

The coupler should be at its best at 10 Gc and at its worst at 20 Gc.

S. S. HARTLEY
M. K. MCPHUN

REVERSE POWER RATED

25 AMPERE CONTROLLED AVALANCHE SILICON RECTIFIERS

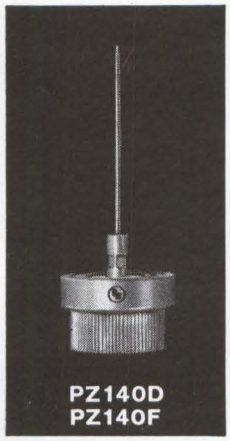
ADDED RELIABILITY AT LOWER COST

■ Especially designed to operate in the avalanche region. Conservatively rated for extra protection against surges and avalanche breakdown. Built-in transient protection for inductive switching applications.

■ Reliability demonstrated by exposure to periodic surges exceeding 3,000 amperes in 100KV clipper service.

■ Even at a case temperature of 150°C, Tung-Sol PZ140's can handle current overloads as great as 400 amperes.

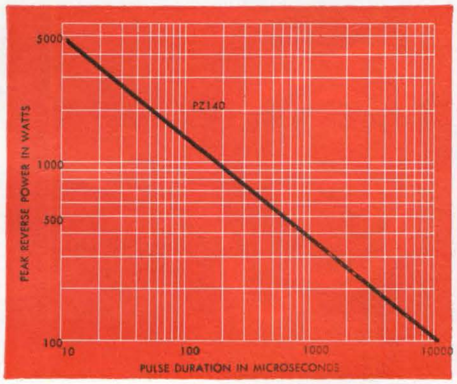
■ Sharply defined reverse breakdown characteristics and reverse power handling capacity make PZ140 rectifiers ideal for high-voltage series stringing. Individual R-C balancing networks are not required.



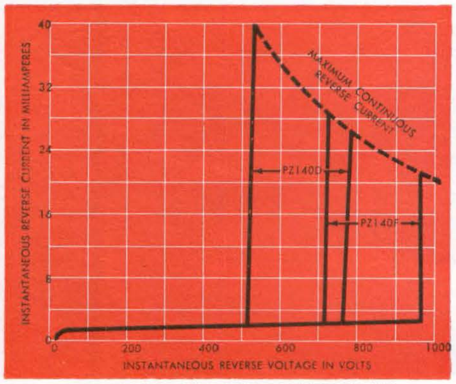
■ Priced in the range of 12 ampere types and lower than conventional 25 ampere rectifiers without reverse power rating.

■ Pressure fit construction provides added savings in assembly costs. Available in both polarities—one heat sink can carry two rectifiers.

■ Write for Bulletin CT22. Tung-Sol Electric Inc., Newark 4, N. J. TWX:201-621-7977.



RANGES OF REVERSE CHARACTERISTICS OVER ENTIRE OPERATING TEMPERATURE RANGE



RATINGS AND CHARACTERISTICS
(60 cps, Inductive or Resistive Load, Single Phase Half Wave)

	PZ140D	PZ140F	UNIT
Maximum Working Peak Reverse Voltage	400	600	Volts
Maximum Working RMS Voltage	280	420	Volts
Minimum Avalanche Breakdown Voltage	500	700	Volts
Maximum Avalanche Breakdown Voltage	750	950	Volts
Maximum Continuous Power Dissipation in Avalanche Region	10.0	10.0	Watts
Maximum Peak (square wave) Power Dissipation in Avalanche Region 10 Microsec. duration	5000	5000	Watts
Maximum Average Forward Rectifier Current at 100°C Case	30	30	Amperes
at 140°C Case	25	25	Amperes
Maximum Peak One-Cycle Surge Overload Current (Superimposed on Full Load)	400	400	Amperes
Operating Temperature Range	−50°C	−175°C Case	

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Sales Offices: Atlanta, Ga.; Columbus, Ohio; Culver City, Calif.; Dallas, Tex.; Denver, Colo.; Detroit, Mich.; Melrose Park, Ill.; Newark, N.J.; Seattle, Wash. In Canada: Abbey Electronics, Toronto, Ont., Canadian Electronics Ltd., Edmonton, Alta.

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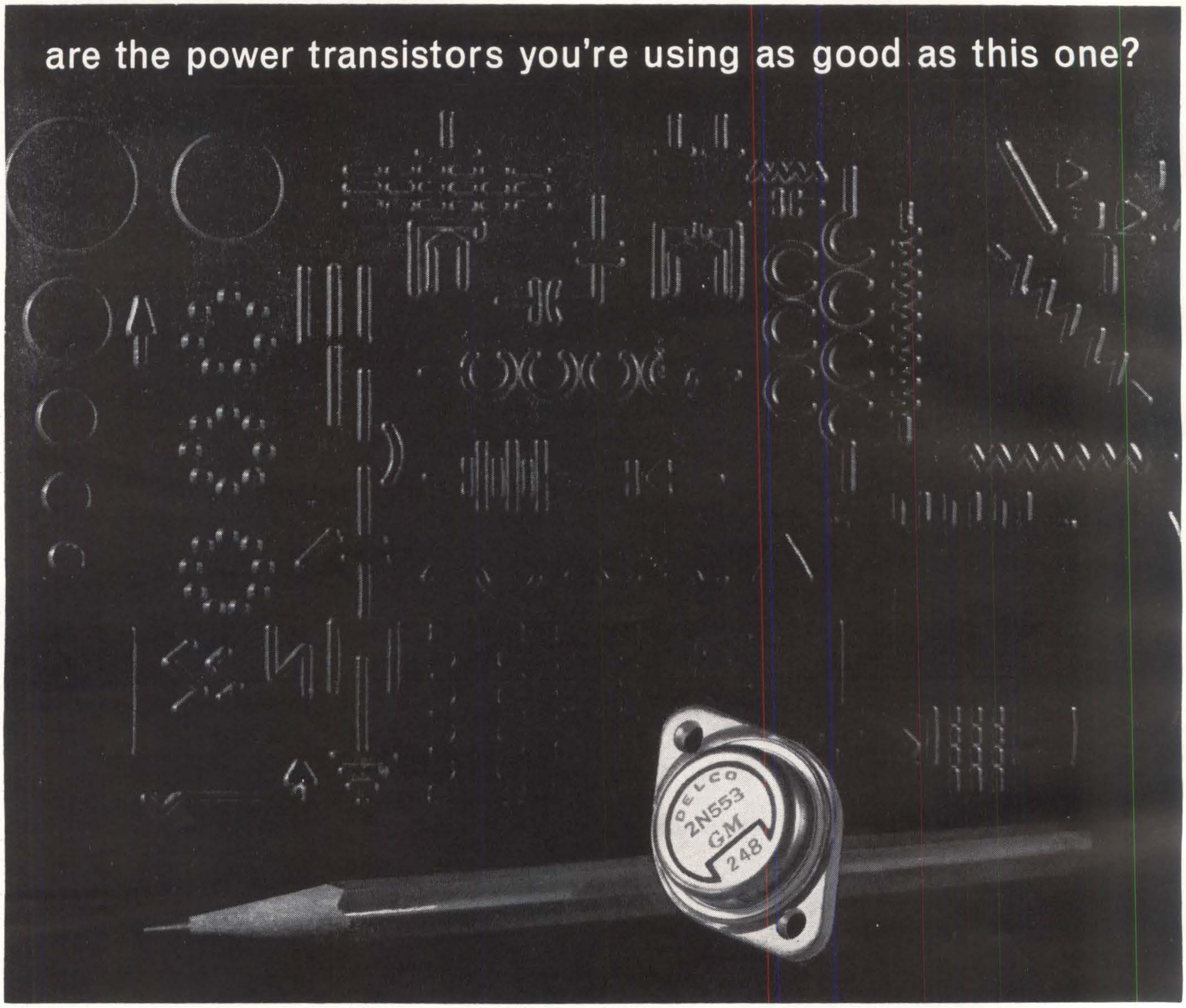

Meet the Delco Radio family of 2N553 high power transistors. This group gives you a wide selection of highly reliable 4-5 amp. power transistors. The perfect choice for direct coupled circuits because of their extremely low collector diode bulk leakage current. Regulator applications? None better than Delco's 2N553. These units have unique thermal stability. Order a handful or a carload and you get uniform high quality. Prove it to yourself and improve your product as a bonus. Contact one of our Sales Offices listed below or your nearby Delco Radio Semiconductor Distributor.

Type	I_C Max Amps	V_{CEO} @ I_C Volts @ Amps		V_{CBO} @ I_{CBO} Volts @ ma		h_{FE} @ I_C Amps		V_{EBO} @ I_{EBO} Volts @ ma		V_{CE} (sat) @ I_C Volts @ Amps		V_{BE} Volts	fae kc	Thermal Resistance
2N553	4	40	.300	60	2	40/80	.500	40	2	0.9	3.0	1.5	25	1.5° C/watt
2N663	4	25	.300	50	12③	25/75	.500	20	4	1.0	3.0	1.5	15	2.0° C/watt
2N665	5	40	.300	80	10	40/80	.500	40	2	0.9	3.0	1.5	20	2.0° C/watt
2N665 Sig C	5	40	.300	80	10	40/80	.500	40	2	0.9	3.0	1.5	20	2.0° C/watt
2N297A	4	40	.300	60	3	40/100	.500	40	3	1.0	2.0	1.5	2	1.5° C/watt
2N297A Sig C	4	40	.300	60	3	40/100	.500	40	3	1.0	2.0	1.5	2	1.5° C/watt
2N1971	4	40	.300	60	2	25/60	.500	40	2	0.9	3.0	1.5	25④	1.5° C/watt
2N256	3	30①	.003②	30	3④	15	.500	30	8	1.0	1.0		100⑤	2.0° C/watt
2N307	3	35①	.015②	35	5④	20	.200	10	2	1.0	.200		3	2.0° C/watt

① V_{CER} ② I_{CER} ③ @ 85°C ④ Typical ⑤ fab

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DEPENDABILITY RELIABILITY

Division of General Motors, Kokomo, Indiana

Is Midas Making a Comeback?

ALTHOUGH STILL unannounced by the Defense Department, a missile-detecting satellite was sent up by the Air Force on the same vehicle that put up the West Ford dipole belt a few weeks ago. Presumably this was Midas, the Missile Defense Alarm System satellite that was in trouble back in January due to difficulties with the infrared sensors (p 7, Jan. 18; p 7 and 10, Feb. 1, and p 7, Feb. 8). The program was cut back at that time, and work on one of the ground stations (The Naval Air Station at Ottumwa, Iowa) for the system was stopped. The new satellite is said to be operating well, picking up hot spots in a satisfactory manner and relaying the data to the ground.

Any speedup of the Midas program would probably hang more on political than technical considerations. Whatever decision is made, it is a good bet it will be made quietly. Since the U-2 incident, the government has been hypersensitive about this area. Lockheed is prime contractor for Midas.

Industrial Accounts Lure Distributors

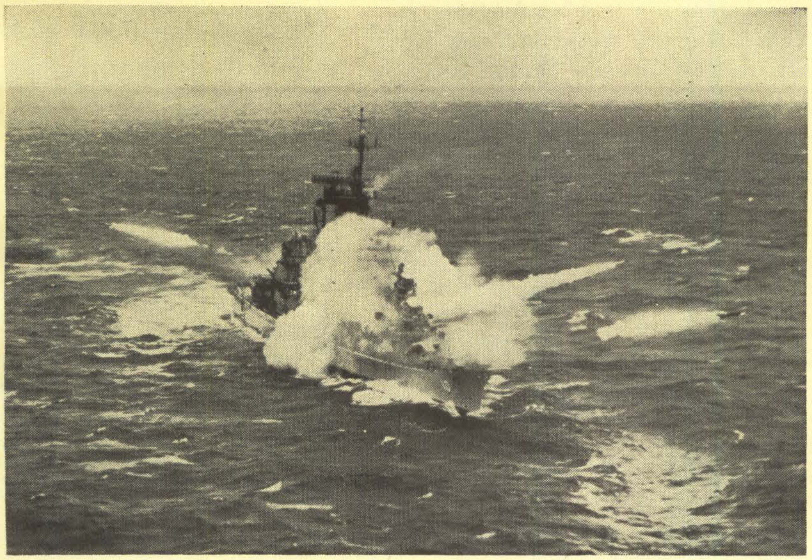
CHICAGO—More and more electronic distributors are handling industrial accounts and finding it takes more technical know-how to do so. That was the consensus at executive conferences of the Electronic Parts Distributors Show here last week.

Less than half the distributors surveyed two years ago had industrial accounts. Now, 7 out of 10 do. More than 90 percent of these added new industrial accounts last year. Nearly 40 percent reported industrial sales of components running more than half of their total sales.

Key Changes Studied For Future Tiros

TIROS weather satellites may be modified to take continuous cloud cover pictures of the entire planet every three days, where the first satellites permitted observation of only 12 to 25 percent of the earth. Possibly beginning with Tiros 9, the satellites would have two tv cameras mounted 180 degrees apart pointed outward from the base and would be launched into a 400-mile polar orbit spinning sidewise like a wheel. To optimize photography, a magnetic attitude control system using a coil of 250 turns of fine wire, 12 resistors and a switch, and consuming 30 mw, will manipulate the spin-axis. NASA awarded a $100,000 evaluation contract to RCA Wednesday.

3-D Radar Finds 3 Targets for 3 Missiles



USS ALBANY *fires two Talos and a Tartar missile simultaneously. Multiple firing was assisted by Frescan 3-D radar. Radar, developed by Hughes Aircraft, uses electronic scanning to locate many targets with a single antenna*

Thermo-Photovoltaic Power Generated

ATLANTIC CITY, N. J.—Germanium and silicon photocells powered by a propane-fueled silicon-carbide radiator have been used by General Motors to generate a usable quantity of thermo-photovoltaic power. A dozen radio receivers were operated simultaneously and with ease, even under conditions of gross spectral mismatch, reported J. Werth, of GM, at the Power Sources Conference here last week.

With the radiator temperature reduced to 1,200 C, and the germanium cells replaced by silicon, adequate power for the receivers could be derived from less than 3 cm^2 of effective cell area, Werth said. The investigations also showed that selective reflection as a method of matching germanium cells to a gray body radiation operating at a surface temperature of 1,400 C or less, has a potential relative spectral efficiency of 70 percent.

In a panel discussion, G. C. Szego, of the Institute for Defense Analy-

DUMMIES WITH BRAINS

Life-size robot figures that talk and move realistically will be featured in GE's exhibit at the 1964-65 World's Fair in New York. The figures will be animated by a preprogrammed seven-track tape utilizing techniques and components developed for sequencing the Polaris missile, according to Walt Disney Enterprises, which designed the display. The GE exhibit will also feature an actual demonstration of thermonuclear fusion.

sis, suggested using fuel cells in vehicles, particularly in Army trucks and tanks. Separate electric motors in each wheel would be driven from the power cell.

Laser-Sharp Tolerances May Boost Quality

CHICAGO — Lasers and associated circuitry may drastically tighten industry's production tolerances, Harry Kiefaber, of the Sheffield Corp., predicted last week at a meeting here of the American Society for Quality Control.

Using light energies expected from lasers or equivalent devices, "one will be able to focus and measure from a point with a surface area of 10^{-10}," he said. Future improvements in optical and electromechanical gratings will provide resolutions of 0.0001, or an accuracy of 1 light band, Kiefaber said.

Cargo Glider Augurs Boom in Radio Items

LARGE MARKET for beacon and radio guidance equipment may result from an air-cargo delivery system being developed for the Army by Ryan Aeronautical Co. Intended for combat conditions, the system employs an aluminum container suspended below kite-like flexible wings.

The glider will be towed to the delivery area by helicopter and then released. A homing beacon or radio control system operated by a ground or helicopter-borne soldier, will guide the throw-away craft to the target location on the ground. A system of cables connected to cams provides longitudinal and fore-and-aft control. The work by Ryan is part of a $2-million contract awarded to the firm for flex-wing developments, including a flex-wing manned utility vehicle. The glider has been tested successfully at Yuma, Ariz., the Army said.

New Hawk Missile Slated for Army

BOSTON—A multi-million dollar new Hawk missile program for the Army is in the works. Raytheon, prime contractor for the original missile, will also produce the ATBM Hawk (Anti-Tactical Ballistic Missile). Original Hawk is a mobile ground-air weapons system for protection of field armies against aircraft, particularly low-flying aircraft, but in field tests it has knocked down missiles, including the Honest John, Little John and Corporal. ATBM Hawk will be designed specially as an anti-missile weapons system.

Raytheon, RCA and Hughes Aircraft have each received $500,000 for separate studies on the technical feasibility of new field Army air defense system for 1970's (AADS-70). Studies will stress defense against tactical missile threat in 1970's.

Australians Blast U. S. Radio-Base Deal

MELBOURNE—The Labor Party here has sharply criticized the treaty with the U. S. providing for the establishment of a U. S. Naval vlf radio base at North-West Cape in western Australia (p 20, Jan. 4). The Laborite attack came after the Government revealed the U. S. insists on sole control of the station, to be used for communicating with atomic submarines.

In Brief . . .

AGREEMENT for a cooperative program in nuclear studies has been signed by the U. S. and the Soviet Union.

TV OF THE FUTURE will be able to bypass the human eye and send electronic impulses directly to the brain, enabling the blind to "see", predicts Allen B. Du Mont of Fairchild Camera.

AEC FLIGHT-TESTED a space reactor mockup from Wallops Island, Va. last week to see if it would break up and disintegrate upon reentry into the atmosphere. Preliminary data indicated that it did, AEC reported, but the vehicle will have to be recovered before this can be confirmed.

VARO is receiving an $8,542,950 contract from the Army for 1,500 infrared searchlight sets for use on tanks.

RUSSIA has launched Cosmos 17, an earth satellite carrying unidentified scientific apparatus.

14 OF 15 West European nations attending a telecommunications conference in Paris last week favored joining the U. S. in a worldwide satellite communications system. France was the lone dissenter.

$19-MILLION contract for decoy subsystems to be carried by ICBM's has been granted Ford Motor Co. by the Air Force.

WEST FORD'S orbiting dipole belt has been used to transmit voice messages "of telephone quality" from California to Boston, the Air Force reports.

STARTING IN JULY, Motorola will offer a course in integrated circuits at its Semiconductor Products Division in Phoenix.

MERGER of Emerson Electric Co. and Rantec Corp. has been approved by the directors of both companies.

CBS IS BUYING 44 image-orthicon tv cameras from Marconi.

CONGRESS will complete action any day now on an "equal pay for women" bill, which President Kennedy is considered certain to sign.

New from Sprague!

2×μF

Get nearly twice the capacitance of older designs in Sprague's new high-gain etched-foil TANTALEX® Capacitors

IMPROVE FILTERING EFFICIENCY WITH NO SACRIFICE IN RELIABILITY, SIZE, OR WEIGHT!

HIGH CAPACITANCE Tubular Tantalex Capacitors with almost double the capacitance of standard etched-foil tantalum capacitors have been developed by the Sprague Electric Company to meet the needs of design engineers.

A new etching technique, the result of an intensive research program, gives considerably higher effective surface area to the capacitor electrodes *without sacrifice in reliability or in any of the electrical parameters* by which foil tantalum capacitors are usually judged.

Unlike other "high capacitance" foil tantalums, Sprague Tantalex Capacitors continue to maintain their rigid standards for shelf and service life under severe environmental conditions. Certain performance characteristics have actually been tightened. For example, allowable leakage current has now been halved, making the use of these capacitors possible in many new applications.

Etched-foil Tantalex Capacitors are available in two operating temperature ranges—polarized Type 112D and non-polarized Type 113D for −55 C to +85 C operation, as well as polarized Type 122D and non-polarized Type 123D for −55 C to +125 C operation.

The Foil-type Tantalex Capacitor Line also includes conventional low-gain etched-foil and plain-foil capacitors in both polarized and non-polarized construction, providing a foil tantalum capacitor for every application.

For complete technical data on 85 C capacitors, request Engineering Bulletin 3601B. For the full story on capacitors for 125 C operation, write for Engineering Bulletin 3602B. Address Technical Literature Section, Sprague Electric Company, 35 Marshall Street, North Adams, Massachusetts.

SPRAGUE COMPONENTS

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4S-402

SPRAGUE®
THE MARK OF RELIABILITY

WASHINGTON THIS WEEK

RS-70 MOVES CLOSER TO CANCELLATION

EVEN IF THE RS-70 aircraft's radar system can be developed before 1970, the outlook is that Defense Secretary McNamara intends to cancel the project as soon as the political climate will allow it.

A high-level Air Force source claims Air Force has demonstrated to McNamara's office that the RS-70's high-data-rate, sharp-resolution radar system (ELECTRONICS, p 18, Feb. 1) could be developed well before 1970. McNamara and the Office of the Director of Defense Research and Engineering have contended that "we could not have such a system early enough to produce an operational RS-70 force capable of useful reconnaissance strike before 1970."

His position now boils down to, the Air Force source says, "there is no requirement for the RS-70."

SBA HEEDS DISTRIBUTOR PROTESTS

SMALL BUSINESS ADMINISTRATION'S proposed new dollar definition for small businesses is likely to be revised upward to satisfy vehement protests from distributors of electronics, electrical equipment and machine tools. For federal procurement purposes, SBA wants to set aside the 500-employe standard and call a small business one whose three-year average of annual gross sales or receipts does not exceed $2 million. Distributors contend the figure is too low, would eliminate many of them from the small business set-aside program.

NEW FCC RULES TO LIFT A-M STATION FREEZE

FCC HAS TAKEN a first step in its effort to get a grip on the population explosion in a-m radio. It proposes putting a ceiling on the number of a-m and f-m stations in each community and to ween f-m and a-m programming. The commission will receive comments on its plans through July 17. When it makes its proposals, or some form of them, final, it will lift the freeze on new a-m assignments that was slapped on a year ago. The proposals reflect a growing opinion that f-m is reaching a point where it can be self-sustaining.

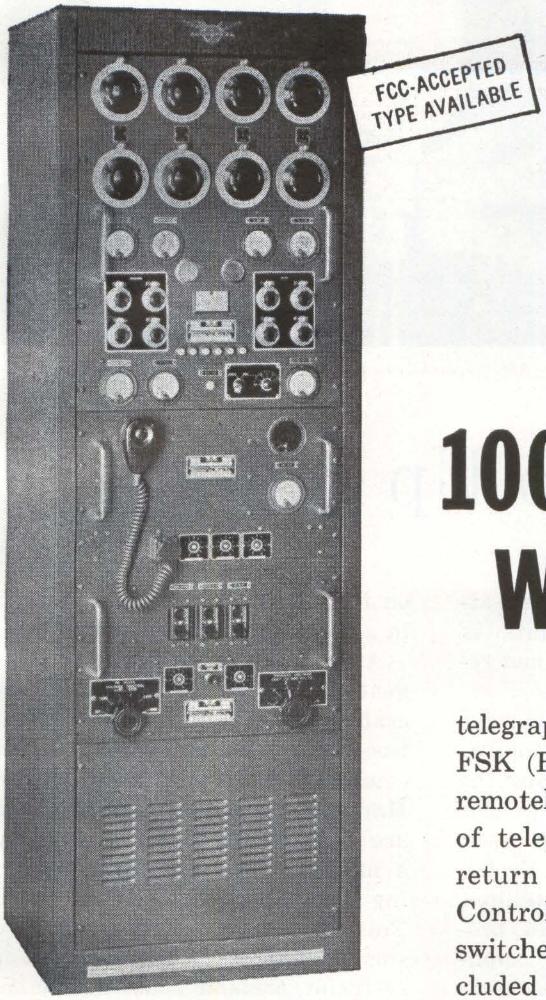
Initially, this policy will only affect the largest markets — those over 100,000 — when there are no longer any more f-m frequencies available in these cities. F-m stations owned by a-m stations can duplicate no more than 50 percent of the a-m programming, beginning a year after adoption of the proposal. In addition, FCC aims to bring a-m radio service to new areas without it, to save spectrum space for new communities, and to prevent new assignments encroaching on existing stations. It proposes a table of quotas for a-m and f-m stations in each community, based on population.

BATTLEFIELD MISSILE GETS MONEY BOOST

CONGRESS HAS APPROVED a Defense Department plan to increase this year's funding for the Army's Lance battlefield support missile (formerly Missile B) by 40 percent, to $17.4 million.

Lance is approved for full system development. Ling-Temco-Vought is prime contractor. Major electronic subcontractors are Telecomputing's Whittaker Controls division, boost-guidance control gyro, and Systron-Donner, velocity control and checkout set.

The House Appropriations Committee had delayed project expansion approval. At issue were claims that project costs would be substantially increased by Army's insistence that LTV, a Texas-based firm, use a government plant in Detroit. The Army pooh-poohed the claim.



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AEROCOM 1046 TRANSMITTER

1000 W CARRIER POWER WITH HIGH STABILITY

The Aerocom 1046 Transmitter is designed to give superior performance for all point-to-point and ground-to-air communications. It is now in use throughout the world in climates ranging from frigid to tropical (operates efficiently at −35° to +55° Centigrade).

As a general purpose High Frequency transmitter, the 1046 supplies 1000 watts of carrier power with high stability (above −10° Centigrade: ±.003% for telegraph and telephone. Temperature controlled oven for FSK). Multichannel operation is provided on telegraph A1, telephone A3 and FSK (Radio Teletype). It can be remotely controlled using one pair of telephone lines plus ground return with Aerocom Remote Control Equipment. Front panel switches and microphone are included for local control.

Four crystal-controlled frequencies (plus 2 closely-spaced frequencies) in the 2.0 - 24.0 megacycle range can be used one at a time, with channeling time only two seconds. Operates into either balanced or unbalanced loads. The power supply required is nominal 230 volts, 50 - 60 cycles, single phase.

The housing is a fully enclosed rack cabinet of welded steel, force-ventilated through electrostatic filter on rear door.

Telegraph keying (A1): Up to 100 words per minute. Model 1000 M Modulator (mounts in transmitter cabinet) is used for telephone transmission; a compression circuit permits the use of high average modulation without overmodulation. Model 400 4 Channel exciter is used for FSK.

Output connections consist of 4 insulated terminals (for Marconi antenna) and 4 coaxial fittings Type SO-239, which can be used separately or in parallel in any combination. For 600 ohm balanced load, Model TLM matching network is used, one for each transmitter channel.

As in all Aerocom products, the quality and workmanship of Model 1046 are of the highest. All components are conservatively rated. Replacement parts are always available for all Aerocom equipment.

Complete technical data on Aerocom Model 1046 available on request.

Also available—Aerocom Model 446 with 350 watts nominal carrier power and Model 100TFA—100 watts

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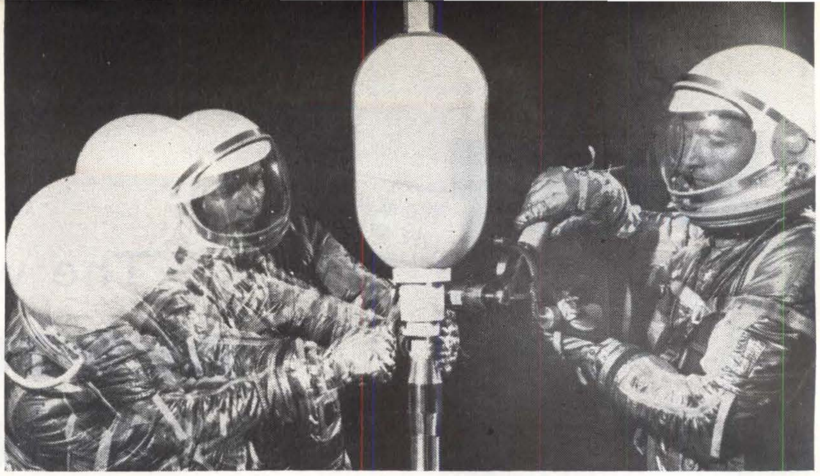
CIRCLE 11 ON READER SERVICE CARD



ZERO-GRAVITY *space tools are designed to move components, not the repairman. Above, AMF "astronauts" in simulated weightless environment use conventional hand tool (left) and special space tool (right)*

If a Satellite Fails—Go Up and Fix It

Alternatives: use a robot repairman, or build in self-repair and redundancy

By JOEL STRASSER
Assistant Editor

IN-ORBIT REPAIR of ailing satellites by men or machines that actually rendezvous with the satellite and fix its circuits looks like the ultimate solution of spacecraft failure problems, say space officials and scientists interviewed by ELECTRONICS.

But when a rendezvous would cost more than launching a new satellite, remote repair will be attempted. Self-healing circuits is one approach, carefully planned redundancy is another.

And then, there are various ways of manipulating equipment operation from the ground to get the system working again. This has been successful in several cases, notably Telstar I, Pioneer V, Relay I and several Tiros satellites. But these stopgap measures provide no specific technique applicable to all future satellites.

DEMONSTRATION *of squeeze wrench at Martin*

RENDEZVOUS REPAIR—One approach to rendezvous repair involves development of tools and methods that men can use in a weightless environment so they can move the tools and parts without being moved themselves by the reaction force.

The other approach is to use remotely controlled tools like the ones that manipulate atomic reactor controls and materials.

Early in June, Grumman is expected to report findings of a study, for NASA, of structural design considerations to make the Orbiting Astronomical Observatory suitable for in-orbit repair. The repairman would carry tools and plug-in replacement modules.

There are also proposals for an orbiting station to maintain manned vehicles as well as satellites. Lockheed has described a 15-man station that would send shuttle craft to repair other spacecraft.

ZERO-GRAVITY TOOLS — Many aerospace companies are working on tools for fastening and drilling in a weightless environment.

Among Martin Company's "first-generation" tools is a wrench operated by squeezing. First-generation hand tools require spacecraft equipped with clips and hooks. Martin's second-generation tools are battery operated and produce a minimum reaction while requiring some restraint of the man. Third-generation tools will be smaller, lighter, longer lasting. For restraint, portable hooks will be applied to the spacecraft by an epoxy adhesive that does not require oxygen. Crimp connections and plug-ins will be required for electronic repairs, says Martin B. Goldman, of Martin. Surface bonding will eliminate much soldering.

Other companies designing hand tools include Hughes, AMF and Chance-Vought. Backup work is being done on space simulators and spacesuit design. Boeing, GE and others are studying the effects of weightlessness on how a man can work.

Hamilton-Standard is investigating electron-beam welding, which can make use of the natural vacuum in space, and the possible use of solar, nuclear and fuel-cell power supplies for the welder. Air Force has just authorized the company to build a prototype welder.

ROBOT TOOLS—Goal of a NASA study contract at MIT is a general-purpose, remotely controlled "hand" that could use simple, special-purpose tools and be senstitive enough to replace a transistor. It would be

RELIABILITY FIRST

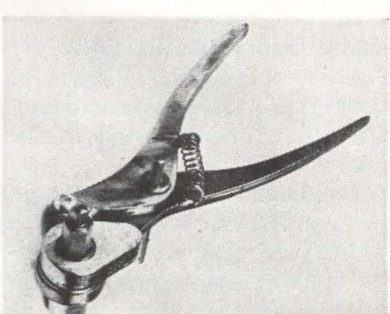
Reliability, rather than repairability, is the prime goal of all spacecraft designers. Efforts to make spacecraft repairable won't relax electronic equipment specifications or the pressure on government and contractor personnel to do better in component selection, circuit design and system assembly and test. But since an imperfection or an accident are always possible, repairability picks up where reliability leaves off

guided from the ground by tv.

One problem, says Prof. Thomas Sheridan, is the time delay produced by the distance to the spacecraft. Humans are accustomed to a rapid step-by-step procedure, but it would take 2.6 seconds for a command to be given a robot near the moon and for the reaction to be observed on earth.

ELECTRONIC SELF-REPAIR — Self-repairing components and the already well-established redundancy method are two ways to build self-repair capability into space equipment. More advanced solutions may well come out of present work on adaptive systems, bionics and other research areas (ELECTRONICS, p 96, Jan. 4).

A description of how to repair transistors by regenerating the critical material was given at this year's IEEE Convention by D. H. Kramer. For example, when a short circuit is detected between collector and base, a regenerative agent is released near the junction and the temperature raised to the point needed for self repair. Similar methods can be used to regenerate resistors, capacitors and printed-circuit substrates, he said.



PLENCH, *a Chance-Vought combination plier and wrench, is squeezed to rotate a ratchet and socket without moving the user*

Air Force is sponsoring research at Honeywell into two methods of self repair. In one, printed circuits are coated with an alloy; a small temperature rise melts the alloy and it flows into a break. Also, metallic whisker growth can be controlled to repair a circuit break, Honeywell says. Air Force is also sponsoring work at Adaptronics.

Redundancy is necessary for deep space and lunar probes, a Jet Propulsion Lab spokesman says. In the Ranger series, JPL relies on automatic control sequencing and radio-command capability for many functions, so if there is a malfunction another channel can be used.

The next step is design redundancy rather than system redundancy. The object is to provide alternate internal paths to accomplish a function. The final step is to make a system that can decide which of several potential circuit paths can be used to work around a malfunction.

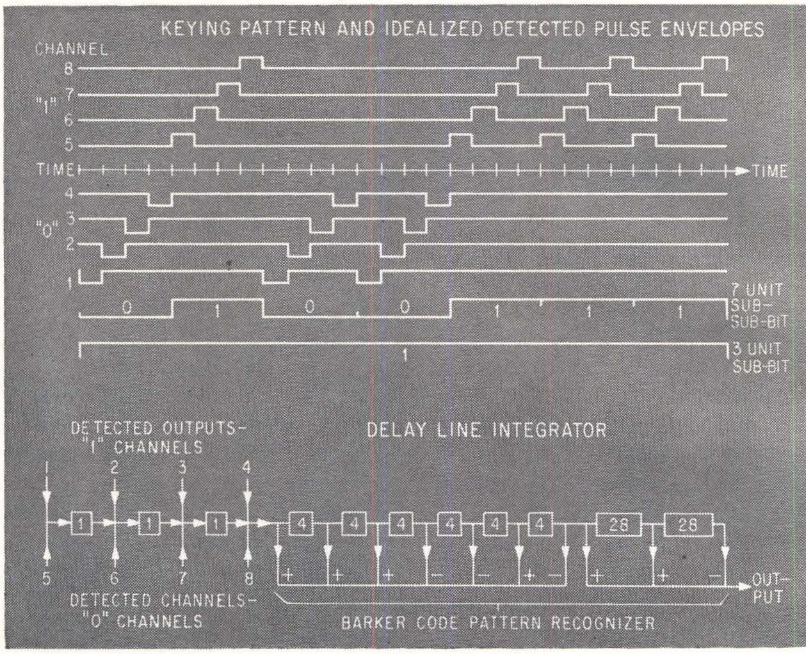
INGENUITY — Several satellite failures in the past few years have been overcome by the ingenuity of ground personnel.

For example, when ionizing radiation caused Telstar I's decoder to fail, a trick code, worked out in the lab, got it working again. In 1960, while Pioneer V was 5.5 million miles from earth, a new translation code got around a defective diode. Relay was given a rest to close an open transistor that was causing a power drain.

Overloading Tiros II vibrated the vehicle and loosened a foreign particle between the points of a clock timer. On Tiros III and IV, when direct readout failed, it was regained by overriding stored readout.

New Chore for ORBITING

Air Force will test long-range, air-ground digital communications



SIGNAL PROCESSING *for narrow pulse widths*

DAYTON, OHIO—Next year, Air Force plans to test the feasibility of a new way to get extended range air-to-ground and ground-to-air microwave communications: reflecting the signals from an orbiting belt of resonant dipoles.

Air Force Systems Command's Aeronautical Systems Division (ASD) is now building the special digital modulation and detection equipment. The airborne complex will consist of a 10-Kw, X-band transmitter and a liquid-helium-cooled maser receiver.

SIGNAL SMEAR—The communications link will be analogous to bistatic radar. The reflected signal energy will be perturbed in time, amplitude and frequency, Charles Gauder, of ASD, reported this month at the National Aerospace Electronics Conference.

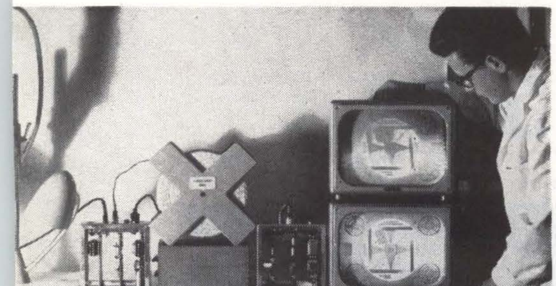
In addition to normal doppler shift, the carrier frequency will be smeared over a discrete frequency range (perhaps 2 Kc) because of differential velocity vectors of the randomly oriented dipoles at the intersection of the transmitting and receiving beams. The new digital equipment is expected to overcome this.

Narrow pulses will be used to minimize smearing and envelope incoherence. Doppler smear of long pulses could be offset by using post-detection integration to improve the signal-to-noise ratio. But the degradation caused by frequency smearing won't permit coherent pulse integration because pulse envelope coherency is destroyed.

German Closed-Circuit Tv Needs No Coax

BONN—A new system for transmitting tv signals over telephone wire has been demonstrated by Grundig. Applications are expected in banks and industrial installations where the transmission distance is too long to justify coaxial cable, but too short for directional transmission.

TELEPHONE-WIRE *tv transmission demonstration by Grundig*



The line is an unprotected, 3,-300-ft-long, 2-wire, Y-form (2×0.-6-mm). The system is based on a corrective amplifier that suppresses line distortion and compensates for signal losses so the 5-Mc bandwidth signal corresponds to the European picture standard.

The system was demonstrated at West Germany's huge Hanover Fair, which ended this month. Other electronic exhibits highlights included:

• Seimens' tv picture reproducer. Ten full-size pictures up to 16-in. diameter are recorded on magnetic foil for storage and reproduction. The disk carrying the foil rotates at 300 rpm to give 10-Mc recording and reproduction.

• Telefunken's new compatible vhf-stereo broadcast transmitter. German manufacturers are going along with the U. S. FCC system since it meets pertinent CCIR recommendations

• Lowe Opta's 16.5-lb, 10-in., tv/f-m radio combination. Battery or a-c powered, it uses 31 transistors. Mesa transistors are used in the vhf and uhf tuners

• Transistor radiation detector, shown by Kirem, is essentially a large-surface silicon diode. Particles striking the diode result in positive and negative charges flowing to diode electrodes to produce a proportional pulse. Device is sensitive, and it requires little power.

DIPOLES

MODULATION — Gauder told ELECTRONICS that a frequency-time dispersed keying pattern—originally developed by Air Force for h-f, air-ground, long-range, digital communications—will be used.

A number of subcarrier oscillators are keyed in a frequency-time manner according to a 7-unit Barker-code pattern (see diagram). Dual-symbol operation is used: two distinct pulses represent the binary 1 or 0; one frequency is keyed for a 1 and another for a 0.

To demodulate: after translation to a suitable i-f, each subchannel is separated, detected, combined, summed through delay lines and applied to a threshold decision circuit. A unique feature of the delay line integrator is the output's excellent peak-to-stray amplitude ratio. This matched-filter characteristic automatically establishes sub-bit timing at coincidence of the incoming Barker code pattern.

All-Channel Tv Array Readied

CHICAGO—JFD Electronics revealed at the Electronic Parts Distributor Show last week that it hopes to have its all-channel, log-periodic tv antenna ready for production by fall.

Now under development at JFD R&D Labs, the antenna uses smaller resonant-V dipole elements at the front end for uhf and larger spaced elements at the back end for vhf (see photo, p 16). It will receive channels 2 through 83.

Feature of the log-periodic design is its ability to pull signals in over long distances. JFD's present antenna, for regular tv/f-m reception, receives from 50 miles, for a 4-element array, and up to 175 miles for an 18-element array. Design is based on work done at the University of Illinois (ELECTRONICS, p 10, Dec. 8, 1961, and p 58, June 17, 1960).

Other antenna news at the show included:

• Comment by John Winegard, president of Winegard Co., that color tv and f-m stereo are creating sales of good outdoor antennas in cities where indoor types were bought almost exclusively. Winegard introduced a transistorized antenna amplifier for uhf tv, color couplers and other devices

- Jerrold's paralog. It has wheel-shaped insulators to transpose interconnections without crossing transmission-line conductors, to keep impedance constant and reflected line losses negligible. Added parasitic elements are said to improve gain while retaining broadband and impedance-match advantages of log-periodic design.

Among the new sets was a prototype five-loudspeaker a-m/f-m stereo portable, previewed by ITT Distributor Products. It has 23 transistors, operates on eight flashlight batteries. A stereo earphone set, by Superex Electronics, has a miniature crossover network and tweeter controls for each ear and reportedly gives 20-cps to 20-Kc response.

Components introduced included

TEST MODEL *of all-channel log-periodic antenna*

a 500-cps magnetic reed switch, by RCA. It weighs 0.3 gram, is expected to find applications in computer and switching equipment. Raytheon offered a silicon planar epitaxial transistor said to offer 20-db power gain at 200 Mc. It can be used as an r-f amplifier to 500 Mc and as an oscillator to 1.6 Gc.

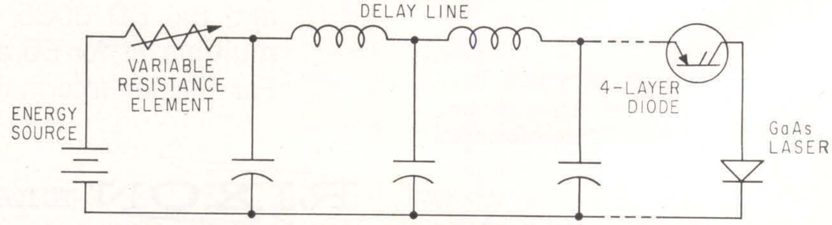
Diode Laser Transmits Audio

AUDIO MODULATION of an injection laser at IBM's Federal Systems Division last week clearly demonstrates that the device, announced only 7 months ago (ELECTRONICS, p 7, Nov. 2, 1962) may go into communications systems sooner than anticipated.

Outstanding feature of the IBM experimental communications setup is its simplicity. Little or no optics is required to transmit and receive acceptable-quality voice and music signals over a short distance using pulse-frequency modulation.

Unlike the gas laser, which has transmitted video and audio (ELECTRONICS, p 28, Feb. 22), the injection laser is modulated by d-c pulses which are converted directly into coherent light. In the gas laser, the beam is modulated after it leaves the laser, greatly reducing system efficiency.

The gallium-arsenide diode used by IBM has a lasing threshold of 2.25 amps. Five-amp, 0.2-μsec pulses are generated by the modulator circuit (see figure). The experimental pfm system transmits audio from 300 to 3,000 cps, but IBM engineers feel circuit and device refinements could extend the pulse repetition rate beyond 100 Kc.



AUDIO SIGNALS *through variable-resistance element (in practice, a transistor) control modulation circuit frequency. When the delay line charges to a preset voltage, the 4-layer diode breaks down, discharging the delay line through the laser*

MEETINGS AHEAD

RADIO FREQUENCY INTERFERENCE NATIONAL SYMPOSIUM, IEEE-PTGRFI; Bellevue Stratford Hotel, Philadelphia, Pa., **June 4-5.**

ARMED FORCES COMMUNICATIONS & ELECTRONICS ASSOCIATION CONVENTION, AFCEA; Sheraton-Park Hotel, Washington, D. C., **June 4-6.**

INTERNATIONAL TELECOMMUNICATION UNION PANEL OF EXPERTS MEETING, IEEE, et al; Geneva, Switzerland, **June 4-23.**

RELIABILITY TRAINING CONFERENCE, IEEE-PTGR, ASQC; Bishop's Lodge, Santa Fe, N. M., **June 10-14.**

BIO-ENGINEERING SYMPOSIUM, ISA; Union Oil Co. Bldg., Los Angeles, **June 14-16.**

SUMMER GENERAL MEETING, IEEE; Royal York Hotel, Toronto, Canada, **June 16-21.**

BROADCAST & TV RECEIVERS CONFERENCE, IEEE-PTGTR; O'Hare Inn, Chicago, **June 17-18.**

JOINT AUTOMATIC CONTROL CONFERENCE, IEEE, ISA, et al; University of Minnesota, Minneapolis, Minn., **June 19-21.**

X-RAY AND ELECTRON PROBE ANALYSIS SYMPOSIUM, American Society for Testing and Materials; Chalfonte-Haddon Hall, Atlantic City, N. J., **June 23-28.**

IMPACT OF MICROELECTRONICS CONFERENCE, Armour Research Foundation and ELECTRONICS Magazine; Illinois Institute of Technology, Chicago, Ill., **June 26-27.**

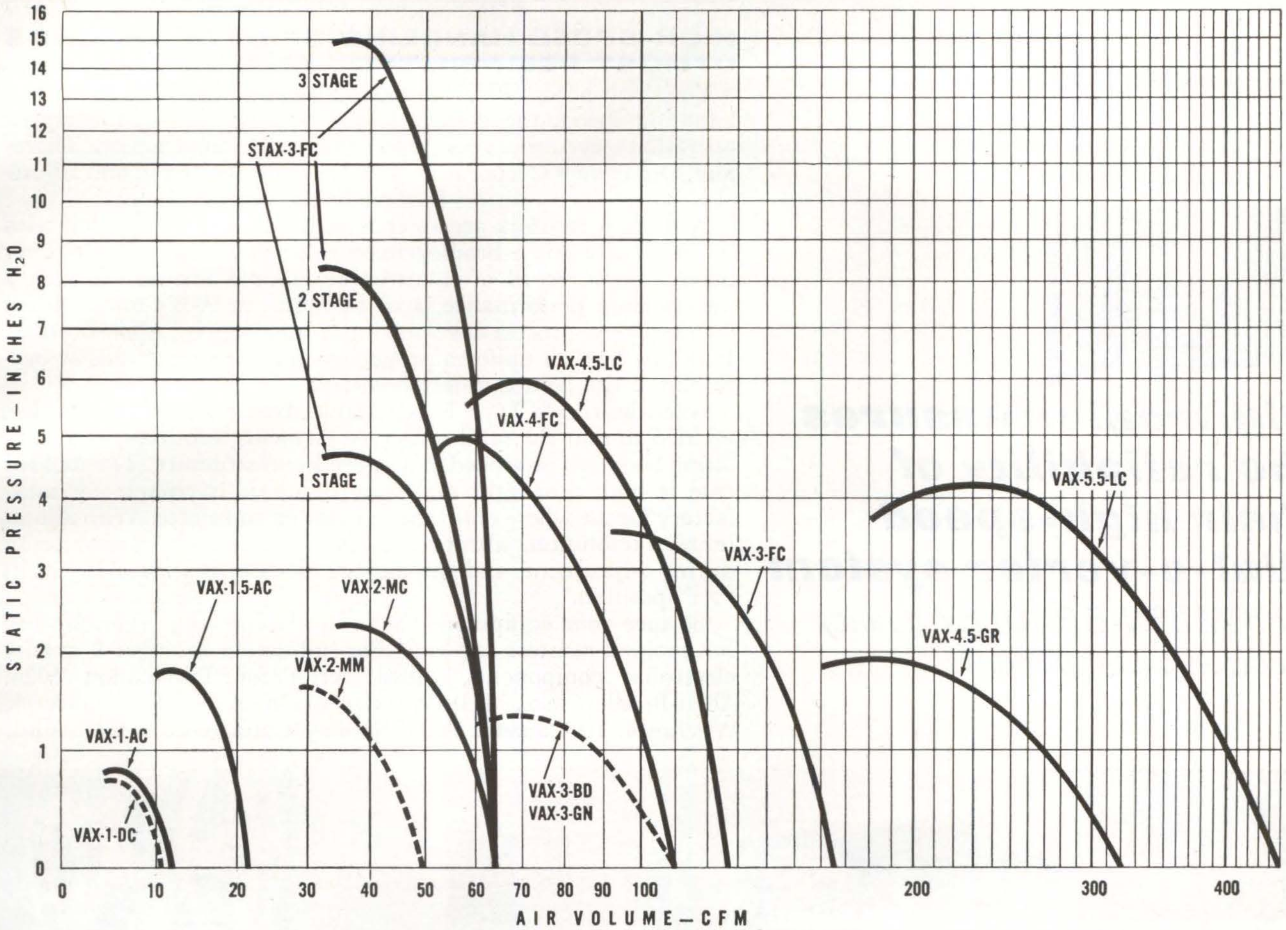
INFORMATION THEORY IN SCIENCE & ENGINEERING SEMINAR, Dartmouth College; at Dartmouth, Hanover, New Hampshire, **July 1-12.**

WESTERN ELECTRONIC SHOW AND CONFERENCE, WEMA, IEEE; Cow Palace, San Francisco, Calif., **Aug. 20-23.**

ADVANCE REPORT

COMMUNICATIONS NATIONAL SYMPOSIUM, IEEE-PTGCS, *Utica, N. Y., Oct. 7-9.* **June 17** *is the deadline for submitting 5 copies of a 100-word abstract and a 500-word summary to: Joseph L. Ryerson, Technical Program Chairman, Director of Communications (RAU), Rome Air Development Center, Griffiss Air Force Base, N. Y. Areas of interest include: space and satellite communications; tropospheric scatter; hardened communications; data processing and transmission; communications theory; communications antennas; infrared and light communications.*

AEROSPACE & NAVIGATIONAL ELECTRONICS EAST COAST CONFERENCE, IEEE-PTGANE; *Emerson Hotel, Baltimore, Md., Oct. 21-23.* **June 17** *is the deadline for submitting 5 copies of a 500-word abstract and a brief author's professional record to: Richard J. Allen, Research & Advanced Technology Dept., Martin Co., Baltimore 3, Md. Areas of interest include: microelectronics; space vehicle guidance & control; design for space environment; space system support equipment.*



VAX-1-DC D.C. VANEAXIAL BLOWER. 1⅛" dia. 26 v.d.c. Rugged sub-miniature unit with good performance. 1.4 oz. Ideal for spot cooling. MIL specs.

VAX-1-AC A.C. VANEAXIAL BLOWER. 1⅛" dia. Operates on 26 v.a.c., 400 cycle, 1 phase. 1.5 ounces. Smallest vaneaxial blower available. MIL specs.

VAX-1.5-AC A.C. VANEAXIAL BLOWER. 1⅝" dia. Uses 115 v.a.c., 400 cycle, 1 phase. 4.0 ounces. Can be supplied variable speed for high altitude use.

VAX-2-MM D.C. VANEAXIAL BLOWER. 2" dia. Operates on 26 v.d.c., other versions available up to 50 v.d.c. Designed for MIL specs., weighs 5 oz.

VAX-2-MC A.C. VANEAXIAL BLOWER. 2" dia. Operates on 115 or 200 v.a.c., 1 or 3 phase. Weighs 5 oz. MIL specs.

STAX-3-FC A.C. MULTI-STAGE BLOWER. 3" dia. Compressor staging in a miniature unit, ideal for heat exchangers, compact "black boxes," etc., 29 oz.

VAX-3-BD D.C. VANEAXIAL BLOWER. 3" dia. Operates on 28 v.d.c., other versions may be wound to 115 v.d.c. Designed for MIL specs., 16 oz.

VAX-3-GN A.C./D.C. VANEAXIAL BLOWER. 115 v.a.c., 60 cycle single phase, and 115 v.d.c. Other voltages available. MIL specs., 16 oz.

VAX-3-FC A.C. VANEAXIAL BLOWER. 3" dia. 115 or 200 v.a.c., 400 cycle, 3-phase. Variable speed high altitude units available. 14 oz. MIL specs.

VAX-4-FC A.C. VANEAXIAL BLOWER. 4" dia. High performance, high altitude unit operates on 115 or 200 v.a.c., 400 cycle. Weighs 2 lbs. MIL specs.

VAX-4.5-LC A.C. VANEAXIAL BLOWER. 4[11]/[16]" dia. 200 v.a.c., 400 cycle. MIL specs., weighs 5½ lbs.

VAX-4.5-GR A.C./D.C. VANEAXIAL BLOWER. 4¾" dia. Universal unit. 115 v.a.c., 60 cycles or 115 v.d.c. Exceptionally quiet.

VAX-5.5-LC A.C. VANEAXIAL BLOWER. 5½" dia. 200 v.a.c., 400 cycle. Large volume delivery against high system resistance.

IF YOUR BLOWER SPECS ARE HERE, YOU JUST SAVED TIME AND MONEY

Charted above are representative curves of **standard** Globe vaneaxial blowers, a.c. and d.c. Telephone us; we stock many of these for 24-hour delivery. Globe also meets most **special** blower requirements promptly, often by modification of one of our standard blowers. And because Globe is the largest manufacturer of precision a.c. and d.c. miniature motors, we can deliver completely custom prototypes in a few weeks. Let us help you solve your electronic cooling problem with a highly efficient, reliable Globe blower. We also make centrifugals, tube-axials, and axial fans. Request Bulletin V-2 from Globe Industries, Inc., 1784 Stanley Avenue, Dayton 4, Ohio. Tel. Area Code 513 222-3741.

GLOBE

CIRCLE 19 ON READER SERVICE CARD

DIGITRONICS DIAL-O-VERTER D520 MAGNETIC TAPE TERMINAL WITH DOOR OPEN SHOWING CIRCUIT CARDS

Digitronics assures the reliability of their high-speed Dial-o-verter system

with ALLEN-BRADLEY quality electronic components

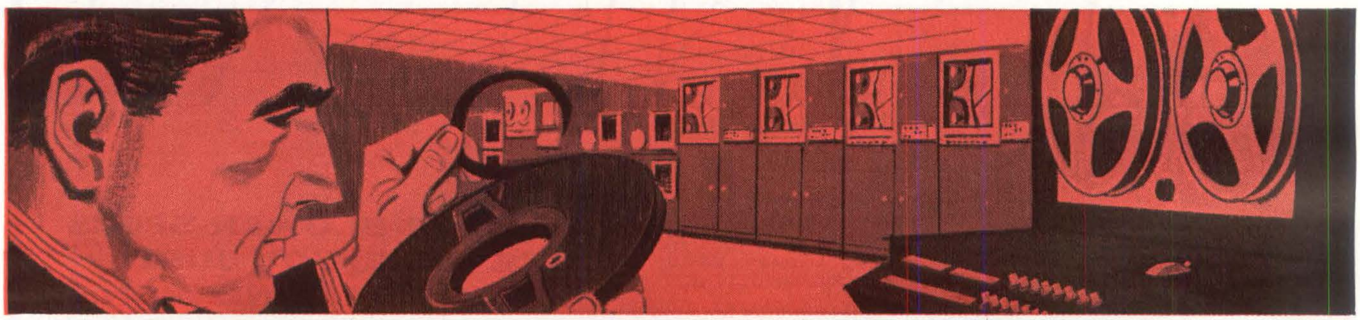
HIGH-SPEED HANDLING OF DATA DEMANDS UTMOST RELIABILITY!

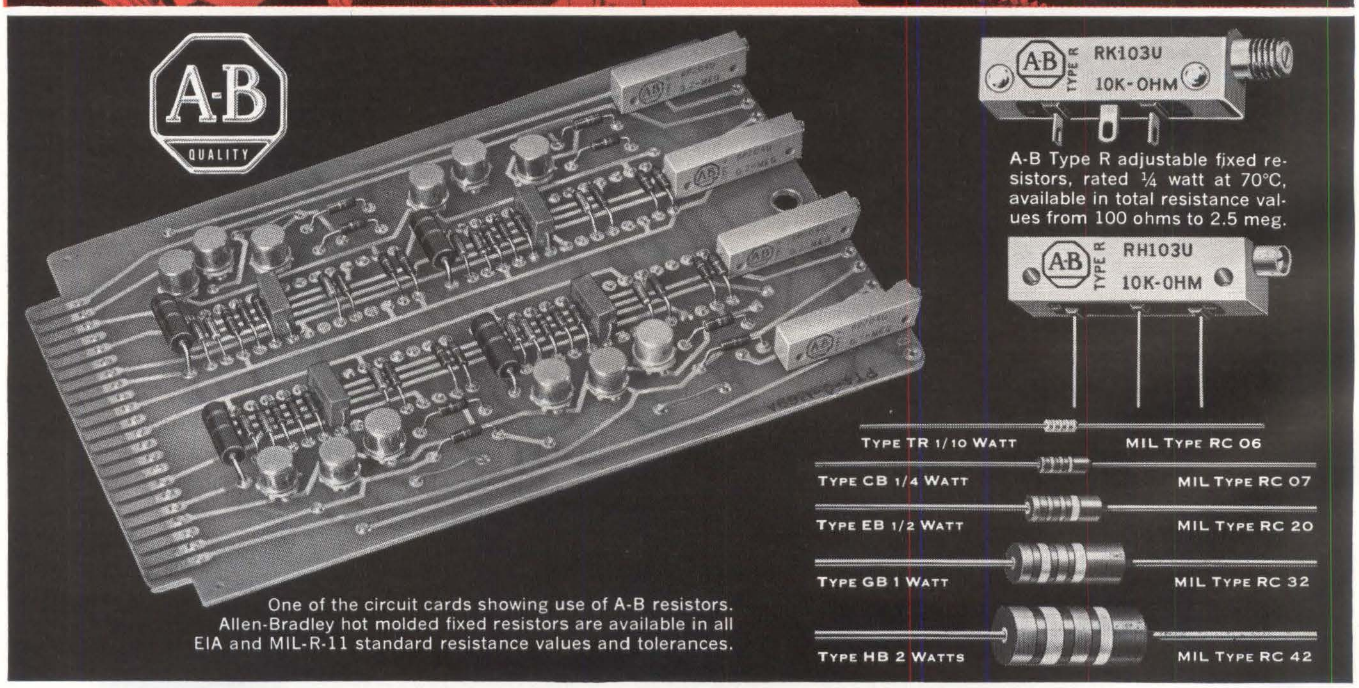
■ You don't need a Ph.D. to understand that the higher the data handling speed, the greater is the necessity for uninterrupted operation—even short delays lose volumes of information. Therefore, Digitronics Corporation uses Allen-Bradley fixed and adjustable hot molded resistors in their Dial-o-verter system.

A-B fixed resistors are so thoroughly reliable that even with the *billions* of Allen-Bradley fixed resistors in use, there's never been a *single* record of catastrophic failure! The key to such a phenomenal performance is to be found in A-B's hot molding technique—a process developed and used *only* by Allen-Bradley. It results in such uniform properties that long term resistor performance can be accurately predicted.

Allen-Bradley's Type R adjustable fixed resistors are also hot molded so that the solid resistance element, terminals, and insulating body are produced in a rugged unit structure. The molded case is both dust-tight and watertight—it is completely satisfactory for use where entire circuits are encapsulated. With almost infinite resolution, abrupt changes in resistance cannot occur during adjustment, and the moving element is self-locking in its "set" position.

Be sure your equipment has the reliability *only* Allen-Bradley hot molded resistors can give. For full details on all A-B quality electronic components, please write for Publication 6024. Allen-Bradley Co., 110 W. Greenfield Ave., Milwaukee 4, Wisconsin. In Canada: Allen-Bradley Canada Ltd., Galt, Ont.





A-B Type R adjustable fixed resistors, rated ¼ watt at 70°C, available in total resistance values from 100 ohms to 2.5 meg.

One of the circuit cards showing use of A-B resistors. Allen-Bradley hot molded fixed resistors are available in all EIA and MIL-R-11 standard resistance values and tolerances.

ALLEN-BRADLEY

QUALITY ELECTRONIC COMPONENTS

electronics

A McGraw-Hill Weekly *May 31, 1963*

FAMILY *of negative resistance elements are checked on a plotter to determine characteristic curves*

The Negative Resistance Element (NRE) A New Circuit Component

The family of electronics circuit components is continuing to grow as modern techniques generate new and versatile devices. This new series of components exhibits a-c negative resistance and has a variety of applications

By **CARL D. TODD,** Hughes Aircraft Co., Newport Beach, Calif.

INCREASE in voltage applied to the usual resistor will cause a proportional increase in the terminal current. Certain electronic devices have regions where an increase in applied voltage produces a decrease in terminal current. This represents an a-c negative resistance.

The four-layer diode, silicon-unijunction transistor and the gaseous discharge tube have a terminal characteristic curve of the general form shown in Fig. 1A. Here, a given value of terminal voltage between V_V and V_P may produce one of three possible terminal currents; however, any set current yields one and only one possible voltage. Thus, a device of this type is referred to as having a current-stable or N-type negative resistance.

The terminal characteristic curve shown in Fig. 1B is exhibited by devices like the tunnel diode, vacuum tube tetrode as used in the dynatron oscillator, and the common-emitter input of a point contact transistor. This characteristic is referred to as voltage-stable or S-type, since any one voltage will control the terminal current and any current between I_V and I_P may have three possible values of terminal voltage.

Negative resistance devices may be used to construct oscillators and Q-multipliers and perform many switching functions; their usefulness, however, is sometimes limited by nonlinearity or unpredictability of their electrical characteristics.

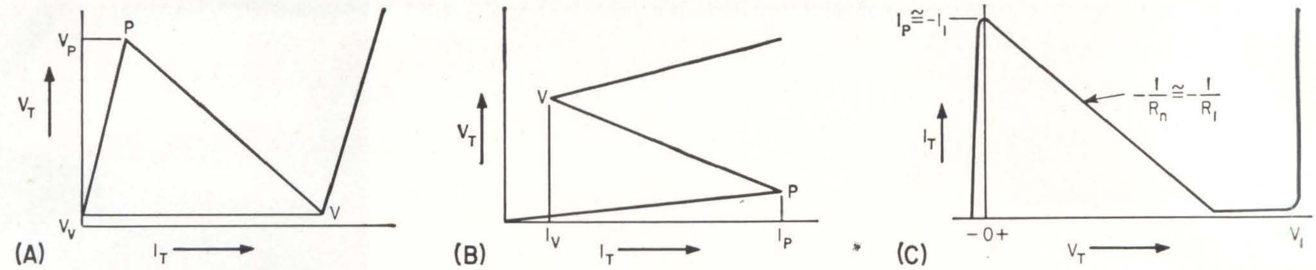
It is possible to design composite circuits with fairly linear negative resistances. Several configurations have been described,[1, 2, 3] but these have a certain amount of dependence on the device parameters of the semiconductors used, are temperature sensitive and lack carefully-controlled characteristics.

A patented[4] composite circuit is currently available tnat overcomes many of the previous limitations of negative resistance devices or circuits. Negative resistance elements (NRE) have predictability and

THE POSITIVE NEGATIVE

The high predictability of the negative resistance element (NRE) characteristic curve makes the device a natural as a d-c switch, circuit breaker, monostable multivibrator and a relaxation oscillator. It is also useful in threshold and comparator circuits.

In linear applications, the excellent linearity and temperature stability of the NRE gives the circuit designer a usable negative resistor for use in Q-multipliers, two-terminal oscillators and filters



NEGATIVE *characteristics of N-type (A) and S-type (B) materials and the terminal characteristics produced by the circuit of Fig. 2B (C)—Fig. 1*

stability that yield performances and permit versatile applications not previously possible; thus, a new component is made available to the circuit designer.

BASIC OPERATION—The circuit arrangement shown in Fig. 2A, has two ideal power amplifiers connected together in a loop. Amplifier 1 is assumed to have unity voltage gain and infinite current gain; amplifier 2 assumes an infinite voltage gain and a current gain of minus one.

An a-c voltage, V_t, applied to the output terminals will produce a voltage at the output of amplifier 1 that is also equal to V_t. This will cause a current to flow in R_1 that is equal to V_t/R_1. This, in turn, is the input current of amplifier 2.

The output current of amplifier 2 will be equal then to $-V_t/R_1$. The terminal current, I_t, is also equal to $-V_t/R_1$ since the current supplied to the input of amplifier 1 is zero. The resulting terminal resistance R_t will be: $R_t = V_t/I_t = V_t/-V_t/R_1 = -R_1$, or $V_t/(-V_t/R_1)$.

The amplifier circuit of Fig. 2A would yield a negative slope without any boundaries, thus implying an infinite power source. A modified equivalent circuit that is realized to a very close approximation in the NRE is illustrated in Fig. 2B.

The resulting characteristic curve seen at the output terminals is shown in Fig. 1C. Boundaries on the negative resistance are established by clamping diodes D_1 and D_2. Voltage V_1 establishes the clamping level for higher values of V_T and D_2 prevents the terminal voltage from going appreciably negative.

The current bias source I_1 provides a terminal current for a zero value of V_T that will be approximately equal to $-I_1$. As V_T is increased in a positive direction, a current I_2, is produced that will add algebraically. For the actual case, the magnitudes will subtract, thus reducing the terminal current linearly and producing a negative terminal resistance.

Diode D_3 aids in simulating the actual input conditions to amplifier 2 as seen from the bias terminal. This indicates a slight temperature dependence of the input voltage of roughly 2 mv per-degree C, that must be considered in designing stable bias conditions.

Diode D_4 prevents a negative voltage from producing a current in R_1 and also compensates for the voltage drop across D_3. The magnitude of the a-c output resistance, R_n, in the negative resistance region, will be somewhat different from that indicated by the first equation because of the finite dynamic resistance R_{d3} and R_{d4} of diodes D_3 and D_4 respectively as $R_n = R_1 + R_{d3} + R_{d4}$.

The values of R_{d3} and R_{d4} may roughly be approximated by the usual equation, $R_d = KT/qI_f = 0.026/I_F$ ohm at room temperature, where I_F is the value of forward current in the individual diode.

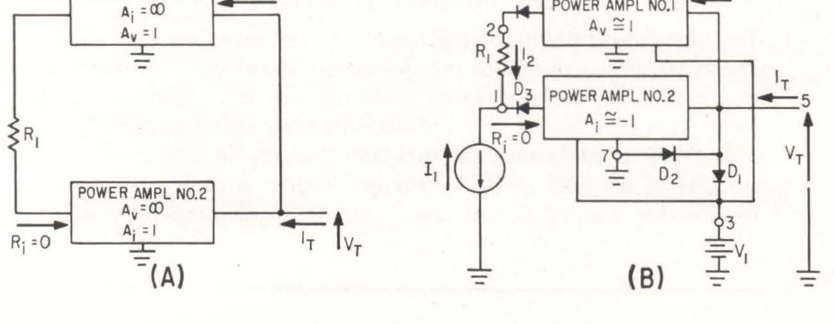
The equivalent circuit as shown, represents the NRE closely in most applications, although it is not an exact circuit.

GENERAL CHARACTERISTICS—Negative resistance elements are composite circuits similar to the equivalent circuit of Fig. 2B, and possess an S-type or voltage-stable output terminal characteristic curve. Two main families are available depending upon the polarity desired for the terminal voltage.

Typical output terminal characteristics for the family of NRE designed for use with negative terminal voltage supplies are given in Fig. 3A. Curves for an NRE with R_n = 1,000 ohms are shown for several different values of bias current I_1 and for two values of supply voltage V_1.

The magnitude of the peak current will be nearly equal to that of the bias current I_1, and the high-voltage clamping point is about 0.7 volt higher than V_1. By varying V_1 and I_1, the characteristic curve may be considerably modified.

Fig. 3B shows the many possible values of R_n represented as R_1, an



BASIC *method of producing a negative resistance (A) and equivalent circuit of an NRE (B)—Fig. 2* external variable resistor connected across the terminals provided. For this curve, biases V_1 and I_1 were held constant at −30V and 10 ma, respectively.

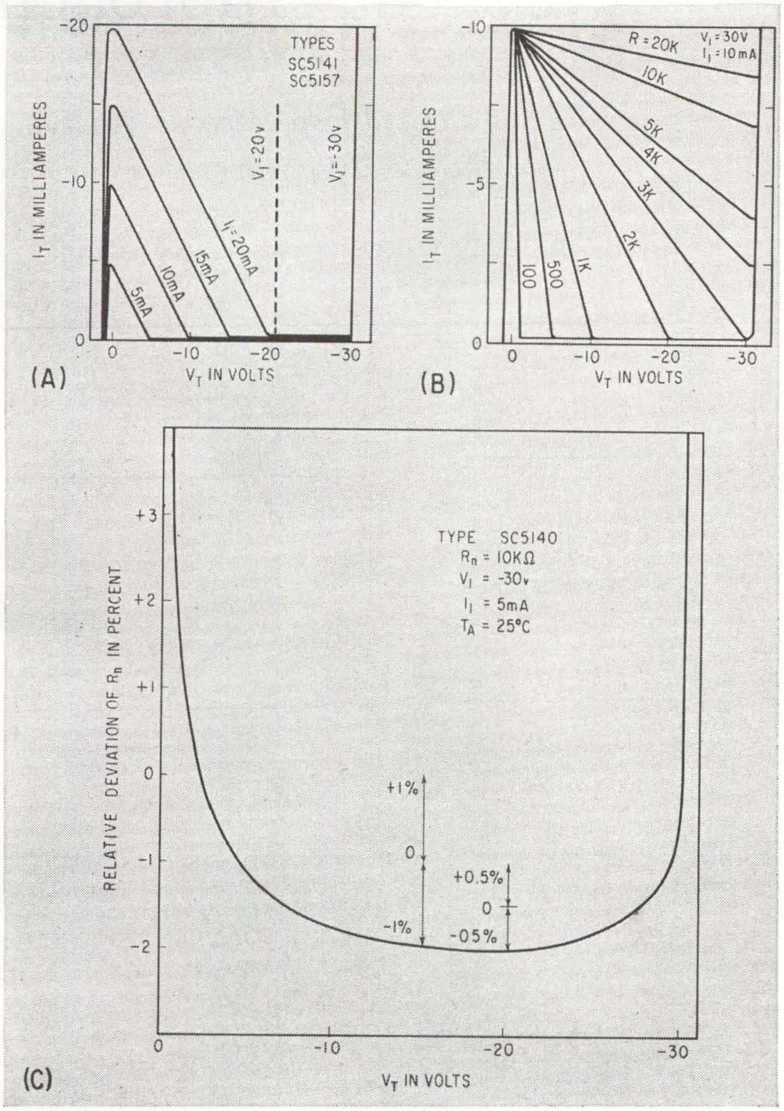
The excellent linearity of R_n for the NRE is illustrated by the typical performance curve shown in Fig. 3C. With the terminal voltage restricted between 1 and 30 volts, linearity is better than 2%. With V_T restricted to the 4.5 to 29.5 voltage range, the linearity is about 0.5 percent.

The temperature coefficient of R_n is a function of the value of R_n. It is possible to achieve a stability of 5 ppm per-degree C over a temperature range of −20 C to +100 C for values of R_n approximately equal to 700 ohms. For optimum temperature stability, wire-wound resistors must be used for the reference resistor R_1.

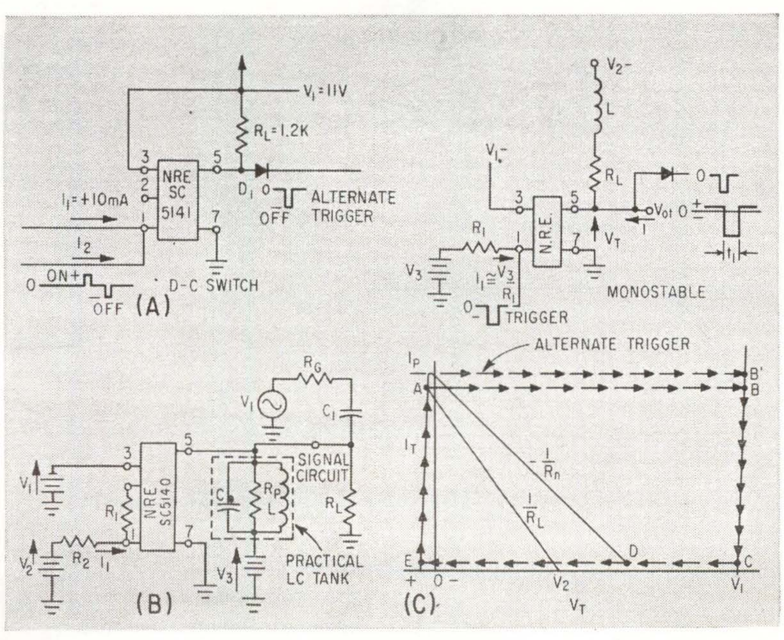
Maximum operating frequency is limited to around 1 Mc for the present negative supply NRE. Higher frequency devices will probably become available later.

The characteristic curves for NRE designed for positive terminal voltages are very similar to those given in Fig. 3 except that the polarities are all inverted; that is, V_T and V_1 will be positive, but I_1 will be negative. The maximum operating frequency for the positive supply NRE family is about 20 Mc.

In non-linear applications, the excellent predictability of the device's characteristic curve is excellent for an efficient d-c switch, a circuit breaker, monostable multivibrator or a relaxation oscillator. Moreover, the linearity and temperature stability of R_n gives the designer a usable negative resistor for use in Q-multipliers, two-terminal oscillators and filters. Some typical applications are shown in Fig. 4.



OUTPUT *curves for Hughes SC5141 and SC5157 devices for R_n=1,000 ohms (A); characteristics for SC5140 and SC5156 for several values of R_1 (B) and typical resistance linearity curves (C)—Fig. 3*



D-C SWITCH *application of the NRE (A); the device applied to a Q-multiplier circuit (B) and monostable vibrator circuit and operating characteristics (C)—Fig. 4*

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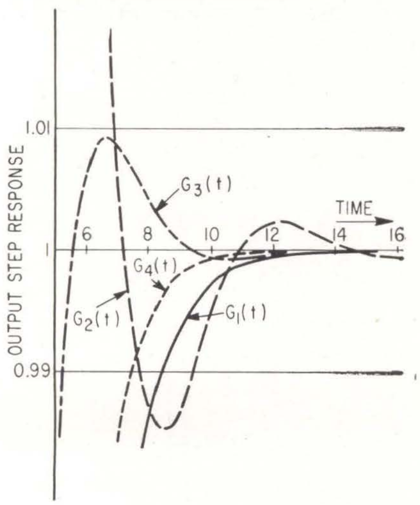
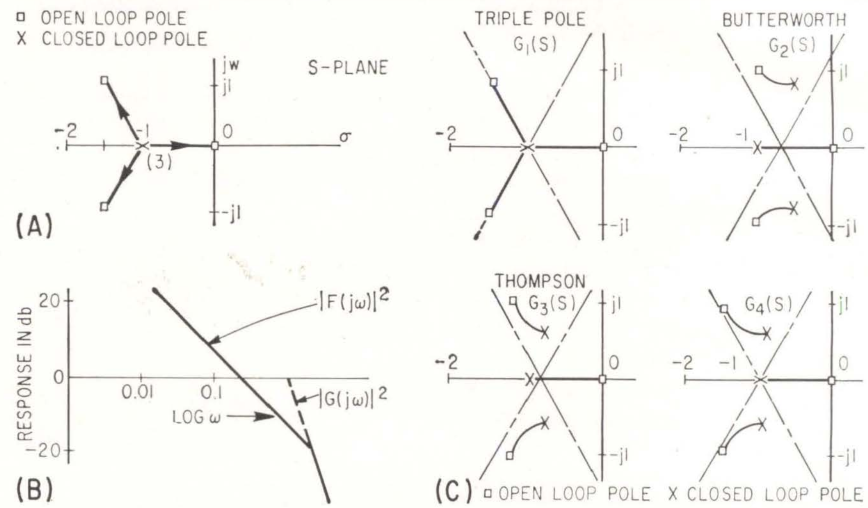
Latest Approach to Integrated

First a closed loop response satisfying circuit specifications is selected, then the open loop response is calculated and errors are considered

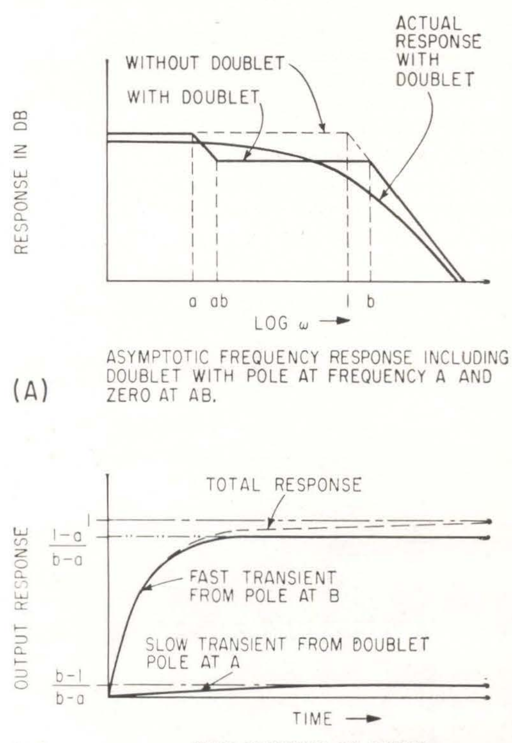
By F. D. Waldhauer, Bell Telephone Laboratories, Inc., Murray Hill, N.J.



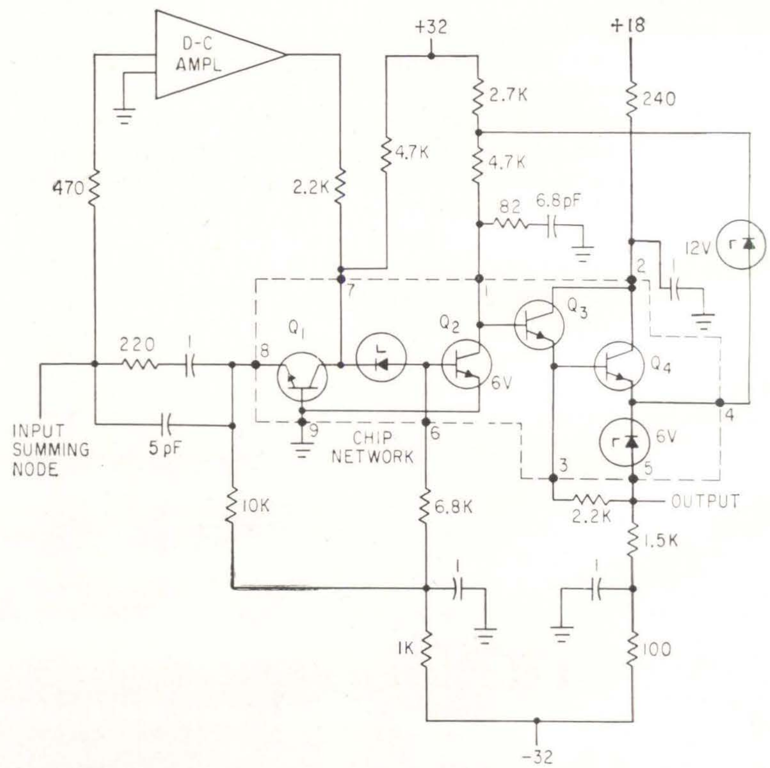
STEP RESPONSES *of the third order functions given in the table —Fig. 1*



OPEN AND *closed loop poles (A) for the triple pole function given in the table and its Bode plot (B). Root loci (curved lines) for functions in the table (C)—Fig. 2*

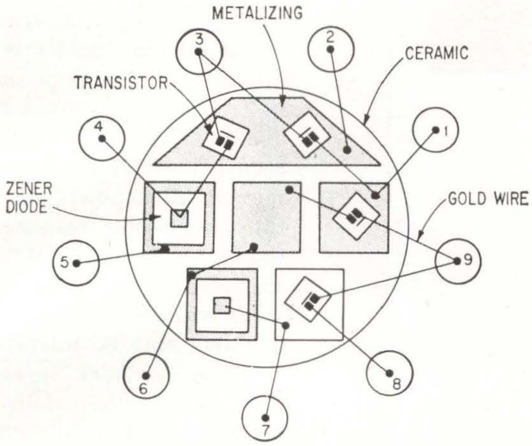


SPURIOUS *pole-zero pairs, or doublets, affect amplifier frequency (A) and transient (B) responses—Fig. 3*

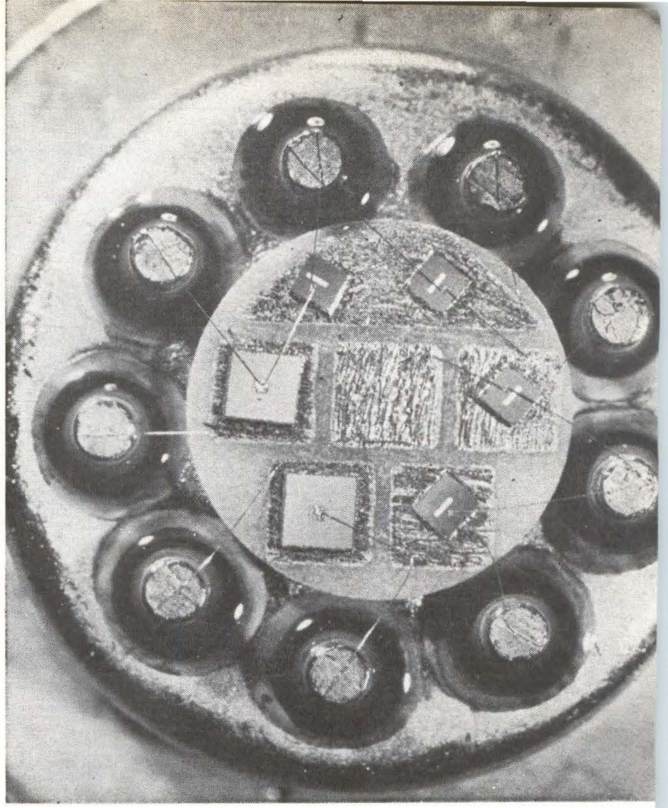


ALL TRANSISTORS *of the wideband amplifier are in the integrated circuit package, thereby reducing the signal path and signal delay and improving response—Fig. 4*

Amplifier Design



LAYOUT *of TO-5 header showing interconnections—Fig. 5*



TO-5 *header holds four transistors and two zener diodes*

IN THE ANALOG portion of analog digital systems, amplification with critical tolerances on time domain performance is often required. The requirements can sometimes be reduced to stating maximum output error for a step input after a stated settling time. For accuracy of 0.1 to 0.01 percent, feedback techniques are mandatory. But to obtain these accuracies in tens of nanoseconds, the bandwidth of the feedback amplifier must be large, which can produce loop delay and parasitics with conventional assemblies. By integrating the circuit using separate chips[1], critical signal paths are made small compared with a wavelength and parasitics and delay are greatly reduced.

But the amplifier must be designed to realize the potentials of circuit integration. Ordinary design using pole-zero cancellation introduces pole-zero pairs or doublets, which cause transients in the response. The new procedure avoids this to a great degree, thereby achieving accurate step and unusually flat frequency response.

First the step responses of various well-known filter functions are examined and a suitable closed-loop pole configuration is selected. From this closed loop function, an open loop function is derived. Allowable error in the open loop in terms of spurious pole-zero pairs due to either parasitics or faulty design is then considered. Then the circuit is put together by integrated circuit techniques.

CLOSED LOOP RESPONSE—To determine the closed loop response necessary to realize time domain specifications, the time response of several common filter functions having the same final (normalized) asymptotic frequency response are compared. Step responses of four such functions in the region of one percent accuracy are shown in Fig. 1. The order has been chosen as three, corresponding to three transistor stages of comparable final asymptotic response.

The table gives the pole locations and settling times for each of the functions of Fig. 1, and shows that the exact function is not particularly critical, as long as the poles maintain sufficient distance ($\frac{1}{2}$ or 1) from the $j\omega$ axis.

The problem therefore is to synthesize an amplifier having the pole configuration of one of these functions for its closed loop gain. Exact pole locations are not important but for accurate response there must be no other spurious poles in the s plane nearer to the origin than the main cutoff poles.

OPEN LOOP RESPONSE — The function having the selected pole configuration represents the closed loop gain $G(s)$ of the equivalent unity gain amplifier; the feedback network is included in the open loop gain function $F(s)$. Thus, $G(0)$ is equal to unity. Open loop gain in terms of the closed loop is given by

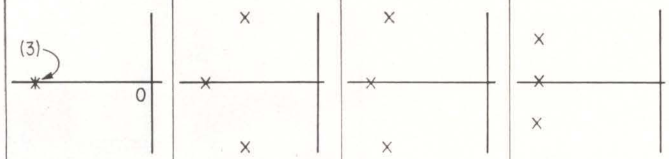
$$F(s) = \frac{G(s)}{1 - G(s)} \qquad (1)$$

When $G(s)$ includes no zeros (as in the functions in the table)

WHY USE INTEGRATEDS?

Now that integrated circuits are starting to come on strong, circuit designers have to learn how to take advantage of the opportunities they present. By keeping the signal path in a feedback amplifier short, for example, propagation delay is minimized and bandwidth is increased. F. D. Waldhauer points out that each linear inch of signal path contributes about 0.1 nanosecond delay. By keeping most of the amplifier's signal path inside the TO-5 header package, he keeps loop delay to a little less than 0.1 nanosecond

Table—Step input setting times for four third-order functions

	$G_1(s)$	$G_2(s)$	$G_3(s)$	$G_4(s)$
Function	Triple pole	Butterworth	Thomson	
Pole locations				
G(s)	$\frac{1}{S^3+3S^2+3S+1}$	$\frac{1}{S^3+2S^2+2S+1}$	$\frac{1}{S^3+2.41S^2+2.41S+1}$	$\frac{1}{S^3+2.82S^2+2.83S+1}$
Error in percent	Settling Time in Seconds			
1	8.4	9.4	5.6	7.5
0.1	11.2	13.5	8.5	9.6
Overshoot	0	8.1%	0.94%	0

$$G(s) = \frac{1}{s^n + \alpha_{n-1}s^{n-1} + \cdots + \alpha_1 s + 1} \quad (2)$$

and

$$F(s) = \frac{1}{s(s^{n-1} + \alpha_{n-1}s^{n-2} + \cdots + \alpha_1)} \quad (3)$$

Equation 3 reduces to 1/s over most of its range as a result of the restriction on closed loop gain that the poles maintain a sufficient distance from the $j\omega$ axis.

Thus, $F(s)$ has a pole at the origin and $|F(j\omega)|^2$ has a unit (6 db per octave) cutoff slope over its entire range from frequencies near 0 to a frequency near the final asymptote cutoff, considering the restrictions on the closed loop gain.

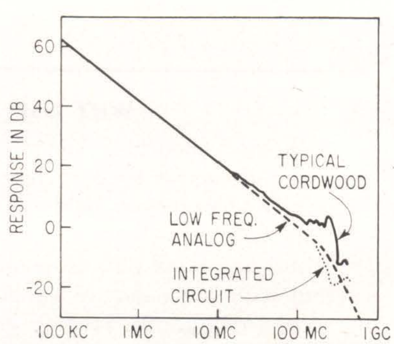
As an example, consider the closed-loop response

$$G(s) = \frac{1}{(s+1)^3} \quad (4)$$

The closed-loop poles are all at $s = -1 + j0$, as shown in Fig. 2A. The open loop poles can be found by following along the root loci; one pole moves into the origin, supplying the unit cutoff slope, while the other two become complex, as shown. The corresponding Bode plot is shown in Fig. 2B. The root loci for the other functions in the Table are shown in Fig. 2C. All have a single open loop pole at $s = 0$.

OTHER ERRORS — The finite speed of the transistors produces an error in step response which is minimized by the selection of the cutoff shape for the closed loop response, which is then translated into open-loop gain requirements. Errors due to the finite transistor speed are not the only ones. Inaccuracy of the feedback resistor will produce a gain error, and drift, in a d-c amplifier, will produce an offset error, but these will not be discussed further here.

Another step response error of importance arises from transients produced by spurious pole-zero pairs, or doublets, which are caused by parasitic reactive elements or by incomplete pole-zero cancellation in pole-zero design. Doublets produce departures from exact flatness in the closed-loop frequency response, and relatively larger departures from exact unit slope cutoff in the corresponding open-loop response.



OPEN LOOP *gain of typical cordwood amplifier shows high frequency instability—Fig. 6*

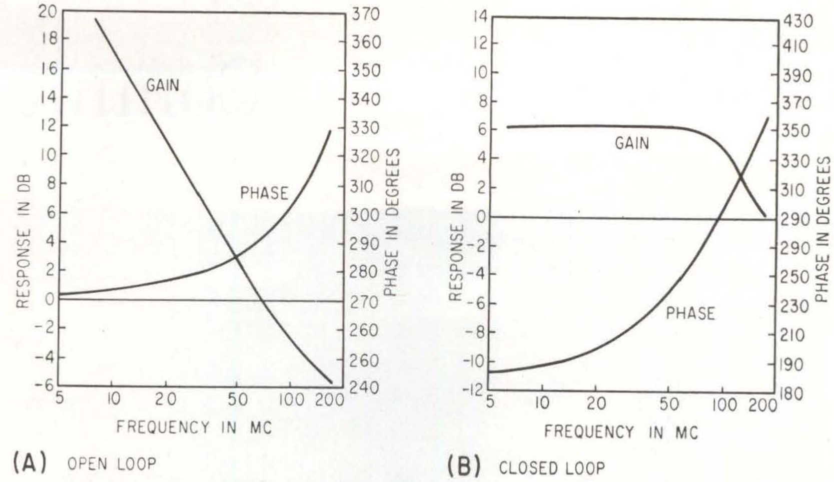
The effect of a real doublet on the asymptotic frequency response and the time response is shown in Fig. 3. The error transient produced by the doublet will have an initial value equal to the variation in frequency response that it produces. Thus, for a step response accuracy of 0.1 percent, the net effect of all doublets must not vary the closed-loop response by more than 0.1 percent. At sufficiently high frequencies, the doublet transient will die out quickly, so larger doublets may be tolerated.

When feedback is removed, the open-loop response falls at 6 db per octave, and doublets express themselves as departures from this cutoff slope. Feedback reduces doublet size (that is, flattens the response) by roughly the magnitude of the return ratio, so open-loop doublets will be larger than their closed-loop counterparts. Thus, since the return ratio varies inversely with frequency, the allowable open-loop doublet size becomes relatively greater at low frequencies.

ACTUAL CIRCUITS—If frequency doublets are to be minimized, it is undesirable to use pole-zero cancellation techniques to synthesize the unit slope cutoff function. Of the four forward transfer functions of a common emitter transistor amplifier, one, namely the forward transimpedance, z_{21}, has a unit slope cutoff over a wide range of frequencies. The forward transimpedance may be made to control the response in the cutoff region by providing open circuit source and load impedances. This can be accomplished by providing a unity voltage gain amplifier at the output, such as one or several tandem common collector stages as shown in Fig. 4 (Q_3 and Q_4). Bootstrapping the d-c bias resistors of these stages keeps the input impedance high.

The basic unit slope cutoff comes about because the output voltage, V_o, appears (slightly increased) at the collector of Q_2, where it creates a base current $V_oC_{c2}s$ through the collector capacity of Q_2. This base current is the input current for the amplifier multiplied by the α of an input common base stage; this α is nearly unity.

This amplifier was designed as a



OPEN *and closed loop responses of the integrated amplifier—Fig. 7*

d-c operational amplifier. A parallel path arrangement was developed in which d-c signals at the input summing mode are amplified in a low drift d-c amplifier and reinserted into the amplifier signal path at the input to the common emitter stage. The common base stage isolates the input from the output of the d-c amplifier and provides a high impedance source for the common emitter stage. A resistor in series with the input of the common base stage provides d-c signal voltage for the d-c amplifier and broadens the bandwidth of the common base stage so that it does not add significant slope to the final asymptote in the cutoff region.

The response of the d-c amplifier in parallel with the common base stage is complementary to the high frequency amplifier comprising Q_2, Q_3, and Q_4, and maintains the unit slope down to about one Kc, where the gain is over 100 db. The junction of the two responses produces a small frequency doublet but at a low enough frequency to avoid excessive time response errors.

FREQUENCY RESPONSE — The transfer function of the whole amplifier is of eight order in the frequency variable, but a reasonably good approximation is obtained from

$$G(s) = \frac{1}{s^3 + a_2s^2 + a_1s + 1} \quad (5)$$

or

$$F(s) = \frac{1}{s(s^2 + a_2s + a_1)} \quad (6)$$

The coefficient of the s^3 term, normalized to unity here, is set by the final asymptotic transistor response. Coefficients a_2 and a_1 establish how the unit slope cutoff joins the final asymptote (the smaller a_2 and a_1 the more lively the response). The last coefficient in the denominator of $G(s)$ (taken as unity) comes about from the feedback, and is accordingly absent from the open loop gain of Eq. 6.

Coefficient a_1 controls the magnitude of the unit slope cutoff. Its value may be increased by increasing the collector capacity of Q_2. Coefficient a_2 will also increase slightly when this is done, as will a_3. The effect on a_3 can be reduced by placing a resistor and perhaps inductance in series with the added capacity. In the amplifiers which have been constructed, the collector capacity of Q_2 was adequate, so that none was added.

Coefficient a_2 may be increased without significant effect on a_1 by adding capacity from the base of Q_3 to ground, again through a resistor to avoid reducing the final asymptotic response. If a_2 is too small, the open-loop gain will have a peak at the asymptotic cutoff frequency.

With these two adjustments, the desired closed-loop filter function of the table can be approximated. Exact analysis is difficult because of both circuit complexity and propagation delay, so experimental work is important.

DELAY — Propagation delay has an unstablizing effect on performance, and since it adds phase proportional to frequency, ultimately limits the bandwidth of the feedback amplifier. Delay comes from two sources: first is excess phase in the transistors (about 0.1 nanosecond in high frequency silicon transistors) and mainly comes about through the lattice-scattering limited drift velocity in the collector depletion region; the second is transport delay around the feedback loop. In a cordwood version in which particular attention was paid to minimizing the distance around the feedback loop, the loop distance measured three inches, representing roughly 0.3 nanosecond of delay. This was reduced to less than 0.1 nanosecond in the integrated circuit version.

Delay modifies the values of the coefficients of s in the open-loop gain, but the general effects of increasing a_1 and a_2 remain.

EXPERIMENTAL WORK—High-speed measurements in the time domain are difficult to perform with sufficient accuracy, so frequency domain measurements were performed on three different amplifiers. First, a low frequency analog was built and tested to check the theory without the complications caused by parasitic reactive elements; second, a full speed cordwood model was constructed, with signal path and ground lead lengths minimized; third, integrated circuit was built using separate chip mounting of the four transistors and three zener diodes.

The structure of the integrated circuit is a gold deposited ceramic substrate on a TO-5 header. Silicon planar transistors and diodes and bulk silicon resistors in chip form are bonded to the substrate, as shown in Fig. 5.

Open loop gain of the three amplifiers is shown in Fig. 6. The separate chip approach helps keep parasitic elements to a minimum. Open and closed-loop gain and phase are shown in Fig. 7.

The fabrication of the integrated circuit was performed by Richard Lindner and Karl Martersteck whose help, along with that of James Goldey, is gratefully acknowledged.

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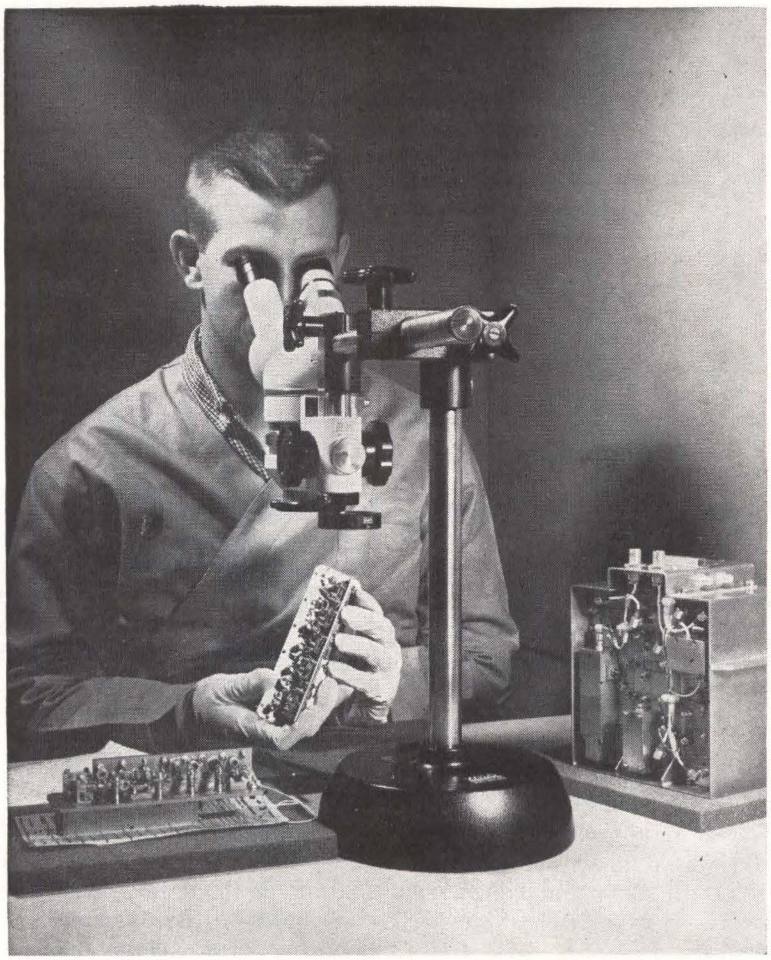
Communicating With



STRICT *inspection and quality control must be exercised for space-vehicle equipment to assure successful operation under changing environment*

The Mariner II Venus probe has shown the validity of deep-space telemetry. Longer flights are planned in the near future. Here is how Mariners communications system functioned to receive commands and transmit telemetry data during the 109-day flight

By WARREN E. DAHL, Motorola Inc., Military Electronics Div., Scottsdale, Ariz.

OUR MARINER II spacecraft recently passed Venus at a miss distance of 21,648 miles, marking the most successful interplanetary space probe ever attempted. At the climax of its 109-day, 181-million-mile journey, it was telemetering information clearly across the 36-million miles to earth, setting a new all-time record for long distance communication. Tracking continued until the spacecraft was more than 53 million miles from earth.

Mariner II's spaceborne communications package has been described as one of the most sophisticated and efficient electronic systems ever devised. Integrating the functions of command, telemetry and tracking, and working in conjunction with the DSIF ground stations, the communications package aboard the probe was built around an L-band transponder. On the spacecraft, an omnidirectional array was used for command and tracking-signal reception, and a directive parabolic antenna for telemetry and tracking signal transmission. Transmissions up to the space craft were on 890 Mc and transmissions down to the earth were on 960 Mc.

The 10.5-lb transponder was designed to provide the functions of a command receiver, a phase-coherent doppler transponder and a telemetry transmitter. It consumed about 7 watts of power and had a carrier threshold of −147 dbm. Commands received by the transponder were detected and relayed to the spacecraft command decoder; scientific and spacecraft engineering data were processed by the flight-data encoder and applied to the transponder-modulator. In addition to the six scientific experiments, a total of fifty spacecraft operating parameters were reported, including voltages, temperatures, antenna-pointing information and transponder agc voltage.

CONSTRUCTION — The transponder configuration bore a striking resemblance to two six-packs of beer; it weighed about 10 pounds, occupied less than a ¼ cubic foot and was gold plated. Individual modules had tee-section construction to provide a rugged unit and to guard against internally-generated coherent signals. Solid state circuits were employed throughout and transistors and other electrical components were screened in a Minuteman type testing program to reduce the possibility of failure. Moreover, the transponder was subjected to at least 500 hours of testing in all anticipated environments prior to launch. No redundant elements appear in the communications system; however, individual modules were designed to accept a ±3-db change in input signal level without performance degradation.

EARTH TO VENUS AND BACK AGAIN

Even when high-power transmitters and large antennas are used, signals received from deep space are very weak. Undaunted, Motorola and JPL engineers designed the equipment aboard our Mariner II vehicle to receive command signals from the Goldstone DSIF tracking station at a distance greater than 36 million miles. Moreover, telemetry data sent back from the low-power transmitter aboard the probe reached Earth without a hitch.

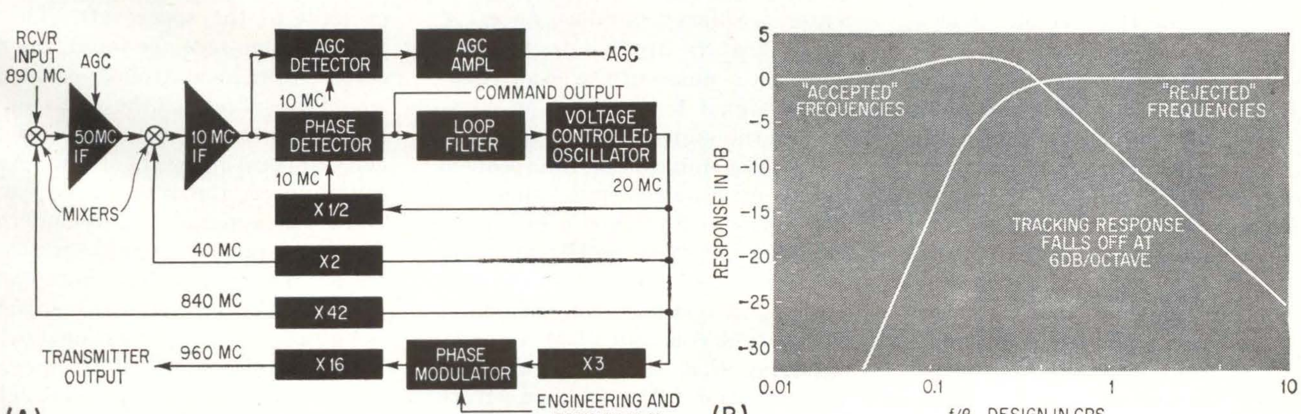
Goldstone transmitter power	10 Kw (+70 dbm)
Goldstone antenna gain	+ 43 db
Free-space loss (L_{FS})	— 247 db
($L_{FS} = -36.6 - 20 \log_{10} 36\times10^{6}$ miles $- 20 \log_{10}$ 890 Mc)	
Spacecraft omni antenna gain (best look angle)	+1.50 db
Losses between antenna and transponder	—1.50 db
Signal level at transponder	— 134 dbm

TRANSMITTER AND RECEIVER—The L-band transponder consists of a double-conversion heterodyne, phase-coherent receiver and a c-w transmitter integrally related in both frequency and phase. The sensitivity of the transponder at threshold is −147 dbm. This is a function of both the receiver noise figure with maximum value of 14 db, and the loop r-f noise bandwidth designed to be 20 cps at threshold.

The phase coherent circuit shown in Fig. 1A is extremely versatile. It can be designed to exhibit a wide variety of characteristics, and the characteristics themselves can be combined in numerous ways to achieve the objectives of specific applications. Effectiveness is contingent upon the amount of prior information designed into the circuit, which is a product of component values and configurations.

The design of the Mariner transponder was based on estimates of the nature of the received signal. This built-in intelligence includes a history of what these signals have been known to do in the past, plus all frequency and phase permutations that could be exhibited in the future.

The r-f phase-lock loop was designed to follow doppler-frequency shifts, ground-transmitter frequency changes and long-term oscillator instabilities. The loop filter exhibits the very narrow information passband characteristics required by the doppler modulations, and can thus use a very narrow passband to reject unwanted noise. The phase-lock loop recognizes the carrier-signal components by comparing them with a locally generated description (a process called correlation) that is designed into the circuit. The portion of the signal which is predicted and tracked by the phase-lock loop is used similarly to provide the basis for dop-

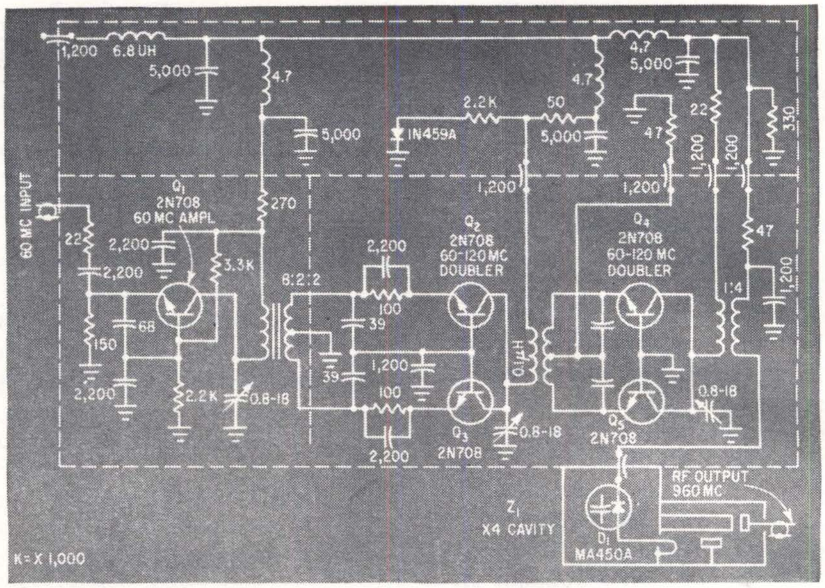


PHASE-COHERENT *circuit and frequency-multiplication system comprise the L-band transponder (A) and phase-lock loop response vs receiver modulation bandwidth (B)—Fig. 1* pler ranging, while the portion that is not predicted or tracked appears as modulation at the command output of the transponder. The circuit ignores the noise components in the loop.

Figure 1B shows the relationship between the loop-frequency response and the receiver-modulation bandwidth; low-frequency characteristics are determined by the tracking capabilities of the loop, while the high-frequency end is set by the passband of the receiver-crystal filter.

TRANSPONDER OPERATION —The 890 Mc input signal mixes with the local oscillator in a balanced-diode mixer and is amplified in a transistor preamplifier operating at approximately 50 Mc as shown in Fig. 1A. The noise figure of the module is typically 13 db and the r-f to i-f conversion gain is about 35 db. The output of the preamplifier is applied to a gain controlled 50 Mc i-f amplifier and second mixer, that provides a 50 Mc to 10 Mc conversion gain for the module and is controllable over the range from +65 db to −40 db by the agc voltage. The fixed-gain second i-f amplifier contains a narrow band crystal filter at its input which limits the noise output of the unit to a 3 Kc passband at approximately 10 Mc. The module furnishes a linear output to the quadrature (amplitude) phase detector, and a limited signal output to the r-f loop-phase detector. The passband of the amplifier is broadened to reduce phase shifts occurring with agc and temperature.

The transponder contains two r-f phase detectors that are identical in design but serving two purposes. Each compares a characteristic of the incoming signal from the 10 Mc i-f amplifier, with a reference signal generated by the r-f loop voltage-controlled-oscillator. When the r-f loop is in lock, the phase detector provides an output that is proportional to the phase difference between the received and reference signals. The quadrature or amplitude detector provides an output that is proportional to the amplitude of the carrier signal. After suitable conditioning, the output of the amplitude detector is used to control the gain of the first i-f amplifier and is telemetered to provide an accurate analog of signal strength. In both detectors, the bridge-reference signals are subjected to a strong limiting (followed by tuned circuits) to ensure dependency on the received-signal characteristic.



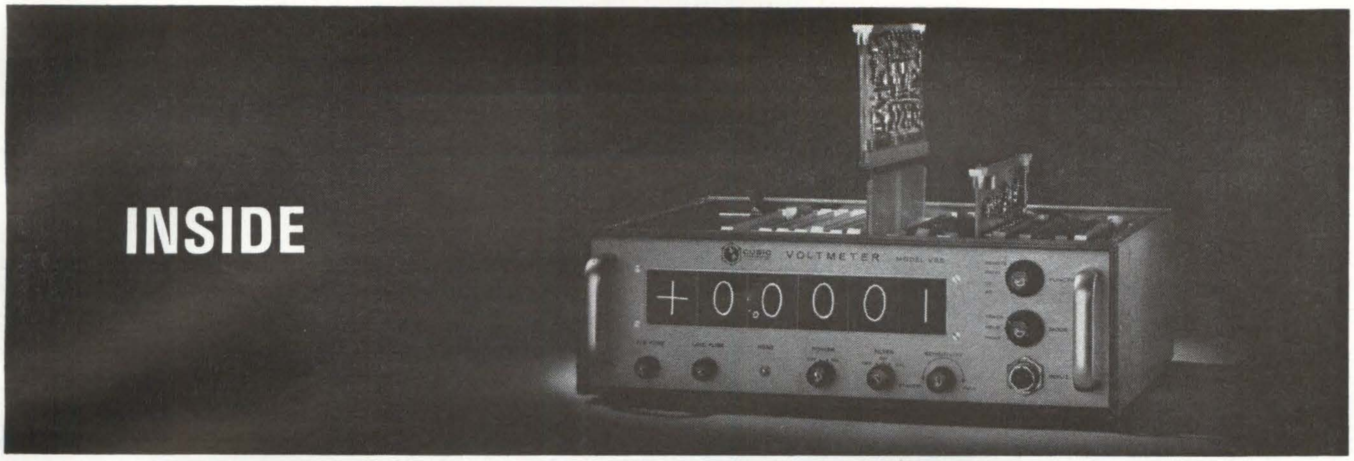
FREQUENCY *multiplier including varactor cavity assembly—Fig. 2*

Each phase detector, in addition to the reference amplifiers, contains a diode-bridge and signal-input network. An error signal is produced at the output of the phase detector bridge whenever the input signal tends to lead or lag the locally generated reference signal in phase. This error signal is applied to the loop-low-pass filter that integrates high-frequency phase jitter. Low-frequency signal components, including any drift of the center frequency, produce an error signal that is applied to the vco causing the phase of the locally generated signal to move up or down toward the signal frequency.

Phase modulation on the received signal is removed preceding the loop-low-pass filter and conditioned for use by the spacecraft command decoder. The loop filter is entirely passive; it contains an RC filter with a time constant of 51 seconds, requiring that the filter capacitor have extremely low leakage. High temperature leakage currents of more efficient capacitors may result in an undesirable change in loop bandwidth and consequent loss of phase lock.

The voltage-controlled oscillator obtains 0.002% frequency stability from a series-resonant, third-overtone quartz crystal. The frequency of the oscillator can be deviated from its nominal value of 20 Mc by the d-c voltage output of the loop filter applied to two back-biased, silicon, voltage-variable capacitors in the oscillator series LC feedback loop. The vco provides the phase detector reference signals, the first and second mixer injection, and the transmitter signal when suitably multiplied.

In normal operation, the transmitter is phase locked with the receiver signal; however, in long, interplanetary flights, it is not necessary to continually send commands or data to the spacecraft. Therefore, with no receiver input, the receiver voltage-controlled oscillator would be subject to the vagaries of an integrated noise output of a receiver operating without agc. As a consequence, the receiver on earth would see a signal that is undergoing phase and frequency variations which may exceed the design bandwidth. Therefore, the transponder is equipped with an auxiliary oscillator that is activated by the absence of receiver agc voltage. This oscillator is similar to the voltage-controlled oscillator in design and frequency and becomes a noise-free



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CMR: 80 db at 60 cps
Power: 40 VA, 50-400 cps, 115-230 V
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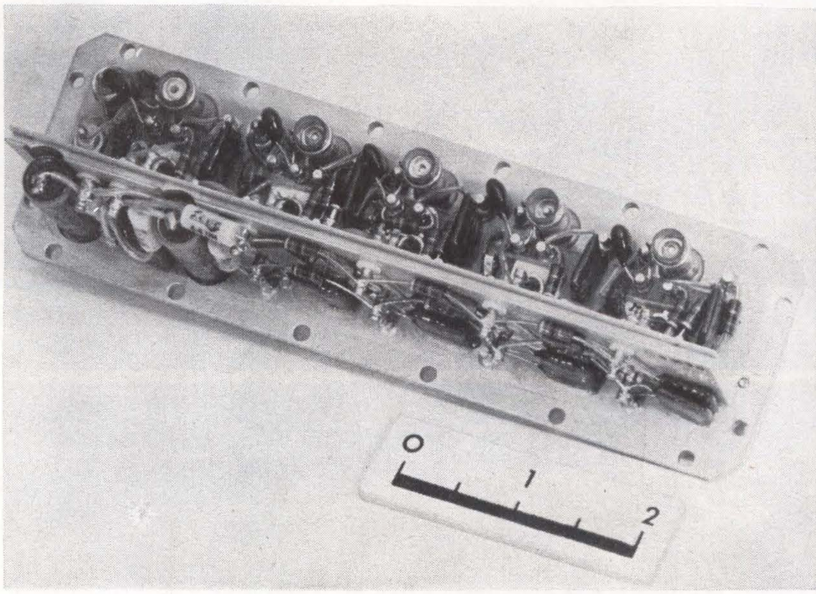


T-SECTION *design is used to reduce signal levels at module surface to less than 10 watts—Fig. 3*

source to lock the ground receiver.

Telemetry information is applied to the transponder transmitter in a series-phase modulator operating at 60 Mc. Modulation is accomplished by varying the tuning of a series-resonant circuit containing silicon voltage-variable capacitors. The capacitance of the circuit is controlled by the amplitude of the modulating signal. The 60 Mc modulated signal is multiplied by a factor of sixteen to provide the transponder-transmitter output.

MULTIPLIER—The X16 frequency multiplier shown in Fig. 2 provides the 960 Mc r-f output signal by frequency multiplying the 60 Mc input signal from the phase-modulator module. The frequency multiplier consists of four stages. The first stage amplifies the 60 Mc signal; the second multiplies it from 60 Mc to 120 Mc; the third multiplies from 120 Mc to 240 Mc and the final stage multiplies from 240 to the required 960 Mc output signal.

The 60 Mc input is applied to amplifier stage Q1 at a nominal power of 10 mw. The output is split into two out-of-phase signals of 30 mw each and applied to the first frequency multiplier stage Q2-Q3. This stage is composed of two transistors in a push-push, Class C combination in a common-base configuration. The inputs are fixed-tuned to 60 Mc and the output, which is split into two out-of-phase signals, is parallel-tuned to 120 Mc. The stage gain is about unity and the transistors are driven into saturation.

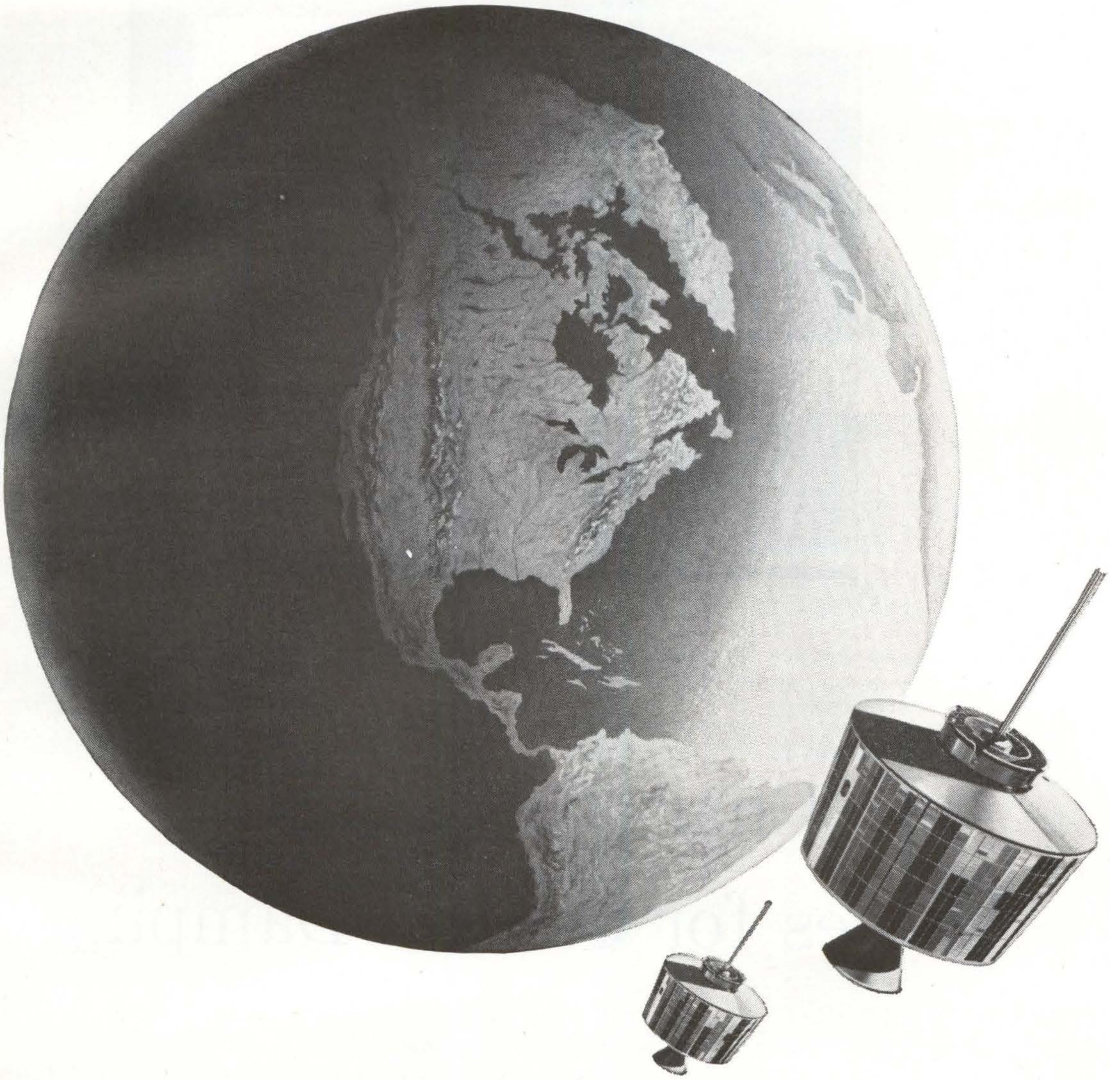
The second frequency multiplier stage Q4-Q5 is also composed of two transistors operating in push-push and class C. The inputs are fixed-tuned to 120 Mc and the output is parallel-tuned to 240 Mc. The stage gain is about unity and the transistors are driven into saturation. The 65 mw, 240 Mc output from multiplier Q4-Q5 is applied to varactor and cavity assembly Z_1. Varactor D_1, by its inherent harmonic generating characteristics, multiplies the signal from 240 to 960 Mc. A fixed reverse bias of 1.4 volts d-c is applied to the varactor for temperature stability. The output of the varactor is inductively coupled to a quarter-wave, series-resonant coaxial cavity tuned to pass the 960 Mc signal. The 960 Mc output is capacitively coupled and is nominally 10 mw. The 10 mw, 60 Mc drive power at the input to the multiplier module can degrade to about 1.5 mw before the output power is affected. This margin is provided by the saturation designed into each stage of the multiplier. Temperature stability is also increased since stage gain changes are ignored.

SPURIOUS SIGNALS—Much of the overall transponder design effort was devoted to the elimination of spurious signal paths. If, for example, the 10 Mc output of the frequency divider is permitted to modulate the first or second mixer local-oscillator signals, a coherent output will be obtained. The presence of this output will certainly prevent the desired signal from being tracked by the transponder.

The T-section module design shown in Fig. 3 is used to reduce all signal levels at the surface of the module to less than 10 microvolts. All hot r-f circuitry is located on one side of the leg of the T-section. Supply lines are decoupled once in going through the leg and at least once more in going through the top of the T. All r-f signals are transmitted through double-shielded 50 ohm subminiature cable and all connectors are threaded to ensure a positive ground. The economical extruded T-section is machined to achieve an r-f seal where it mates with supporting sections of the main housing.

RELIABILITY—The general tenets of the reliability program, as carefully followed in the Mariner transponders, emphasize conservative circuit design and repeated inspection and testing of parts, modules and transponders. The specific approach includes: microscopic inspection of all parts that are later sealed into containers; heat soak of all semiconductors for 200 hours at 150 degrees centigrade; temperature cycle of all passive components; vibration test of electromechanical devices; continuous in-process microscopic inspection on all modules; complete transponder testing over required temperature range; disassembly of transponder for microscopic inspection, and reassembly and complete acceptance tests.

This approach has resulted in a stable transponder whose final reliability figure has been greatly increased by careful attention to manufacturing processes and repeated testing to eliminate weak parts. Since each electrical part is identified and carries an IBM card tabulation of test history, all failures are easily correlated with inspection data, manufacturing lots, and other controls.



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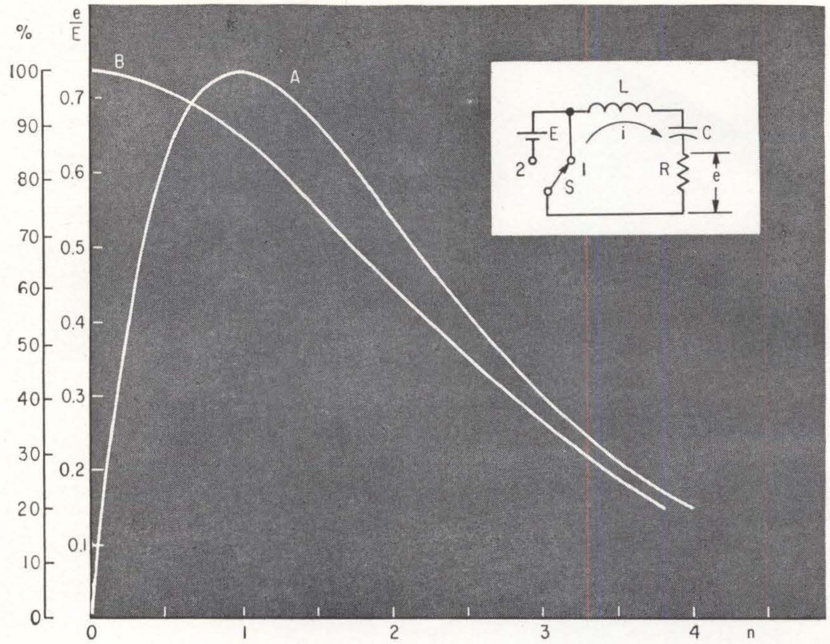

FOR *the critically damped circuit shown, curve A gives the ratio e/E versus n. Curve B shows the ratio e/E versus pulse width in terms of n. The percent scale refers to the percent of maximum pulse amplitude for either curve*

Chart Gives RLC Values for Critical Damping

By ARTHUR B. MOULTON,
P.O. Box 24, Livermore, California

SELECTING component values for generating a critically damped transient in a simple RLC circuit is a cut-and-try process under conditions frequently encountered in practice. The selection of components for a circuit such as that shown is facilitated by the normalized graphs. When the switch transfers from contact 1 to contact 2, a transient is generated as described by E. A. Guillemin in "Communication Networks," volume 1, page 55. Variations of this circuit may be used to generate pulses for resetting counters in pulse-operated equipment either manually or by remote control.

If $R/4L = 1/RC$, the circuit will be critically damped. The voltage across resistance R will be a pulse described by Eq. 1

$$e = \frac{REt}{L} \epsilon^{-Rt/2L} \qquad (1)$$

The pulse will have a maximum of $e = 2E\epsilon^{-1}$ when $t = 2L/R$. This cannot be solved explicitly for t, consequently the pulse width can not be determined. If the substitution $t = 2L/R$. This cannot be solved expulse may be described by the normalized Eq. 2

$$\frac{e}{E} = 2n\epsilon^{-n} \qquad (2)$$

Curve A represents Eq. 2. Curve B, obtained graphically from curve A, shows the amplitude of the normalized pulse as a function of the normalized pulse width in n units. Consider the simplification of calculations resulting from the use of these curves in the following example.

Given: $R = 25$ ohms; desired pulse amplitude = 8 v maximum; desired pulse width at 6 v = 1.5 μsec; Find E, L, and C.

The maximum pulse height is 0.736 E, therefore $E = 8/0.736$ or $E = 10.9$ volts. Six volts is 75 percent of the maximum pulse height. Referring to curve B, the pulse width in n units is 1.5.

$$L = \frac{tR}{2n} = \frac{(1.5)(25)(10^{-6})}{(1.5)(2)} = 12.5\mu h$$

$$C = \frac{4L}{R^2} = \frac{(4)(12.5)(10^{-6})}{625} = 0.08\mu f$$

To determine any other characteristics of the pulse from the normalized curve A, simply multiply the ordinate by E and the abscissa by $2L/R$.

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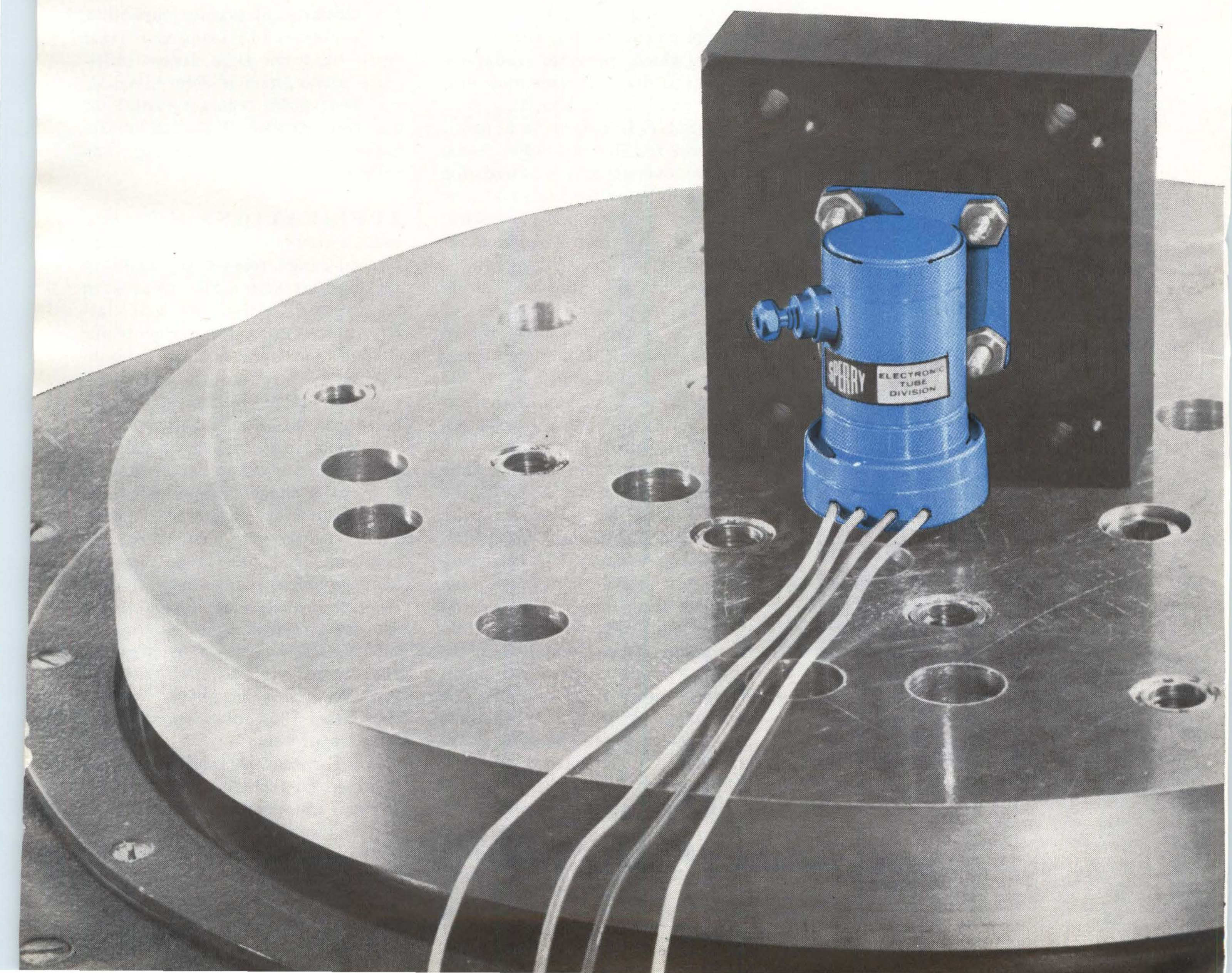
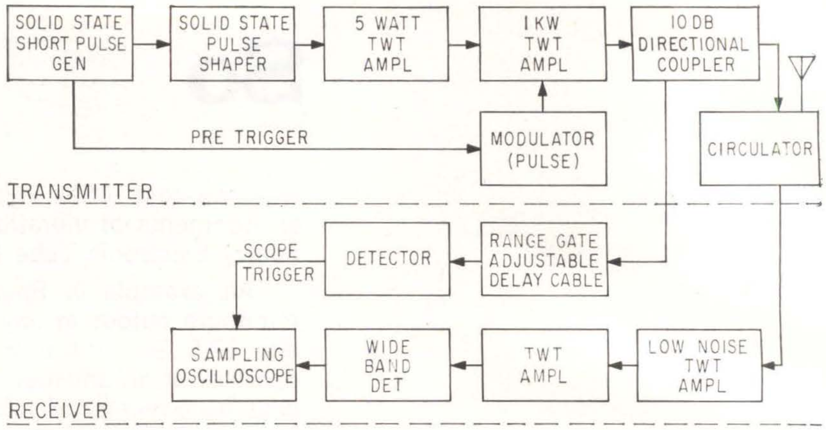


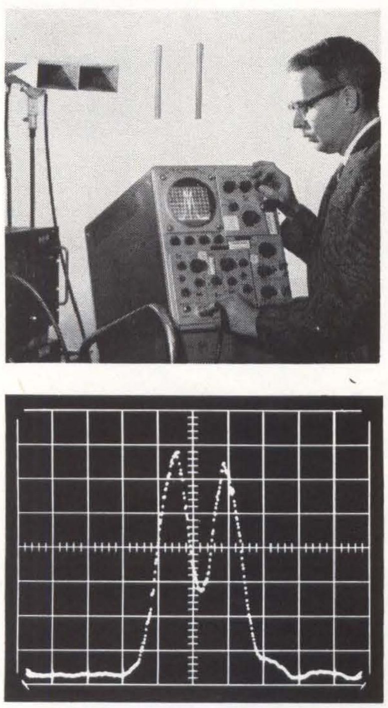


TWT CHAIN *completes General Dynamics/Electronics' new system. Frequency is 8 Gc to 9.6 Gc, pulse duration 0.6 nanoseconds, peak power 1.8 kilowatts—Fig. 2*

Subnanosecond Radar Shows High Resolution

Novel technique yields unprecedented detail from target returns

NEW RADAR SYSTEM that operates with very short pulses, having a duration of less than one nanosecond, has been developed by General Dynamics/Electronics. Effective range resolution of the new equipment is less than three inches, which provides radar-return detail from targets not previously possible, see Fig. 1.



RESOLUTION TEST *shows that new radar can distinguish between closely spaced plastic rods, top. Rods were about 4 inches apart for return reading shown at bottom —Fig. 1*

The radar developed as a result of several feasibility studies, some of them government sponsored, for radar techniques for ice and snow thickness measurement, measurement and analysis of surface reflection coefficients and signal attenuation of sea water, and so on.

Techniques presently used for r-f short pulse generation have evolved from a series of techniques (previously used but not included in the present system) including investigation of diode switches, modulation of travelling wave tubes, impulse data generation, and TR tube leakage. Until recently, the TR tube spike leakage technique was the most successful known for short-pulse work; however, it is relatively inefficient. In the new technique used, the basic pulse is generated by a solid-state subnanosecond pulse generator and shaped by pulse shaping circuits. A chain of travelling-wave tubes then amplifies the subnanosecond pulses to the required power level. The system arrangement is illustrated by the block diagram in Fig. 2.

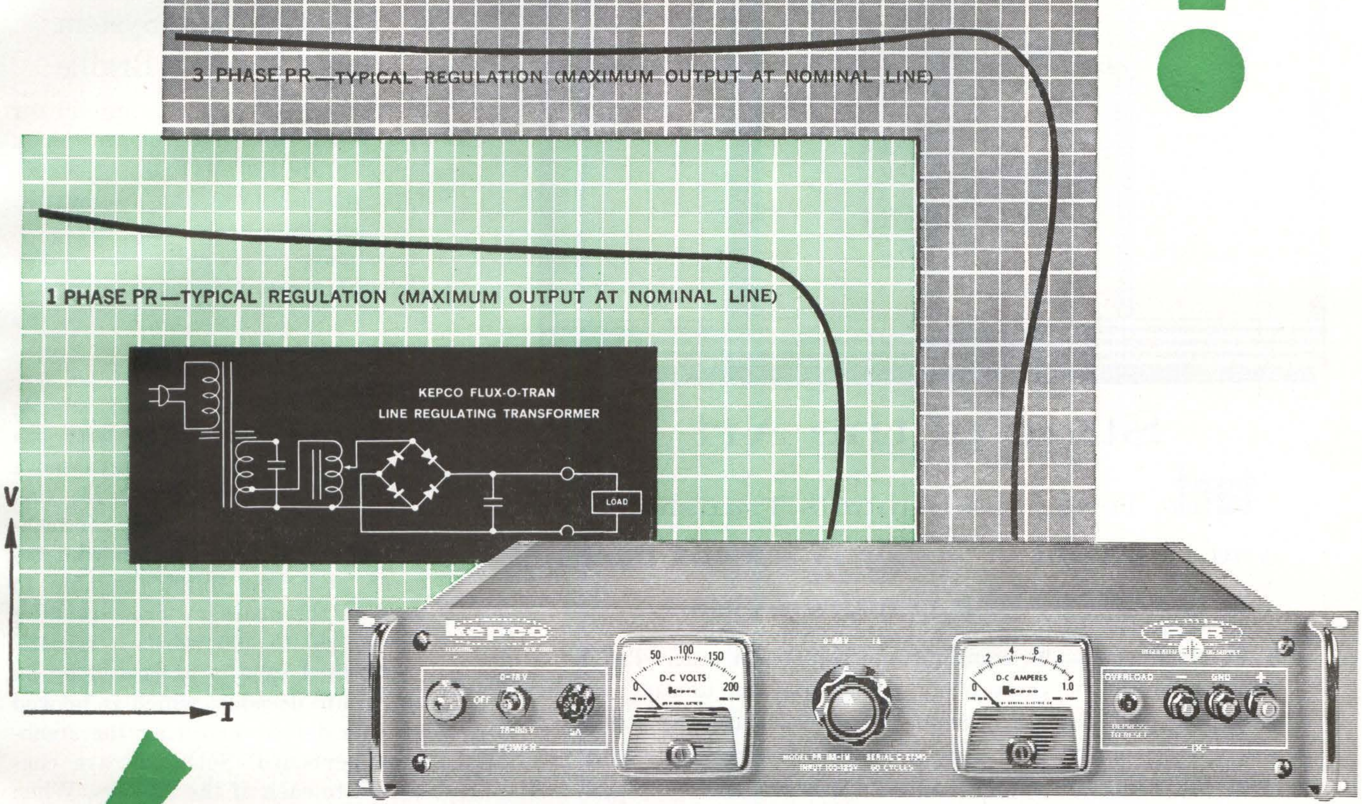
In the system shown on the cover, about one-half watt of generated r-f power was used. When the final output stages are added, the system has a peak output power of 2 kilowatts, and greater capability can be obtained by using additional travelling-wave tube stages. Ultimate power limit is determined by the breakdown characteristics of the transmission lines and subsequent equipment following the transmitter.

APPLICATIONS — The new radar's simple approach and demonstrated range resolution capability make it attractive for areas such as target discrimination and classification, airport and harbor traffic control and surveillance, antisubmarine-warfare studies and periscope detection, battlefield surveillance and target identification.

A short-duration-pulse radar can be used to advantage in the laboratory to conduct remote thickness measurements, evaluate recovery times, breakdown phenomena, relaxation times and other time-dependent microwave effects; to determine locations of imperfections in waveguides and microwave tubes, and to explore propagation phenomena such as multipath reflections and atmospheric indirect time delays due to weather, clouds, temperature etc.

Basic research applications are expected to include the evaluation of radar cross-sections of individual scattering points on complex geometric shapes such as cone tip and base, edges and base of a wedge or *can you use the advantages of Kepco's*

STATIC MAGNETIC VOLTAGE STABILIZER ?



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The **FLUX-O-TRAN** is the heart of Kepco's PR GROUP of DC Power Supplies. By delivering a squared-waveform to the rectifier, the **FLUX-O-TRAN** increases rectifier utilization and improves the loading characteristics of the filter capacitors. This characteristic provides a relatively low intrinsic source impedance, improving load regulation and affording a low ripple content. The result is a simple FOOL-PROOF, high efficiency source of regulated DC power in *minimum space* and at *minimum cost.*

The PR GROUP offers a wide choice of *adjustable* output voltage and output ratings with:

- *typical ripple values 0.5 to 3%*
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	±1% LINE REGULATION — 105-125 V AC, 60 CPS ± 5% — 1 PHASE										±2% LINE REGULATION 208/230 V AC ±10% 60 CPS ±5%—3 PHASE		
VOLTS	0–7.5–15	0–15	0–19–38	0–38	0–40–80	0–80	0–78–155	0–155	0–165–310	0–310	0–20	0–40	0–50
AMPS	0–10	0–30	0–5	0–15	0–2.5	0–8	0–1	0–4	0–0.6	0–2	0–100	0–50	0–40
MODEL	PR 15–10M	PR 15–30M	PR 38–5M	PR 38–15M	PR 80–2.5M	PR 80–8M	PR 155–1M	PR 155–4M	PR 310–0.6M	PR 310–2M	PR 20–100M	PR 40–50M	PR 50–40
PRICE	$345	$495	$325	$475	$325	$450	$325	$430	$345	$430	$1,125	$950	$950

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corner reflector, Fresnel and shadow region of a sphere, and to investigate the properties of sea and land clutter targets, and for general radar cross-section measurements.

Punched-Tape System Could Replace Braille

CAMBRIDGE—A new reading aid for the blind, being developed as a thesis project at MIT, uses a stenotype machine working backwards. Punched tape containing words in the stenotype phonetic code is fed through a special mechanism which depresses corresponding keys on the stenotype machine.

By learning the stenotype system, a blind person would be able to read the information with his fingers as he feels the keys move up and down. Air Force Lt. Col. Cheadle, who is developing the technique, says a blind person who became proficient might be able to read at the ordinary prose-reading speed, 300 to 400 words a minute.

Punched tape is processed by an electronic decoder, which is hooked up to a device operating the stenotype keyboard. Solenoids are connected to each of the 22 keys. When triggered by a signal from the decoder, the solenoid pulls down the corresponding key.

Radar Master and Slave Pinpoint Their Target

ROME Air Development Center is putting together in-house a dual-radar, air-surveillance system that will pinpoint target locations by trigonometric techniques. Called the Active Swept Frequency Interferometer Radar (ASFIR), it is designed to obtain extremely high-precision angle and range information.

A master radar transmits and receives signals. A slave radar receives and reflects back to the master. The time it takes the master's signal to reflect to the slave and back to the master is converted into distance for an accurate triangulation. Adding a second slave would give both range and altitude. RADC hopes to have the radar operating by the end of summer.

Conference on

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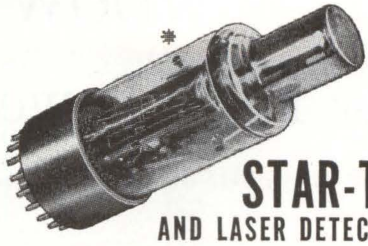

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WINDOW MATERIALS
For High-Power Microwave Tubes

By R. J. BONDLEY, Power Tube Dept., General Electric Co., Schenectady, N. Y.

Guide helps select ceramics for proper window design

REGARDLESS of the amount of power generated within the vacuum envelope of a device by electron interaction, this power must be extracted through the sealed barrier commonly called the window.

To be effective, the window must be transparent to microwave energy, thus should neither reflect nor absorb energy.

When selecting the window material, and arriving at a suitable design, the physical properties of the barrier material must be evaluated and bartered against conditions imposed by the environment and by the mechanical design of the frame.

MATERIALS — Dielectric materials that have the most suitable physical properties for windows include the fused oxides of aluminum, beryllium and silicon. As the purity of these materials has improved, their loss factor has decreased accordingly. However, the type of the impurity, even though present in very small amount, may greatly affect the loss factor of the body.

The published values of the physical properties of various ceramic bodies at X-band are given in the table.

TABLE—CHARACTERISTICS OF MICROWAVE WINDOW MATERIALS

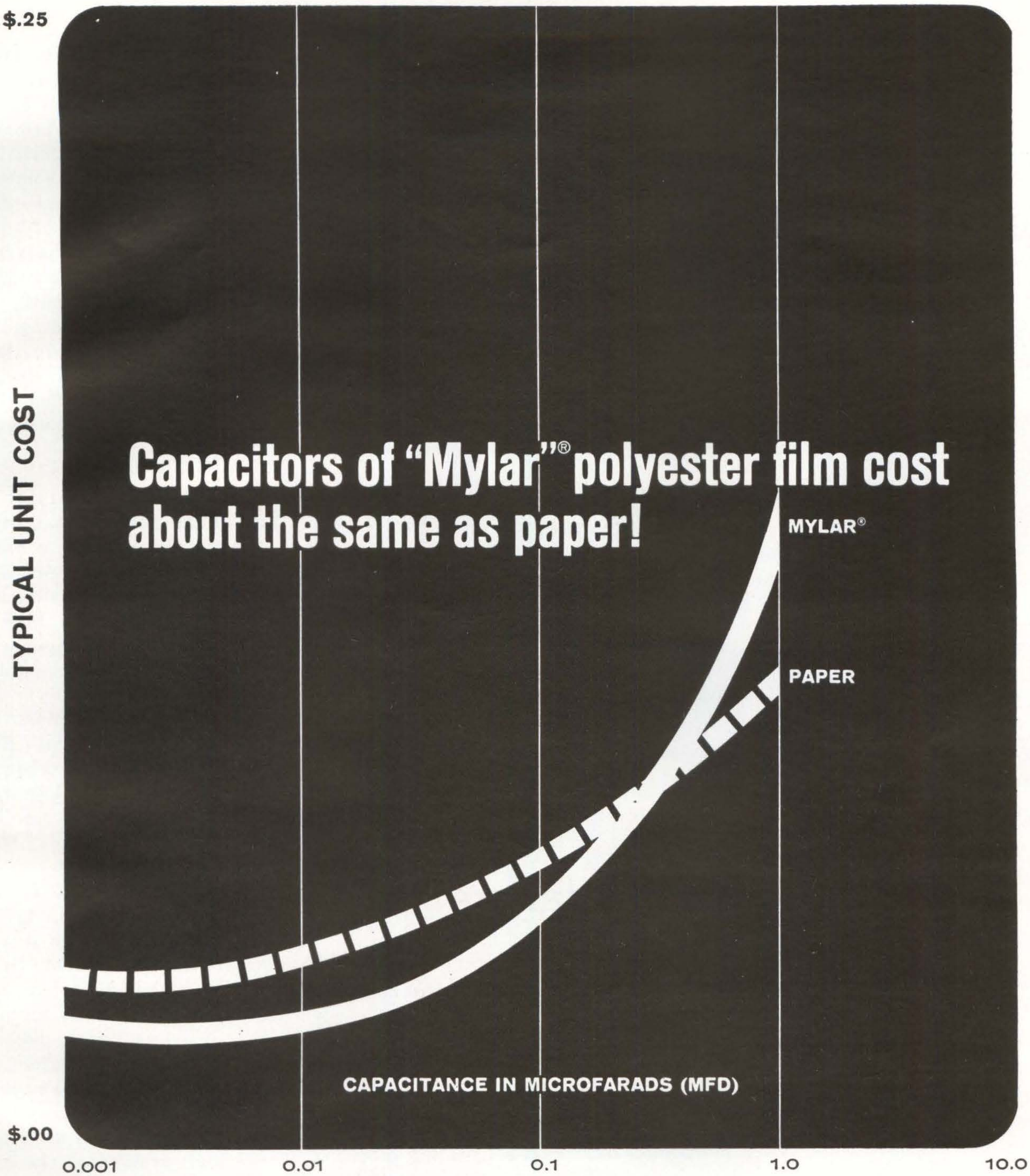
	Dielectric Constant	Tan δ	Therm Coef of Linear Expan- Per °C $\times 10^{-6}$	Therm Conduct Cal/Sec/ Cm^2/ Cm/°C	Tensile Str $\times 10^3$	Young's Modulus $\times 10^6$	Dielec Str V Per Mil	Vol Resist
Alumina								
Wesgo AL-300	9.04	0.00045	8.5	0.064	26	39	1,100	$>10^{14}$
	9.32[a]	0.0004[a]						1×10^{12} [a]
Wesgo AL-995	9.37	0.00009	6.9	0.070	30	....	800	$>10^{14}$
	9.61[a]	0.00014[a]	8.5					2×10^{11} [a]
Coors AD- 94	8.75	0.0011	6.7		25	40.2	330	$>10^{14}$
	9.05[a]	0.0016[a]	7.6					9×10^{11} [a]
Coors AD-995	9.44	0.00008	6.8			50	330	......
	9.88[a]	0.00028[a]	8.3					
Lucalox	9.9	0.000025	6.8	0.085		56.1	1,700	$>10^{14}$
			6.9[a]	0.003[a]				2×10^{14} [a]
Sapphire								
⊥ to C Axis	11	0.000026	5	0.065	>20	55	1,200	......
		0.000065[a]	7.7[a]					
Beryllia								
Coors BD-96	6.7	0.00041	9.23[b]	0.52	16	46	.....	10^{14}
BD-98	6.6	0.00056	9.23[b]	0.52	18	46	.....	10^{14}
Quartz	3.8	0.00005	0.57	0.0035	>7	10		10^{18}

a—300 deg C, b—500 deg C.

It appears that fused quartz (quartz glass or fused silica) would be the outstanding choice for microwave windows. Its extremely low expansion makes it immune to thermal fractures. In addition, its low dielectric constant and loss tangent are desirable electrical properties.

In evaluating all of the physical properties of fused quartz, it is apparent that its poor thermal conductivity can contribute to very high temperatures in the center of a disc, particularly if the only cooling is via the outer periphery and frame. The low thermal expansion which makes quartz particularly immune to cracking also makes it difficult to seal to metals in true concentric joints free from electrical discontinuities. Thus the precise perspective on just where quartz can be used most advantageously has not been entirely determined. Perhaps high Q-circuit requirements where the seal is enclosed by a cavity may eventually dictate the use of quartz of these or similar applications.

Beryllium oxide is unique in that it has a very high thermal conductivity. However, the beryllia now obtainable is more lossy than the best alumina bodies, and it is not as strong mechanically. Thus



For capacitors, specify the extra performance of "Mylar"

Studies of manufacturers' average prices show that capacitors of "Mylar"* are comparable in cost with paper units, over a range of capacitances and voltages. At comparable cost, the higher reliability you get makes capacitors of "Mylar" a better value by far.

Only "Mylar" gives you the extra performance of higher dielectric strength, wider temperature range and higher moisture resistance—at about the same price! Also, capacitors of "Mylar" are smaller than paper units with the same capacitance. In circuits for home-entertainment radio and TV they're perfectly compatible with AC voltages imposed on a DC circuit as long as total voltage doesn't exceed the rated voltage of the capacitor, and the AC component does not exceed the AC corona level. Remember, within the range from .001 to 1 mfd under 600 volts DC, you can get the added reliability of "Mylar"—at costs similar to paper.

For the full story, write for our detailed booklet comparing performance and prices of various insulation systems. Du Pont Co., Film Department, N-10452, Wilmington 98, Delaware.

*Du Pont's registered trademark

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... THROUGH CHEMISTRY

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CIRCLE 41 ON READER SERVICE CARD

increased conductivity is largely offset by the dielectric loss. The one notable exception is a situation where large additional heating is caused by external effects such as particle bombardment rather than internal dielectric heating.

High-purity alumina appears to be the best window choice at this time. Its high strength, ease of fabrication and sealing, and its low loss factors are favorable properties. Its high dielectric constant can lead to difficulties from modes and broad bandwidth requirements.

POWER CAPABILITIES — The maximum power capability of an X-band disc window, a half centimeter thick and 1½ in. diameter, as limited by tensile strength shows that for a high purity alumina, such as 995, operation at a level near 300 Kw should be possible.

A lower-loss alumina, such as sapphire or General Electric's Lucalox, should just about double this value. How close to those values the window can be used in practice can only be determined by experiment.

A similar estimate for a Coors BD-96 Beryllia disc, 1½ in. dia. indicates a maximum power level of 367 Kw at X-band. In the future, if the dielectric loss for beryllia decreases as the purity of the body is increased, beryllia windows may ultimately surpass alumina in power handling capability.

Since quartz will not crack with thermal gradients, the question arises as to what a safe operating temperature might be since 900 deg C is often taken as the temperature at which quartz deteriorates. If this value is taken as an upper limit and 0.00038 as the loss factor, quartz should transmit a power of 66 Kw. However, at 900 deg C, considerable energy would be radiated, so that the 66 Kw figure is conservative.

These calculated power levels are not absolute, but they serve to point out the relative merit of the three ceramic bodies, when edge cooling only is the heat sink for the absorbed power.

Growing Ruby With Strain-Free Crystals

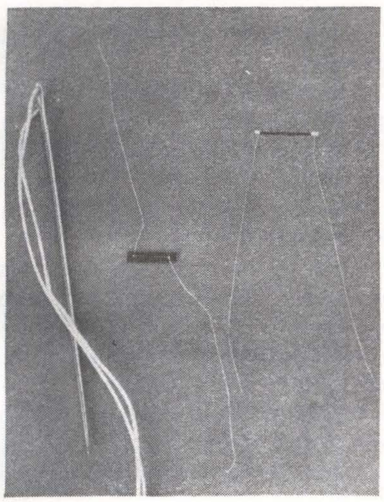
FLUX-GROWN ruby crystals that can be cut $1\frac{1}{2}$-in. long and $\frac{1}{8}$-in. in diameter have been made to lase.

Growth process was reported by J. W. Nielson of Litton's Airtron Div., N. J.

Crystals are said to be remarkably strain free, and have low etch pit density.

Flux-grown crystals have a compositional gradient, but this is said to be uniform.

Firm to Market Strain Gage Elements



SEMICONDUCTOR strain sensor elements that use an epitaxially-grown silicon will be offered by General Electric's Semiconductor Products Department.

In announcing G. E.'s entry to the strain gage field, J. H. Sweeney, manager of marketing said that new semiconductor strain elements were developed for space age equipment. Use of an epitaxial layer on a high-resistance silicon material allows the strain sensor to be soldered or alloyed directly to the stress member. Sweeney said that the new semiconductor strain elements are 60 times more sensitive than conventional wire strain gages.

Sensor element in photo on the right is a conventional semiconductor strain gage. Device on the left is an epitaxial element strain sensor.

Hot-Air Machine Speeds Soldering

Metal bonding, modular packaging, breadboards are other meeting topics

NEW CONFERENCE FOR PRODUCTION ENGINEERS

The conference previewed here is devoted entirely to production people. The nine sessions include: thermal design of equipment for military service; the connector as a factor in production design; miniaturization I: structures and assemblies; miniaturization II: intercomponent connection in manufacturing; advances in fabrication and assembly of electronic equipment; applications of materials and processes to electronic assemblies and structures; airborne and spaceborne packages; structural design of electronic equipment; modular packaging—design and manufacture

COLISEUM in New York City will be the scene next week (June 4-6) of the first National Electronic Packaging and Production Conference. Sponsored by the Industrial and Scientific Conference Management, Inc. of Chicago, the meeting "is designed solely for the men who build and produce electronic equipment," says ISCM president, Milton S. Kiver.

HOT-AIR SOLDERING — Terminal pin connections in printed circuit boards have been soldered in place by a hot-air technique to be described by E. J. Wooldridge of Bendix's Computer Division. Technique is carried out by a machine that:

- Positions solder preforms at the joints
- Transports board assembly under a hot-air blast (temperature of which is closely controlled) so that blast is directed onto joints to complete soldering operation.

Machine was developed to fulfill following requirements:

- Strict localization of solder at joint—neither printed circuitry nor terminal pin are to have any solder coating beyond joint area
- Minimize heat effect of temperature-sensitive components on opposite side of board
- Yield solder joints as good or better than with hand soldering and at less cost.

Cost is a particularly important item since an average of 300 joints per board had to be soldered.

WELDING & HONEYCOMB—Welded-honeycomb module technique will be presented by S. Konsowski and C. Johnson of Sperry Gyroscope. The technique uses the Sperry honeycomb: a molded thermosetting shell with holes in it to accept components; holes are undercut to support component bodies to eliminate loading problems of board modules and to provide component accessibility before, during and after welding of component interconnections. Authors will describe the use of printed circuitry with removeable substrates in conjunction with honeycomb configuration to improve module reliability and reduce costs; there are a few disadvantages of this approach with respect to point-to-point wiring: loss of component accesibility for repairs and interference with flow of potting resins (this is lessened by use of removable substrate).

Removeable substrates were developed jointly by Sperry Gyroscope and Intercon Division of Amphenol.

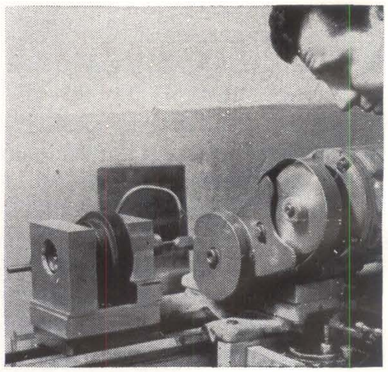
DIP BRAZING—Advantages of dip brazing of aluminum in the manufacture of electronic equipment chassis will be extolled by John Turnwall of Collins Radio. Essentially, the process is one in which parts are first assembled, then chemically cleaned; this is followed by addition of filler aluminum material before dipping assembly into a molten salt bath. The bath provides both heat (for melting filler material) and flux (for oxide removal). Filler materials are available as: brazing clad sheet, sheet, preforms, wire, powder.

Advantages of process are said to include:

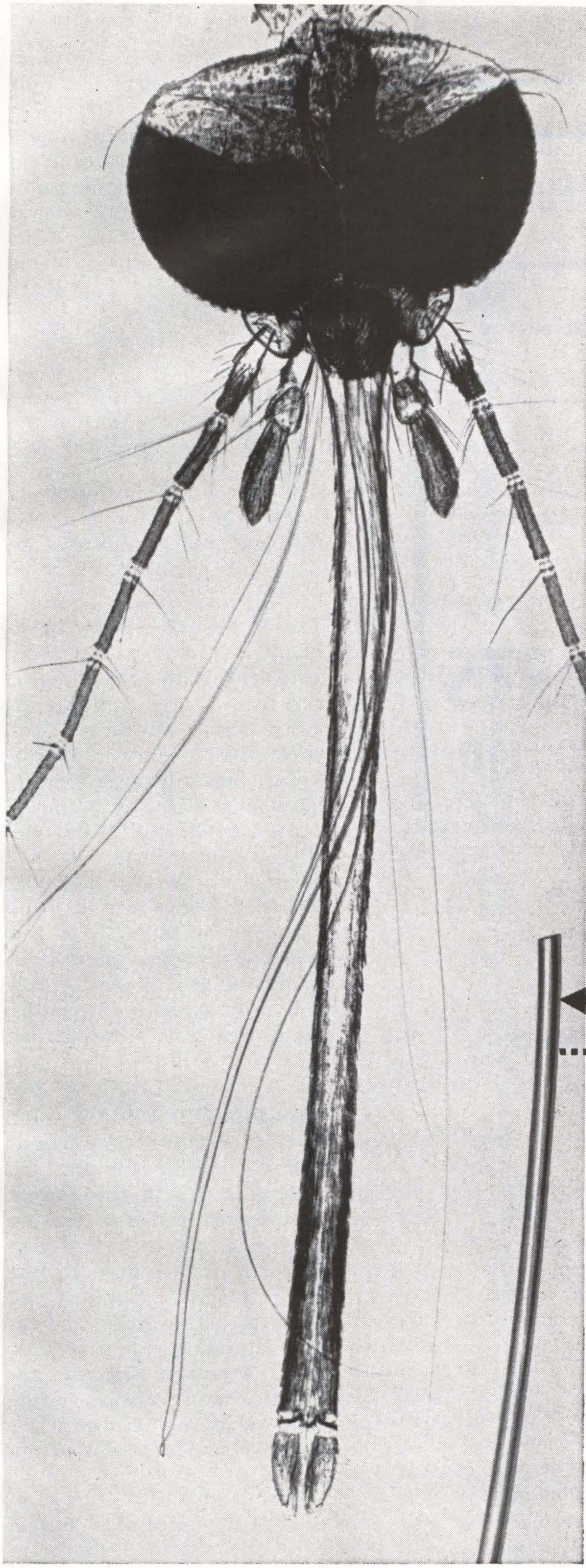
- Brazing of all joints in a single operation
- Minimum distortion in brazed assembly
- Uniform heating of thin and thick sections
- Use of joints that would be inaccessible to brazing by other processes
- Protection of parts against hot atmosphere corrosive effects
- Reduction of material weight and cost

After being chemically cleaned

Lathe Crystal Rounder



ONE HUNDRED *crystal blanks are cemented and stacked together before being fed into and across a diamond wheel by a lathe. Resulting high-precision crystals are reported to be formed in 3 to 5 percent of time for diamond-core drilling. Technique was developed by Itek-Electro Products*



SMALL WONDER

...that tubing finer than a mosquito's stinger calls for a Huntington Alloy!

Nature has given the mosquito a proboscis that measures 0.0031 of an inch at its widest point. Nickel makes it possible to produce tubing that's much finer.

How fine? The tubing pictured here—drawn by the Superior Tube Co.—has an outside diameter of 0.0019 of an inch, and an inside diameter of 0.0004 of an inch!

But the smallest tube ever made is still much finer. The fact is, that nickel tubing has been drawn down to 0.00061 outside diameter and 0.000036 inside diameter. *That's* really fine!

Tiny tubing like this is just one example of how you can get Huntington Alloys in any form or size you may want, right down to the fine sizes produced by specialists in strip wire and tubing. In commercial production, Huntington high-nickel alloys are made in tube forms from 0.010 inch outside diameter to the giant welded cylinders used in paper-making machinery. They're also available in wire and strip forms. And in all the other various shapes and sizes needed for electronic applications.

Perhaps a Huntington high-nickel alloy can help you solve one of your electronic problems? Write for the informative booklet, "Huntington Alloys for Electronic Uses." It will give you a convenient reference on the properties, available forms and typical applications of these alloys.

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and before being put in bath, parts are preheated till dry and near brazing temperature. On being transferred to the salt bath, precautions have to be made to avoid entrapping air, excessive drag out, shocks or bumping. After removal from bath, parts are allowed to cool sufficiently to prevent distortion before going into a hot water bath to remove solidified flux.

Buoyancy of molten salt bath requires that parts be self-aligning or external fixturing be used. Recommended techniques: tab and slot construction, spot welding, tack welding.

Of two basic joints commonly used, the butt joint is preferred over the lap joint because of considerable space savings.

OPTIMUM WELDS—R. A. Geshner of RCA's Defense Electronic Products organization will describe methods for accurately defining an "acceptable weld" joint in terms of "optimum weld" joints. He will point out that although certain combinations of welded materials—copper, Kovar, Dumet, nickel, etc.—produce comparatively weaker tensile-torsion strengths, they may be exposed to comparatively little stress during operation in a system. He will show how to arrive at optimum strength of weld joints on the basis of stress (or strength) of joints versus joint population density.

COPPER-PLATED EPOXY — R-f and i-f submodules in Transit satellite command receivers are pre-encapsulated in a hard epoxy and then copper plated to provide shielding at Sippican Corp. Incorporating circuits designed by the Applied Physics Laboratory at Johns Hopkins University, the receivers, according to paper by Charles C. Pierce of Sippican, are one of the most complex single pieces of welded and hard-encapsulated electronics in production to date.

Assembled submodules are connected by a welded-wire matrix prior to an initial encapsulation that leaves voids. Gain and bandpass components selected during temperature cycling tests are installed in voids. Encapsulation of assembly is then completed prior to copper plating. Each submodule includes 200 components in a 8.4 × 3.5 × 1.3-inch package weighing 1.66 pounds. Receivers have a 5-year life expectancy.

RESONANT PROBLEMS—Harold B. Nichols of General Dynamics/Astronautics will describe a construction solution to a present-day mounting problem in aerospace systems: Conventional mounting methods use beams and diaphragms in various shapes to support and restrain components. Resonant frequencies of these mountings are so low that they are easily excited with components suffering accordingly.

Solution proposed by Nichols is obtained with following technique that produces a "solid-block" assembly having a resonant frequency above limit of forcing frequency:

Encapsulated modules having all terminals on one face are positioned on an assembly plate with terminals protruding into plate. Entire assembly is then placed in a case having block configuration giving desired high-frequency response, with assembly plate at open side of case. A rigid-cell foam (polyurethane, epoxy, etc.) is poured into voids surrounding modules. After curing of foam, assembly plate is removed. Exposed terminals are interconnection wired. Case cover is secured and a clear silicon or epoxy gel is poured through small holes therein, completely sealing interconnections. A solid mounting block for circuitry thus results with shock forces attenuated by the foam and gel. Modules can be placed as close together as 0.020 inch.

In addition to shock and vibration reduction, technique eliminates need for cable clamps, facilitates wiring and testing by placing all wiring on one plane. Testing by probing self-sealing gel can be done without destroying contaminant-and-moisture-proof seal.

BREADBOARD INTEGRITY—In breadboards, mechanical integrity, good workmanship and pleasing appearance are closely related. This is theme of paper by Richard S. Moeller of GE's Advanced Electronics Center. He will examine breadboard construction needed to achieve such characteristics with respect to: assembly and component-change techniques, standardization of mechanical hardware, standardization of electrical accessories, marking control panel production and finishing; these are discussed in relation to cost and schedule. Examples include a mixture of digital and r-f circuits.

Says Moeller: A breadboard is built to prove a circuit. Unfortunately, it often leaves the laboratory looking somewhat less than professional. It is delivered to a customer or taken for sales purposes. Since most people will have only visual contact with the breadboard, its appearance does much to register an impression.

It is generally assumed, he says, that the breadboard works electrically. Equally important, however, is that it can withstand the rigors of handling and shipment and still continue to function.

He maintains that such breadboards can be built within existing costs and schedules.

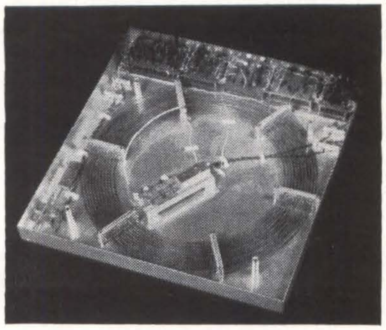
RAIL CONCEPTION—Three authors from Ling-Temco-Vought will describe a rail-construction concept for ease of breadboarding and modular standardization that fulfills following requirements: self-jigging capability, encapsulation ease, automation capability, heat-sink capability, ease of external connections.

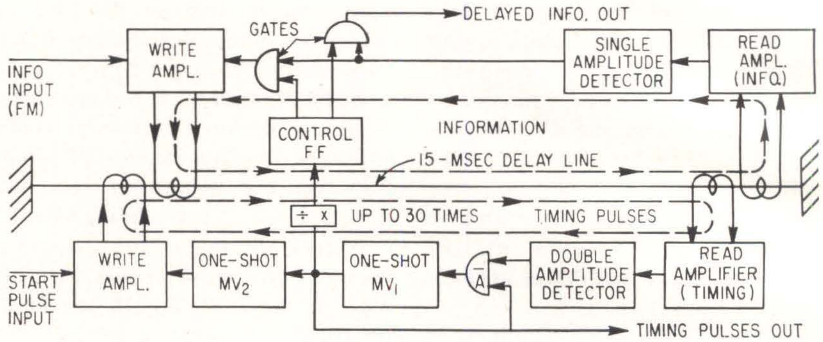
Plastic rails hold individual components at each end by their leads. Component spacing is fixed. Heat sinks can be inserted in place of components on an as-required basis. Each rail-pair unit slips into a holder that provides a dense cordwood module ready for production to eliminate redesign at completion of breadboard phase.

The authors—K. W. Allen, H. D. Roberts, A. J. Lephakis—claim that simplicity and flexibility of design greatly reduce complexity of fabrication and tooling in both limited and mass production of modules.

WORKSHOPS—Six workshop sessions will be held including: commercial electronic production, miniature packaging, large electronic structures.

Recirculating Analog Data for Long Delays





Built-in control circuits decide number of round trips, initiate readout

MAGNETOSTRICTIVE delay line recirculates analog information to produce time delays that are multiples of the length of the line. Built-in circuits control data handling, readout-out, and timing functions.

The line accepts the analog information in f-m form, with incoming information presented as sharp edged pulses representing crossovers of the f-m data. For a bandwidth of 1 Mc the delay line provides 15 msec delay; greater delays for short bursts of data are achieved by recirculating the information for a predetermined number of counts.

The block-diagram illustrates the processes involved. Two channels are used for simplicity, one handling analog information, the other keeping track of timing. The timing pulses travel down the line with the analog information. A counter *X* determines the number of recirculations, and trips the control flip-flop when the correct number of recirculations have been attained. The delay line, plus additional custom accessories to increase its versatility, are available from Digital Devices Inc., 212 Michael Drive, Syosset, Long Island, N. Y.

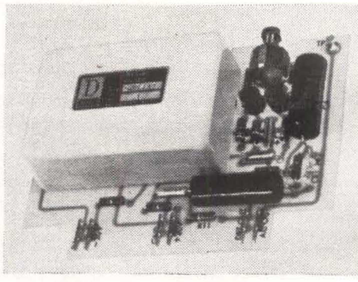
CIRCLE **301**, READER SERVICE CARD

Transistor Puts Out 1 Watt at 500 Mc

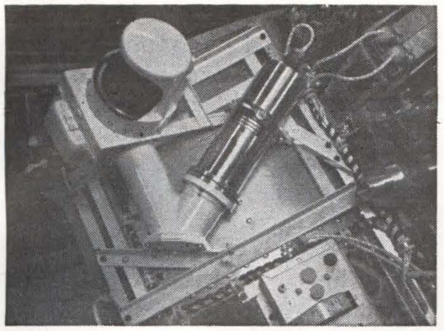
THIS planar epitaxial transistor, besides operating as an amplifier or oscillator at 500 Mc, will deliver 1 watt of r-f power at 1 gigacycle using 2 frequency-doubling steps, beginning with a fundamental frequency of 500 Mc. The new device will have a minimum gain-bandwidth product of 400 Mc at 10 volts and 50 ma. Used from a 15 volt supply as a 200 Mc class-C amplifier, the unit yields a typical output of 2 watts at 6 db gain and collector efficiency of 70 percent. These transistors designated 2N2884 and 2N2883 by the manufacturer, Fairchild Semiconductor Division of Fairchild Camera & Instrument Corporation, 545 Whisman Road, Mountain View, California, will become available June 3, 1963. **(302)**

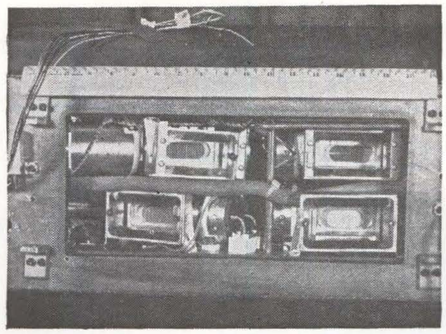
Xtal Filters Give Amplifier 0.02-Percent Bandwidth

FOUR-POLE version of this filter-amplifier-detector, which uses the piezoelectric effect for stability, selectivity, and a wide, linear, dynamic range, has a −3 db bandwidth of 20 ± 3 cycles/second in the 20-Kc model; −50 db bandwidth is less than 130 cycles for a shape-factor of 6.5/1. Units can be obtained singly, or in matched comb-filter sets covering the range 10 Kc to 30 Mc.



Advantages of using crystals as the filter-elements, according to the manufacturers, Damon Engineering, Inc., 240 Highland Avenue, Needham Heights 94, Massachu-





Here, in Lockheed Missiles & Space Company's Physical Sciences Laboratories, scientists are engaged in a comprehensive space physics research program embracing experimental and theoretical work in space radiation, aurora, atmospheric structure, geomagnetic micropulsations, x-ray astronomy, and the propagation of electromagnetic waves in space. Experimental programs include the measurements of geophysical and space properites, both in space and in the laboratory.

Currently, measurements of variations on the earth's magnetic field are being made at remote islands in the Pacific Ocean, providing clues to the effect of solar activity on its shape and stability. The influence of solar wind on the geomagnetic field is also being investigated in laboratory experiments, by bombarding magnetic fields with clouds of highly ionized gases.

Scientists at Lockheed are engaged in a continuing program of designing and placing density gages, mass spectrometers, ion traps, and similar instruments on space vehicles to measure the density, composition, and temperature of matter in space. These experiments lead to a better understanding of the chemical reactions occurring in the atmosphere high above the earth.

Important investigations of the low energy x-rays emitted by stars are being carried out and interpreted to give information on the structure of stellar coronas.

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Consider Lockheed's leadership in space technology. Evaluate its accomplishments —such as the Polaris missile, the Agena vehicle's superb record of space missions. Examine its outstanding advantages —location, advancement policies, creative climate, opportunity for recognition.

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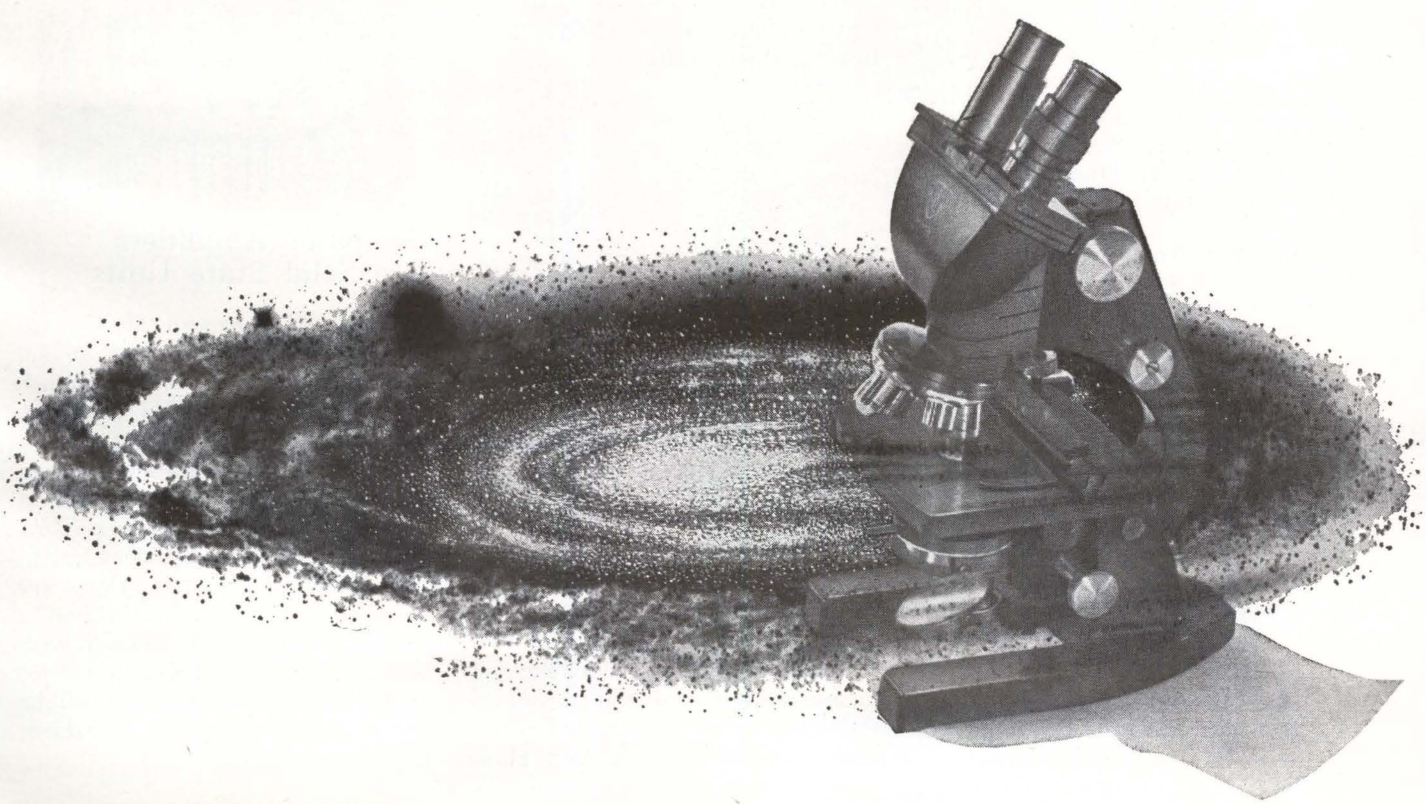
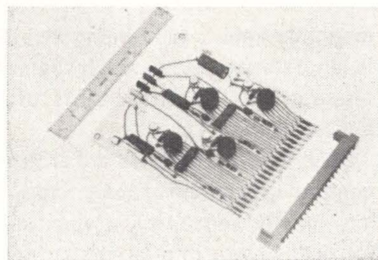
LOOK AT LOCKHEED IN SPACE PHYSICS:

Continuing investigation of matter and forces in space



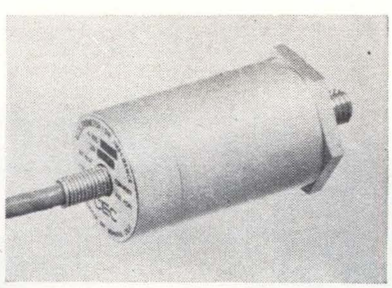
setts, lie in their inherently linear characteristics, hence the wide dynamic range that they afford. They are, additionally, very stable, and offer low insertion losses, permitting operation with low-power amplifiers.

CIRCLE **303**, READER SERVICE CARD



Magnetic Logic On Plug-In Card

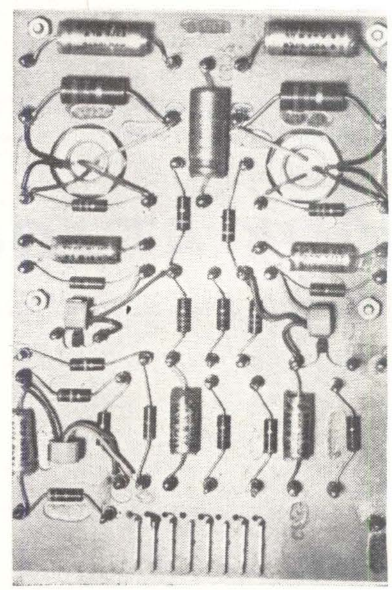
UNIVERSAL CTL magnetic core-transistor-logic circuits mounted on a low-cost plug-in card are announced. Each CTLA-4 card carries 4 independent magnetic core-transistor-logic circuits. By appropriate backboard interconnection, each CTL can perform any logical function such as AND, OR, INHIBIT, or COMPLEMENT—making available to the designer a complete logic system capability through the use of a single card type. A single card can be a decade scaler or one bit's worth of parallel arithmetic. No additional components are required. DI/AN Controls, Inc., 944 Dorchester Ave., Boston, Mass. **(304)**



Integral Emitter Follower Mates Transducer to Line

CONNECTING CABLES used with various forms of electrical transducer are often a major bugbear because line capacitance as high as 30 pf/ft seriously degrades transducer performance. Moreover, the transducer often has to be recalibrated whenever it is given a new lead. These problems are overcome, as in this piezoelectric accelerometer, by building an amplifier right into the transducer head, thereby matching transducer and line impedances.

The Type 4-280 accelerometer can be used with cables up to 100 feet length without serious loss of performance. The accelerometer, manufactured by Consolidated Electrodynamics, Inc., 360 Sierra Madre Villa, Pasadena, California, provides a 6 to 6,000 cps response, operating to 250 peak-g, and covering temperatures within the -65 F to 200 F range. Voltage sensitivity is said to be 20 peak mv/peak-g at 77 F while operating at 100 cps into a 50,000 load. Response to cross-axis motion is limited to 5 percent, amplitude linearity is 1 percent and the unit operates from a 28 volt supply. **(305)**



Computer Amplifiers Are Solid State Units

A COMPLETE range of 60/400 cps solid state amplifiers for analog computer use has been developed. All types are assembled on $\frac{1}{16}$ in. plug-in cards, measuring $6\frac{1}{2}$ in. by $4\frac{1}{2}$ in., designed to fit standard card boxes. Types include: transformerless summing servo-amplifiers, summing amplifier, resolver amplifier and relay amplifier. Units are packaged in a typical installation in 17 in. by $10\frac{1}{2}$ in. card boxes, each box housing up to 34 modules. Price range: $165 to $195. Transdyne Corp., 43 Albertson Ave., Albertson, L. I., N. Y. **(306)**

Literature of the Week

INSTRUMENTS Keithley Instruments, Inc., 12415 Euclid Ave., Cleveland 6, O., has available a 44-page catalog describing its full line of sensitive electronic instruments for research and industry. **(307)**

GLASS-ENCASED R-F CAPACITORS Captronics, Inc., 9 Cricket Terrace, Ardmore, Pa. Technical bulletin 402 lists low loss silicon oil impregnated r-f capacitors with voltage ratings from 2.5 Kv to 30 Kv. **(308)**

ENERGY DISCHARGE CAPACITORS Sangamo Electric Co., Springfield, Ill. Technical bulletin contains reference data for electrical and mechanical design criteria covering energy discharge capacitors. **(309)**

SILICON ZENER DIODES Transitron Electronic Corp., 168 Albion St., Wakefield, Mass., has published an alphanumerical guide to its silicon zener diodes. **(310)**

SPACE SIMULATION Ilikon Corp., Natick Industrial Centre, Natick, Mass., has a two-color brochure describing and illustrating its advanced space simulation facilities. It also contains space data charts. **(311)**

BERYLLIUM-COPPER TUBING Uniform Tubes, Inc., Collegeville, Pa. Data sheet covers beryllium-copper tubing and fabrications. **(312)**

ION BEAM GENERATOR CBS Laboratories, High Ridge Road, Stamford, Conn. Bulletin IBG-1 describes a new ion beam generator for the production of steady, controllable beams of metal ions. **(313)**

SEMICONDUCTORS Bendix Semiconductor Division, South St., Holmdel, N. J., has published a guide listing a wide range of semiconductor products by type number with information on pertinent electrical characteristics and case type. **(314)**

TIN OXIDE RESISTORS Corning Electronic Components, Raleigh, N. C. Methods of manufacturing, selecting and proving performance of high-reliability tin oxide resistors are given in a bulletin. **(315)**

DELAY LINE SERIAL MEMORY SYSTEMS Computer Control Co., Inc., Old Connecticut Path, Framingham, Mass., offers an 8-page brochure featuring applications of delay line serial memories to 3 C digital systems. **(316)**

CHOPPER Solid State Electronics Co., 15321 Rayen St., Sepulveda, Calif. Catalog sheet describes model 75 silicon transistorized chopper with isolated transformer drive. **(317)**

NANOSECOND DELAY LINE Lumatron Electronics, Inc., 116 County Courthouse Road, New Hyde Park, N. Y. Mailing piece illustrates and describes model 1202AR variable step delay line. **(318)**

COMPUTING SCIENCE Electronic Associates, Inc., Long Branch, N. J. A 20-page illustrated brochure describes the activities and facilities of the EAI Research and Computation division. **(319)**

ROTARY POTENTIOMETERS Weston-Instruments & Electronics division, 614 Frelinghuysen Ave., Newark 14, N. J. Data sheet covers the 349 series rotary Multipots. **(320)**

TOUCH CONTROL SWITCH Tung-Sol Electric Inc., 1 Summer Ave., Newark 4, N. J. Brochure discusses various possible applications of the Dynaquad touch control module. **(321)**

SPECTROMETERS Strand Labs, Inc., 294 Centre St., Newton 58, Mass. A 24-page technical brochure describes a full line of electron-paramagnetic-resonance spectrometers. **(322)**

TRIMMING POTENTIOMETERS Techno-Components Corp., 18232 Parthenia St., Northridge, Calif. Catalog covers line of $\frac{5}{8}$ in. square precision and commercial trimming potentiometers with resistance values to 50,000 ohms. **(323)**

RELAY SOCKET PUNCH Greenlee Tool Co., Rockford, Ill. Bulletin E-324 pictures and describes a punch that makes clean, accurate, finished holes for miniature relay sockets. **(324)**

RECEIVING TUBES Raytheon Co., 55 Chapel St., Newton 58, Mass. A full line of industrial, military, and special purpose receiving tubes is detailed in a 16-page condensed data brochure. **(325)**

QUARTZ CRYSTAL UNITS Connolly & Co. Inc., 914 Rengstorff Ave., Mountain View, Calif. An illustrated 24-page booklet covers Genalex low frequency quartz crystal units. **(326)**

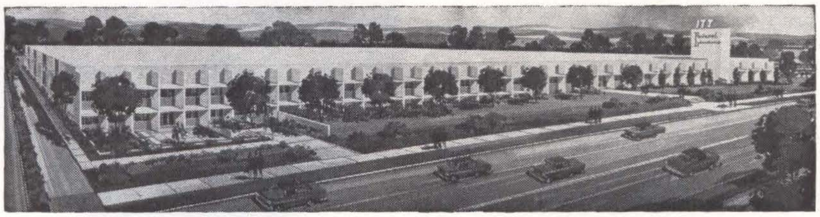
FERRITE CORE Electronic Memories Inc., 9430 Bellanca Ave., Los Angeles 45, Calif., offers an 8-page technical bulletin on the two-aperture Transfluxor ferrite core. **(327)**

SILICON POWER TRANSISTORS Westinghouse Semiconductor Division, Youngwood, Pa. Procurement specifications are available as a series of five booklets for the company's entire line of silicon power transistors. Request on company letterhead.

POWER SUPPLIES Behlman-Invar Electronics Corp., 1723 Cloverfield Blvd., Santa Monica, Calif., has issued a catalog on a line of solid state d-c power supplies, a-c Invertrons and plug-in oscillators. **(328)**

SEMICONDUCTOR PRODUCTS Motorola Semiconductor Products Inc., P.O. Box 955, Phoenix 1, Ariz. A 22-page condensed catalog covers a complete line of standard industrial and MIL-type semiconductor products. **(329)**

ITT Erecting Laboratories Addition



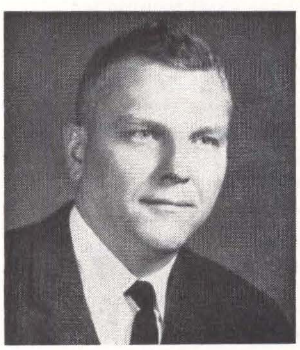
INTERNATIONAL Telephone and Telegraph Corporation is building a 53,000-square-foot addition to the ITT Federal Laboratories plant in San Fernando, Calif.

Norman E. Friedmann, vice president of ITTFL and general manager of its California operations, said the additional building and plant equipment will represent an investment in excess of $1 million. The expanded plant will be ready for occupancy by the end of August. The addition will provide a threefold increase in size of the present ITTFL California facility and will employ approximately 350 persons.

The California operations of ITT Federal Laboratories are engaged in research and development of electronic, electro-optical, and electromechanical equipment to meet advanced aerospace applications. Specific activities include the development of optical communications, tracking and navigation systems, self-organizing and adaptive machines, physiometric data systems, inertial navigators and components, attitude reference sensors, and electronic surveillance systems, in addition to a basic research program in these areas.

The addition will allow consolidation of research, engineering, and fabrication facilities in one integrated plant, and will be equipped with the latest in scientific equipment and laboratory facilities.

Friedmann indicated that the new facility is part of a continued program of expansion of the ITT Federal Laboratories activity in California.



Sprague Electric Hires Vogel

F. LINCOLN VOGEL, Jr. has been named head of the Semiconductor Research department of the Sprague Electric Co., North Adams, Mass.

Before joining Sprague, Vogel was manager of advanced materials at the Semiconductor division of Radio Corp. of America, Somerville, N. J.

TIC of California Names Moore President

MILFORD B. MOORE has been appointed president and general manager of Technologly Instrument Corp. of California, a subsidiary of Bowmar Instrument Corp., Fort Wayne, Ind.

Moore was director of manufacturing of Bowmar's Fort Wayne division.

Hildebrand Joins Silicon Transistor

APPOINTMENT of G. A. Hildebrand to the post of director of marketing at Silicon Transistor Corp., Carle Place, N. Y., has been announced by Randolph Bronson, executive vice president of the semiconductor manufacturing firm.

"Bud" Hildebrand comes to STC after 14 years with RCA where he served in numerous executive capacities.

According to Bronson, Hildebrand's responsibilities at Silicon Transistor will include military, OEM and distributor sales, plus applications engineering. He will also be wholly responsible for other phases of marketing such as product planning and market development.

Weiner Accepts New Position

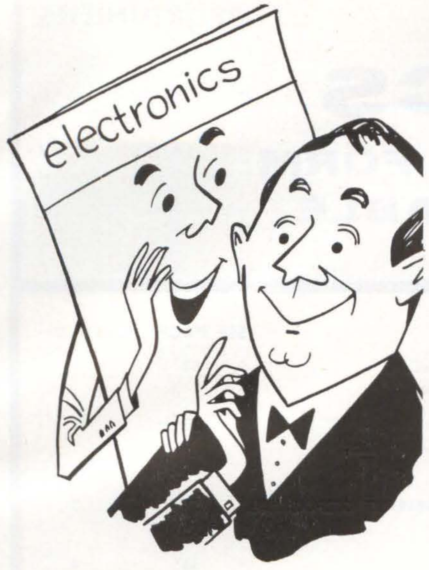
SHERMAN B. WEINER has joined United States Instrument Corp., Charlottesville, Va., as vice president in charge of engineering.

He comes to the new post from the Stromberg-Carlson Telecommunication division of General Dynamics in Rochester, N. Y., where he was chief engineer-electronic engineering.

Houston Fearless Shifts Executives

HOUSTON FEARLESS Corporation's board of directors has named former president George E. Johnson as chairman, replacing Noah Dietrich. At the same time the board elected Fred C. Mehner president and chief executive officer of the Los Angeles based company.

Mehner joined the company in early 1961 and has most recently been corporate vice president. He was formerly vice president, general manager, and a board member of Acoustica Associates.



electronics IS EDITED TO KEEP YOU FULLY INFORMED—

a "well-rounded" engineer

What's your *present* job in electronics? Do you work on computers? (**electronics** ran 158 articles on computers between July, 1961 and June, 1962!) Are you in semiconductors? (For the same period, **electronics** had 99 articles, not including transistors, solid-state physics, diodes, crystals, etc.) Are you in military electronics? (**electronics** had 179 articles, not including those on aircraft, missiles, radar, etc.

In all, **electronics'** 28-man editorial staff provided more than 3,000 editorial pages to keep you abreast of all the technical developments in the industry. No matter where you work today or in which job function(s), **electronics** will keep you fully informed. Subscribe today via the Reader Service Card in this issue. Only 7½ cents a copy at the 3 year rate.

electronics

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EMPLOYMENT OPPORTUNITIES

(Additional Employment opportunity Advertisement on page 55)

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.

SEARCHLIGHT SECTION

(Classified Advertising)

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CHOICE ORANGE COUNTY, CALIFORNIA, LOCATION

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Klystrons, Transmitting, Magnetrons, Amplitrons, Rectifiers, Thyratrons, BWO, TWT, Exotic Types, XFA, MBK, COAX Mag, Image converters, Orthicon, Photomultiplier, Transistor, Zener, Cathode-Ray, Storage.

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AUTO-TRACK & TELEMETRY ANTENNA PEDESTALS
3 & 10 CM. SCR. 584 AUTOTRACK RADARS.
AN/TPS-1D SEARCH. AN/TPS-10 HT. FINDERS.
AN/FPN-32GCA. AN/APS-10 NAVIG. & WEATHER.
AN/APS-15B PRECISION. AN/APQ-35B PRECISION.
AN/APS-31A SEARCH. DOZENS MORE.
.5-1-2 MEGAWATT HIGH POWER PULSERS.

RADIO RESEARCH INSTRUMENT CO.
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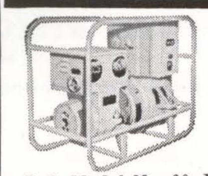
RADAR SYSTEMS & COMPONENTS/ IMMEDIATE DELIVERY

CIRCLE 951 ON READER SERVICE CARD

LOOKING FOR
USED/SURPLUS ELECTRONIC EQUIPMENT/COMPONENTS?
For an up-to-date listing of such equipment see Searchlight Section of May 10th.

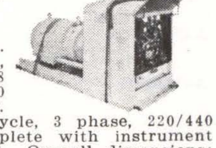
SAVE! BIG MONEY on GENERATOR SETS



MOTOR-GENERATOR, AC TO DC

Motor: 5 H.P. 3510 RPM, 220/440 volts, 60 cycles, 3 phase. Type OGX, Frame 225, Class G, Form B. Generator: 28 volts, 100 amperes D.C. Model No. 60. Made by Motoresearch Co. Equipped with motor starter box and generator control panel. Complete assembly mounted in tubular frame for portability. Shpg. wt. 250 lbs. F.O.B. Chicago
No. AS-G764 . . . . ONLY $175.00

50 KW, 400 CYCLE MOTOR GENERATOR SET



Ideal Type F-1. Rated 62.5 KVA, 50 KW, 120/208 volts, 3 phase, 400 cycles, 0.8 P.F. Powered by 60 cycle, 3 phase, 220/440 volt motor. Complete with instrument and control panel. Overall dimensions: 85" L, 34" W, 41" H. Shpg. wt. 2100 lbs. F.O.B. Chicago.
No. AS-G964 . . . . . . ONLY $1,250.00

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Write today for Groban's NEW 72 page Equipment Catalog and Hydraulic Reference Manual. Tremendous Savings on hundreds of items.

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CIRCLE 952 ON READER SERVICE CARD

EMPLOYMENT OPPORTUNITIES

electronics

WEEKLY QUALIFICATION FORM FOR POSITIONS AVAILABLE

ATTENTION: ENGINEERS, SCIENTISTS, PHYSICISTS

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.

STRICTLY CONFIDENTIAL

Your Qualification form will be handled as "Strictly Confidential" by ELECTRONICS. Our processing system is such that your form will be forwarded within 24 hours to the proper executives in the companies you select. You will be contacted at your home by the interested companies.

WHAT TO DO

1. Review the positions in the advertisements.
2. Select those for which you qualify.
3. Notice the key numbers.
4. Circle the corresponding key number below the Qualification Form.
5. Fill out the form completely. *Please print clearly.*
6. Mail to: Classified Advertising Div., ELECTRONICS, Box 12, New York 36, N. Y. (No charge, of course).

COMPANY	SEE PAGE	KEY #
ATOMIC PERSONNEL INC. Philadelphia, Penna.	53	1
EXECU-SEARCH Division of Davies-Shea Inc., Chicago, Ill.	76***	2
HIGH VOLTAGE ENGINEERING CORPORATION Burlington, Mass.	79**	3
HONEYWELL St. Petersburg, Florida	58*	4
LOCKHEED MISSILES & SPACE CO. Div. of Lockheed Aircraft Corp. Sunnyvale, California	49	5
NORDEN Div. of United Aircraft Corporation Norwalk, Conn.	89*	6
PAN AMERICAN WORLD AIRWAYS INC. Guided Missiles Range Div. Patrick AFB, Fla.	55	7
UNION CARBIDE NUCLEAR COMPANY A Div. of Union Carbide Corporation Oak Ridge, Tennessee	88*	8

* These advertisements appeared in the May 10th issue.
** This advertisement appeared in the May 17th issue.
*** This advertisement appeared in the May 24th issue.

(cut here) **electronics WEEKLY QUALIFICATION FORM FOR POSITIONS AVAILABLE** (cut here)

(Please type or print clearly. Necessary for reproduction.)

Personal Background

NAME ....
HOME ADDRESS ....
CITY ....................ZONE.......STATE............
HOME TELEPHONE ....

Education

PROFESSIONAL DEGREE(S) ....
MAJOR(S) ....
UNIVERSITY ....
DATE(S) ....

FIELDS OF EXPERIENCE (Please Check) 53163

☐ Aerospace	☐ Fire Control	☐ Radar
☐ Antennas	☐ Human Factors	☐ Radio—TV
☐ ASW	☐ Infrared	☐ Simulators
☐ Circuits	☐ Instrumentation	☐ Solid State
☐ Communications	☐ Medicine	☐ Telemetry
☐ Components	☐ Microwave	☐ Transformers
☐ Computers	☐ Navigation	☐ Other ....
☐ ECM	☐ Operations Research	☐ ....
☐ Electron Tubes	☐ Optics	☐ ....
☐ Engineering Writing	☐ Packaging	☐ ....

CATEGORY OF SPECIALIZATION

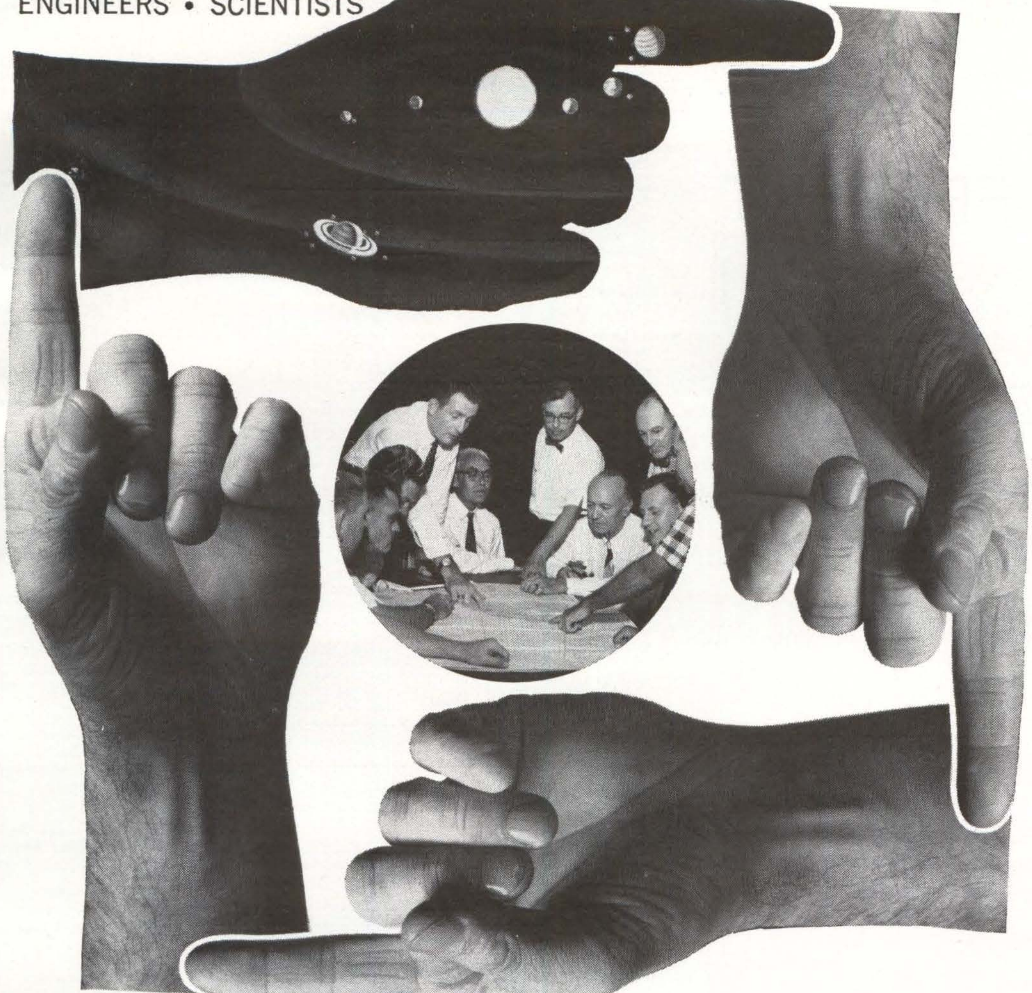
Please indicate number of months experience on proper lines.

	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 16 17 18 19 20 21 22 23 24 25

ENGINEERS • SCIENTISTS



One big systems field known only to a handful of engineers

(. . . outside of PAN AM's Guided Missiles Range Division)

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From the systems viewpoint, a striking metamorphosis has taken place since 1953 when GMRD undertook range engineering, operation and development at Cape Canaveral for the Air Force.

A comparatively simple set-up existed in the early '50's (to monitor missile flights up to 500 miles). **Today** this has been transformed into a vast, integrated systems complex of new generation tracking, monitoring, data handling, data support and communications sub-systems.

Present range capabilities can support the launch of global flights; lunar and interplanetary space probes. **New** capabilities are under development now—to meet the unprecedented requirements of the Apollo Program. And GMRD's Advance Planning Group is engaged in projecting range needs as far ahead as the late '70's.

In fact the giant range system at Cape Canaveral and down-range is always a **system-in-transition,** calling for the highest technical contributions from engineers and scientists of many disciplines, to keep pace with the needs of the nation's new missile systems and space vehicles.

YOU ARE INVITED TO INQUIRE ABOUT CAREER OPPORTUNITIES FOR:

Systems Engineers—EE's, Physicists capable of assuming complete project responsibility for new range systems.

Instrumentation Planning Engineers—EE's, Physicists to be responsible for specific global range instrumentation concepts.

Advance Planning Engineers—EE's, Physicists to evaluate and project the state-of-the-art in all applications of range instrumentation.

Experience in one or more of these areas: Pulse radar, CW techniques, telemetry, infrared, data handling, communications, closed circuit TV, frequency analysis, command control, underwater sound, timing, shipboard instrumentation.

Why not write us today, describing your interests and qualifications in any of the areas above. Address Dr. Charles Carroll, Dept. 28E-5.

PAN AM

GUIDED MISSILES RANGE DIVISION

PAN AMERICAN WORLD AIRWAYS, INC.
P. O. BOX 4465, PATRICK AIR FORCE BASE, FLORIDA

An Equal Opportunity Employer

Additional Employment Advertisement on page 53

INDEX TO ADVERTISERS

• See advertisement in the July 25, 1962 issue of Electronics Buyers' Guide for complete line of products or services.

This Index and our Reader Service Numbers are published as a service. Every precaution is taken to make them accurate, but **electronics** assumes no responsibilities for errors or omissions.

electronics

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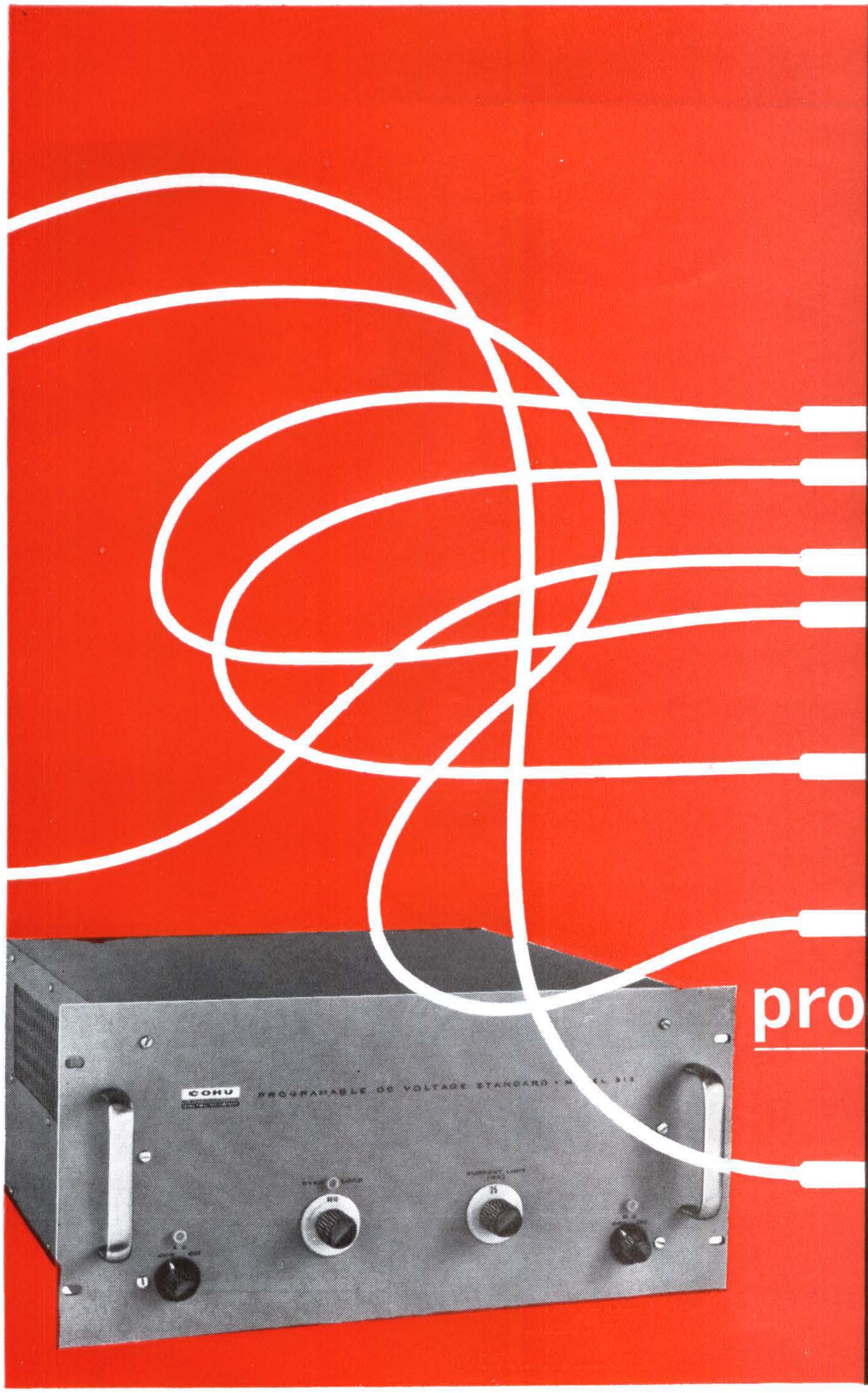


world's first programable DC voltage standard!

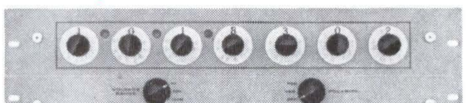
With KIN TEL's new Model 313 DC standard, you can select voltages — *automatically, and in any sequence* — from 0 to 1111.1110 volts, with an accuracy of 0.01% having either polarity, and in steps as small as 1 μv. It responds to any program applied to it in the form of parallel entry, 28 volts @ 25 ma per relay, 1-2-4-4 binary-coded-decimal signals. Switching is done internally with mercury-wetted relays.

The Model 313 is ideal for such applications as automated quality control, missile checkout and missile system test, semi-conductor production test and evaluation, and computer reference. It can be driven by punched cards, paper tapes or by remote manual switching.

OTHER IMPORTANT SPECIFICATIONS include a stability of 0.005% over a 30-day period, output current 0 to 25 ma in 4 ranges (with overload protection), 0.001 ohm source impedance, remote sampling terminals, and a floating guarded circuit.

PRICE: $3995. All prices FOB, San Diego, Calif. (additional export charge)

WRITE TODAY for detailed information or a demonstration. Representatives in all major cities.



REMOTE CONTROL, TOO. (Illust.) A manual remote control unit is available at $500. unit price. This unit (Model 313-51) is also helpful in checkout and calibration of the basic 313 standard.

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KIN TEL DIVISION

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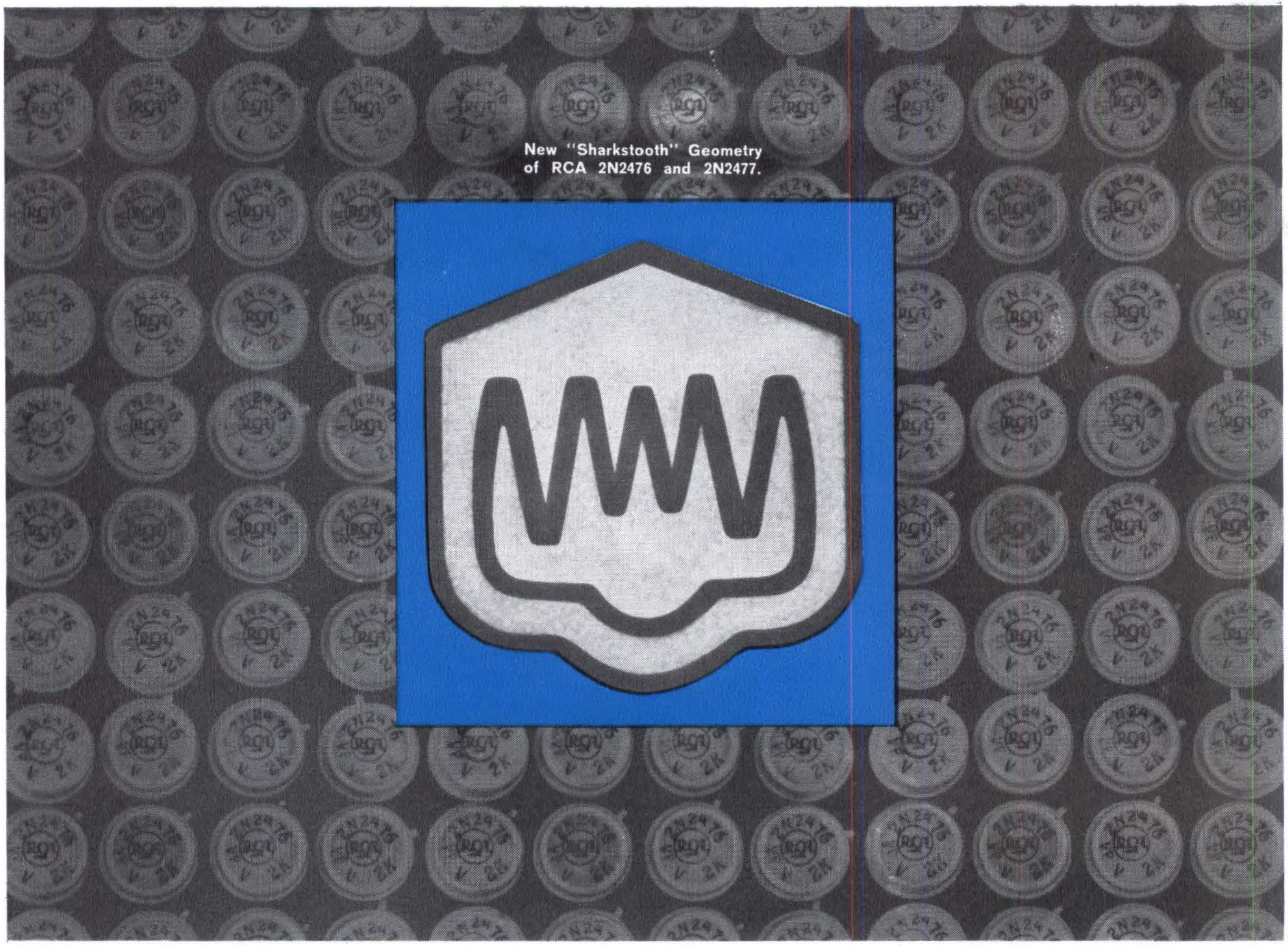

New "Sharkstooth" Geometry of RCA 2N2476 and 2N2477.

The Revolutionary New RCA 2N2476 & 2N2477

Switch 500 Milliamperes in 50 Nanoseconds

Unique "SHARKSTOOTH" geometry of RCA's new Silicon NPN 2N2476 and 2N2477 provides new levels of performance as core or line drivers in high-speed memory circuits, and in other high-frequency, high-current applications.

The unique internal geometry of RCA's new 2N2476 and 2N2477 achieves a much larger emitter periphery AND a substantially reduced emitter area, providing high beta over a wide range of collector currents AND excellent switching speeds at high currents. For example, these new types have more than adequate speed and current capabilities for driving RCA's new Microferrite Memory Stacks. Check these outstanding performance features:

- **Excellent high-current beta**...20 typ. at $I_C = 1$ amp. for the 2N2476; 40 typ. for the 2N2477 (pulsed condition).
- **Low V_{CE} (Sat) at High Currents**... V_{CE} (Sat) $= 0.75V$ max. for the 2N2476, 0.65V max. for the 2N2477 at $I_C = 500$ ma, $I_B = 50$ ma.
- **Low Collector Capacitance** . . . 10pf max.
- **Short Turn-On Time**...25nsec. max., $I_C = 150$ma, $I_{B_1} = I_{B_2} = 15$ma.
- **Short Turn-Off Time**...45nsec. max., $I_C = 150$ma, $I_{B_1} = I_{B_2} = 15$ma.
- **Dissipation**...0.6 watt max. free-air temp. up to 25°C (in TO-5 case).
- **Gain-Bandwidth Product**...250 Mc min.

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500 MA TEST CIRCUIT

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