A McGraw-Hill Publication *75 Cents* *January 18, 1963*

electronics

PROBING SHOCK-EXCITED PLASMA

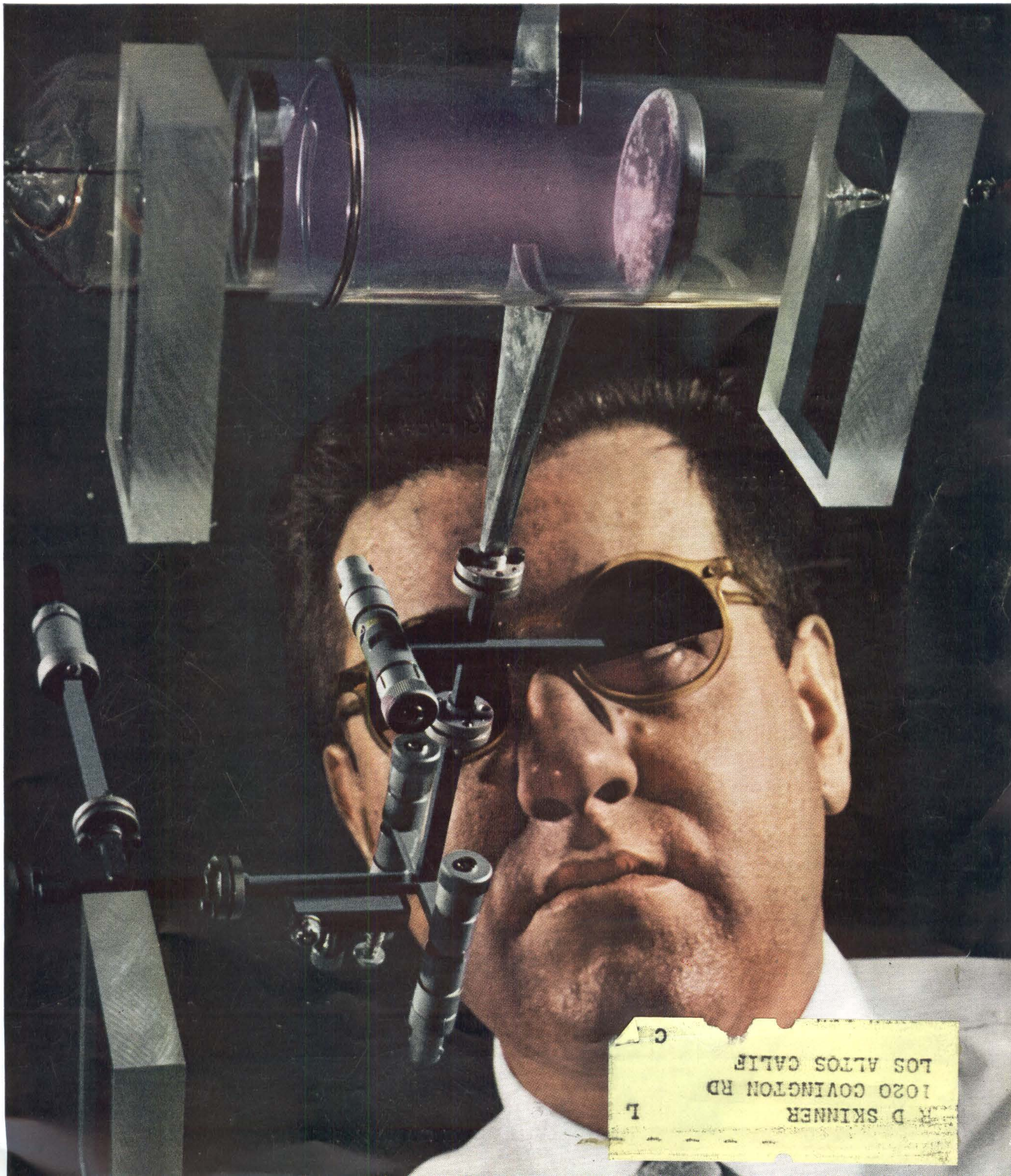
Microwave tells the story, p 56
(photo below)

DESIGNING WITH SOLID CIRCUITS

Networks make up computer logic, p 35

RADAR GIVES MORE DATA

Sideband coherence is the secret, p 40

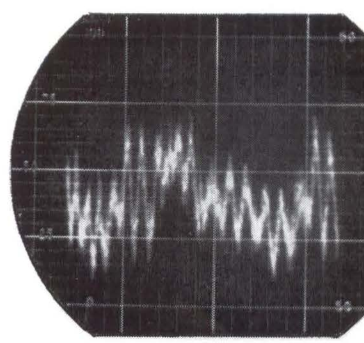


1 µV

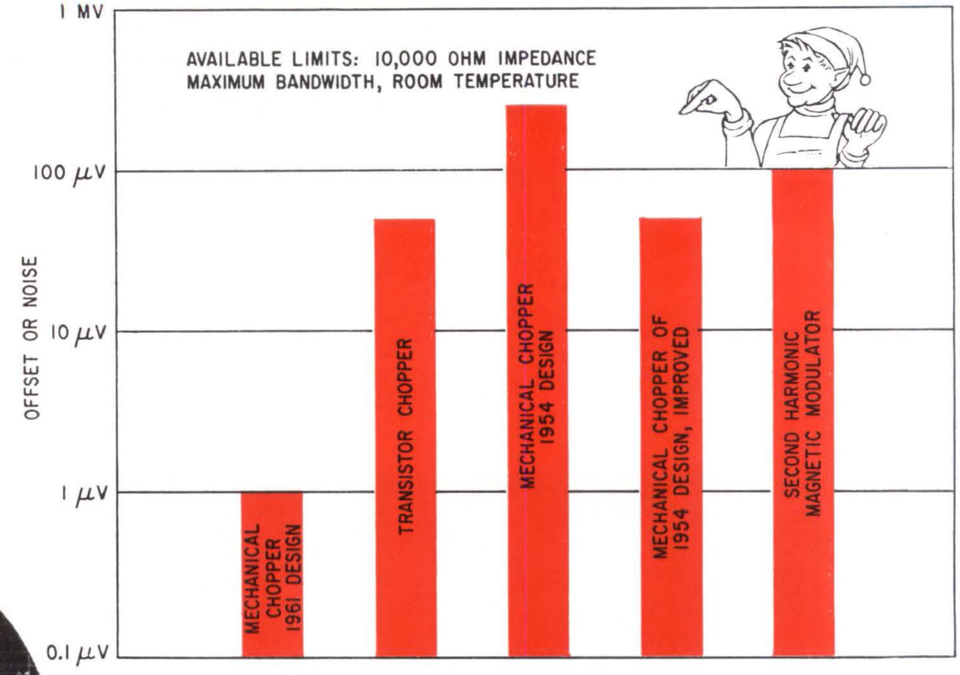
3 µV

THE LITTLEST ARE THE LEAST NOISY

35 µV



NOISE CONSISTING PRINCIPALLY OF LEAKAGE ACROSS THE SOCKET



THE LIMITS OF CHOPPER NOISE

PART ONE OF A SERIES ON THE STATE OF THE CHOPPER ART

Nothing is ever simple in the electronics business. Not even graphs. The bar chart compares three kinds of modulators. We make all three. It makes the assumption that the circuit impedance is 10,000 ohms, that the system bandwidth is as wide as possible, that we stick to room temperature, that we ignore size and ignore expense. Finally, it tries to compare choppers (a component) with a magnetic modulator (a little system).

Almost anybody can claim he has a chopper or modulator device with a noise level below one microvolt. You should immediately ask him what that means.

Why? Well, what *is* chopper noise? It is that signal remaining when we ain't got no signal. Or it is unwanted signal. Now if the noise consists of harmonics of the drive, and if the amplifier will not respond to them, your measurement is likely to look pretty good.

Or, suppose a chopper is needed for an input circuit of one megohm impedance. But we measure at 1,000 ohms. Again, the answer may look good.

But the noise in the chopper is complicated by outside effects, like thermal junctions, resistive coupling in printed circuit boards, and the like.

The smallest choppers have the least noise. It was planned that way. And, as it may be plain, the little ones use less power, make less fuss, spray less flux into sensitive circuits, and reap benefits having little to do with noise. Now it's a fact that the circuit noise will be pretty troublesome, because you don't need a chopper for a DC amplifier unless you are trying to rescue low level signals.

Part Two provides aspirin for the headaches encountered when we try to look at signals above and below one microvolt.

We have much more information — it's yours for the asking.

AIRPAX ELECTRONICS

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CIRCLE 900 ON READER SERVICE CARD

January 18, 1963

electronics

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electronics

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CONTENTS continued

DEPARTMENTS

Not One Profession, But Two

TWO DISTINCT SCHOOLS of thought seem to be developing as to the mission of the undergraduate engineering school.

On one hand there are those, principally educators, who appear to judge an undergraduate engineering curriculum solely on how well it prepares its graduates to undertake advanced work. In colleges where this viewpoint predominates there is heavy emphasis on mathematics and science, less on design work.

On the other hand there are those, frequently employers, who seem to judge a curriculum on how well it prepares its graduates to fill existing jobs in industry. Where this viewpoint predominates there tends to be more emphasis on design, and much of this highly specialized.

Are the two objectives mutually incompatible? Perhaps. We often hear old-time engineers growl about green kids who have a lot of theory and can't design anything. And we hear also of engineering graduates who must spend the better part of a year making up undergraduate deficiencies before getting into graduate work as such.

Then there is a third viewpoint, that of the technical institute. The better technical institutes today give their graduates almost as much engineering as some four-year graduates received before the war. Many schools feel they should increase their courses of study from the traditional two years to three or even four years to prepare their graduates more adequately for today's electronics industry. Thus technical institutes could easily fall into the same traps that beset colleges.

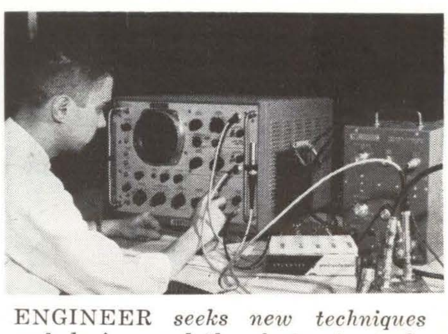
We believe that all these conditions are closely interrelated. We believe, further, that the problems that beset both educators and employers on both the engineering college and technical institute level are symptoms of a fundamental change in our art.

There is today not one profession in electronics but two, electronics engineering and electronics technology.

The electronics engineer, strictly speaking, is the innovator. His milieu is the research and development laboratory, where he may work with untried materials, components, circuits, systems or techniques. He requires a deep understanding of the mathematical and scientific fundamentals of the art and will frequently find himself handicapped without an advanced degree.

The electronics technologist is also a professional man. But he deals with the reduction to practice of new devices and ideas. Design of circuits and systems, test and evaluation, manufacturing, operation and maintenance and sales engineering service are clearly within his purview. He must have a broad knowledge of electronics theory and practice. More theory and more of the humanities than most technical institutes give. Possibly less theory and math than some colleges give. And, unless he chooses to teach electronics technology, a graduate degree will not be especially useful. He may want to take graduate work in management or business administration.

Once we recognize the professional dichotomy that exists in the field of electronics we will have a clearer idea of what kind of men we need and what we may reasonably expect of them. We can then prepare our engineers to be true innovators, while at the same time recognizing our technologists as the truly professional men they are.



ENGINEER *seeks new techniques and devices and the electronics technologist puts these into practical use. The industry needs both types of professionals*

COMMENT

F-M and SSB

I find I have little sorrow in my heart for the plight of the Land Mobile Radio services, and their bandwidth problems (p 18, Nov. 30). They promoted their own problems with f-m, where many of the channels *still* allow ± 15-Kc deviation. Return to a-m could cut these considerably, or *use* f-m, ± 5-Kc deviation, as on the 150-Mc band. SSB (a-m) could cut even *this* nearly in half. And the equipment replacements! I'm sure they buy new vehicles for their services, when they become antiquated or worn out—why not radios? As for degraded service, I'm sure the SAC wouldn't be using a-m (ssb) if this was a degraded mode of operation.

R. E. Brobst (K9EOC)
Godfrey, Illinois

There is no question that sophisticated, spectrum-saving modes such as ssb can ease the congestion, but the problem extends further than that. The meteoric rise in the use of Land Mobile Radio service far outdistances any improved mode utilization. Also, SAC will find it far easier to get more frequencies in terms of national security than will land-mobile services on the basis of their needs.

Land-Mobile got f-m for technical reasons, long before ssb was a reality for practical use. And SAC's range requirements make ssb almost mandatory.

Lab Courses

Congratulations on your editorial condemning the vast wasteland of most undergraduate lab courses (p 3, Dec. 14, 1962). The overloaded engineering student soon learns to expend earnest effort in proportion to the credits earned (don't we all?) and not dissipate time for 1 or 2 lab credits. "Experiments" often are worked out theoretically, empirical "data" calculated (including "measurement" errors) and the results presented with the properly "deduced" conclusions.

Any credits received are not for genuine lab work, but for the ability to compose reports at 3 a.m. on the due day. Really—is all this necessary? Schools that cannot afford truly instructive lab courses should either drop them or, as you suggest, offer a form of occupational apprenticeship.

Robert M. Dekovich
New York, New York

That editorial generated many letters, pro and con (mostly pro). Another pro letter is on p 4, Jan. 4.

Normalizing Speech

An article in the Nov. 30, 1962, issue of Electronics, Better Speech Quantizing for Pulse-Code Modulation (p 84), by J. D. Howells, was noted with more than usual interest, since it closely parallels work done here at AFCRL.

We have been using the technique of normalizing speech with respect to mean amplitude for several years here, and, in fact, have been issued U. S. Patent 2,901,697 on this technique, issued in 1959.

The technique of normalization is especially useful not only for straight pcm, but for speech pattern recognition and speech "compression" in the data-rate sense, such as vocoder applications. We specified this feature for a special multiplex and digital-to-analog and analog-to-digital system built for us under contract several years ago at Epsco, Inc. We have also specified this arrangement for the polymodal digital vocoder equipments being built under contract at Texas Instruments, Inc., due to be delivered next month.

Normalization permits the digital data rate to be significantly reduced for the same level of speech quality; with normalization, it is possible to operate the vocoder at data rates as low as 1,200 bits per second with useful intelligibility and quality.

Caldwell P. Smith
Air Force Cambridge Research Laboratories
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United States Air Force
Bedford, Massachusetts

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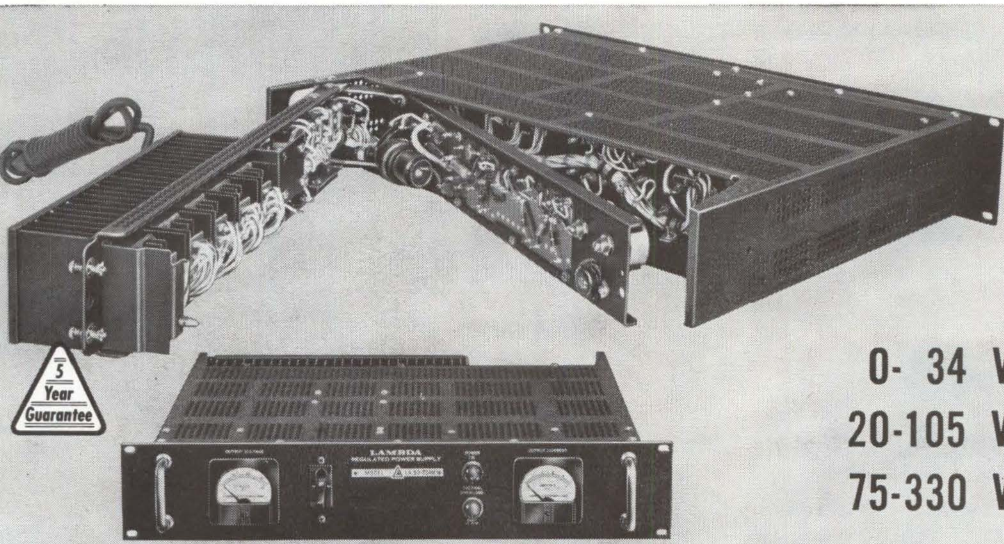

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ALL MODELS 105-140 VAC INPUT

CONDENSED DATA—LA SERIES

DC OUTPUT (Regulated for line and load)

Model	Voltage Range(1)	Vernier Band(2)	Current Range(3)	Price(4)
LA 50-03B	0- 34 VDC	4 V	0- 5 AMP	$ 350
LA100-03B	0- 34 VDC	4 V	0-10 AMP	465
LA200-03B	0- 34 VDC	4 V	0-20 AMP	685
LA 20-05B	20-105 VDC	10 V	0- 2 AMP	350
LA 40-05B	20-105 VDC	10 V	0- 4 AMP	495
LA 80-05B	20-105 VDC	10 V	0- 8 AMP	780
LA 8-08B	75-330 VDC	30 V	0- 0.8 AMP	395
LA 15-08B	75-330 VDC	30 V	0- 1.5 AMP	560
LA 30-08B	75-330 VDC	30 V	0- 3 AMP	860

Regulation (line) ...... Less than 0.05 per cent or 8 millivolts (whichever is greater). For input variations from 105-140 VAC.

Regulation (load) ...... Less than 0.10 per cent or 15 millivolts (whichever is greater). For load variations from 0 to full load.

Ripple and Noise....... Less than 1 millivolt rms with either terminal grounded.

Temperature Coefficient............. Less than 0.025%/°C.

(1) The DC output voltage for each model is completely covered by four selector switches plus vernier range.

(2) Center of vernier band may be set at any of 16 points throughout voltage range.

(3) Current rating applies over entire voltage range.

(4) Prices are for unmetered models. For metered models add the suffix "M" and add $30.00 to the price.

AC INPUT 105-140 VAC, 60 ± 0.3 cycle (5)

(5) This frequency band amply covers standard commercial power line tolerances in the United States and Canada. For operation over wider frequency band, consult factory.

Size

LA 50-03B, LA20-05B, LA 8-08B	3½" H x 19" W x 14⅜" D
LA100-03B, LA40-05B, LA15-08B	7" H x 19" W x 14⅜" D
LA200-03B, LA80-05B, LA30-08B	10½" H x 19" W x 16½" D

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Specifications alongside indicate basic features of this important new, time-saving instrument. Other special features include: matched diodes protected against burnout; probe temperature compensated for low drift; amplifier photochopper eliminating contact noise, guaranteeing high sensitivity and zero-drift freedom; extra probe tips available including a 500 kc to 250 mc UHF tip, 100:1 Capacity Divider tip for measurements up to 1000 v peak, and Type N Tee tip for coax use to 1000 mc. Get a new 411A into action on your bench now!

SPECIFICATIONS

Voltage Range:

10 mv rms full scale to 10 v rms full scale in seven ranges; full scale readings of 0.01, 0.03, 0.1, 0.3, 1, 3 and 10 v rms

Frequency Range:

500 kc to 1 gc with accessory probe tips; usable indications to 4 gc

Accuracy:

500 kc to 50 mc, ± 3% of full scale; 50 mc to 150 mc, ± 6% of full scale; 150 mc to 1 gc, ± 1 db using appropriate probe tips

Meter Scales:

Two linear voltage scales, 0 to 1 and 0 to 3, calibrated in the rms value of a sine wave; db scale, calibrated from +3 to —12 db; 0 db=1 mw in 50 ohms

Probe Tip Furnished:

411A-21E BNC open circuit tip, 500 kc to 500 mc; shunt capacity less than 5 pf; max. input 200 v dc; input resistance at 10 mc typically 80K ohms

Galvanometer Recorder Output:

Proportional to meter deflection, 1 ma into 1000 ohms at full scale deflection

Power:

115 or 230 v ± 10%, 50 to 60 cps, 35 watts

Dimensions:

Cabinet Mount: 11¾" high, 7½" wide, 12" deep
Rack Mount: 6 - 31/32" high, 19" wide, 10⅜" deep behind panel

Price:

hp 411A, (cabinet) $450
hp 411AR (rack mount) $455

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

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Congress and DOD Weigh Future of RS-70

WASHINGTON — No matter how the Defense Department treats the RS-70 in the budget that was to be presented to Congress yesterday, Congress will hotly discuss in the weeks ahead both the RS-70 and the already-cancelled Skybolt.

An authoritative source says the manned bomber is not yet dead, that highly classified information in favor of keeping manned bombers operational must be considered by DOD eventually, if not now. If Skybolt, which would extend the B-52's life, stays dead because of international political reasons, chances are good for a continuance of the RS-70 program.

RS-70's immediate fate may be revealed by DOD's reaction to the Air Force plan for a $50-million program to develop a sensor system for the long delayed Mach-3 reconnaissance-strike plane. If DOD accepts the plan the prognosis for continuation of the RS-70 program is fairly good. If it turns down the plan, the program's immediate outlook is bleak.

DOD approved the $50 million in November, but its actual release depends on acceptance of Air Force's proposal for spending it. The money would boost the amount released for fiscal year 1963 to $221 million—still far short of Congress' $362.6 million appropriation.

The sensor system includes side-looking radar, data processing and display. The once-discussed extension of the system to communicate and actually display the radar picture back at home base is probably not part of the plan.

Plans to Cut Back Midas Satellite Program Reported

WASHINGTON—Air Force's Midas satellite program is reportedly going to be sharply curtailed by the Department of Defense. However, the program will be continued. Air Force Secretary Eugene M. Zuckert is understood to have made a strong plea for the program, arguing that the only thing DOD could hold against the program was its cost, not technical problems in the infrared-equipped spy satellite. The problems are not considered unsolvable. Some of DOD's negative attitude toward Midas has been caused by failures of the launch boosters, not of the satellite itself.

Its Trouble Bypassed, Relay Goes on the Air

WITH THE TROUBLE in its power supply overcome and a later problem in its command circuit (p 7, Jan. 11) compensated for, Relay began transatlantic tv transmission last week and contacted Rio de Janiero for the first satellite radio transmission to South America.

A transistor acting as a voltage regulator in the No. 1 transponder caused the power drain, NASA and RCA said. Tests on a prototype indicated it was sensitive to temperature change, but no one knew whether this or a faulty internal signal was responsible.

The command problem was skirted by using a new command sequence, different from the programmed sequence.

Detection of Orbiting A-Bombs Is Under Study

SYLVANIA Electronic Systems is studying methods to detect or prevent the placing of nuclear weapons in orbit and to restrict the flight testing of missiles. The study is being performed at Sylvania's Electronic Defense Laboratories in Mountain View, Calif., under a $354,000 contract from the U. S. Arms Control and Disarmament Agency. Scheduled for completion in 1963, the study will assess verification techniques for future arms control and disarmament needs.

Reentry Gliders Will Check Ion Sheath Effect

INFORMATION on radar tracking under ion-sheath conditions will be one object of Project Asset, scheduled to get underway this summer

Board Meets, IEEE Officially in Business

IEEE'S BOARD of Directors met for the first time last week, bringing that massive body officially to life. The meeting held few surprises, according to Donald G. Fink, general manager. Appointments previously announced were approved, by-laws already acted on by IRE and AIEE boards were accepted and in general all the routine business of getting the organization into motion was completed.

The two biggest problems—merging the technical committees and eliminating the $260,000 debt anticipated by the end of the year—shape up like this, Fink said:

The board is letting the individual committees of the old societies work out their mergers for themselves. This will take several months. No one knows the committees' work better than the committees themselves, Fink said, and it would be difficult for outsiders to decide the makeup of the merged committees.

Fink said IEEE should be operating in the black by 1965, through economies resulting from combining IRE and AIEE staffs and functions. These, he said, should compensate for the loss of revenues resulting from lower dues. Despite the deficit there will be no cut in services, he stressed with the launching of the first of six recoverable reentry gliders by Air Force from Cape Canaveral.

The stubby, delta-wing vehicles, built by McDonnell Aircraft, will provide reentry tests for aerodynamic theories and structural approaches for reentry vehicles, as well as information on radar tracking, guidance, control and instrumentation.

Nose temperature is expected to reach 4,000 F. More than 140 measuing devices will collect data on each flight.

Scatter System Hops Over Vietnam Jungle

TROPOSPHERIC scatter system has been set up by Air Force in South Vietnam and Thailand to give those countries and their military advisors a first-rate communications net. A scatter system was selected to put communications out of reach of enemy troops in the jungles, and interception, interference or sabotage. Equipment, built by Page Communications Engineers, was airlifted from the U. S. in 30 trailers. The project was rushed through under high-priority.

Semiconductors Smooth Home Washer Controls

CHICAGO — "Solid-state" automatic washer introduced last week at the Winter Furniture market is the first such appliance for the consumer market, according to Whirlpool. It will be test-marketed at premium prices this spring.

An encapsulated black box was said to contain silicon-controlled-rectifier circuits that permit loss-free but continually variable agitation and spin speeds. Although cost has kept semiconductors out of mass-produced appliances until now, Whirlpool said, their reliability and versatility promise dramatic changes in appliance designs.

New Computer Analyzes Brainwaves in Real Time

BOSTON—New family of computers emerging from an MIT Lincoln Laboratory prototype is expected to have extensive applications in life sciences, communications theory and speech research.

Linc computer designed by Wesley A. Clark features programming that can be changed step by step during an experiment. One of users is AF Cambridge Research Laboratories, which has modified the Linc to permit direct, real-time processing of waveform data from an animal's brain while experiments are in progress.

Basic Linc designed at Lincoln Laboratory uses commercial printed circuit cards and core memory, clock rate of 500 Kc.

Thermoelectric Icebox Competitive by 1970?

CHICAGO—Home-size thermoelectric refrigerators will probably cost no more than everyday compressor types by 1970, Arthur Schnipper, of Borg-Warner's Norge division, told the NARDA (National Appliance and Radio-Tv Dealers Association) convention last Friday. Some 50 major corporations are spending a total of $6 million annually on research to improve efficiency of thermocouple materials, he said.

All-channel uhf tv sets promise to obsolete all existing sets by 1970, Mort Farr, NARDA board chairman, predicted. Farr also predicted all tv broadcasting will be in color within ten years. B & W will be left to portables, with 16-inch picture tubes or smaller, in a trend toward multiple tv sets in most homes.

NAB Urges FCC Toughen Rules for A-M Applicants

NAB URGED FCC last week to raise engineering standards and financial qualifications for applicants for a-m radio station licenses. Purpose would be to curb the growing number of a-m stations, already at the saturation point, according to the National Association of Broadcasters. NAB said it was backing this kind of rule because it "could not subscribe to any proposal which would arbitrarily place a limitation on the number of radio stations in a given market."

In Brief . . .

SUCCESS of the Mariner II mission has led NASA to modify its program of planetary exploration. Instead of repeating the Venus mission in 1964, NASA will concentrate on other projects such as the Mars missions now also planned for 1964 and later Venus missions with advanced Mariner spacecraft.

IN ANOTHER development in newspaper automation (p 7, Jan. 11), the Associated Press has installed an IBM computer to transmit stock market tables to newspapers. The tables will be punched out on tape at 1,000 words per minute.

BILLION-DOLLAR laser market by 1970 is predicted by Robert W. Jagoe, manager of Sperry Rand's Group. Sperry expects to capture 5 percent of the 1963 market, estimated at $15-$20 million.

NEW LASER developed by Raytheon delivers 55 to 350 joules of energy with one-degree beam spread. It is seven times more powerful than the ruby laser used by a Raytheon-MIT team to bounce laser light off the moon last year. Price is $45,000.

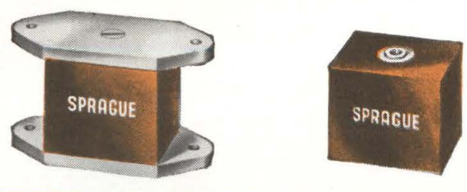
SINGER MANUFACTURING has agreed to buy Sensitive Research Instrument Corp., which it will transfer from New Rochelle, N. Y., to its Bridgeport, Conn., plant.

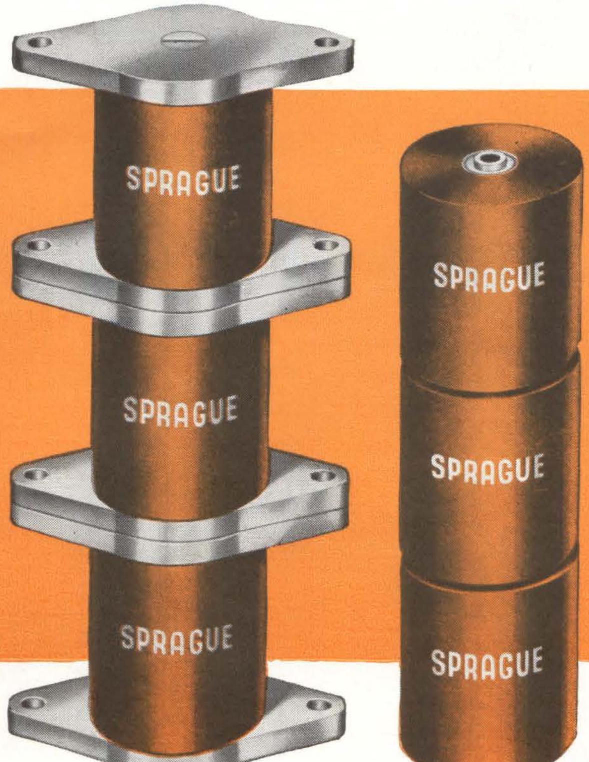
ARGEEMENT for the nonexclusive exchange of licenses under specified patents for data processing devices has been reached by Teleregister and IBM, the companies have jointly announced.

OAK MANUFACTURING has acquired Marco Industries. Oak Electronics, an Oak Mfg. subsidiary, has been dissolved. It will operate as a Marco division in Marco's plant at Anaheim, Calif.

HUGHES AIRCRAFT, GE and Litton are competing for a multimillion-dollar contract to provide Japan with an air defense early warning system, according to a report from Tokyo.

New from Sprague!





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- ✓ **Cooler Operation**

For application engineering assistance without obligation, write to Mica Capacitor Section, Field Engineering Dept. For complete technical data write for Engineering Bulletins 1230 and 1240 to Technical Literature Service, Sprague Electric Company, 35 Marshall Street, North Adams, Massachusetts.

● SOMETHING NEW and important has happened to transmitter-type mica capacitors! In place of the old-fashioned, bulky assemblies you've had to use in the past, Sprague now offers modern, miniaturized Cast Mica Capacitors—30% smaller in size, 30 to 40% lighter in weight, available in new shapes and mountings for liberal new design possibilities.

● Encapsulated in high-temperature epoxy resin by a patented process, Sprague Cast Mica Capacitors will operate at temperatures to 125 C *without derating*—greatly in excess of the 70 C or 85 C limits of conventional capacitors. This exclusive construction also provides superior thermal conductivity—far better than with porcelain—enabling these capacitors to carry higher r-f currents.

● Unlike older units with fragile insulating housings, Sprague Cast Mica Capacitors are rugged. Their tough epoxy resin encapsulation, with improved hermetic seals, eliminates use of potting waxes which tend to melt and cause damage to electron tubes and other components.

● Sprague Cast Mica Capacitors, designed not only to meet but *exceed* MIL Specifications, are made in both the familiar cylindrical as well as a new rectangular shape, with female threaded terminals on opposite ends. Although smaller in size than conventional capacitors, Cast Micas can be procured—for interchangeability—with one or two aluminum plates having the same center-to-center mounting holes as standard types. Where space is critical, they may also be mounted or stacked without plates by means of dual-ended headless screws.

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MICROCIRCUITS	TOROIDAL INDUCTORS	ELECTRIC WAVE FILTERS

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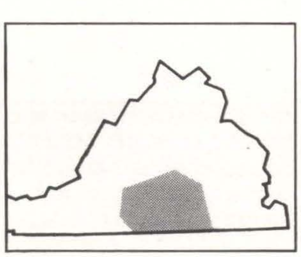
Southside Virginia's within overnight range of New York, Cleveland, Cincinnati, and within a few hours of the world port of Hampton Roads. Yet it offers many advantages of an industrial frontier. You can locate your plant riverside, forest side, or in a charming old community. And you'll find changing agriculture is freeing a fresh, stable, highly trainable working fc-ce.

One man in five, and four women in five, are now available to staff new industries. Ask VEPCO



for facts on their proven high per-dollar productivity. Ask, too, for available plant-site data, and economic studies on the hospitable communities in this land of pleasant living. Write, wire or phone in confidence, without cost or obligation.

VIRGINIA ELECTRIC and POWER COMPANY

J. Randolph Perrow, Manager—Area Development
Electric Building, Richmond 9, Virginia • Milton 9-1411
Serving the Top-of-the-South with 2,540,000 kilowatts—due to reach 3,500,000 kilowatts by 1965.

WASHINGTON OUTLOOK

HI-FI STANDARD TOO LOW, PHONO FIRMS COMPLAIN

HOW 'HIGH' IS HI-FI? In the face of sharp dissent from makers of phonograph components, Electronic Industries Association ventures this answer, for packaged phonographs: the amplifier's music power output must be 5 watts, as defined by EIA's "Power Output Ratings of Packaged Audio Equipment for Home Use," and the system must have a minimum acoustical output of 77 db at 100 cps. 80 db at 1 Kc, and 74 db a 8 Kc. Since no two producers seem to agree on what high fidelity is, EIA offered this rating reluctantly.

The Federal Trade Commission is eager to curb indiscriminate use of "high fidelity" in advertising, and asked EIA a year ago to work up an industry consensus of standards. If adopted by FTC, EIA's ratings would prohibit calling some of the cheaper packaged sets "high fidelity." Most component producers think the standards are far too low and are fighting what would amount to a government stamp of approval on packaged equipment they don't think is entitled to be called hi-fi.

SELF-REPAIR SATELLITES?

SOME SPACE OFFICIALS are now predicting that future satellites may well be designed to make repairs in space easier. Why? Because of the way that laboratory "repair shops" got the Relay and Telstar communications satellites working again this month.

Working with duplicate equipment, Bell Telephone Labs figured out how to trick Telstar into working again (ELECTRONICS, p 30, Jan. 11). Relay ran into a power drain problem that was overcome (p 7, Jan. 11).

RCA engineers made laboratory tests that pointed to Relay's trouble as failure of a transponder's voltage regulator to turn off completely. Because dual electronic equipment is carried in Relay, the trouble area could be bypassed.

AIR FORCE SEEKS NEW SKYBOLT USE

AIR FORCE has reportedly asked Defense Secretary McNamara to continue some development work on Skybolt's stellar-inertial guidance for possible application to future systems. Air Force also proposes a modified Skybolt vehicle for potential use as an antisatellite system or as an airborne space booster rocket.

The Air Force spent $330.1 million on Skybolt R&D and $23.1 million to begin production. It had committed at least $72.7 million more and was set to put out $232 million in new orders this year. Cancellation of Skybolt means to Northrop, the guidance contractor, a cut of 15 percent of its backlog, at least.

SENATORS PROBE TFX CONTRACT

MAJOR SQUABBLE IS BREWING over the TFX fighter plane award to General Dynamics and Grumman after competition with Boeing. Sen. John L. McClellan's Senate Investigations Subcommittee has inquired into charges that GD and Grumman got the award on the basis of "political pressures rather than merit and cost." Shortly, the committee will vote on whether to pursue the investigation, or drop it. Sen. Henry Jackson, a Democrat from Boeing's home state of Washington, instigated the inquiry. He told ELECTRONICS he is not making the charges, but believes they should be investigated.

...IT GLOWS *when* *the* FUSE BLOWS!

NEW INDICATING 3AG FUSE POSTS

EXAMINE THESE FEATURES

1. **New patented knob design to assure high degree of illumination for instant blown fuse indication.**
2. **Positive finger grip for knob extraction.**
3. **Quick service bayonet lock.**
4. **Constant tension beryllium copper coil & leaf spring for positive contact & lower millivolt drop.**
5. **Optional—at extra cost—neoprene "O" ring to assure splash-proof feature.**
6. **New high degree vacuum neon lamp for greater brilliance & visibility.**
7. **Impact black phenolic material in accordance with MIL-M-14E type CFG.**
8. **One piece brass hot tin dipped non-turning bottom terminal.**
9. **Double flats on body to permit mounting versatility.**

SPECIFICATIONS:

LITTELFUSE

PART #	VOLTAGE RANGE
344006	2½- 7 volts
344012	7 - 16 volts
344024	16 - 32 volts
344125	90 -125 volts
344250	200 -250 volts

Maximum current rating 20 amps.

PHYSICAL CHARACTERISTICS—Overall length 2⅜" with fuse inserted • Front of panel length 13/16" • Back of panel length 1 9/16" • Panel area front 15/16" dia. • Panel area back 15/16" dia. • Mounting hole size (D hole) ⅝" dia. flat at one side.

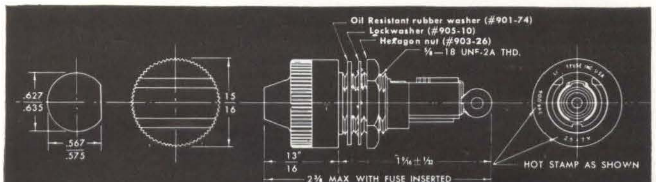
TERMINAL—Side—one piece, .025 brass—electro-tin plated • Bottom—one piece, lead free brass, hot tin dipped.

KNOB—High temperature styrene (amber with incandescent bulbs —2½ thru 32 volts—and clear with high degree vacuum neon bulbs—90 thru 250 volts) • Extractor Method—Bayonet, spring grip in cap.

HARDWARE—Hexagon nut—steel, zinc cronak or zinc iridite finish • Interlock lock washer—steel, cadmium plated • Oil resistant rubber washer.

MILITARY SPECIFICATIONS—MIL-M-14E type CFG. Fungus treatment available upon request per Jan-T-152 & Jan-C-173.

TORQUE—Unit will withstand 15 inch lbs. mounting torque.



LITTELFUSE

DES PLAINES, ILLINOIS

Lacing Problems?

HEMINWAY & BARTLETT

solves them for you with specially processed

NYLON and DACRON

Cords and Flat Braided Tapes

- Greater stability under high heat!
- Tie faster...easier... *tighter!*
- Fungus-proof!
- Knots won't slip!
- Wax-coated, wax-free or G. E. Finish!
- Meet Govt. Spec. MIL-T-713B

For ultra-high temperature work use

TEFLON-COATED FIBERGLAS TAPES

withstand temperatures up to 600°...in ¼" and ⅛" widths

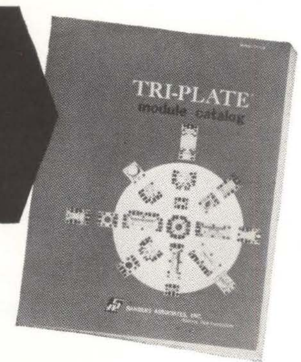
WRITE FOR FREE SAMPLES

THE HEMINWAY & BARTLETT MFG. CO.

Electronics Division: 500 Fifth Avenue, New York 36, N.Y.

CIRCLE 201 ON READER SERVICE CARD

First of its kind microwave catalog



Over 600 TRI-PLATE® strip transmission line modules described

Complete details — including frequency ranges, dimensional diagrams, electrical characteristics and prices — about the more than 600 TRI-PLATE Modules are covered in this new 32-page catalog. Included are ferrite circulators, hybrid rings, directional couplers, delay lines, impedance transformers and many other components used in microwave circuitry. In addition, the catalog lists over 150 mounts for advanced semiconductors. With these modular components you can breadboard and test circuit ideas quickly and easily... go from paper schematics to functioning circuits in minutes.

®Registered Trademark, Sanders Associates, Inc.

CREATING NEW DIRECTIONS IN ELECTRONICS

Send coupon for FREE copy

Sanders Associates, Inc. E-1
Microwave Products Department
Nashua, New Hampshire

Please send copy of new Bulletin TC-118.

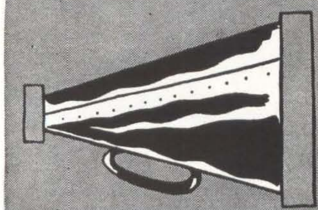
Name.......................... Title....................

Company..

Street...

City................... Zone.......... State............

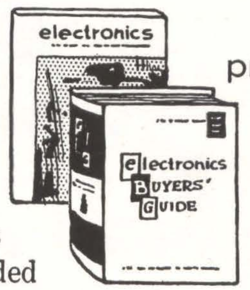
CIRCLE 200 ON READER SERVICE CARD



ANNOUNCING FOR 1963
a tremendous
electronics BUYERS' GUIDE Issue

NEW LOW CATALOG RATES ALLOW SUFFICIENT SPACE FOR YOU TO PROVIDE COMPLETE BUYING INFORMATION ON YOUR ENTIRE PRODUCT LINE

Take complete advantage of marketing's
MAGIC COMBINATION



electronics every Friday—to create preference for your products...

The 1963 BUYERS' GUIDE to make product preference pay off in buying action

For 22 years this combination has worked magic for thousands of sales-minded companies. It will work for you in 1963 more effectively and economically than ever before. Your **electronics** representative has full information on how this can be accomplished. Look at these new eBG catalog rates:

CATALOG ADVERTISING RATES PER PAGE:

Without "EARLY BIRD" Discounts

Space Used	Rates	Space Used	Rates
1 page	$900	12-15 pages	$545 per page
2-3 pages	740 per page	16-19 pages	495 per page
4-5 pages	670 per page	20-23 pages	465 per page
6-7 pages	630 per page	24 or more	440 per page
8-11 pages	590 per page		

FOR THE SAME PRICE AS 1962, FROM 33% TO 60% MORE SPACE!

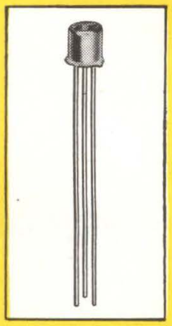
Rates with "EARLY BIRD" Discounts

1 page	$837.00	12-15 pages	$506.85
2-3 pages	688.20	16-19 pages	460.15
4-5 pages	623.10	20-23 pages	433.45
6-7 pages	585.90	24 or more	409.20
8-11 pages	548.70		

"EARLY BIRD" Closing Dates (For Discounts)

Reservations for space Feb. 15th / Copy to set April 16th / Complete plates April 25th

For Complete Information, Contact Local Sales Offices Listed on the Last Page of This Issue



- **Operation to 150°C Ambient**
- **300 Nanosecond Turn-on Time**
- **High Gate Sensitivity**

NEW SILICON PLANAR CONTROLLED SWITCHES

Transitron announces a new series of low current silicon planar controlled switches in the TO-18 package with specifications and ratings exceeding anything now available. The stepped-up performance of these premium devices makes possible many new applications for controlled switches, especially where temperature and switching speeds are critical.

Now in full production, this series, 2N2679-2N2682, features 150°C ambient temperature operation with no voltage derating; 300 nanoseconds total turn-on time; extremely high gate sensitivity; plus the added feature of having all key parameters specified @ −65°C and 150°C wherever applicable.

Furthermore, the planar construction features extremely low leakage — 100 nanoamperes @ 25°C, 100 microamperes @ 150°C — thereby offering increased reliability. These new switches also offer increased current-carrying ability of 350 mA @ 55°C ambient and 75 mA @ 130°C ambient.

For further information, write for Transitron's "planar switch" bulletins.

2N2682 — 200 Volt Type[1]

Specification	Symbol	Min.	Max.	Units
Forward Breakover Voltage @ 150°C[2]	V_{BO}	200	—	volts
Reverse Voltage @ 150°C	V_R	200	—	volts
Forward and Reverse Currents @ 25°C[2] @ Rated Voltage @ 150°C[2]	I_S, I_R	— —	0.1 100	μA μA
Gate Current to Fire @ 25°C @ −65°C	I_{GF}	— —	20 100	μA μA
Gate Voltage to Fire @ 25°C @ −65°C @ 150°C	V_{GF}	— — 0.2	0.7 0.9 —	volt volt volt
Holding Current @ 25°C[2] @ −65°C[2]	I_H	— —	0.5 2.0	mA mA
Forward Voltage @ 200mA @ 25°C	V_F	—	1.25	volts
Turn-On Time @ 25°C	$t_d + t_r$	—	300[3]	nanosecs

1 30, 60, and 100 volt types are also available as the 2N2679, 2N2680 and 2N2681 respectively.

2 With 10K ohm bias resistance between gate and cathode.

3 For maximum limit of 300 nanoseconds, add suffix /A to type designation. For example 2N2682/A.

MEET US AT THE PARIS COMPONENTS EXHIBITION, FEB. 8-12, STAND 159

Transitron
electronic corporation
wakefield, melrose, boston, mass.

1952 10 1962 YEARS LEADERSHIP IN SEMICONDUCTORS

SALES OFFICES IN PRINCIPAL CITIES THROUGHOUT THE U.S.A. AND EUROPE • CABLE ADDRESS: TRELCO

CIRCLE 17 ON READER SERVICE CARD

What Can Be Done About Those

FCC says it could restrict compression of sound signals

REQUIRING BROADCASTERS to transmit the full dynamic range of sound signals now appears to be the best method of eliminating objectionably loud radio and tv commercials (p 12, Dec. 28, 1962), according to the Federal Communications Commission.

Such a rule, an FCC spokesman said, would put the clamps on voice compression and volume limiting, the techniques the FCC suspects are most commonly used for raising the average power of commercials. These methods necessarily result in restricted dynamic ranges.

McIvor L. Parker, FCC engineer, emphasized, however, that there is nothing final yet in FCC's thinking. The matter will be open for comment from interested parties for the next several weeks.

RANGE CONTROL—In essence, Parker said, control over dynamic range would require broadcasters to transmit accurate reproductions of sound levels as actually heard in the studio. Tolerances have not yet been decided, but would be close.

As for tapes and recordings, manufacturers would be required to furnish the amount of compression used. If this exceeded acceptable limits, stations would have to pass the signal through equalizing circuits before transmitting it.

Stations would be spot-checked to see that they were complying with the rule. Violators would be subject to fines or loss of licenses.

A dynamic range rule would not be the complete answer to commercials that wake the baby in the next room, FCC admits, but it would go a long way. Other factors relating

Nuclear Gyro—It Really Works

Research model for Air Force uses optical pumping

ACTUAL OPERATION of a nuclear gyro has been achieved by General Precision, it was revealed last week by R. W. Lee, president of GPL division. He called it a "breakthrough" in the field of aircraft, missile and space vehicle guidance research.

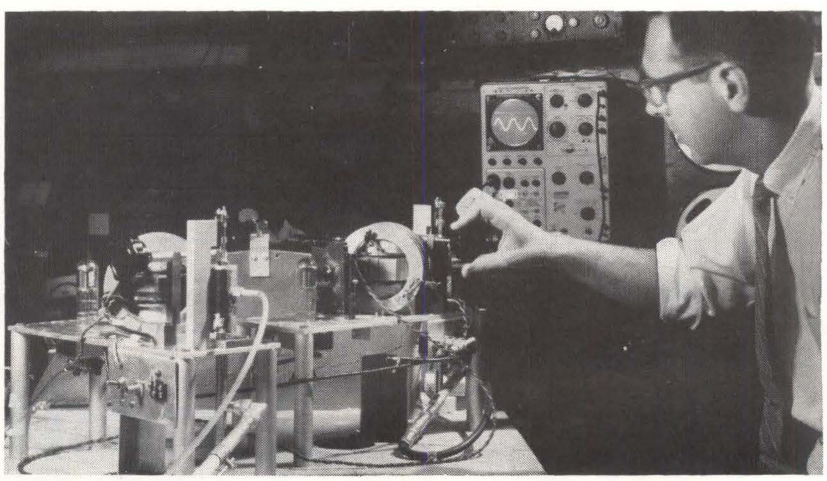
Lee confirmed that the research model uses optical pumping (for detailed reports on nuclear gyro operating principles, see ELECTRONICS, p 20, Feb. 16, 1962, and p 48, Dec. 28, 1962). GPL uses the pumping techniques to align mercury isotopes.

The model is being used to obtain data for final design of an experimental model to be delivered to Air Force. GPL has been studying the nuclear gyro since 1957. Present work is being done by J. H. Simpson, I. A. Greenwood, J. T. Fraser and Donald Sherboff, working with Air Force Aeronautical Systems Division scientists.

Lee said that size, weight and power requirements for a fully developed gyro are expected to be competitive with conventional gyros. Nuclear gyros will be frictionless, have indefinite life, will require little or no warmup time and will apparently be cheaper to produce than conventional gyros, Lee added.

Initial applications are expected on spacecraft. They may also be used on missiles, ships and aircraft.

ABSORBTION CELL *containing mercury isotope is sealed*



TEST BENCH *research model is adjusted. GPL plans to refine this gyro into one Air Force can experiment with*

LOUD COMMERCIALS?

to sound now appear to be completely subjective, unmeasureable by present-day instruments.

One purpose of the inquiry is to determine if measuring equipment can be developed. If not, the commission's "in the public interest" rule will be applied more closely to stations whose commercials incite numerous listener complaints. Stations failing this test could lose their licenses.

POLITICAL PUSH—FCC's apparent determination to do something about annoyingly loud commercials stems from pressure by Sen. Clifford P. Case (R-N. J.) and other congressmen, who in turn are pressured by their constituents. Newton N. Minow, commission chairman, recently wrote Case:

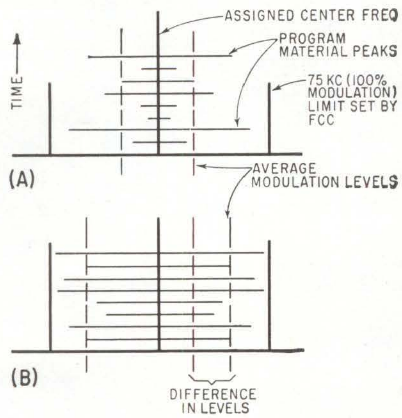
"I would like very much to have a Rule of the FCC which limits the volume of commercials to the volume of adjacent program material."

GEORGE DID IT—Meanwhile network and tape studio officials were keeping mum. "No comment" or exclamations of innocence answered reporters' questions. Though some network officials did admit that commercials sometimes are louder than the preceding program material, they denied that this is deliberate.

If there are any deliberate discrepancies in sound levels, they must be the fault of the tape makers, network officials said.

Officials of the two studios that turn out a lion's share of taped commercials for tv—MGM Telestudios and Videotape Center—had a slightly different view. If there are any deliberate discrepancies, it's not our fault, they said, it must be the networks'.

No one had an answer to listeners' complaints, except to say they are subjective. According to many experts, there may be truth in this—especially as concerns hard-sell rapid-talking announcers reading commercials in a strained voice. Then there is the effect of repetition of commercials on listeners' nerves and an ever more basic fact of life: most people dislike commercials anyhow.



AUDIO SIGNAL *as it might look during natural transmission (A) and after it has been doctored by a volume-raising technique like voice compression (B)*

MOOT POINTS—But is it all subjective or unintentional? FCC, which monitors the modulation percentages of broadcast transmitters across the nation, has noticed that average modulation often goes up when a commercial comes on the air. Under present rules there is nothing illegal about this so long as a broadcaster stays within limits, 85 to 100 percent modulation on peaks of frequent recurrence.

H. H. Scott, Inc., surveyed sound levels on Channels 4, 5 and 7 in Boston from August 15 through September 12 last year. Commercials on 65 percent of the 40 programs monitored were louder than the feature portion. On 20 percent of the shows, commercials were the same level as program material, and on only 15 percent were they softer. The increases in loudness were usually significant, as much as 78 percent (or about 5 db) for two shows.

The Scott study raised questions not yet answered by networks officials or companies that produce commercials. If the increase in loudness of commercials is largely subjective, why did the decibels rise? If the discrepancy in sound levels is unintentional, why weren't there as many soft commercials as loud ones? Lady Luck, like love, may be blind but is she deaf, too?

Cubic announces first low-cost militarized digital voltmeter

Cubic Corporation has designed and is producing the first low-cost digital voltmeter based on military specifications. This new Model V-72 is now in continuous production and is available for all applications requiring a militarized instrument. It features all-solid-state plug-in circuitry. The virtually lifetime reed relays used for bridge switching are good for more than 200 million operations. The package is compact, rugged and lightweight, weighing only 22.5 lbs. A special snap-out replacement readout insures minimum down-time, should maintenance be required. The V-72 sells for approximately $3,400 and quotations on special configurations are available upon request. For additional information, write to Department B-102.

SPECIFICATIONS

Absolute Accuracy .01% of reading, ±1 digit

Sensitivity 1 mv

Reference Stability .005% for 1 month; .01%, 1 year

Bridge Linearity .003%

Temperature Range
Non-operational: −50°C to +72°C
Operational: 0°C to +55°C

Input Specs (Floating)
Z = 10 megs at balance

CMR AC 80 db @ 400
100 db @ 60 cps
DC 120 db

Range & Polarity 0.001 VDC to 999.9 VDC, completely automatic

Average Balance Time 400 msec; worst case, 800 msec

Calibration Cycle 6 months

Input Power 115 VAC 400 cps

Dimensions 16" wide, 5.25" high, 9.75" deep
Weight – 22.5 pounds

Special Configurations Quoted upon request

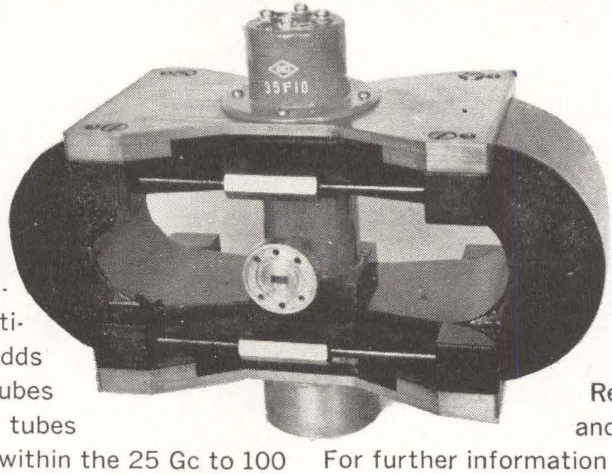
STANDARDS

MIL-STD-16B	Electrical and Electronic Reference Designations
MIL-STD-167	Mechanical Vibrations
MIL-STD-202B	Test Methods

CUBIC CORPORATION
SAN DIEGO 23, CALIFORNIA

OTHER OFFICES: LOS ANGELES, CALIFORNIA – ROME (CUBIC EUROPA S.p.A.) REPRESENTATIVES IN PRINCIPAL U.S. AND CANADIAN CITIES

THE NEW MM-WAVE GENERATOR LADDERTRON®
FROM OKI ELECTRIC
▪ HIGH POWER ▪ LONG LIFE ▪ STABILITY



Oki Electric announces a new development in high power mm-wave research, the Oki Laddertron. The Laddertron, a single-cavity multi-gap floating drift klystron, adds another series of mm-wave tubes to the Oki Electric reflex tubes which are currently available within the 25 Gc to 100 Gc range. The Laddertron has been developed to meet the needs of modern electronics for more reliability in mm-wave sources. It has a frequency range of 33.2—34.8 Gc and maximum power output of seven watts. Resonator voltage is 1850 volts and resonator current is 110 mA.

For further information concerning the new Laddertron, write on your letterhead to:

Butler Roberts Assocs., Inc.
A Subsidiary of
OKI Electronics of America
202E, 44 St. NY. MU-2-2987
4471 NW 36 St. Miami Springs, Fla. T 4-7351

OKI
electric industry co., ltd. TOKYO JAPAN

10 Shiba-Kotohira-cho, Minato-ku,
Tokyo, Japan
Cable Address: "OKIDENKI" Tokyo

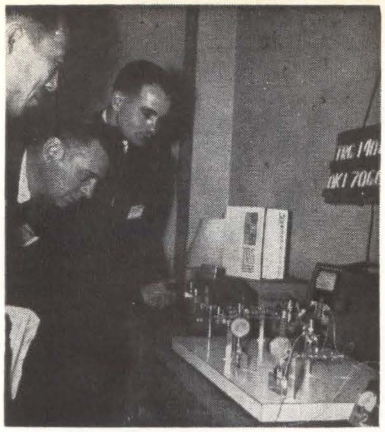
CIRCLE 22 ON READER SERVICE CARD

MAKE SURE YOU KNOW YOUR electronics BUYERS' GUIDE

Review THE CONTENTS PAGE

- **PRODUCT LISTINGS,** streamlined by engineers for engineers.
- **COMPANY STATISTICS:** number of employees, product lines, names of key people, dollar volume.
- **EDITORIAL INDEX** to **electronics** for July 1961 through June, 1962.
- **ABSTRACTS** of Feature Articles in the current Editorial Index.

eBG has much for you. Be sure to use it all . . . Review the Contents Page



PLANO-CONVEX *polystyrene lens system is used in millimeter demonstration setup by TRG*

OSCILLATOR *in Sperry's new line is shown by W. R. Day. Its range is 80 to 110 Gc*

KLYSTRONS *weighing 93 grams for use at 35 Gc are held by S. Aoi and K. Fujisawa, Oki Electric*

Looking for Something to Do? Try Developing MM Components

Major plea at conference last week was for a stepup in hardware work

By LAURENCE D. SHERGALIS
Associate Editor

ORLANDO, FLA.—Millimeter wavelengths are still very much a frontier—an exciting one, one with great potential, but not one that very many companies or very many scientists are willing to go for broke in right now.

Technical quality of the 70 papers presented at the IRE's Millimeter and Submillimeter Conference here last week was unusually high. Total registration reached about 400. Somewhat over 50 percent of the attendees are working directly in mm waves.

Today, most of the work is in physical research in plasmas and materials—the groundbreaking stage. There is little long-range work on such systems as, for example, Republic's 50-Gc communications system. Nor has enough work been done on components and power sources, although a variety of hardware was introduced at the conference.

Much fresh ground has been covered recently (ELECTRONICS, p 37, Oct. 12, 1962, and p 33, Jan. 11, 1963), but numerous problems remain unsolved.

A statement by J. J. Gallagher, of Martin Co., was typical. He doesn't think that engineers spend enough time developing mm components. Martin's efforts are aimed at using mm waves as a research tool, but very few good components are available for this work.

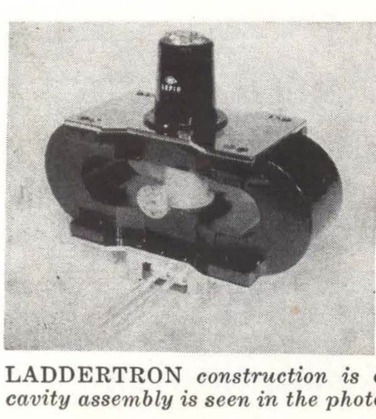
It was evident at the conference that most company and government funding is for use of mm waves as research tools. Some companies were at the conference merely to keep abreast of the competition. Most of the papers were slanted to high-level research.

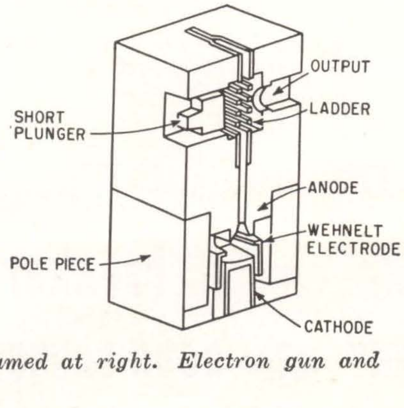
PROBLEMS AND PROSPECTS—Biggest problem in mm waves is still power generation and next comes detectors, according to Paul Coleman, director of the University of Illinois ultramicrowave group.

He says most effort is going into improving the performance of tube-type devices. Recent developments include electron gun structures with higher convergence ratios and current densities, and better fabrication techniques.

Coleman doesn't expect any new ideas in the next year or so. Progress, he says, will be mainly technological—new techniques applied to existing ideas. Coleman gave the conference's opening address on the state of the art.

Engineers, he said, have been trying nonlinear devices to produce r-f at frequencies above 300 Gc by har-





LADDERTRON *construction is diagramed at right. Electron gun and cavity assembly is seen in the photo*

VARIABLE *directional coupler from Amperex for 2-mm service has a 3 to 40-db coupling range*

monic generation. Several problems doom them to failure: Q of these devices approaches 1 at about 150 Gc and the nonlinearity is lost; impedance matching, attenuation, fabrication and tolerances are difficult problems; heat dissipation and breakdown prevent operation at reasonable power levels.

QUANTUM DEVICES—Many researchers are confident that quantum electronics will sooner or later answer the generation problem.

Optical mixing of laser outputs, while interesting, doesn't convert efficiently. Much hard work needs to be done on this.

Tunnel diode oscillators are ruled out at frequencies above about 300 Gc. The limiting factor is the microwave structure in which the diode must be mounted.

One of the most exciting devices is the *p-n* junction laser (ELECTPONICS, p 24, Nov. 16; p 14, Nov. 23, and p 7, Dec. 7, 1962). Coleman told ELECTRONICS he thinks the junction laser gives the most promise for a breakthrough in power generation.

Makers of these devices, mostly for laboratory use, include Hoffman, Lincoln Lab, GE, IBM and Texas Instruments. It is many orders of magnitude better than the ruby laser, much more efficient, much cheaper to make, and doesn't need precision polishing, said Coleman.

Presently, its application is somewhat divorced from mm waves. The idea is applicable and intriguing, according to Coleman, but everyone is guessing at the moment because they don't know the theory. He suspects that Hoffman has worked out the theory, but they haven't published anything yet.

It is possible to pulse these lasers to about 1,000 amps/cm². Up to 100 watts output may be realized, even more if area is increased.

GENERATION — Crystal diodes now have the frequency multiplication record. Plasmas and bunched electron beams appear to offer the most promise.

Work on bunched beams is going to be pushed for some time. The use of intense magnetic fields to compress an electron beam and achieve circuit densities of as high as 2,500/cm² was proposed by E. A. Ash, of Standard Telecommunication Labs, England (ELECTRONICS, p 7, Jan. 11). A frequency multiplier with an output of 2 watts at 4 mm was achieved. Higher outputs are expected.

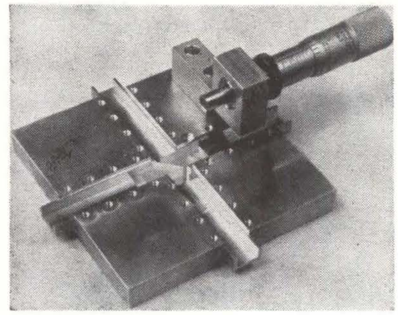
Microwave gas discharge devices are strongly competitive in the frequency multiplication area, are most efficient device in the ultramicrowave band today.

Coleman predicts that multiplier work with ferrites will remain in the lower frequencies. Ferrite probably will not invade the low-millimeter range because of small sample size, waveguide circuits and saturation, he says.

LADDERTRON—Oki Electric Industry, of Tokyo, has a new, tunable, klystron that can continuously put out several watts in the mm range. Output of a typical unit, the 35F10, is 12 w at 34 Gc. A 50-Gc tube will give 5 w minimum.

The tube employs a pair of slotted-plane, ladder-like structures in the center of a rectangular cavity. A flat, high-density beam passing between the ladders is coupled to the cavity through 12 coupling gaps.

LADDERTRON *inventor K. Fujisawa, is interviewed by Associate Editor Shergalis*



OVERSIZED *variable directional coupler developed by AIL for use at 300 Gc. It is shown disassembled. Micrometer adjusting screw moves the prism*

The cavity has two waveguides coupled through apertures on opposite side walls. One varies frequency and the other couples the output to the load. The laddertron will oscillate even if a few ladder rungs are burned out. Its efficiency is about 80 percent.

The laddertron is being produced for O-mode operation. A pi-mode laddertron for up to 200 Gc is under development.

ELECTRONICS learned that backward-wave oscillators and traveling-wave tubes using a modified laddertron construction will be produced soon. For the same operating voltages, traveling-wave tube output is expected to be doubled. Maximum frequency will remain the same. A 44 to 48-Gc twt operating with a circuit voltage of 2.1 to 2.3 Kv has achieved more than 20 db gain.

SWEPT OSCILLATOR — Another significant development, announced by Sperry Electron Tube division, is a series of voltage-tunable, swept oscillators for the 65 to 110-Gc range. Outputs range from 30 mw, for low frequency units, to 10 mw.

The most important feature of these devices is that they may be injection phase locked with a very-low level signal, ELECTRONICS learned. A few microwatts of power will stabilize frequency output, enabling ultrastable operation.

DETECTORS—Coleman is disappointed in progress of work on detectors. Only heat-sensing devices and thermal detectors are practical for power measurement now. Mak-

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- Noise figures measured directly in db.
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CIRCLE 27 ON READER SERV

ing good, coherent detectors for the mm region is a difficult problem.

Crystal diodes are still used in great quantities as low-level mixers and video detectors. Tunnel diodes biased near oscillation are very sensitive detectors. Just how high in frequency they go hasn't yet been determined.

WAVEGUIDES—There is much research on waveguides for frequencies above 100 Gc. Smooth waveguide, most engineers think, cannot compete with optical or quasi-optical systems.

Lower-loss, low-dielectric material that is reasonably easy to fabricate is needed for lens optical systems. Only optical systems are appropriate for the ultramicrowave region, says Coleman.

D. D. King of Electronic Communications, also says that engineers will have to learn optics, that optics are the key to the solution of many problems in the mm field.

Work on components using quasi-optical techniques with oversize waveguide was reported by J. Taub, of AIL division, Cutler-Hammer. Conventional waveguide at frequencies above 300 Gc is difficult to construct and is excessively lossy, typically about 10 db per foot. Waveguide roughly 10 times bigger cuts loss per foot at 400 Gc from 7 db to 0.7 db and is easier to construct.

A good approximation to plane-wave propagation is obtained in oversize guide if most of the power is contained in the TE_{10} mode. The TE_{10} mode is launched by careful tapering from standard size guide. Since many undesirable modes may be propagated in oversize guide, discontinuities cannot be used. Optical structures such as prisms, reflectors and gratings are suitable because they operate uniformly over the entire plane wavefront.

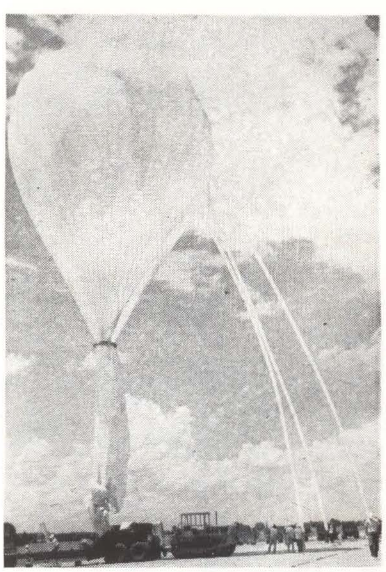
Components built at AIL include directional couplers with coupling ratios of 0 to 30 db, attenuator and phase shifter, all variable.

A new groove-guide was disclosed by F. J. Tischer, of the University

High-Flying Spectrometer to Peer

Analysis of planet's infrared spectra may indicate life on Mars

PALESTINE, TEXAS — A huge plastic balloon carrying a 6,300-pound payload is to be launched from near this small East Texas town in early February. If the mission is completely successful, man will learn whether life can exist on Mars.



TEST LAUNCH *of Stratoscope II flight system last year. Inflation takes 14,500 pounds of helium*

The unmanned mission, part of Project Stratoscope II, will mark the first attempt to detect life-related substances on Mars by analyzing infrared spectrum of light received from the planet.

The launch is the first in a series of Stratoscope II flights timed to coincide with the opposition of Mars to earth—the biennial period when they are closest and Mars' reflected light is most intense on earth.

Later flights will include photographing Mars and other planets.

FLIGHT PLANS—An 8-hour flight is to be made to an altitude of 80,000 feet. At this altitude, a 36-inch telescope feeding a spectroscopic system will be aimed at Mars to measure its electromagnetic radiation.

The system will be outside about 96 percent of the earth's atmosphere. As a controlled check on the slight atmospheric interference remaining, scientists plan to compare Mars' spectra with that of the moon's lifeless surface.

Radio contact with earth will be maintained by a command-telemetry system. The telescope will be aimed by an optical system that locks onto stars (ELECTRONICS, p 30, Sept. 2, 1962).

EXPERIMENT—Specific objective is acquiring high-resolution infrared spectra of Mars and the moon in the wavelength range of 1 to 7 microns.

The experiment is expected to provide a check on the abundance of CO_2. Scientists will also be looking for CO from the photodissociation of CO_2, for CH_4 and other organic gases as a clue to biological activity, for nitrogen oxides of biological and photochemical origin, and for C_3O_2 which may be involved in the Martian "blue haze."

EQUIPMENT — Infrared light from the telescope's reflecting mirror will be spread into a spectral band by a prism. A moving slit will pass light from each "color" segment into detectors.

Energy intensity at each spectrum segment will be telemetered to earth and will also be tape-recorded in the instrument capsule.

Spectrometer components include Wadsworth-mounted fluorite of Alabama. It's like the popular H-guide, but has no dielectric. Walls are grooved parallel to the direction of wave propagation. The guide has application to long-distance transmission, delay lines and phase shifters.

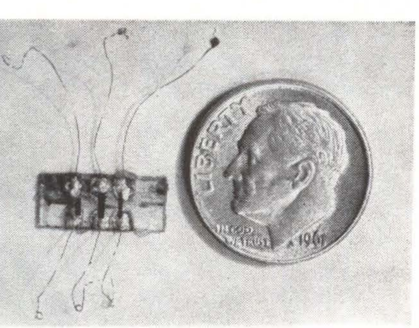
STANDARD—Martin's molecular-beam frequency standard (ELECTRONICS, p 7, Jan. 11) uses hydrogen sulfide gas instead of cesium and electrostatic beam deflection instead of magnetic. Expected accuracy is 1 part in 10^{13} at 300 Gc. Now being assembled, it will be used for plasma and materials studies, and as a time standard in development of mm guidance systems.

at Mars

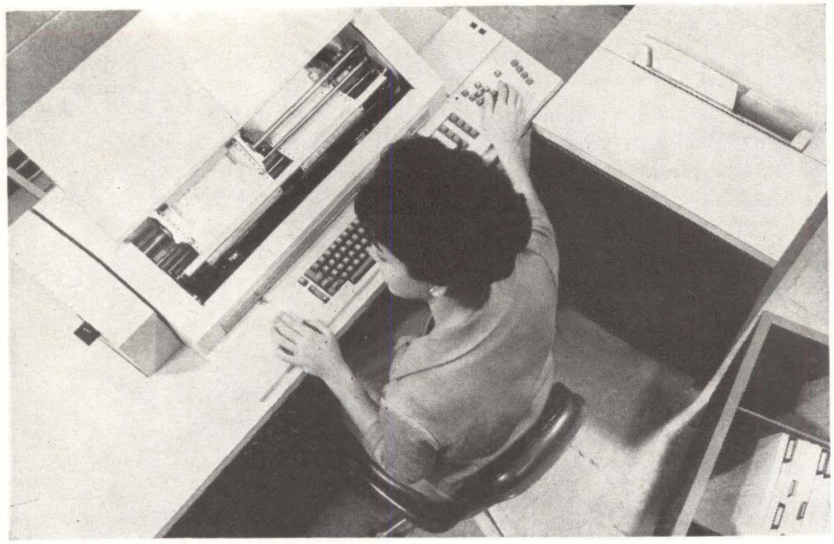
prism and reflection optics, and three liquid-helium-cooled germanium bolometers as radiation detectors. The bolometers, developed by Texas Instruments, are made of single-crystal germanium with gallium added. TI reports that they have demonstrated an ability to detect radiation signals as small as 1 picowatt.

Data from each bolometer will be amplified and recorded separately, providing three independent spectra for each spectral scan.

The project is supported by the National Science Foundation, Office of Naval Research and NASA. Project director is Martin Schwarzschild, of Princeton University.



BLACK BARS *are the three cryogenic bolometers that make up the radiation detector*



ACCOUNTING MACHINE *in the IBM 6400 series includes a core-storage computer. Magnetic ledger card unit is at top right*

New Competitor Enters Magnetic Ledger Field

Automatic bookkeeper uses magnetic strip on ledger card, too

MAGNETIC-STRIPE ledger cards, a field that now includes such firms as National Cash Register and Burroughs, was entered by IBM this month with its 6400 series of accounting equipment.

The ledger card has a horizontal stripe laminated to its reverse side, and according to IBM, is the first to store alphabetic information as well as numeric data.

DESK-SIZED—The main unit is a desk-size accounting machine with a two-address, core-storage computer programmed by a wired control panel.

Standard functions include add, subtract, multiply, divide, negative and zero test, and automatic branching of subroutines. There are 2,952 cores in the main storage unit, plus a working memory of up to 40 numeric characters.

Numeric data is stored in pure binary; alphabetic data is stored in 36-bit words in the computer.

The machine's printer uses the sphere-shaped "golf-ball" printing head first seen in the IBM Selectric typewriter. Speed is 930 characters a minute on a 220-character line. Up to three different documents can be printed for one application, so that, for instance, inventory control, accounts receivable and billing can all be performed at one operation. All operations are automatic, except for entry of variable information. Command keys interrupt and modify the computer program as desired.

MAGNETIC LEDGER—The optional magnetic ledger unit's printer is like the accounting machine's, but has a 130-character line. The magnetic stripe, 8½ inches long and ¾ inch wide, can store 252 alphabetic characters in 6 bits plus a check bit for each, and stores numeric data in pure binary.

The ledger unit accepts cards of varying widths and lengths. Sensing fingers determine stripe location. The stripe is then read by one pass of a four-track head.

A hole is punched at the left end of each line printed, enabling the ledger unit to find the next printing line. Fully-printed cards are automatically rejected while heading and other information are held for printing on a new blank card.

MEETINGS AHEAD

RELIABILITY & QUALITY CONTROL SYMPOSIUM, IRE-PGRQC, AIEE, ASQC, EIA; Sheraton Palace Hotel, San Francisco, Calif., **Jan. 21-24.**

INSTITUTE OF ELECTRICAL & ELECTRONICS ENGINEERS WINTER GENERAL MEETING & EXPOSITION, IEEE; Statler and New Yorker Hotels, New York City, **Jan. 27-Feb. 1.**

MILITARY ELECTRONICS WINTER CONVENTION, IRE-PGMIL; Ambassador Hotel, Los Angeles, Calif., **Jan. 30-Feb. 1.**

QUANTUM ELECTRONICS INTERNATIONAL SYMPOSIUM, IRE, SFER, ONR; Unesco Building and Parc de Exposition, Paris, France, **Feb. 11-15.**

INFORMATION STORAGE AND RETRIEVAL SYMPOSIUM, American University; International Inn., Washington, D. C., **Feb. 11-15.**

ELECTRICAL & ELECTRONIC EQUIPMENT EXHIBIT, ERA, ERC; Denver Hilton Hotel, Denver, Colo., **Feb. 18-19.**

SOLID STATE CIRCUITS INTERNATIONAL CONFERENCE, IRE-PGCT, AIEE, Unversity of Pennsylvania; Sheraton Hotel and U. of P., Philadelphia, Pa., **Feb. 20-22.**

PACIFIC COMPUTER CONFERENCE, AIEE; California Institute of Technology, Pasadena, Calif., **March 15-16.**

BIONICS SYMPOSIUM, United States Air Force; Biltmore Hotel, Dayton, Ohio, **Mar. 18-21.**

IEEE INTERNATIONAL CONVENTION, Institute of Electrical and Electronics Engineers; Coliseum and Waldorf-Astoria Hotel, New York, N. Y., **March 25-28.**

ENGINEERING ASPECTS OF MAGNETO-HYDRODYNAMICS SYMPOSIUM, IRE-PGNS, AIEE, IAS, University of California; UCLA, Beverly, Calif., **April 10-11.**

OHIO VALLEY INSTRUMENT-AUTOMATION SYMPOSIUM, ISA, et al; Cincinnati Gardens, Cincinnati, Ohio, **April 16-17.**

CLEVELAND ELECTRONICS CONFERENCE, IRE, AIEE, Case Institute, Western Reserve University, ISA; Hotel Sheraton, Cleveland, **April 16-18.**

INTERNATIONAL NON-LINEAR MAGNETICS CONFERENCE, IRE-PGEC, PGIE, AIEE; Shoreham Hotel, Washington, D. C., **April 17-19.**

ADVANCE REPORT

RADAR SYMPOSIUM, *U. S. Army Electronics Command, University of Michigan; U. of M. campus, Ann Harbor, Mich., June 4-6. Feb. 1 is the deadline for submitting an unclassified title along with 10 copies of a 300-word abstract to: Coordinator, Ninth Annual Radar Symposium, Institute of Science and Technology, P. O. Box 618, Ann Harbor, Michigan. Secret clearance and need-to-know certification are required for attendance. Suggested areas of interest include: components and techniques; propagation phenomena; engineering applications; new data and their organization (millimeter waves, pulse and frequency analysis, noise, target returns, frontiers, sources of radar performance). Special information may be obtained by telephoning Symposium Coordinator at 663-1511, Extension 313W, Ann Harbor (Area Code 313).*

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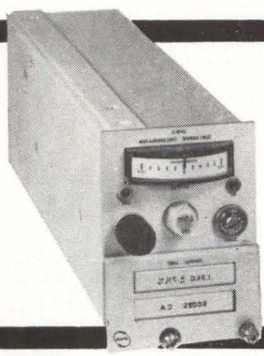

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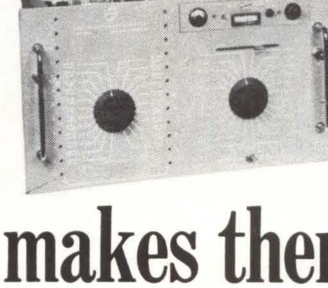

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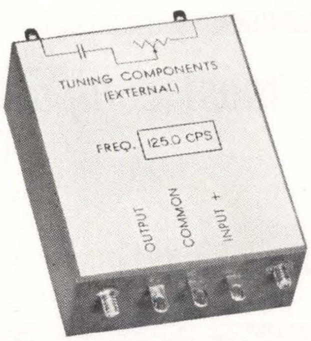

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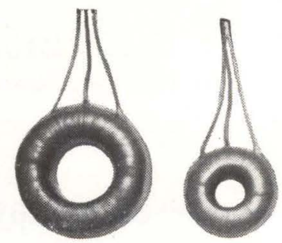

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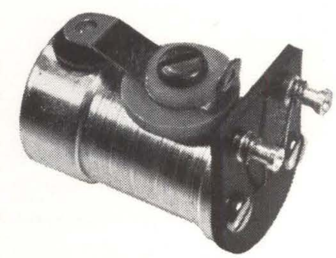

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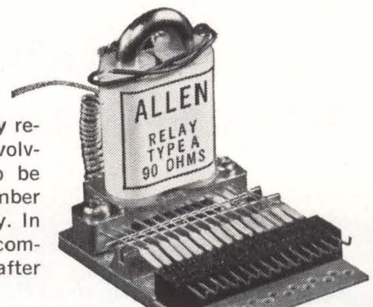

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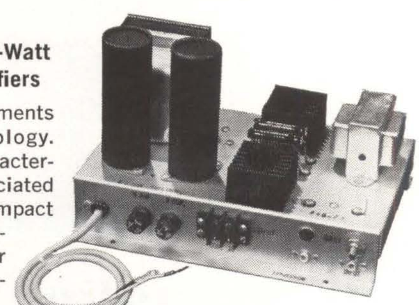


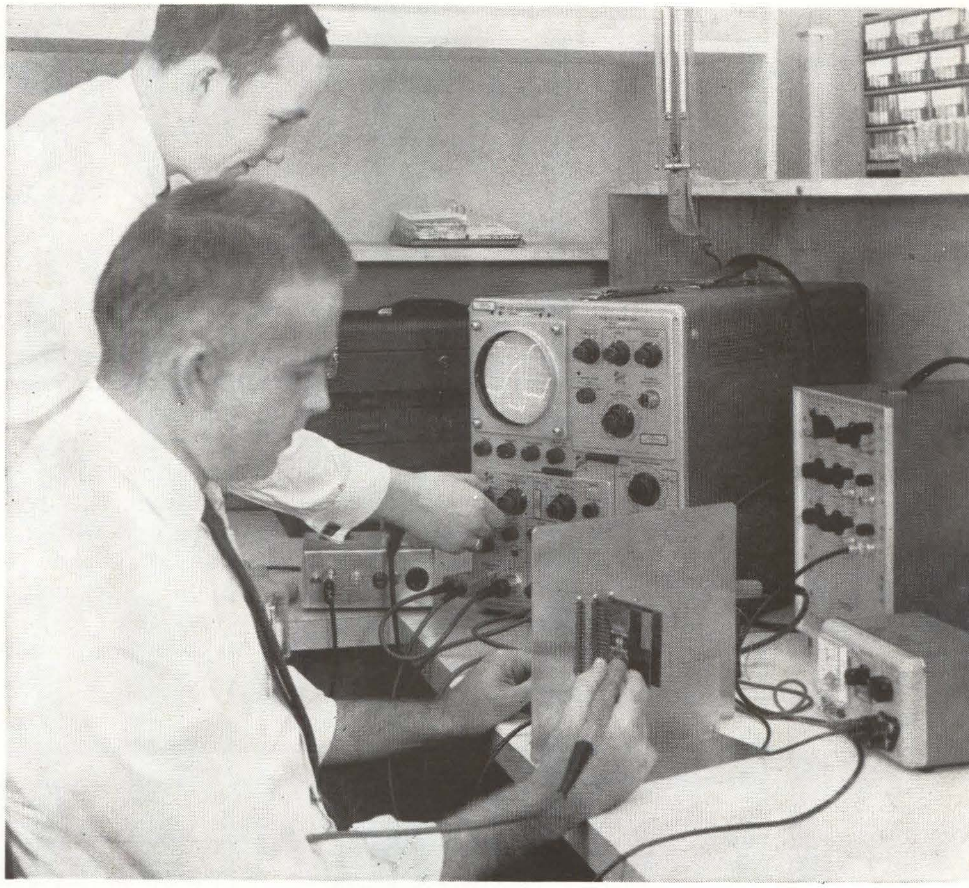
Allen Organ Company, Macungie, Pa. Phone 965-9801

Allen COMPONENTS DIVISION

electronics

January 18, 1963

To apply semiconductor networks in digital equipment, the designer has to understand the application rules and design points brought out here



BREADBOARD CIRCUITS *of semiconductor networks are checked out*

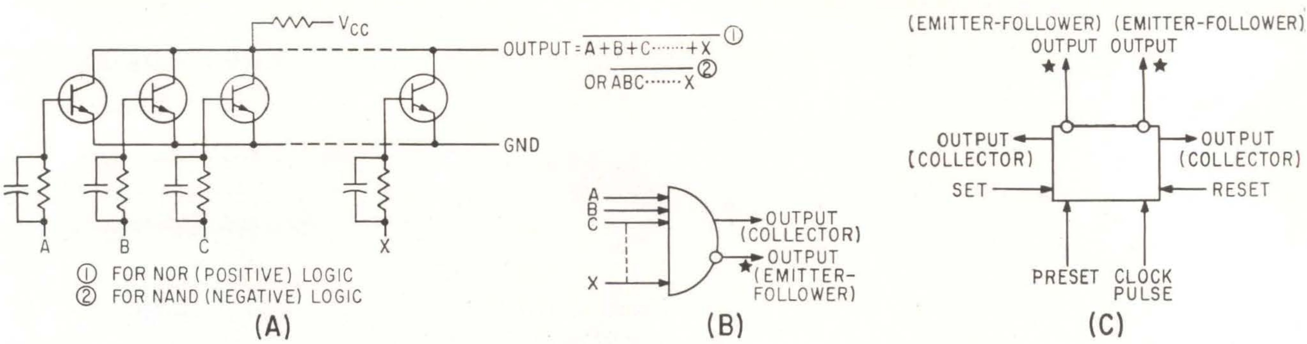
DESIGNING DIGITAL EQUIPMENT WITH Semiconductor Networks

By THOMAS COOPER and GENE McFARLAND, Engineers, Texas Instruments Inc., Dallas, Texas

ALTHOUGH semiconductor networks are still new to many equipment designers, the logic layouts and circuit functions are well-known. The techniques for implementing logic equations are similar to those used with discrete component circuits.

A series of these semiconductor networks, called Series 51, has been fabricated for application in digital equipment designs. Each network is a complete electronic circuit fabricated within a single piece of silicon (Solid Circuit). Fabricated using planar diffused structures with oxide protection and deposited leads on the surface to connect the components within the bar in the desired circuit configuration, the network bar is placed in a hermetically sealed package $\frac{1}{4}$ in. × $\frac{1}{8}$ in. × $\frac{1}{32}$ in. with 10 lateral leads.

LOGIC—This series of networks uses the RCTL (Resistor-Capacitor-Transistor-Logic) NOR/NAND configuration. This logic was selected because RCTL is widely used in present equipment design and be-



RCTL *is the basic circuit configuration (A). Logic symbol for the* NOR/NAND *gate (B), and logic symbol for R-S flip-flop (C)—Fig. 1*

cause RCTL lends itself to good power-speed compromises. Also, wide tolerances of component values can be used without affecting circuit performance.

The NOR/NAND configuration is shown in Fig. 1A. The logical symbol for the RCTL NOR/NAND gate is shown in Fig. 1B. The star on the gate output designates the emitter-followers available on the SN 511 and SN 513 (see Fig. 2). Also among the networks is a reset-set (R-S) flip-flop shown in Fig. 1C.

For implementing binary algebra, two logic assignments are possible, either NOR or NAND. In one system, NOR, a logical *one* is represented by a voltage level and a logical *zero* is represented by no voltage. The NAND system results if the assignments are reversed:

	Binary 0	Binary 1
NOR	Low voltage	High voltage
NAND	High voltage	Low voltage

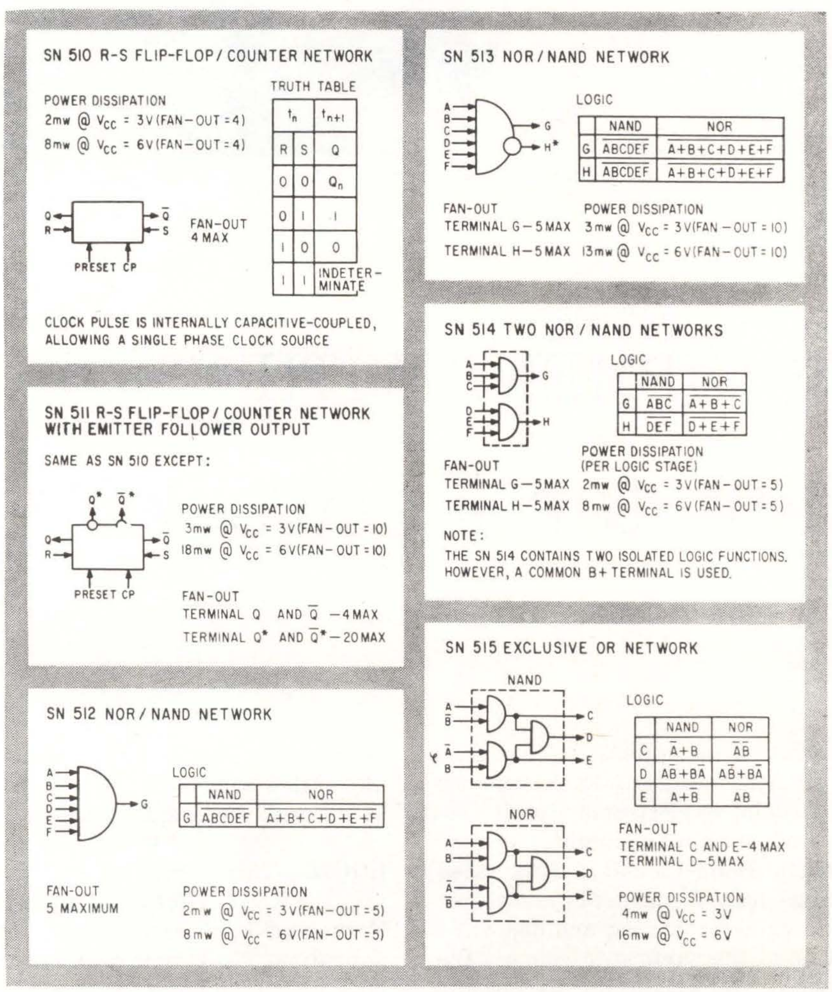
A gate can be used as either a NOR or NAND gate, depending upon the logic system selected. The transfer functions of the gates are:

	Inputs	Outputs
NOR	$A, B, \ldots X$	$\bar{A}\bar{B}\ldots\bar{X}$ or $\overline{A+B+\ldots+X}$
NAND	$A, B, \ldots X$	$\bar{A}+\bar{B}+\ldots+\bar{X}$ or $\overline{AB\ldots X}$

The two logic systems are duals with the NOR logic favoring maxterm type equations and the NAND logic favoring minterm type equations. (A maxterm equation is one in which the logic is arranged as a product of sums, that is, $(A + B)(C + D)$; in the minterm type equation, the logic is arranged as a sum of products, that is, AB + BC.) Implementing an equation with its favored type of logic ordinarily results in the best system with respect to economy and speed. It is sometimes possible to reduce the number of gates connected in series, hence increasing speed at the expense of using extra networks.

Any equation may be readily reduced to its simplest minterm form; however, it is often difficult to expand an equation in minterm form into a maxterm type that is reduced to the optimum form for implementation. For this reason, NAND logic is usually preferred. Further, the input equations of the R-S flip-flop (SN 510-511) (see Fig. 2) are defined to be compatible with NAND logic.

Logic types should be chosen after giving consideration to the requirements of a particular system. A combination of the two types is often used, especially where a



LOGIC, *schematic, fan-out and power drain for semiconductor networks applicable to digital equipment—Fig. 2*

TABLE—FAN-OUT CAPABILITIES

	D-C Fan-Out	A-C Fan-Out Clock Frequency <500 Kc	A-C Fan-Out Clock Frequency >500 Kc
SN510	4	5	Use SN511
SN511	20	5	5 (from e-f output)
SN512	5	5	Use SN513
SN513	25	5	5 (from e-f output)
SN514	5	5	Use 513
SN515 (each gate)			
Exclusive OR	5	5	Use SN513
Auxiliary	5	5	Use SN513

subsystem interface requires a change in logic levels.

EQUIPMENT DESIGN — Specifications applicable to all these networks are: supply voltage, 3 v to 6 v d-c; operating temperature range, − 55 deg C to + 125 deg C. The individual logic, schematic diagrams, fan-out and power drain are shown in Fig. 2.

The flip-flops can be used either in synchronous or asynchronous systems and can, without additional steering, be connected as either counter or shift-register stages.

For digital equipment design, the designer may set up application rules for each circuit to be used. In this way, the connection pattern that conforms to the rules will operate properly and no individual pattern analysis is required. The rules that must be established are: (1) maximum fan-out to be allowed; (2) maximum fan-in available; (3) maximum number of gates which may be connected in series between clocked flip-flops.

FAN-OUT & FAN-IN — Fan-out represents the number of parallel loads that can be driven from one output node as shown in Fig. 3A.

A load, which for these networks is a d-c load, can be represented by the equivalent circuit in Fig. 3B.

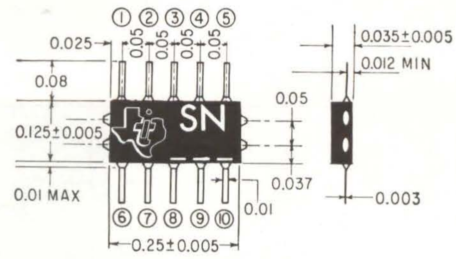
Any of these networks will drive any other network in the series. For high fan-out requirements ($N = 20\text{-}25$), emitter-followers can be used on the flip-flop (SN 511) and gate (SN 513). If maximum d-c fan-out of the emitter-follower output on SN 511 or SN 513 is used, fan-out from the collector output is not available; otherwise, a combination of loading from the emitter-

SEMICONDUCTOR NETWORKS FOR DIGITAL EQUIPMENT

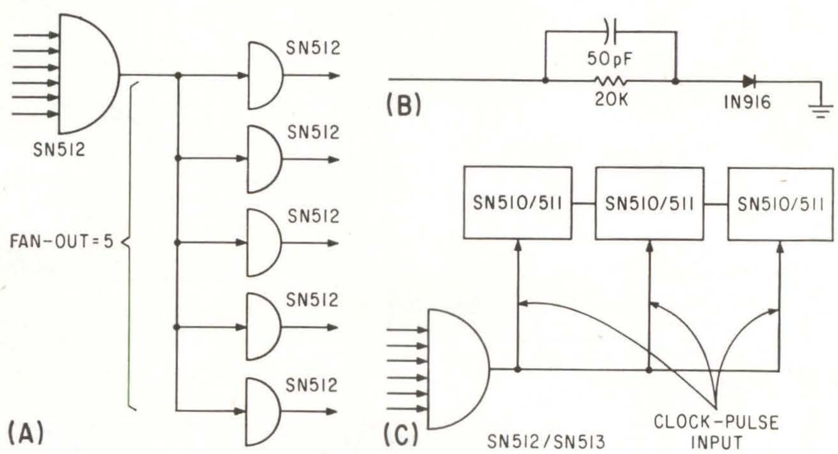
All the semiconductor networks discussed in this article are encased in the hermetically sealed package shown here.

This 0.001 cubic inch package weighs 0.05 gram. A Kovar-glass seal around the leads and metal-to-metal bond of the final package creates the hermetic seal.

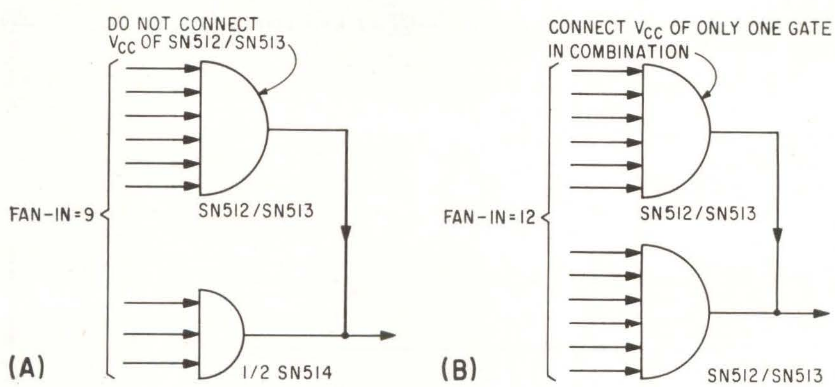
Leads are gold-plated Kovar allowing bonding to external conductors by either welding, soldering or thermocompression bonding. The center-to-center lead spacing of 0.05 in. is a unit multiple of preferred spacing for many interconnection techniques



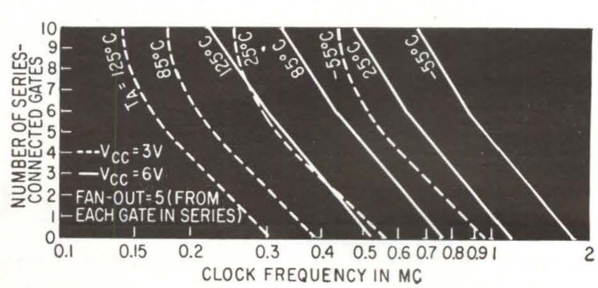
ALL DIMENSIONS IN INCHES



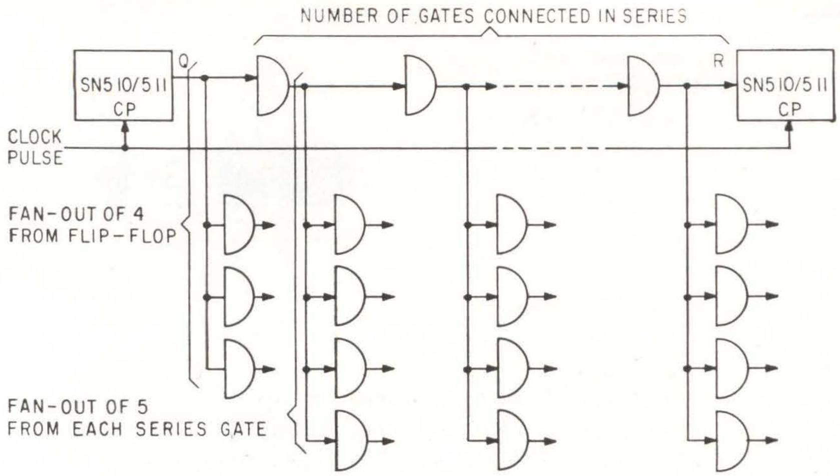
GATE *with a fan-out of 5 (A); equivalent circuit for one d-c load (B); and example of a-c loading on a gate (C)—Fig. 3*



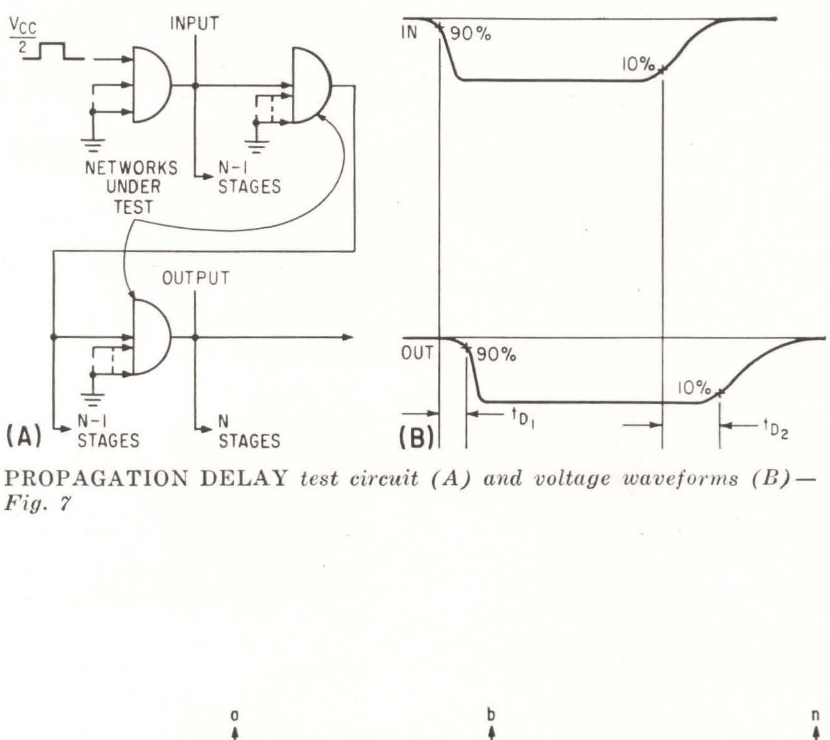
HOW TO *increase fan-in for two types of logic gates, a SN514 (A), and a SN512 (B)—Fig. 4*



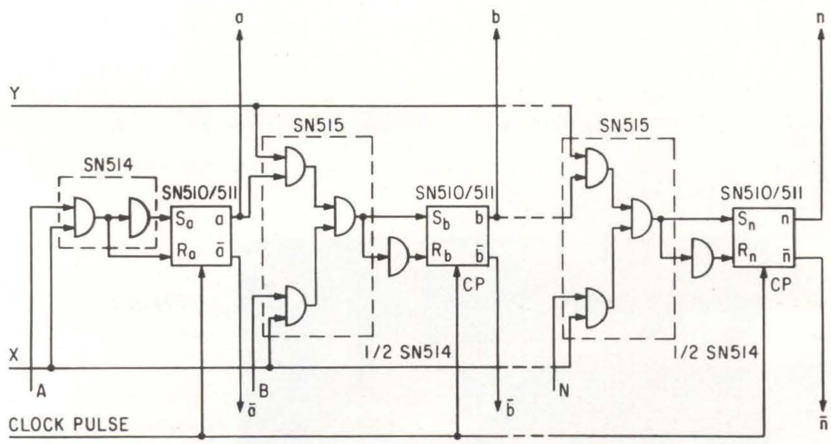
NUMBER of *gates that can be connected in series between clocked flip-flops plotted against operation frequency—Fig. 5*



LOGIC ARRANGEMENT *used to determine the maximum clock frequency —Fig. 6*



PROPAGATION DELAY *test circuit (A) and voltage waveforms (B)—Fig. 7*



SHIFT REGISTER *having parallel read-in and serial read-out, with transfer at each clock pulse—Fig. 8*

follower and collector outputs can be used. All gate inputs and the reset, set, or preset inputs of the flip-flop are considered d-c loads.

Alternating-current loading of a network occurs when its output drives the clock-pulse input of a flip-flop (Fig. 3C). The effect of the added capacitance (approximately 100 pf per clock pulse input) limits a-c fan-out from the networks to 5. Also, at clock rates above 500 Kc, only emitter-follower outputs should be used when driving a-c loads.

A summary of the fan-out capabilities over the − 55 deg C to + 125 deg C operating temperature range is shown in the Table.

In certain cases, simultaneous fan-out into both d-c and a-c loads from the same gate is required. If a gate is driving the maximum number of a-c loads (5) it can simultaneously fan-out into 60 percent of the maximum number of d-c loads. For example, maximum loading (a-c and d-c simultaneously) for SN 512 is 5 a-c loads + 3 d-c loads, and for SN 513 is 5 a-c loads + 15 d-c loads.

Fan-in represents the number of inputs that can be connected to a logic network that will give one output. The fan-in for a logic gate can be increased by connecting the output nodes of two gates and using only one common load resistor (Fig. 4A and Fig. 4B).

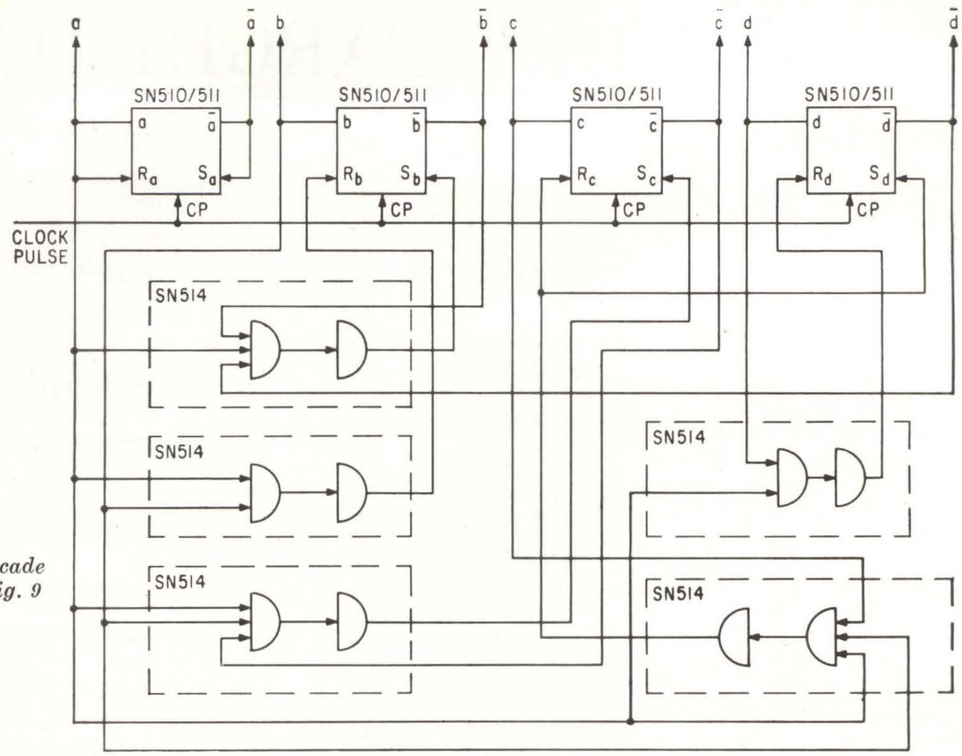
PROPAGATION DELAY—In design of digital equipment, it is normally necessary to know the maximum number of gates that can be connected in series between clocked flip-flops. This is a function of the frequency of operation, the supply voltage, the fan-out of the gates connected in series and the temperature range for which the equipment is designed. For the Series 51 networks, this function is shown in Fig. 5 at V_{cc} = 3 v and at V_{cc} = 6 v. Fig. 6 shows the logic arrangement used to determine the maximum clock frequency. A fan-out of 5 from each series gate is used, which is probably more severe than normal systems require. Maximum clock pulse frequencies will be increased (average propagation delay decreased) if the fan-out is less than 5 from each gate in series. Also an increase of 10 to 20 percent in clock frequency can be obtained if the emit-

SEQUENCE

	d	c	b	a
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	0	1	0	1
6	0	1	1	0
7	0	1	1	1
8	1	0	0	0
9	1	0	0	1

DECODING

$0=\bar{a}\bar{b}\bar{c}\bar{d}$
$1=a\bar{b}\bar{c}\bar{d}$
$2=\bar{a}b\bar{c}\bar{d}$
$3=ab\bar{c}$
$4=\bar{a}\bar{b}c$
$5=a\bar{b}c$
$6=\bar{a}bc$
$7=abc$
$8=\bar{a}d$
$9=ad$



SYNCHRONOUS *binary decade counter having a count of ten—Fig. 9*

ter-follower outputs of the SN 513 are used for the gates connected in series between clocked flip-flops rather than the collector outputs.

The propagation delay of a gate is defined as the time required for a signal to propagate through a gate and is shown in Fig. 7A and Fig. 7B. Average propagation delay equals $(t_{d1} + t_{d2})/4$ for 2 stages, $(t_{d1} + t_{d2})/2$ for a single stage.

APPLICATIONS—The following illustrations show how these networks can be used to implement logic designs. NAND logic is used for these illustrations; however, NOR logic can also be implemented to perform the same functions.

For a shift register having parallel read-in and serial read-out, with transfer at each clock pulse, the logic is

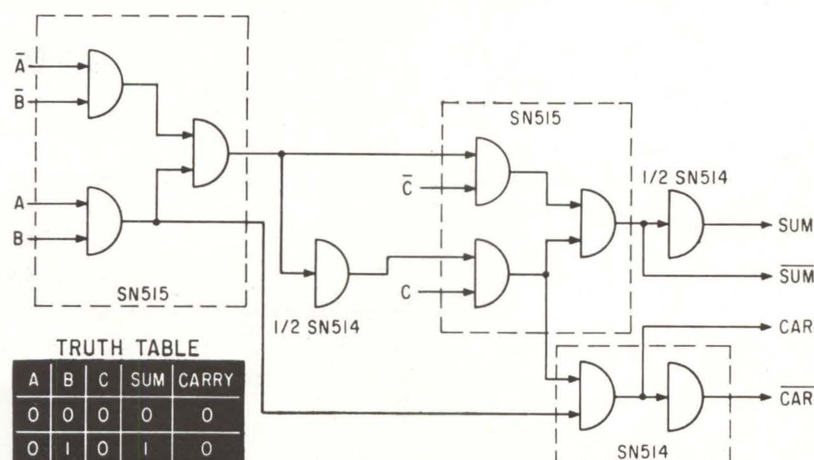
$$\text{1st stage}\begin{cases} S_a = AX \\ R_a = \bar{S}_a \end{cases}$$
$$\text{2nd stage}\begin{cases} S_b = BX + aY \\ R_b = \bar{S}_b \end{cases}$$
$$\text{typical stage}\begin{cases} S_n = NX + (n-1)Y \\ R_n = \bar{S}_n \end{cases}$$

The block diagram is shown in Fig. 8 where: X = parallel transfer gate; Y = shift gate; $A, B \ldots N$ = word to be transferred into shift register; and $a, b \ldots n$ = bit positions of shift register.

This register will shift or transfer at every clock pulse. When X and Y are both zero, the entire register will be reset to 0. Unless a reset of this type is desired, the functions X and Y may be the Q and Q outputs of a control flip-flop. The condition $X = Y = 1$ is not permitted.

A synchronous binary decade counter may be modified to a count of ten as in Fig. 9. Its logic is

$$\text{1st stage}\begin{cases} S_a = \bar{a} \\ R_a = a \end{cases} \quad \text{3rd stage}\begin{cases} S_c = ab\bar{c} \\ R_c = abc \end{cases}$$
$$\text{2nd stage}\begin{cases} S_b = a\bar{b}\bar{d} \\ R_b = ab \end{cases} \quad \text{4th stage}\begin{cases} S_d = abc = R_c \\ R_d = ad \end{cases}$$



TRUTH TABLE

A	B	C	SUM	CARRY
0	0	0	0	0
0	1	0	1	0
1	0	0	1	0
1	1	0	0	1
0	0	1	1	0
0	1	1	0	1
1	0	1	0	1
1	1	1	1	1

FULL ADDER, *shown with truth table, uses a minimum number of networks and minimizes the load on the input circuit—Fig. 10*

A full adder is shown in Fig. 10. Its logic is

$$\text{SUM} = [(A\bar{B} + \bar{A}B) + C][(AB + \bar{A}\bar{B}) + \bar{C}]$$
$$\text{CARRY} = (A\bar{B} + \bar{A}B)C + AB$$

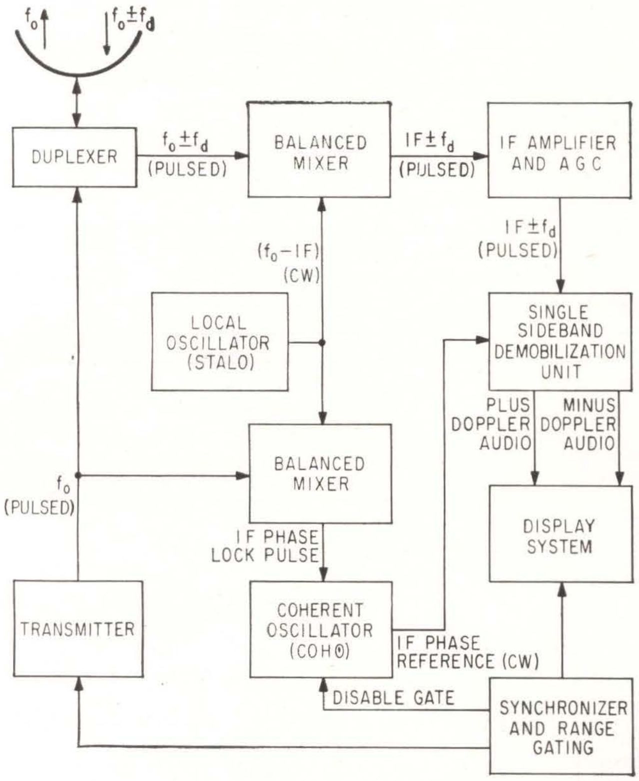
This adder uses a minimum number of networks and minimizes the load on the input circuit.

If minimum propagation delay is an important factor, adders and subtracters can be assembled which have a maximum of three gates in series, but these require more total networks.

MORE TARGET DATA WITH

Single-sideband demodulator separates doppler return from targets moving toward and away from radar into two separate channels

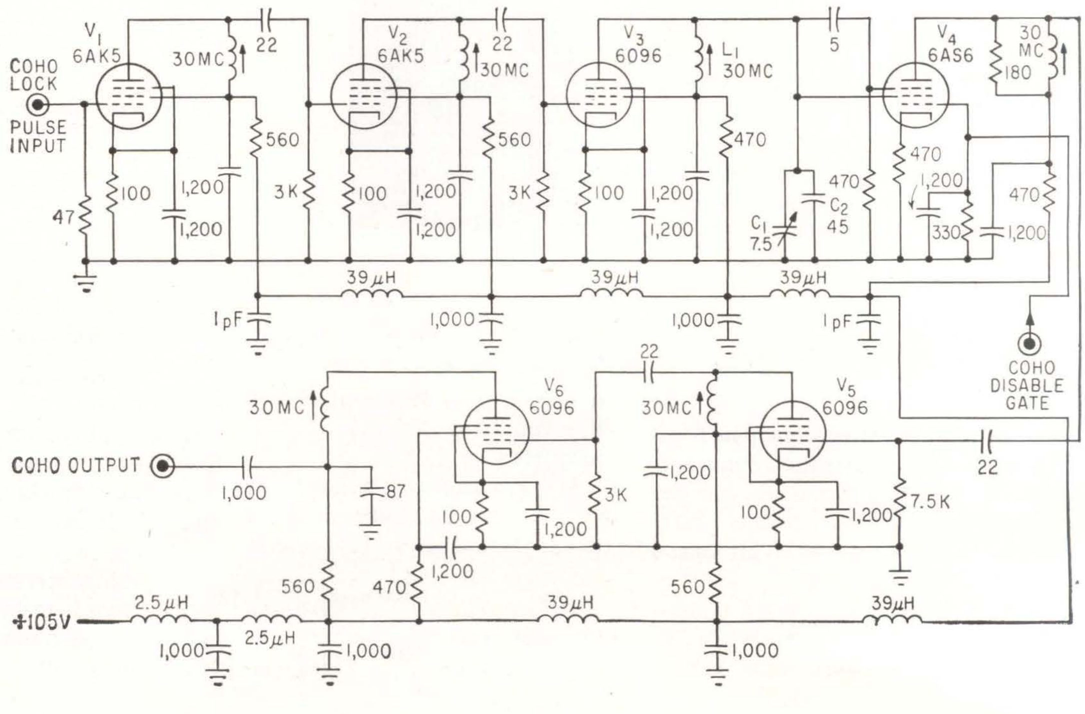
By JOHN B. THEISS, Project Director,
Applied Research Laboratory,
University of Arizona, Tucson, Arizona



LOOKING INSIDE CLOUDS

This pulse doppler radar was developed for the Institute of Atmospheric Physics at the University of Arizona to obtain accurate data on vertical movements of ice and water particles within clouds. This capability is needed in the study of storms that contain strong updrafts. Completely mobile, the radar has been in operation outside Tucson for several months and has been collecting data on the interior dynamics of clouds

PHASE INFORMATION *of each transmitted pulse is stored in the coherent oscillator and used as reference in the demodulator to sort out the plus and minus doppler frequencies—Fig. 1*



COHERENT OSCILLATOR *is easily locked in phase with good free-running stability; V_3 is the oscillator tube —Fig 2*

SIDEBAND COHERENT RADAR

COHERENT PULSE RADAR, developed for cloud physics studies, measures vertical velocities of ice and rain particles. Its unique feature is its ability to separate doppler return from rising and falling particles into two separate channels. The radar return from a moving reflector will change from pulse to pulse, and the time-rate of phase change is proportional to the radial velocity of the moving reflector. In addition, the phase is advanced or retarded depending upon whether the reflector is approaching or receding from the radar. In the conventional "beat" method of doppler detection no provision exists for resolving the ambiguity that results when two targets move in opposite directions at the same speed. The phase-shift method[1] of single-sideband demodulation is used to resolve this ambiguity.

Output of the radar is velocity spectrum data of the particles as a function of altitude and the average power of the radar return. An automatic range stepping capability allows any 500-ft altitude increment between 500 and 60,000 feet to be selected. Range increments are advanced in steps of 500, 1,000, 2,000 or 4,000 feet. The time to scan in altitude is 0.66 second per altitude increment.

Peak power output is 40 Kw; maximum coherent range is 60,000 ft; pulse width is $\frac{1}{4}$ μsec; frequency is X band (3 cm); pulse repetition rate is 4,000 pps; velocity range is $\pm$20 meters/sec; velocity resolution is $\frac{1}{2}$ meter/sec; antenna is a 6-foot paraboloid, and the minimum detectable power is -105 dbm. Figure 1 shows the complete system.

VERTICAL DISH *used with coherent pulse doppler radar for cloud studies is mounted atop the mobile unit*

TRANSMITTER—The transmitter is conventional and uses an APG/32 modulator modified to generate a $\frac{1}{4}$ μsec pulse at a repetition rate of 4 Kc. A 40 Kw tunable X-band magnetron is used. The prime requirement on the modulator is that it produces a flat-topped pulse which does not frequency modulate the magnetron. Frequency modulation at an audio rate would be detected by the demodulation system as a false velocity.

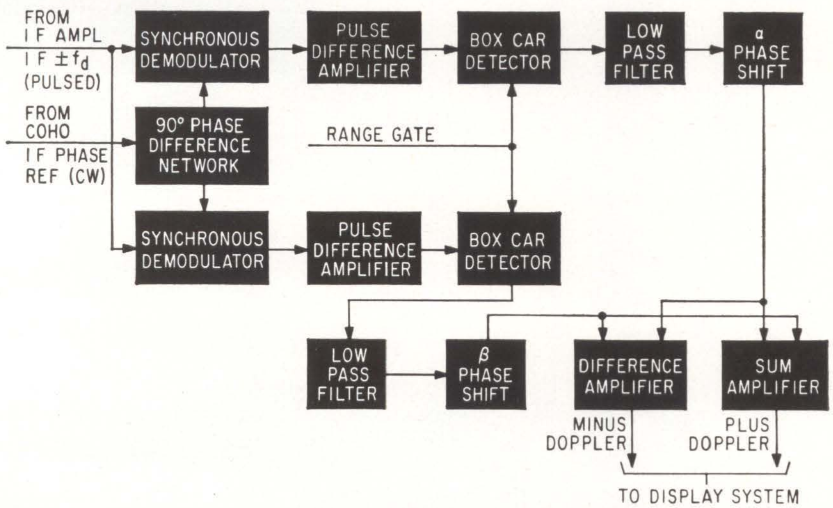
A portion of the magnetron output is mixed with the stable local oscillator (stalo) output. This 30-Mc pulse initiates oscillation and locks the phase of a coherent oscillator (coho) to that of the transmitted pulse.

LOCAL OSCILLATOR—The stalo provides a common mixing signal for both the i-f phase lock pulse and the reflected radar return. It consists of a VA201B klystron stabilized by a VA1280B cavity. The unloaded cavity Q is 110,000 and the stabilization factor is 120. To reduce frequency modulation of the klystron output, a d-c filament supply with less than 1-millivolt ripple is used.

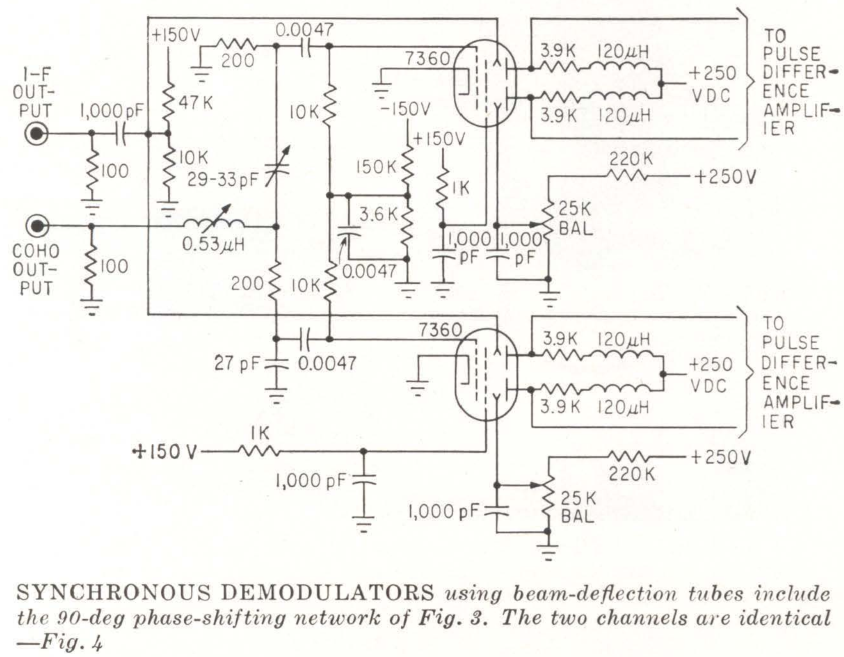
Overall short term stability of

the stalo output is one part in 10^9. Such stability is necessary to detect doppler frequencies as low as 33 cps (½ meter per sec.).

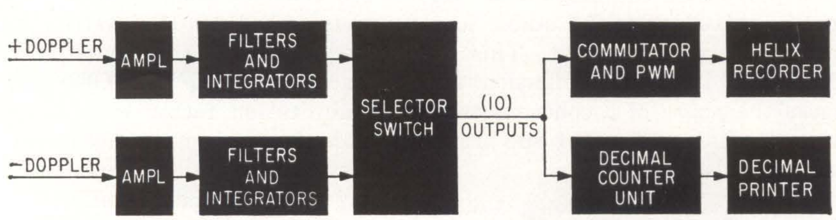
COHERENT OSCILLATOR—The coho stores the phase information of the transmitted pulse. A disable gate stops oscillations just prior to each transmitted pulse, thereby destroying all previous phase information. Thus each i-f phase-lock pulse initiates oscillations in phase with the carrier frequency of the transmitted pulse. The oscillator must be easily locked in phase but have good free-running stability[2]. Phase locking is performed at the lower i-f frequency rather than at X band because of the relative simplicity of i-f locking as compared with r-f locking.



DEMODULATOR *separates sidebands without the use of band-pass filters by comparing the phase of the i-f output with the phase of the coho output —Fig. 3*



SYNCHRONOUS DEMODULATORS *using beam-deflection tubes include the 90-deg phase-shifting network of Fig. 3. The two channels are identical —Fig. 4*



DISPLAY SYSTEM *provides outputs to both a paper recorder and a decimal printer—Fig. 5*

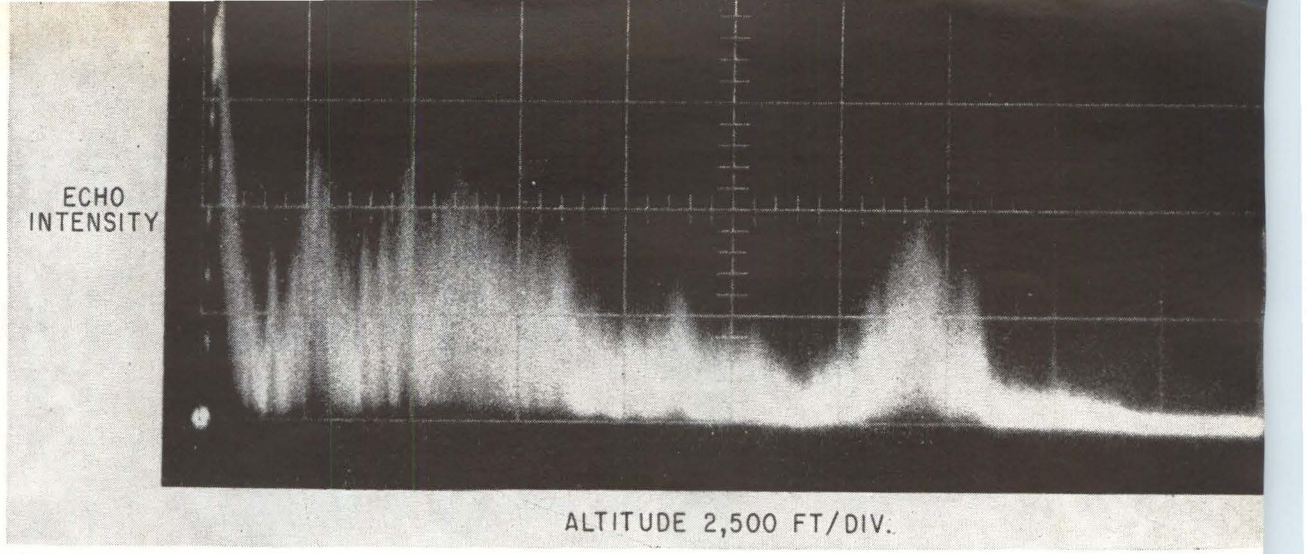
A balanced mixer produces the i-f phase-lock pulse. This was found necessary because the coho would be shock excited by the large pedestal produced from a single ended mixer. The balanced mixer reduces the pedestal sufficiently to avoid this trouble.

In Fig. 2 V_3 is the oscillator and its tank circuit is L_1, C_1 and C_2. The remaining five tubes are amplifiers. The coho disable gate is applied to the control grid of V_4.

The phase of the carrier frequency of any received echo pulse with respect to the phase of the transmitted signal is dependent upon the range of the reflector. If the range changes from pulse to pulse, the phase of the receiver carrier will also change from pulse to pulse. Range change during the transmitted pulse width is negligible for all reasonable rainfall velocities. A target remaining at a fixed radial distance from the radar antenna will produce a zero phase change from one pulse to the next and will not appear in the output of the demodulation system.

The reflected echo signals are received by the antenna and are also heterodyned with the output of the stalo from X band to 30 Mc. Thus both the 30-Mc i-f output signals and the 30-Mc output of the coho preserve their relative phases. After amplification in the i-f amplifier, the 30-Mc pulses are applied to the demodulation.

DEMODULATION—The phase-shift method of single-sideband demodulation separates the plus and minus doppler frequencies. The demodulator, Fig. 3, compares the phase of the i-f output with the phase of the coho output and achieves separation of sidebands without band-pass filters. Since the phase of the i-f signal is changing from pulse to pulse for a moving reflector and the coho phase is constant, the synchronous demodulator output has a frequency proportional to the rate at which the phase of the i-f signal changes. When the



SCOPE RECORDING *of radar return from heavy cloud cover. Spike at extreme right (25,000 ft) is a —112 dbm reference signal—Fig. 6*

antenna beamwidth contains many reflectors moving at various velocities, the doppler output from the synchronous demodulators is an audio spectrum extending from a lower frequency corresponding to the slowest-moving particles to an upper frequency corresponding to the fastest-moving particles.

The demodulator is divided into two identical channels except that the coho output signal is applied to the two channels 90 degrees out of phase. The synchronous demodulators, Fig. 4, use type 7360 deflection tubes. With the c-w coho output applied to the control grid and the i-f output applied in push pull to the deflecting plates, the i-f signal and the modulation products are in push pull at the two anodes, while the c-w signal components are in the same phase. The c-w components are cancelled in the difference amplifiers and the outputs of the pulse difference amplifiers consist only of the doppler components, and harmonics of the 4-Kc repetition rate. After the pulsed signal is stretched in the box-car circuit, the audio frequencies are passed through a low-pass filter that removes frequencies above the doppler audio range.

An additional phase-shift network[3] in each channel following the low-pass filters increases the phase difference between the audio signals to 180 degrees. Thus, by simultaneously adding and subtracting these signals, an output will be obtained from either the sum network or the difference network depending upon whether the i-f carrier phase lagged or led the coho output phase, that is, whether the reflectors are receding or approaching.

The rejection between channels is primarily dependent upon maintaining constant gains and phase shifts in the two channels. Tests under normal maintenance and operating conditions have shown the rejection to be approximately 25 db throughout the audio range of 30 to 1,400 cps.

DISPLAY—Output of the demodulator consists of two channels; one channel is the doppler return from falling particles, and the other channel is the doppler return from rising particles. The bandwidth of each channel extends from 33 to 1,333 cps.

To obtain a spectrum analysis of these two outputs, a display system was constructed of a bank of filters, commutating system, helix recorder that prints the spectrum data as line lengths, and a decimal printer that prints the spectrum data in decimals, Fig. 5.

The filter system contains a bank of 20 filters covering the audio range of interest. The output of each filter is integrated and any 10 adjacent integrator outputs can be selected by a switch for display. These ten outputs are commutated in synchronization with a helix recorder and energizes a pulse-width modulator (pwm). The pwm provides the helix current that records line lengths on the fax paper. The result is 10 recorded channels of doppler information for each altitude.

The filters use L-C components in a Q multiplier[4] to achieve narrow bandwidths. Each filter has a 3-db bandwidth of 16 cps. The fax recording is primarily used for a quick look and indicates the general pattern of the spectrum. The 10 commutation filter outputs also go to a decimal read-out system that drives a decimal printer to provide tabulated numerical data of the velocity spectrum.

Pictures of the oscilloscope presentation are taken every minute on 35-mm film. This provides information on the intensity of the radar return and the location of bright bands or layers of melting snow or ice, Fig. 6. An X-band test signal of known intensity is inserted into the waveguide system through a directional coupler and provides a means of determining the average power returned. Continuous 35-mm motion pictures of an oscilloscope, intensity modulated by the video return, provide a height-time history of the development of the storm.

The author thanks Andrew Longacre of the Syracuse University Research Corporation and J. D. Gooch of the Coordinated Science Laboratory at the University of Illinois for their suggestions and assistance in obtaining drawings and information regarding a similar radar which was constructed at CSL several years ago. Thanks are also due J. Blanchard, D. Brumbaugh and J. Frecker who contributed to this project.

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VERSATILE SERVO AMPLIFIER

For 50, 60 or 400-Cycle

Up to the minute circuit design, construction tech-

have been used in designing this 10-watt solid-state servo

By MICHAEL BODNAR
Chief Electronics Engr.
Diehl Mfg. Co., Somerville, N. J.

THE PROBLEM of designing a transistor servo amplifier is an old one, but new components, techniques and requirements allow for improvements. This design uses the newest transistors, zener diodes, transformers and other materials to achieve a small, high temperature, low cost, repairable servo amplifier. The amplifier delivers a maximum of 10 watts, and works on either 50, 60 or 400 cps carriers.

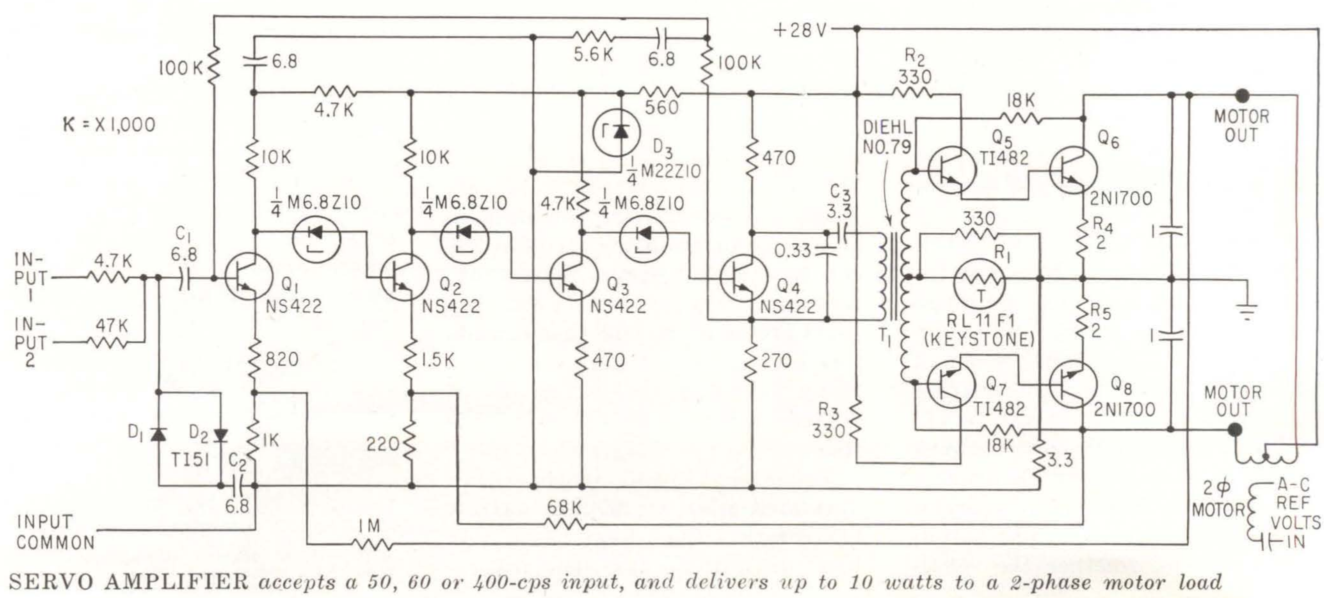
DESIGN CRITERIA—A servo amplifier must have low output impedance for best motor performance, high input impedance to work from standard voltage sources, stable voltage gain and input impedance for servo-system reliability, and an insensitivity to poor power-supply regulation and high ripple. Phase shift in the amplifier instead of shifting the motor reference is often considered; in this design, phase-shift networks were not used because they limit dynamic performance at 60 cps and because voltage feedback is used around the whole amplifier. Gain adjustment must be external to the amplifier so that amplifiers can be interchanged without resetting gain controls.

The schematic details the amplifier circuit. The preamplifier and drive stages (Q_1 to Q_4) are all d-c coupled through zener diodes. There is a d-c feedback around all four stages to produce stable biasing with temperature changes and to permit large component tolerances.

The advantage of d-c coupling is appreciable in servo amplifiers because of the likelihood of long periods of saturation. If capacitor coupling or bypass capacitors are used, they can charge during saturation and consequently delay the amplifier's return to normal operation once the servo reaches null.

Even with d-c coupling, the input must be limited to protect over voltage on the first transistor and charging of decoupling input capacitors C_1 and C_2; this is done by diode pair D_1-D_2. Input limiting is especially important in a servo amplifier since maximum output of a standard synchro can be 60 to 90 volts. About 35 mv at input 1, or about 75 mv at input 2, produces a full output; both inputs may be used for signal mixing.

A zener regulator (D_3) is included in the amplifier to allow for a maximum amount of power-supply ripple and poor regulation. Since a 22-volt zener is used, the preamp is insensitive to changes in the d-c supply that bring it to as low as 22 volts. The output transistors (Q_5 to Q_8) must be protected from over voltage, but ripple in the output is a minor effect, especially since the output signal will probably be in phase with the ripple. Zener D_3 increases quiescent drain

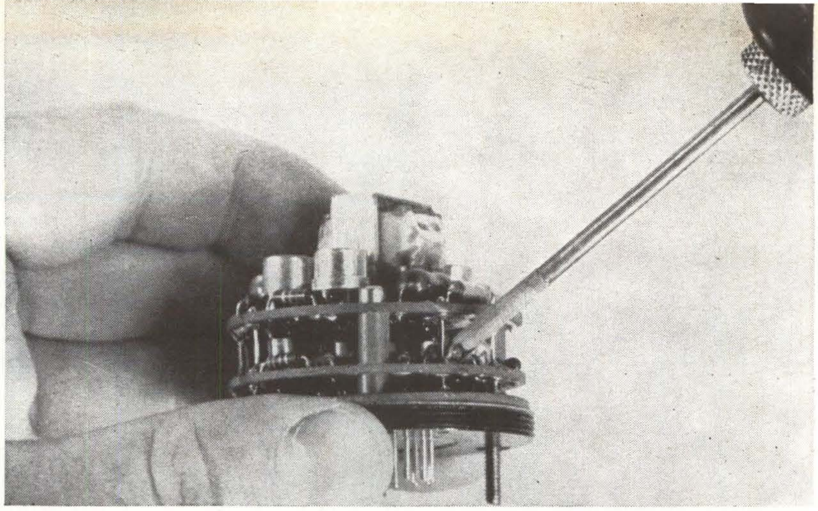


SERVO AMPLIFIER *accepts a 50, 60 or 400-cps input, and delivers up to 10 watts to a 2-phase motor load*

Operation

niques and components

amplifier



AMPLIFIER PACKAGING *uses three printed-circuit wafers, which are connected by bus-bar feedthroughs*

in the preamp to about 15 ma.

POWER STAGE—The drive power is supplied to the Darlington-circuit output stages (Q_5-Q_6 and Q_7-Q_8) from a small, high-inductance transformer (T_1). This transformer is critical, since it must operate on 50, 60 or 400 cps. To achieve maximum inductance, enabling a 50 or 60-cps square wave to pass, requires a special high-mu core and no d-c in the primary. Even the leakage of the 3.3-μf solid tantalum capacitor (C_3) must be considered.

Actually, T_1 is an inefficient driver transformer, but the power gain in the output transistors is a vast help. The need for a square-wave drive is important in a servo amplifier. The square wave allows the output to exceed the normal rms output obtained from a 28-volt d-c push-pull amplifier. If a square wave is applied to the motor, the motor will filter the fundamental, whose peak is greater than the peak of the square wave. The square-wave output also increases the amplifier's efficiency when it is supplying maximum power.

Low-frequency gain, however, should be kept to a minimum because of possible low-frequency oscillations. Even with the d-c feedback in the preamp, the use of d-c coupling produces high low-frequency gain. This can be controlled by choosing the minimum d-c blocking capacitor (C_3) to the driver transformer that will still pass a satisfactory square wave to the output stage.

Using silicon transistors in the output stage, the Darlington-circuits produce satisfactory thermal stability in the mechanical configuration. The thermometer (R_1) helps by correcting for the resistive changes in the transformer secondary with temperature.

Collector resistors R_2 and R_3 of driver transistors Q_5 and Q_7 can be chosen to limit the maximum drive to output transistors Q_6 and Q_8, respectively. This is excellent protection against shorting the output, since only a controllable current will flow, protecting the output transistors during a short.

The efficiency of the output stage will equal that of the ideal class B, especially as the output becomes a square wave. The only power loss will be the small standby current, about 40 ma at room temperature and 60 ma at 100 C, plus the loss in the 2-ohm emitter resistors (R_4 and R_5).

Open-loop a-c gain is unusually high, due to the extremely high gain of the transistors in the preamp and the high gain of the transformer - driver - Darlington - output configuration. This open-loop gain, however, is reduced by a number of overall feedback loops to produce the desired servo performance.

TRICKS OF AMPLIFIER'S DESIGN

Direct coupling is used almost entirely. This results in:

- minimum phase shift, hence less need for phase compensation on the input networks;
- wider signal range;
- fast recovery from saturation.
- The unit is compact, yet repairable. Wafer subassemblies can be checked and replaced independently

FEEDBACK—Since the amplifier works directly into a 36-volt center-tapped motor, no feedback winding is available. This means that, for symmetrical feedback, both ends of the motor must be used for feedback. This two-phase feedback means that stages Q_1 and Q_2 in the preamp must be used and that the feedback gains are varied by resistors in each feedback leg.

With the two feedback loops, the overall voltage gain is reduced to about 1,000 from the input to across the motor. This strong feedback results in a high input impedance (about 40,000 ohms), low output impedance (about 20 ohms) and insensitivity to component-parameter changes caused by temperature, age or manufacturing variations.

Insensitivity to component parameters is important because wider tolerances are a source of savings in purchased parts as well as an improvement in dependability. Low output impedance is also important in a servo amplifier because the servo motor varies its loading effect as the speed reduces.

In packaging the amplifier, the desired features were repairability, good heat transfer and the ability to operate in military environments. Round printed circuit wafers are used with feed-through terminals around the edge for interconnection (photo). A threaded can is the external package and the can is filled with aluminum-oxide particles. With the proper density, the thermal gradient is quite a bit less than that obtainable with the standard epoxy fillers.

RESONANT-CAVITY TUNING Now

Normalized curves permit predicting tuning results when using the simple adjustment technique of axially moving a discontinuity within the cavity

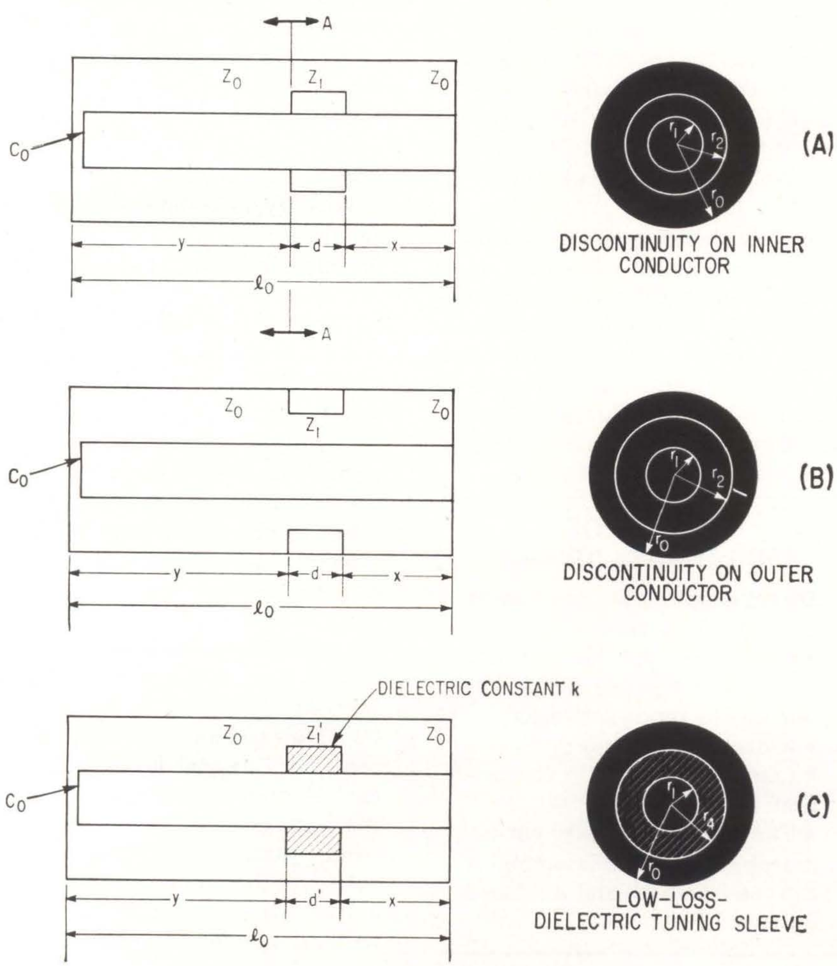
By J. GREGG STEPHENSON
Airborne Instruments Laboratory,
Division of Cutler-Hammer Inc.,
Deer Park, N. Y.

COAXIAL-CAVITY resonators are usually tuned by varying the length of the cavity with a movable plunger, of either the contacting or noncontacting type.[1] Design situations sometimes arise, however, when it becomes desirable or necessary to keep the length of the cavity fixed and to tune by some other means.

One method is to vary the value of a lumped shunt capacitance at a point of high electric-field intensity in the cavity. Tuning ranges with this method can be predicted by laboriously calculating through trial and error the effect of the changed lumped capacitance. Problems may arise, however, because of the asymmetry of configuration and the difficulty of achieving the required change in capacitance and linearity of tuning without causing tuning noise.

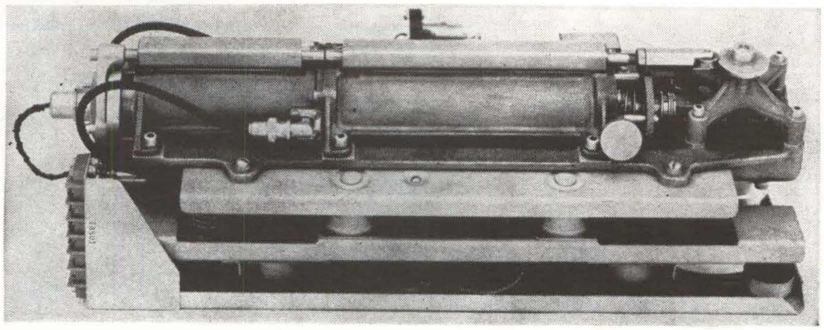
Another method is to move a coaxial discontinuity axially within the cavity; with this method, the configuration is radially symmetrical and mechanically simple. Tuning can be made noiseless by eliminating rubbing metallic contacts. No d-c connection across the cavity is necessary, and the incremental tuning range can be made approximately constant and linear with an adjustable center frequency. By choosing a discontinuity of the proper size, large tuning ranges can be covered with only a small axial movement. Alternatively, a large translation per megacycle can be obtained for vernier tuning. This method has been used to advantage in stable local oscillators and similar applications where repeatable, noiseless, linear, incremental tuning was required, combined with an adjustable center frequency.[2]

A generalized solution to the problem of finding the parameters of a coaxial-cavity resonator to be tuned by a movable discontinuity is presented in normalized form. Solu-



PARAMETERS *of a resonant coaxial cavity with discontinuity tuning. Discontinuity on inner conductor, (A); discontinuity on outer conductor, (B); dielectric tuning sleeve on inner conductor, (C)—Fig. 1*

Made Easy



L BAND STABLE LOCAL *oscillator, using a discontinuity tuning sleeve*

tions are given for a practical range of magnitude of the discontinuity —relative to the size of the cavity —and for the $\lambda/4$, $3\lambda/4$ and $5\lambda/4$ coaxial TEM resonant modes. These parametric solutions can predict the tuning range and linearity for a given dimensional configuration of cavity and discontinuity. They can also be used with linear interpolation to derive the dimensional configuration of a cavity and discontinuity for a desired tuning range.

NORMALIZING PARAMETERS —The parameters of a coaxial-cavity resonator that is tuned by a movable discontinuity or tuning sleeve are defined in Fig. 1. In deriving generalized parametric solutions for cavities with this method of tuning, three assumptions were made: (1) the internal cavity losses can be neglected, (2) the equivalent terminating capacitance C_0 is lumped at one end of the cavity and (3) the effects of fringe capacitance at the edges of the tuning sleeve can be neglected. The first two assumptions result in negligible errors, but the third may require that a correction be applied to the tuning curves when the edges of the tuning sleeve are sharp.

The coaxial cavity of length l_0 has a characteristic impedance Z_0; the tuning sleeve is regarded as a section of transmission line having a characteristic impedance Z_1 smaller than Z_0, and a length d shorter than l_0. One end of the cavity is short-circuited by a wall or plunger, while the other end is terminated in a small lumped capacitance C_0. The movable discontinuity can be a metal sleeve that is either an enlargement of the center conductor of the coaxial cavity, as in (A) of Fig. 1, or a shrunken section of the outer conductor, as in (B) of Fig. 1. The tuning sleeve has highly conductive surfaces.

The tuning noise resulting from metal-to-metal sliding contacts can be eliminated by inserting a thin-walled cylinder of low-dielectric-constant low-loss material between the sleeve and the inner or outer conductor of the coaxial cavity. The tuning sleeve can be moved axially by push rods that extend through one end of the cavity, or it can be moved by low-dielectric-constant pins that reach it through axial slots in the inner or outer conductor of the cavity.

The tuning sleeve can be made entirely of a low-loss dielectric, or it can be made partly of dielectric and partly of metal; the tuning curves apply in either case, but the characteristic impedance Z'_1 must be calculated as defined in Eq. 4 and the length d' must be calculated as in Eq. 5.[3]

Three types of tuning sleeves are illustrated in Fig. 1. The characteristic impedances are related to the various dimensions by the following equations:

Characteristic impedance of basic coaxial cavity

$$Z_0 = 138 \log_{10} \frac{r_0}{r_1} \text{ ohms} \qquad (1)$$

Characteristic impedance of discontinuity on inner conductor

$$Z_1 = 138 \log_{10} \frac{r_0}{r_2} \text{ ohms} \qquad (2)$$

Characteristic impedance of discontinuity on outer conductor

$$Z_1 = 138 \log_{10} \frac{r_3}{r_1} \text{ ohms} \qquad (3)$$

When a tuning sleeve is composed of a solid material of dielectric constant k, an equivalent characteristic impedance Z'_1, and an equivalent length of d' must be used in Eq. 8 or 9 and in referring to the tuning curves.

Equivalent characteristic impedance for dielectric sleeve on inner conductor

$$Z'_1 = Z_{01} + Z_{02} + \frac{1}{2}\left(\sqrt{k} + \frac{1}{\sqrt{k}} - 2\right)\frac{Z_{01}Z_{02}}{Z_{01}+Z_{02}} \qquad (4)$$

where[3]

MOVING A DISCONTINUITY

Although a coaxial cavity resonator can be tuned by axially moving a discontinuity within the cavity, the method is not widely used, because it is hard to predict tuning range and linearity for a given cavity. But movable-discontinuity tuning has several advantages. And generalized parametric solutions, reduced to normalized curves, can simplify prediction of results

$$Z_{01} = \frac{138}{\sqrt{k}} \log_{10}\left(\frac{r_4}{r_1}\right)$$

$$Z_{02} = 138 \log_{10}\left(\frac{r_0}{r_4}\right)$$

Equivalent normalized length of dielectric sleeve

$$\frac{d'}{\lambda_0} = \left(\frac{d}{\lambda_0}\right)\left(\frac{Z_0}{Z'_1}\right) \qquad (5)$$

where d = physical length of sleeve, and d' = equivalent length of sleeve.

Referring to Fig. 1, the resonant wavelength λ_0 of the basic coaxial cavity with no discontinuity is

$$\frac{\lambda_0}{2\pi\nu C_0 Z_0} = \tan 2\pi\left(\frac{l_0}{\lambda_0}\right) \qquad (6)$$

where

λ_0 = the resonant wavelength of the basic coaxial cavity in cm, C_0 = the equivalent, terminating, lumped capacitance in fd, Z_0 = the characteristic impedance of the basic coaxial cavity in ohms, ν = the velocity of propagation, 3×10^{10} cm/sec, and l_0 = the total length of the coaxial cavity in cm.

Note (Fig. 1) that

$$l_0 = x + d + y \qquad (7)$$

Define λ_0 and l_0 as in Eq. 6 and 7, introduce the normalizing parameter λ/λ_0 in which λ is the tuned wavelength in cm. The equation defining resonance in the coaxial cavity can be obtained by dividing the cavity at some arbitrary plane perpendicular to the axis and equating the impedances seen looking in each axial direction. The normalized equation is

$$\frac{\frac{\lambda_0}{2\pi\nu C_0 Z_0}\left(\frac{\lambda}{\lambda_0}\right) - \tan 2\pi\left(\frac{y}{\lambda_0}\right)\left(\frac{\lambda_0}{\lambda}\right)}{1 + \frac{\lambda_0}{2\pi\nu C_0 Z_0}\left(\frac{\lambda}{\lambda_0}\right)\tan 2\pi\left(\frac{y}{\lambda_0}\right)\left(\frac{\lambda_0}{\lambda}\right)} =$$

$$\frac{Z_1}{Z_0}\left[\frac{\frac{Z_1}{Z_0}\tan 2\pi\left(\frac{d}{\lambda_0}\right)\left(\frac{\lambda_0}{\lambda}\right) + \tan 2\pi\left(\frac{x}{\lambda_0}\right)\left(\frac{\lambda_0}{\lambda}\right)}{\frac{Z_1}{Z_0} - \tan 2\pi\left(\frac{d}{\lambda_0}\right)\left(\frac{\lambda_0}{\lambda}\right)\tan 2\pi\left(\frac{x}{\lambda_0}\right)\left(\frac{\lambda_0}{\lambda}\right)}\right] \qquad (8)$$

For the special case where $C_0 = 0$, $l_0 = m\lambda/4$ (m = 1, 3, 5, etc), and the equation becomes

$$\text{Cot}\, 2\pi\left(\frac{y}{\lambda_0}\right)\left(\frac{\lambda_0}{\lambda}\right) =$$

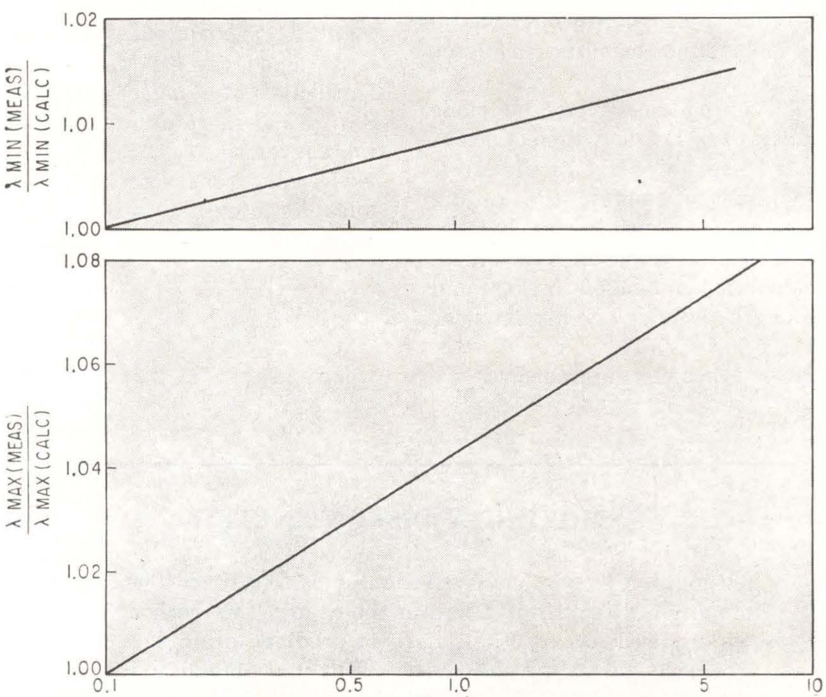
$$\frac{Z_1}{Z_0}\left[\frac{\frac{Z_1}{Z_0}\tan 2\pi\left(\frac{d}{\lambda_0}\right)\left(\frac{\lambda_0}{\lambda}\right) + \tan 2\pi\left(\frac{x}{\lambda_0}\right)\left(\frac{\lambda_0}{\lambda}\right)}{\frac{Z_1}{Z_0} - \tan 2\pi\left(\frac{d}{\lambda_0}\right)\left(\frac{\lambda_0}{\lambda}\right)\tan 2\pi\left(\frac{x}{\lambda_0}\right)\left(\frac{\lambda_0}{\lambda}\right)}\right] \qquad (9)$$

The transcendental equations defined by Eq. 8 or 9 can be solved in various ways, but each solution requires a converging, iterative approach. To obtain useful generalized tuning curves, many solutions must be obtained and plotted. It was found most convenient to obtain the solutions by the Smith chart,[4] using systematic substitution and interpolation. The curves are subject to slight inaccuracies in calculation and plotting, but are sufficiently accurate for most engineering purposes.

EFFECTS OF ASSUMPTIONS—Cavity losses can be made low enough to be negligible, and the principal effect of the loading of the lumped capacitance C_0 is to shorten the length l_0 of the cavity for a given resonant wavelength λ_0. This means that the displacement x of the tuning sleeve from the short-circuited end of the cavity cannot be as large when C_0 is finite as when C_0 is 0. The basic tuning curves, however, are valid for attainable values of x/λ_0.

The fringe capacitance created by a tuning sleeve with sharp edges has a significant effect on the tuning curves. By comparing measured values with calculated values of resonant wavelengths in the 15 to 60-cm region, it was observed that the total tuning range covered by a tuning sleeve with sharp edges was actually somewhat greater than that predicted by the tuning curves. This effect correlates well with the magnitude of the total discontinuity capacitance C_d, at the sharp edges of the tuning sleeve, as defined by Whinnery, Jamieson, and Robbins.[5] In all cases, fringe effects caused a slight increase in the minimum tunable wavelength λ_{min}/λ_0 and a greater increase in the maximum tunable wavelength λ_{max}/λ_0.

Figure 2 shows the average correlation between the total discontinuity capacitance C_d (twice the capacitance at one edge of the tuning sleeve) and the tuning limits λ_{min}/λ_0 and λ_{max}/λ_0 for various values of d/λ_0 and in various resonant modes. Figure 3 enables determination of the approximate value of the total discontinuity capacitance for a sharp-edged coaxial tuning sleeve. Where a sharp-edged tuning sleeve is used, the accuracy of prediction of the tuning limits can be improved

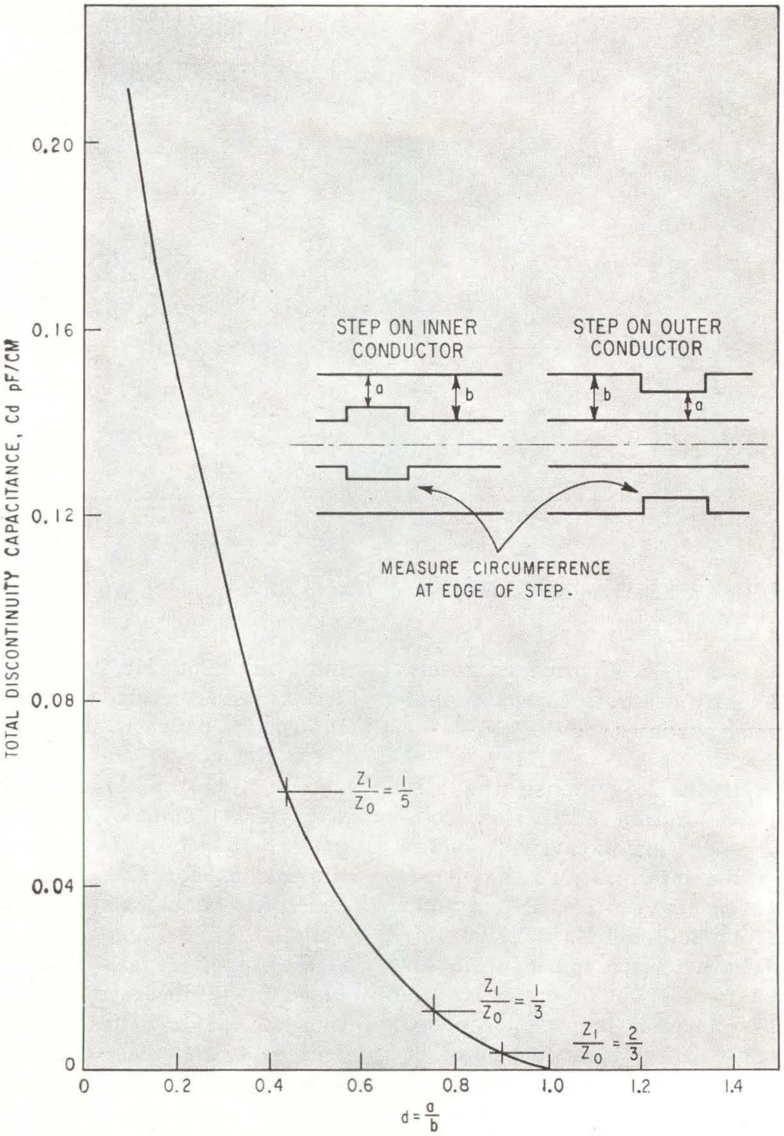


AVERAGE *correction factors for* λ_{min}/λ_0 and λ_{max}/λ_0 *as a function of total discontinuity capacitance* C_d*—Fig. 2* by using Fig. 2 and 3. Corrections for discontinuity capacitance are less significant for incremental tuning than for total-range tuning. The effects of discontinuity capacitance can be minimized by rounding or chamfering the edges of the tuning sleeve. The effects of discontinuity capacitance are small for values of Z_1/Z_0, greater than 1/2, as shown in Fig. 3.

NORMALIZED CURVES — Nine charts of normalized tuning curves (Fig. 4) have been derived, using the resonant wavelength λ_0 of the coaxial cavity as the reference wavelength. The curves reveal the variation of λ/λ_0 as a variable function of x/λ_0, where λ/λ_0 is the normalized resonant wavelength, and x/λ_0 is the narmalized distance from the short-circuited end of the cavity to the tuning sleeve. The three most common modes ($\lambda/4$, $3\lambda/4$ and $5\lambda/4$) are covered in the nine charts. Three values of the normalized sleeve length d/λ_0 were chosen: 0.02, 0.05 and 0.08. Finally, three values of the ratio of the characteristic impedance of the discontinuity to that of the basic coaxial cavity Z_1/Z_0 were selected for the families of curves: 2/3, 1/3 and 1/5.

These values of the parameters cover most of the range of interest for tuning. It is possible to interpolate linearly, with little error, to find solutions that fall between the curves. The corrections for discontinuity capacitance (Fig. 2 and 3) should be applied when sharp-edged tuning sleeves are used and when the greatest accuracy in predicting total tuning range is desired.

The examples illustrate how the generalized tuning curves can predict tuning ranges or design discontinuity-tuning sleeves to attain a desired tuning range and linearity. Because of the method of derivation and plotting, results should be accurate within about 10 percent when the corrections for discontinuity capacitance are included. The charts should help in predicting the approximate maximum tuning range obtainable, the linearity of tuning for various values of x/λ_0, and the effects of changes in the resonant TEM mode. Linear interpolation between plotted values

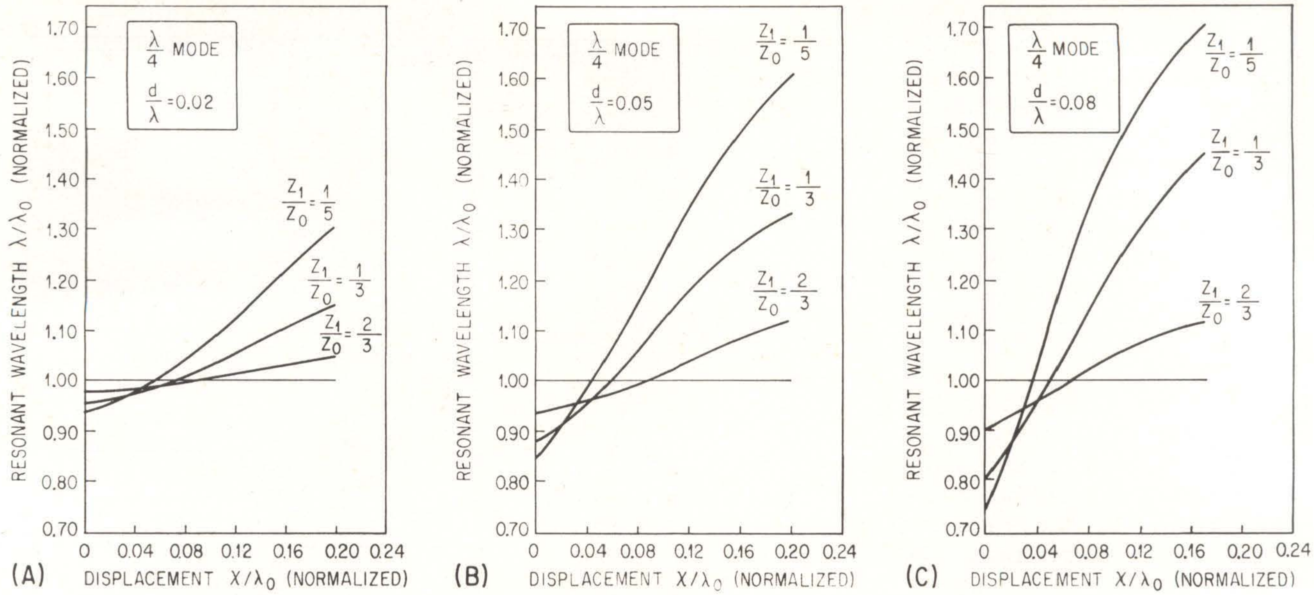


TOTAL *discontinuity capacitance for coaxial tuning sleeves per centimeter of circumference at edge of step—Fig. 3*

TABLE—RESULTS FROM CHARTS FOR EXAMPLE 3

$$\frac{d}{\lambda_0} = 0.08 \text{ and } \frac{Z_1}{Z_0} = \frac{1}{3}$$

Mode	λ_{max}/λ_0 From Curves	λ_{max}/λ_0 Corrected for C_d	λ_{min}/λ_0 From Curves	λ_{min}/λ_0 Corrected for C_d	Final Corrected Values Maximum Frequency (Mc)	Final Corrected Values Minimum Frequency (Mc)
$\frac{\lambda}{4}$	1.45	1.51	0.80	0.805	1,117	596
$\frac{3\lambda}{4}$	1.182	1.23	0.93	0.936	962	732
$\frac{5\lambda}{4}$	1.110	1.153	0.95	0.957	940	778



NORMALIZED *tuning curves give tuning range, in terms of wavelength against displacement, for different*

of d/λ_0 and Z_1/Z_0 provides results sufficiently accurate for most engineering purposes.

EXAMPLE 1—Suppose that the size and location of the sleeve of a $3\lambda/4$ mode coaxial-cavity resonator are to be determined so that it can be tuned between $\lambda = 24$ cm and $\lambda = 21.4$ cm (1,250 Mc to 1,400 Mc). The characteristic impedance of the resonator is 50 ohms, and the lumped terminating capacitance C_0 is 1.9 pf. Total linear motion of the tuning sleeve can be 1.5 cm maximum.

Choosing $d/\lambda_0 = 0.08$, Fig. 4F shows that the best linearity of tuning can be obtained at wavelengths longer than λ_0. Therefore select λ_0 to be 21.4 cm. The normalized linear motion of the sleeve can be called $\Delta x/\lambda_0$ and is equal to 1.5/21.4 or about 0.07. The curve for $Z_1/Z_0 = 1/5$ in Fig. 4F shows that $\lambda/\lambda_0 = 1$ at $x/\lambda_0 = 0.383$. Subtracting 0.07 and going to $x/\lambda_0 = 0.313$ on the curve (the other extremity of sleeve motion permitted), λ/λ_0 has changed to 1.15. This exceeds the desired limit of 1,250 Mc, where $\lambda/\lambda_0 = 1.122$. It is therefore necessary to interpolate between values obtained from the curves for $Z_1/Z_0 = 1/5$ and $Z_1/Z_0 = 1/3$. Linear interpolation yields a value of $Z_1/Z_0 = 0.265$, or $Z_1 = 13.2$ ohms. The approximate dimensions for the tuning sleeve can then be calculated from this value of Z_1.

Figure 4F reveals that the frequency will increase with the dimension x if x/λ_0 lies between 0.30 and 0.40. Between $x/\lambda_0 = 0$ and $x/\lambda_0 = 0.20$, the frequency would decrease with increasing values of x. In the vicinity of $x/\lambda_0 = 0.25$, a reversal of the tuning direction would occur. Since incremental tuning is the principal interest here, corrections for discontinuity-capacitance effects can be omitted without introducing serious errors, particularly if the edges of the tuning sleeve are rounded appreciably.

EXAMPLE 2—The second example involves the determination of location and motion of the sleeve in a $5\lambda/4$ mode coaxial-cavity resonator, where $C_0 = 1$ pf, $\lambda_0 = 10$ cm, $Z_0 = 30$ ohms, $Z_1 = 17$ ohms, $d = 0.8$ cm. The total desired incremental tuning range is 70 Mc.

From equation 1, $l_0/\lambda_0 = 1.167$, and $l_0 = 11.67$ cm in this case. Because $Z_1/Z_0 = 0.567$, it is necessary to interpolate from the curves in Fig. 4I, $\Delta f/f_0 = \Delta \lambda_0/\lambda = 0.02335$. Figure 4I shows that good linearity of tuning can be obtained in selected regions of x/λ_0; for example, for $x/\lambda_0 = 0.52$ to 0.65. A motion of about 0.7 cm (from $x = 5.3$ cm to $x = 6$ cm) of this tuning sleeve is required to produce a frequency change of 70 Mc at the center frequency of 3,000 Mc. As before, the discontinuity-capacitance correction was omitted, because only incremental tuning ranges are of interest.

EXAMPLE 3—It is desired to find the maximum tuning range near 900 Mc (33.3 cm) on various modes for a coaxial cavity of $Z_0 = 77$ ohms, using a movable metallic sleeve of length $d/\lambda_0 = 0.08$, and

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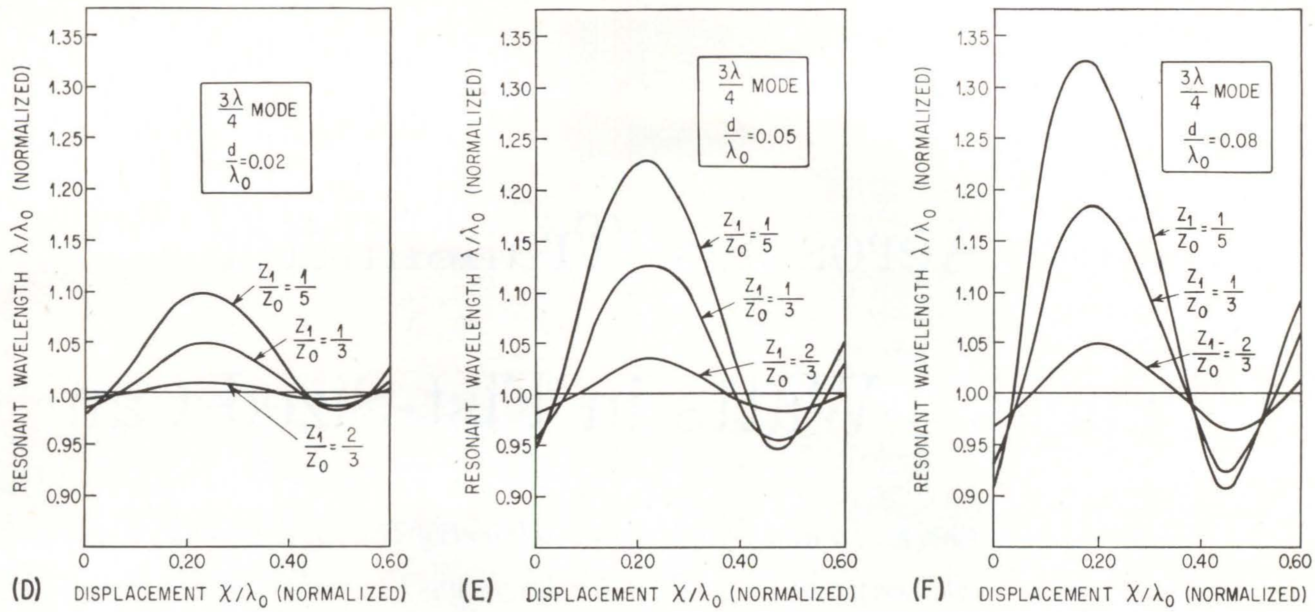
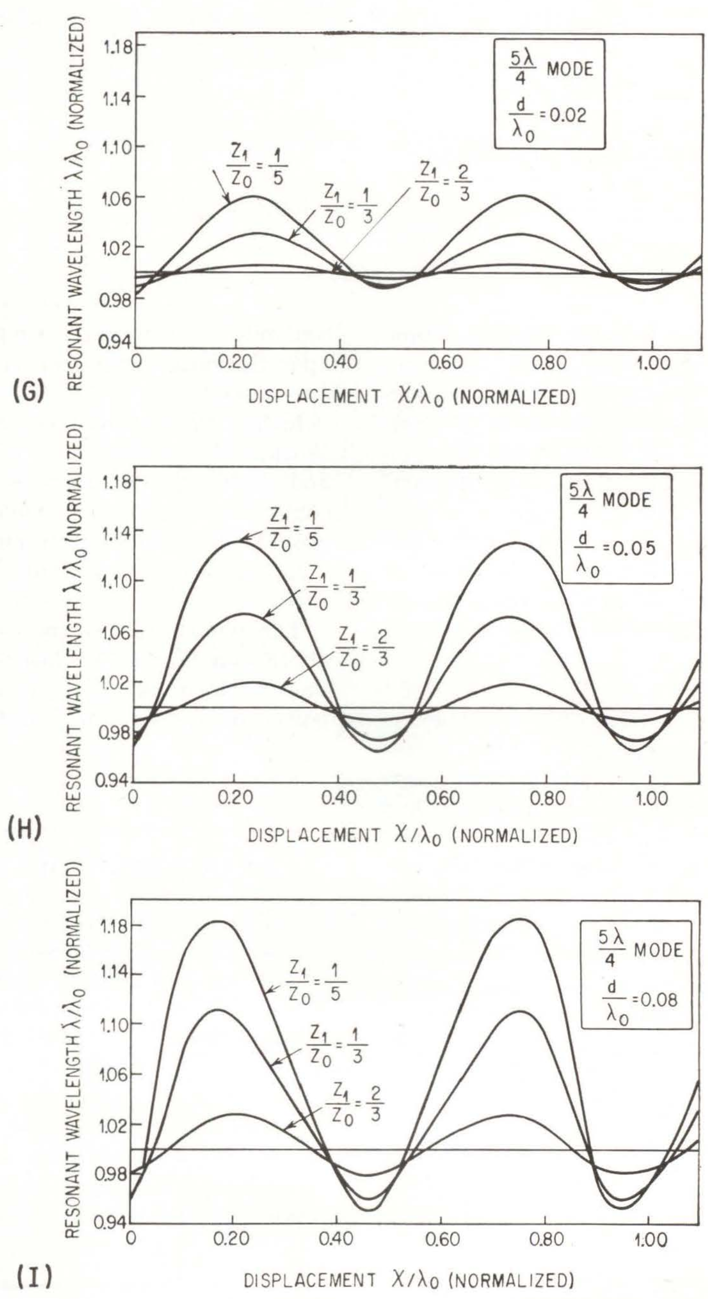


modes from λ/4 to 5λ/4—Fig. 4

$Z_1/Z_0 = 1/3$. At 900 Mc, $\lambda_0 = 33.3$ cm and $d = (0.08)\ (33.3) = 2.66$ cm. The correction factor for discontinuity capacitance C_d should be used in this example, because maximum rather than incremental tuning ranges are desired. From Fig. 3, C_d is found to be 0.9 pf for a sharp-edged tuning sleeve having a Z_1/Z_0 ratio of 1/3, following methods described by Whinnery, Jamieson, and Robbins.[5] Using the data from Fig. 4C, F, and 4I for the λ/4, 3λ/4, and 5λ/4 modes, respectively, and the correction factors from Fig. 2, the results of the table are obtained.

Normalized tuning curves for coaxial-cavity resonators tuned by movable discontinuities make it possible to predict approximate tuning ranges, tuning linearity and dimensional configurations without laborious trial-and-error calculations and tests. Inherent advantages of this method of tuning are simplicity of construction, absence of tuning noise, linearity of tuning in selected portions of the tuning curves and radial symmetry. Publication of the normalized tuning curves should encourage wider use of the movable-discontinuity method of tuning. The maximum tuning range obtainable with coaxial tuning sleeves increases with the relative magnitude of the discontinuity. The tuning range for a given sleeve is greatest on the λ/4 mode and becomes progressively smaller on the 3λ/4 and 5λ/4 modes.



New Aerospace Transmitter Packs 3-Watts in Fist-Sized Can

Operating between 215 and 260 Mc, this telemetry transmitter has capacity to operate at high temperature and under large mechanical stresses. Frequency stability is attained by mixing f-m modulator and crystal oscillator outputs

By B. W. PATTON, Sr. Eng., Electronic Communications, Inc., St. Petersburg, Florida

THIS F-M SOLID STATE transmitter was developed to meet NASA specifications for rocket-borne telemetry transmitters operating between 215 and 260 Mc. Primary considerations were 2 watts minimum power output and prolonged operation at 85 deg C ambient. Overall dimensions were set at 3 in. × 4 in. for the base and 3½ in. in height with a total weight of 32 ounces.

OVERALL DESIGN—To operate at high temperature with better than 2 watts r-f output, the transsistors in the power amplifier and the varactor in the frequency tripler must be specially mounted. The collector of each transistor is securely mounted to the power-amplifier case, using the complete transmitter chassis as a heat sink. Likewise, the cathode of the varactor is connected directly to the frequency tripler case.

Frequency instability over wide environmental changes is minimized by mixing the output from the f-m modulator with the output of a crystal-controlled oscillator. Frequency stability is therefore primarily determined by the crystal-controlled oscillator (depending upon the ratio of the respective frequencies).

Large mechanical stresses from shock, acceleration and vibration and high altitude problems are alleviated by potting all modules, except the r-f board, with a rigid, low dielectric constant, foam-in-place resin.

The transmitter is shown in the photo and in Fig. 1. Closed dotted lines separate modules. A nominal power of 7 watts, within the frequency range of 72 Mc to 87 Mc, is generated with transistors; this frequency is multiplied by a frequency tripler, using a varactor, to obtain the output frequency with a nominal power of 3.5 watts. Another combination that can obtain the required frequency and power is a transistor exciter followed by frequency doublers or quadruplers; however, tripling provides a compromise between the advantages and disadvantages of each. At these frequencies, the gain of vhf power transistors falls off at 6 db per octave; consequently, the lower the frequency of operation, the higher the efficiency. This frequency is limited by the power that can be generated by the final power transistor or transistors and the power that can be handled by the varactor in the following frequency multiplier. At the time this development started, the maximum power dissipation of varactors was ¾ watt. Frequency triplers are slightly more inefficient than doublers (nominally, 70 percent as compared to 80 percent, but a power-gain loss of 3.5 db would occur in the final transistor power amplifier if it were operated at one-half instead of one-third the

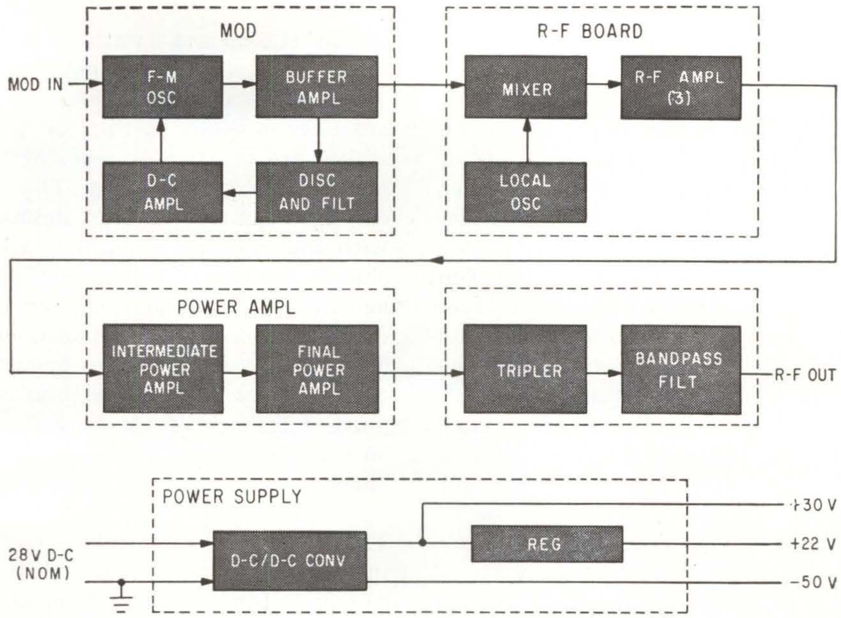
DESIGNERS' CORNER

When communication-type transistors and varactors began to come along over the past few years, the production of several watts of r-f power with solid-state devices at vhf ceased to be a problem. However, to get this power in a compact package that would operate over a wide range of environmental conditions was something else again output frequency.

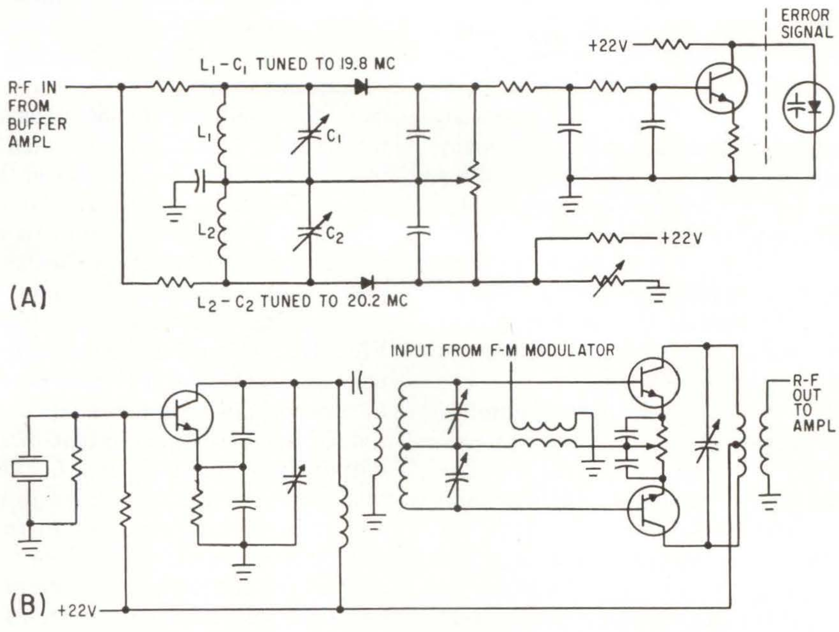
General specifications are: input voltage—+28 v d-c; deviation—125 Kc/v; modulation frequency—100 cps to 125 Kc; distortion— 1 percent; temperature— −20 deg C to + 85 deg; frequency stability—0.01 percent; spurious radiation—−60 db.

The transmitter is fixed-tuned and covers the telemetry band from 215 to 260 Mc. Only one crystal has to be changed to change frequency. A field-intensity receiver, wattmeter and r-f voltmeter are required to tune the transmitter.

F-M MODULATOR—The modulator consists of an oscillator, buffer amplifier and afc loop using a discriminator as the frequency-sensing element. Oscillator frequency is varied by applying the modulating voltage across a varactor in a tuned circuit. Exact circuit description is withheld due to possible patent rights. The oscillator can be deviated ±50 Kc at a center frequency of 20 Mc with one volt rms of modulating voltage. No preamp is required for amplifying the modulating voltage. Frequency response is from 50 cps to 250 Kc with a distortion figure typically 0.8 percent up to 100 Kc. The buffer amplifier consists of a grounded-base circuit and isolates the f-m oscillator from load changes and amplifies the 20 Mc carrier before it is applied to the discriminator. The discriminator is a balanced type using two L-C parallel resonant circuits tuned 200 Kc above and below the carrier frequency (Fig. 2A). Coils L_1 and L_2 are wound on a Rexolite form to minimize inductance change with temperature. Capacitors C_1 and C_2 are NPO (negative-positive-zero). Linearity must be good so that center frequency does not shift as the carrier is deviated. Initially, a balanced discriminator with crystals 75 Kc above and below center frequency was used. However, crystals are subject to spurious modes at higher modulation rates, typically 20 Kc and up, and produce a center-frequency shift. Output of the discriminator is passed through a two-section low-pass r-c filter to a d-c amplifier. Overall loop gain is 15. The correction voltage from the d-c amplifier is fed back to a varactor

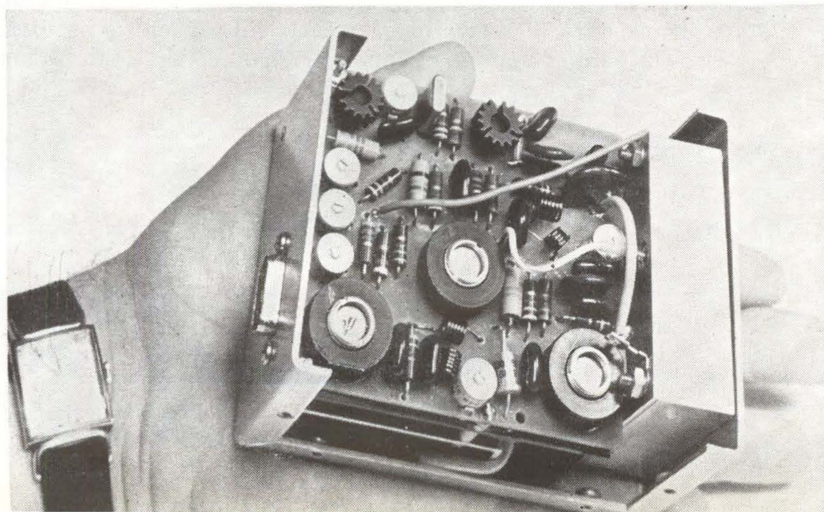


DOTTED LINES *represent separate modules of 3-watt transmitter—Fig. 1*



DISCRIMINATOR *and d-c amplifier (A) and local oscillator (B)—Fig. 2*

FOR AEROSPACE *telemetry, this solid-state transmitter delivers several watts of r-f power*



in the f-m oscillator to correct for frequency drift.

R-F CIRCUIT BOARD—As shown in Fig. 1 the r-f board consists of a mixer, oscillator and three stages of r-f amplification. Mixing is employed to reduce the frequency stability requirement of the f-m modulator. The local oscillator (Fig. 2B) is a grounded-base Colpitts with the crystal operating in the series mode between base and ground. The oscillator is tunable over the range of 52 to 67 Mc and has a stability of 0.002 percent from −20 deg C to + 85 deg C. Output voltage from the local oscillator to the mixer is 3 volts rms.

A balanced mixer (Fig. 2B) is required to eliminate spurious frequencies at the output of the mixer. Since the output frequency of the mixer is the sum of the local oscillator frequency and f-m modulator frequency, a number of spurious frequencies would be generated around the desired output frequency that would be impossible to filter out without a balanced circuit. Signal from the f-m modulator into the mixer is 0.3 volt. Excessive drive from the modulator produces large spurious signals. Conversion gain of the mixer is typically 6 db with a power output of 5 mw.

Three cascaded stages amplify the mixer output to 0.5 watt; providing a power gain of 20 db. The stages are grounded emitter and unneutralized. The first two r-f stages use 2N2218 transistors and the last stage uses a TA1938 due to the increased power level. Heat radiators are used in the last two stages to increase the transistor heat dissipation. Output impedance is 50 ohms.

The power amplifier consists of two 2N1709 transistors, cascaded to provide a power gain of approximately 11.5 db and 7 watts of power in the frequency range of 72 to 87 Mc. A schematic of the final power amplifier is shown in Fig. 3A. Both stages are identical except for the method of output coupling. The circuit is a common-emitter amplifier with the collector connected to the chassis for heat sinking; L_7 is a neutralizing coil and tunes out the internal capacitance between collector and base. Each stage operates class C since there is no bias applied. Efficiency of the final PA is 55 percent. Output impedance is 50 ohms.

TRIPLER—The tripler is depicted in Fig. 3B. Its single varactor uses self bias. Input to the tripler is 50 ohms, coupled through a coaxial cable from the power amplifier. Since the input to the tripler is highly reactive, until properly matched, care must be observed in tuning the tripler; the power amplifier will oscillate if not properly terminated. This is accomplished by inserting an in-line wattmeter between the power amplifier and the tripler and tuning for a null in the reflected power, which indicates a true 50-ohm match. The flow of fundamental currents is shown in Fig. 3B.: C_3 and L_2 are tuned to parallel resonance at ω_1 and C_5 and L_4 are parallel resonant at ω_2 to reduce the harmonic content of the output frequency; C_4 and L_3, with associated circuits, are tuned to the second harmonic frequency to form a second harmonic idler circuit. A flow of second harmonic current is necessary in a shunt-type circuit to form higher harmonic voltages. Due to the low impedance of the varactor, large r-f currents flow in the tripler and it is important that all components have high Q's for good efficiency. All capacitors use quartz dielectric and coils are air wound.

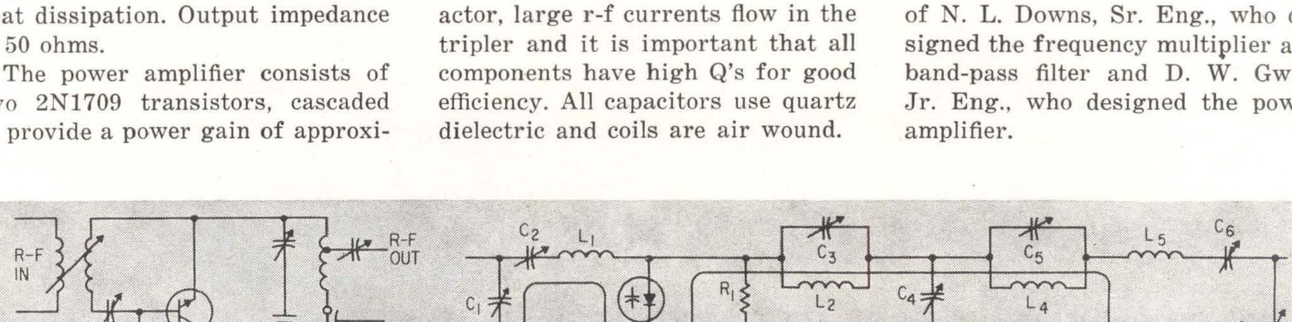
A band-pass filter (215 to 260 Mc) is located between the output connector and the tripler to reduce spurious frequencies. The filter is fixed tuned and requires no adjustment after initial alignment.

CONVERTER—The d-c to d-c converter is of conventional design using two silicon transistors, transformer coupled and operating push pull. Switching frequency is 2 Kc. Two secondary windings provide +30 volts and −50 volts output. Each output voltage is rectified in a full-wave bridge network. The +30 volts is fed to a single transistor regulator to provide a regulated +22 volts. Overall efficiency of the converter is 85 percent.

The r-f output and input impedance of each module of the transmitter is 50 ohms, connected by coaxial cables. Designing all input and output impedances for 50 ohms causes some redundancy between modules but it allows ease in alignment and checkout of each module and makes them adaptable as building blocks for other applications. The power amplifier and tripler module are mounted on the base plate of the chassis to minimize the thermal resistance between the modules and an external heat sink. Modular construction is employed to isolate the stages electrically and to provide rigid mechanical mounting for high shock and vibration. A single connector, containing a coaxial plug, is used for external connection to the transmitter.

The unit is being tested under various environmental conditions.

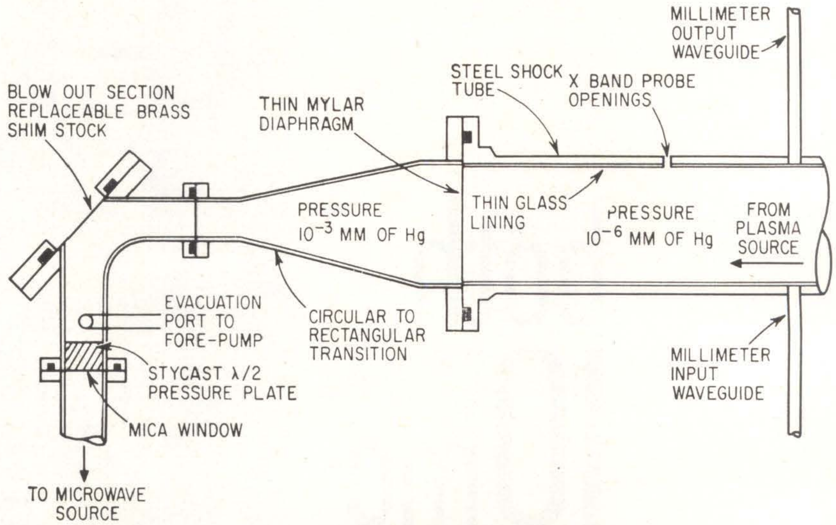
The author acknowledges the help of N. L. Downs, Sr. Eng., who designed the frequency multiplier and band-pass filter and D. W. Gwin, Jr. Eng., who designed the power amplifier.



FINAL POWER *amplifier (A) and tripler (B) employed in telemetry transmitter—Fig. 3*

Microwave Radiation Probes Shock Plasma

Millimeter waves can measure electron density without affecting plasma



SHOCK TUBE *waveguide assembly with blow-out section shows how measurement is made by injecting 8.3-Gc r-f power from lower left, and diagnostic 60-Gc r-f across plasma at top right—Fig. 1*

ELECTRON DENSITY and concentration in shock-induced plasmas can be measured by a method developed by E. G. Schwarz and H. H. Grimm, General Electric Co. in Syracuse in a plasma instrumentation project (see cover).

The shock-excited plasma, contained in a cylindrical glass-lined metal tube, is investigated with microwave instrumentation, see Fig. 1. The plasma moves from right to left. Two microwave signals are launched into the plasma. A high-power 8.3-Gc signal is transmitted from left to right along the tube. Its transmitter consists of four Varian 823 klystrons in parallel, rated at 20 Kw nominally, 80 Kw peak. Tubes with c-w capability are used to sustain a pulse of several milliseconds duration. The signal is passed through a circulator to separate incident and reflected power existing in the test region. The second microwave signal, at 60 Gc, is a low-level diagnostic signal which propagates perpendicularly to the shock tube axis.

MICROWAVE SYSTEM—Transmitters and receivers for both microwave signals are phase-stable equipments using superheterodyne receivers, limiting amplifiers and phase detectors, see Fig. 2A. They are designed to measure and record the magnitude and phase of received signals as a function of time. Bandwidth of the receivers is 5 megacycles, a large value for a phase-stable receiver using limiting amplifiers. Time required for measuring a step in phase is about 0.25 microsecond.

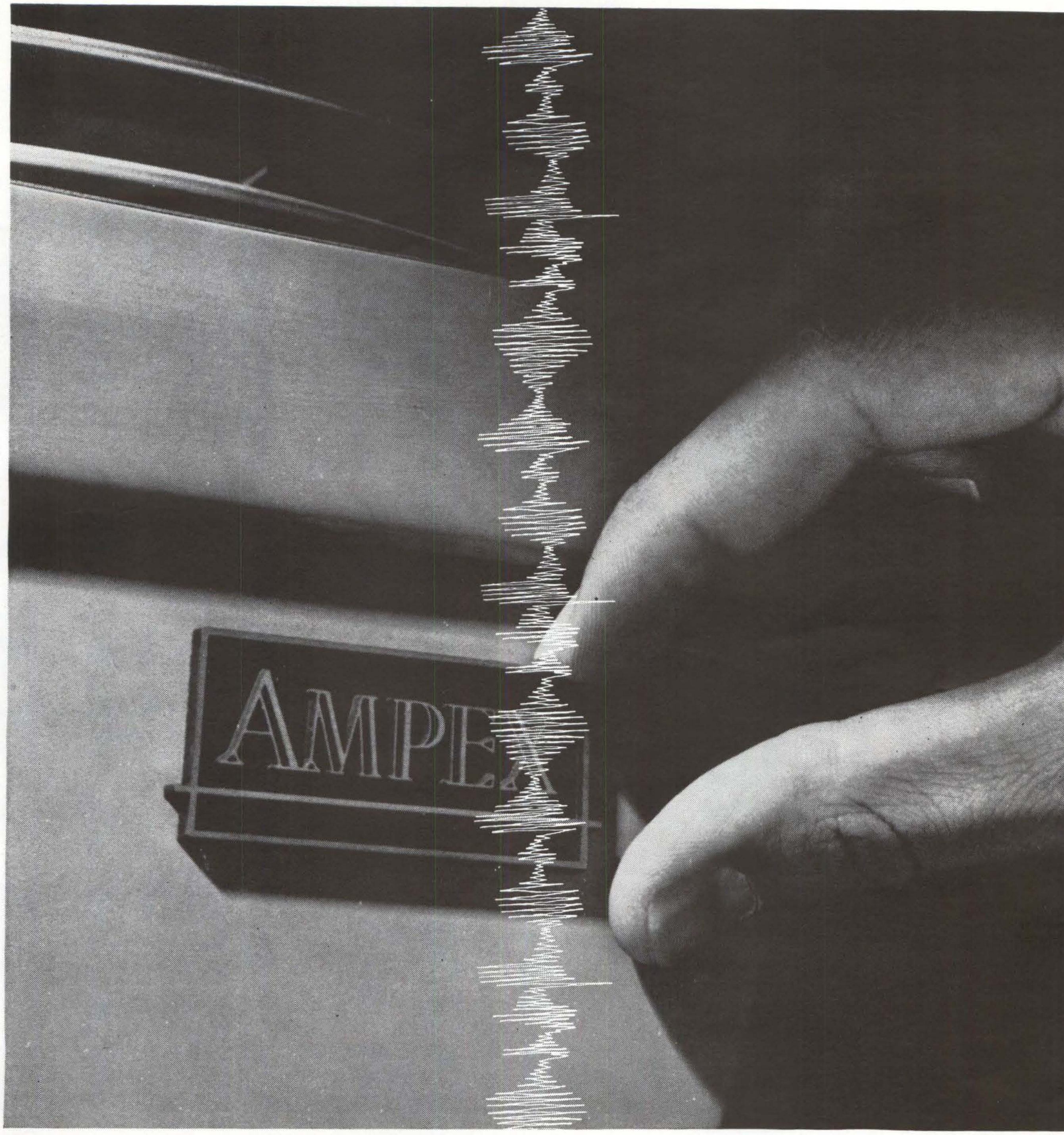
The 8-Gc portion of the equipment is fully phase coherent. The signal originates in the 8-Gc oscillator, then goes to a single-sideband modulator and to the receiver mixer. The modulator is also driven with a 30-Mc oscillator; the signal-sideband output is thereby offset by 30 Mc. This signal is amplified, passed through the circulator, and introduced into the terminated test section containing the plasma.

MEASUREMENT SIGNALS—Five outputs are available to the receiver. One is a portion of the wave reflected from the plasma; this shows the large doppler shift to be expected from a high-speed plasma front. The other four outputs come from fixed metal probes along the circular metal shock tube; the principal interest in these signals centers around transmis-

MEASURING PLASMAS

Conventional means of measuring electron density and distribution within a plasma tend to affect the plasma's properties, and thus introduce inaccuracies. By irradiating a plasma with microwave r-f signals and measuring the effect on the signals, accurate plasma measurements can be made. The method for doing this was described by H. L. Bunn in ELECTRONICS, April 7, 1961, on p. 71.

This improved method is fast: a measurement is made in a fraction of a microsecond. This makes it suitable for measuring short-lived shock induced plasmas, that exist for only milliseconds, and cannot be accurately measured by any other means. Such plasmas occur during space vehicle reentry and may cause the communication blackout



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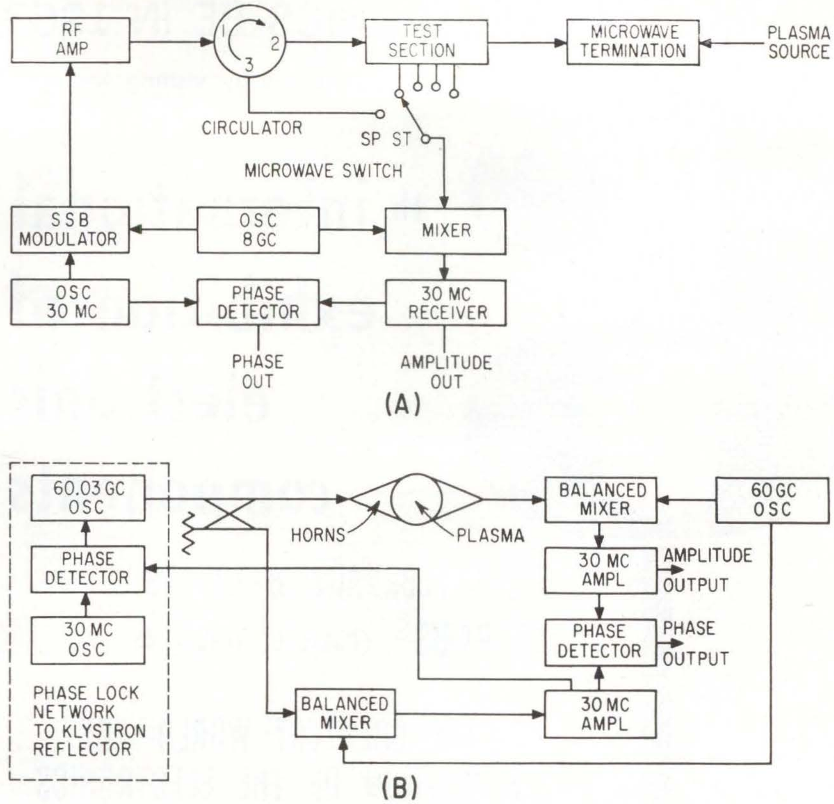


IRRADIATION AND MEASUREMENT *system for 8.3 Gc, (A); millimeter wave probing system for 60 Gc, (B)—Fig. 2*

sion through the plasma. After the plasma passes, the doppler shift here is negligible. Since the test section is well terminated the resonances in it are small.

The receiver mixer receives both the original oscillator signal and the single-sideband signal transmitted into the plasma; a signal near a 30-Mc output frequency results, that differs from 30 Mc by the doppler frequency. The phase of this signal is compared with the phase of original 30 Mc used to drive the ssb modulator, and two outputs are obtained. One gives the phase of the signal from the plasma region, the other its magnitude.

The c-w outputs available at 60 Gc are low, and ssb modulator performance is poor. This resulted in another arrangement, shown in Fig. 2B, to obtain a phase-coherent measurement system. Two oscillators near 60 Gc are phase-locked with a 30-Mc frequency difference. One of the 60-Gc signals, the controlled one, provides the signal injected into the plasma. The other supplies the reference to the phase lock circuits. The signal transmitted through or reflected from the plasma goes to a balanced mixer which also receives as local oscillator the uncontrolled 60-Gc signal. The output of this mixer is a 30-Mc signal containing phase fluctuations due to the varying electron concentration in the plasma. By comparing this signal with the 30-Mc signal derived from the balanced mixer used in the phase-lock circuits, the phase fluctuations due to the plasma are measured. Magnitude information is also obtained from this 30-Mc signal.

This program was carried out under sponsorship by the Air Research and Development Command, Rome Air Development Center, Griffiss Air Force Base, N. Y.

Reentry Plasma Heating Studied by Laser Technique

DURING REENTRY into the atmosphere, a spacecraft communications blackout is caused by heating and ionization of the surrounding air, due to speed and friction.

In order to find a way to maintain communication with spacecraft during this crucial phase, reentry plasma is being studied by Texas A&M College scientists under a $100,000 NASA contract. It is planned to simulate the reentry plasma in the laboratory and to measure its thermodynamic properties. A laser is used to probe the plasma and determine its temperature and density.

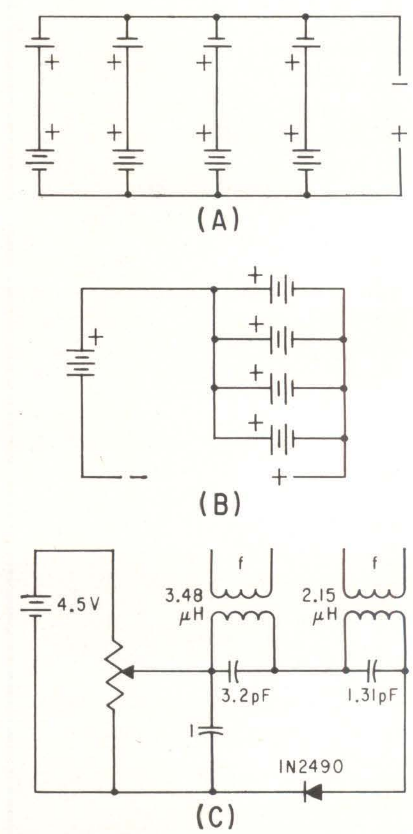
Plasma is generated by passing a high current through helium gas. The light scattered by the plasma is measured and photographically recorded using a flash from the laser.

Supplying Low-Impedance Power for Tunnel Diodes

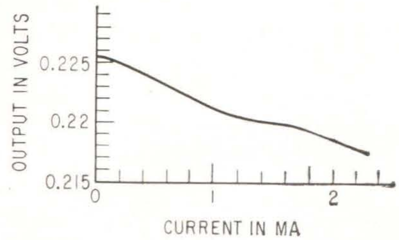
By RUSSELL MOSSER
W. REESE TURNER
Electrical Engineering Dept.
University of Colorado
Boulder, Colorado

POWER supplies having suitable characteristics for laboratory experiments with tunnel diode circuits can be obtained using simple combinations of batteries. For these applications, current of a few milliamperes from a low-impedance source is required at 0.2 to 0.4 volt.

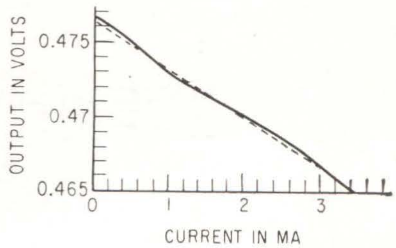
A practical method for obtaining 0.2 volt is to connect a mercury bat-



OUTPUTS *of 0.2 volt (A) and 0.4 volt (B) provide low-impedance bias supply for testing tunnel diode circuits such as harmonic generator (C)—Fig. 1*



(A)



(B)

CURVES *show current-voltage characteristics of 0.2-volt (A) and 0.4-volt (B) battery power supplies —Fig. 2*

tery and a dry cell so that their voltages subtract (1.55 − 1.345 = 0.205 volt). A lower internal impedance can be obtained by connecting the two positive terminals together and using the negative terminals as output leads.

Sufficiently low internal impedance can be obtained by connecting size D dry cells with E-3 mercury batteries to form a 0.2-volt battery. Four such batteries are then connected in parallel as in Fig. 1A.

Output from this battery is 0.2 volt and internal impedance is about 3.18 ohms. The current-voltage curve is shown in Fig. 2A. At low current values, a slight curve appeared in all batteries tested, although its size and length varied for each battery tested. After four hours of continuous drain of 1 milliampere, battery output dropped 0.008 volt.

A 0.4-volt battery can be made in essentially the same way except that a standard Willard cell is used with 0.5 molar KOH as electrolyte. This cell provides 0.9 volt.

For E1 mercury batteries are connected in parallel, and their output opposes that of the wet cell, as in Fig. 1B. Output in Fig. 2B is 1.345 − 0.9 = 0.45 volt, and internal impedance is 4 ohms or less.

The 0.4-volt supply has been used successfully to provide low-impedance bias for tunnel-diode amplifier circuits and for the tunnel-diode harmonic generator in Fig. 1C.

Capacitor Provides Outer Coupling For Modern Coaxial-Line Circuits

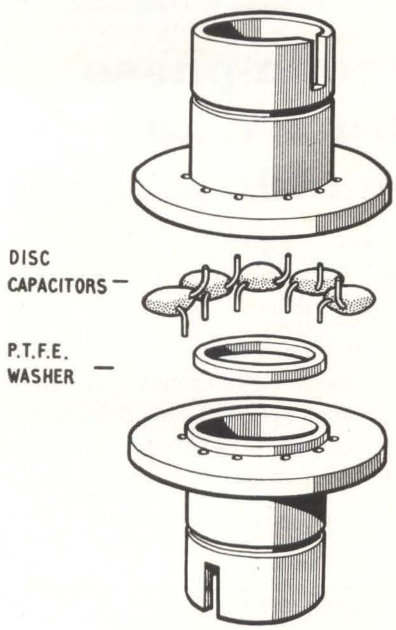
Useful technique provides d-c isolation over frequency of 2 to 1,500 Mc

By J. M. ROLLETT
British Telecommunications Research Limited, Taplow Court, Taplow, Nr. Maidenhead, Berks, England

EXPERIMENTAL coaxial - line circuits are often built with unit components such as lines, tees, and stubs. If diodes or transistors or other devices requiring Dc are included, it may be useful to have parts of the coaxial circuit at different d-c potentials, while still continuous to r-f.

Coupling capacitors which isolate inner conductors are available commercially, but the complementary components for isolating outer conductors are not. This article describes the construction and properties of a coaxial-line outer coupling capacitor, and includes examples of its use.

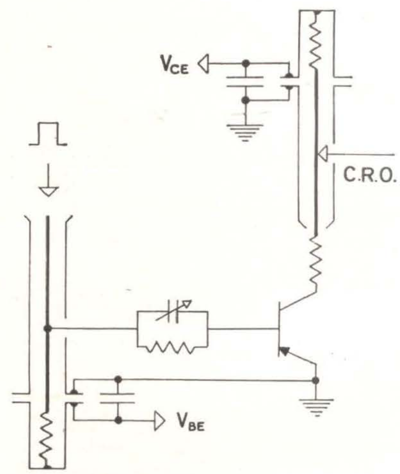
The capacitor conforms with the General Radio type 874 series, since other components of this series were available in the laboratory. Design is easily modified for use with other systems.



SMALL *disk capacitors bridge gap between sections of outer conductor. Five front capacitors are omitted for clarity. Groove and keyway at each end are for General Radio connectors—Fig. 1*

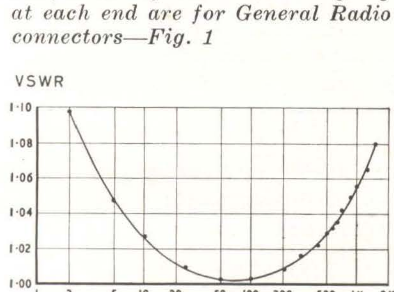
CONSTRUCTION—The basic principle is to bridge a gap between two short lengths of outer conductor with small disk ceramic capacitors. The outer conductor sections are provided with flanges to protect the capacitors, and are separated by a PTFE plastic washer; the remaining space between the flanges is filled with Araldite epoxy resin, to bond the sections together, see Fig. 1.

Ten disk capacitors are used, diameter somewhat less than 5/16 in., nominal capacitance 1,500 pf. The diameter of the flanges, 1 1/8 in., is chosen so that two components can be plugged into a General Radio (G.R.) transistor mount (which is U-shaped) without mutual interference. The length, 1 9/16 in. without connectors, is the same as the G.R. inner coupling capacitor, for convenience in building circuits where both types of capacitor are used. The center conductor is a rod of correct diameter supported by standard G.R. type 874 hermaphrodite connectors. If it is desired to isolate both inner and outer conductors in the same component, then the center assembly of a G.R. inner coupling capacitor could be used instead. The mechanical strength of the epoxy-resin bonded-structure is excellent.

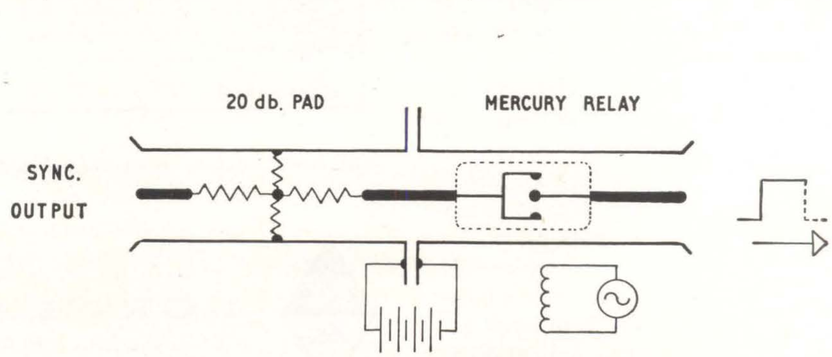


CIRCUIT *measures charge control parameters of high-speed switching transistors—Fig. 4*

PROPERTIES — Low frequency capacitance is between 0.015-



PLOT *of VSWR against frequency —Fig. 2*



FAST *step generator incorporates outer coupling capacitor—Fig. 3*

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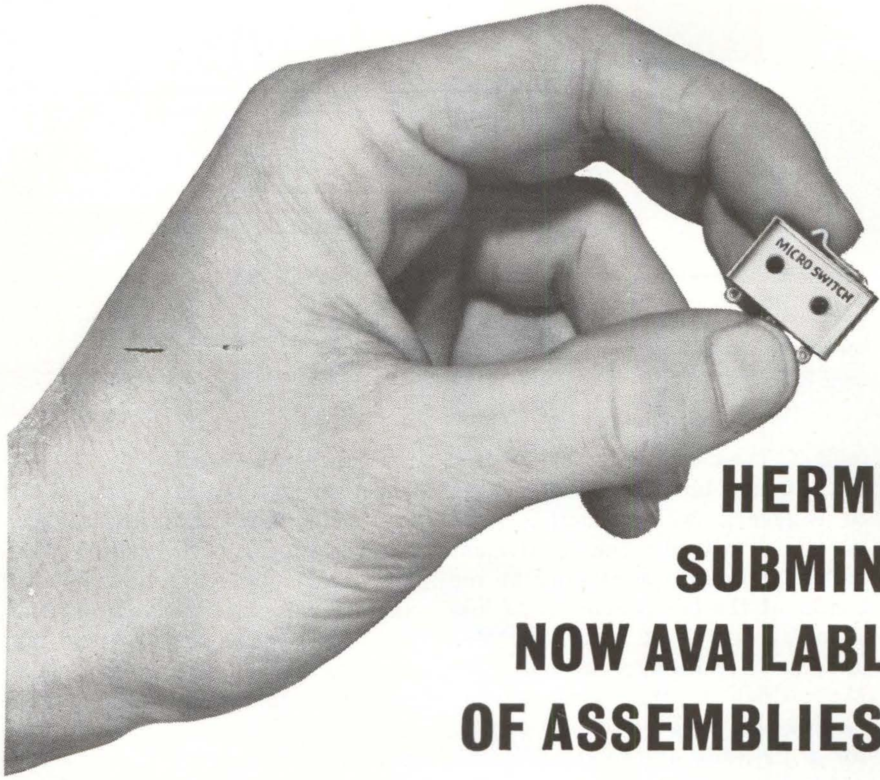

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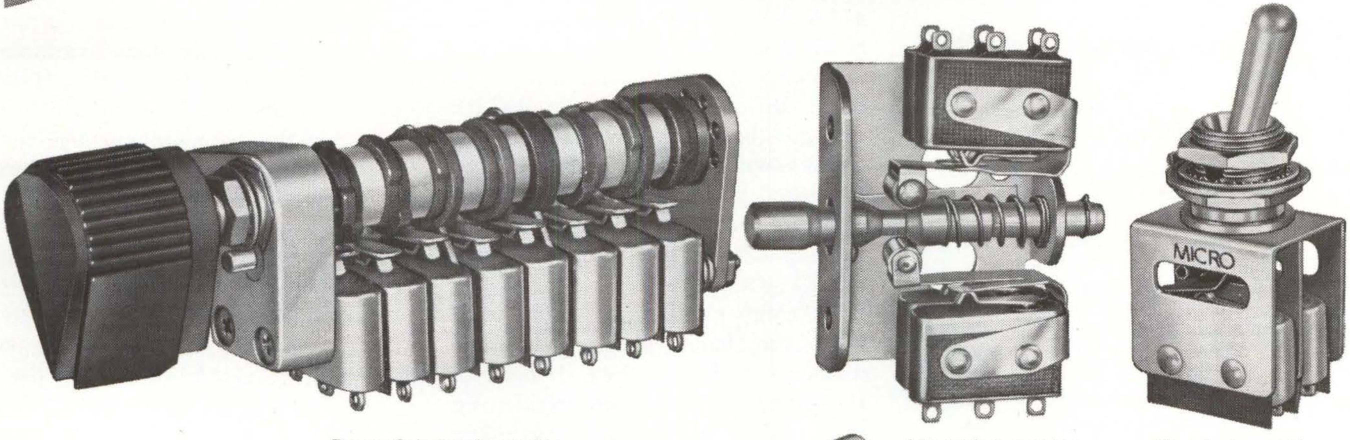
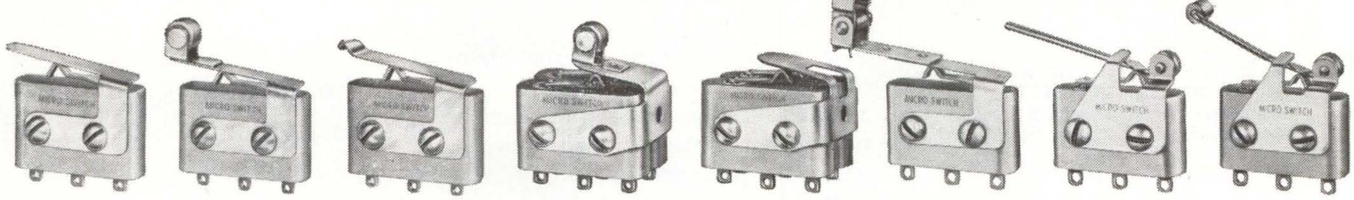


Rotary Selector Assembly | Interlock Assembly | Toggle Assembly



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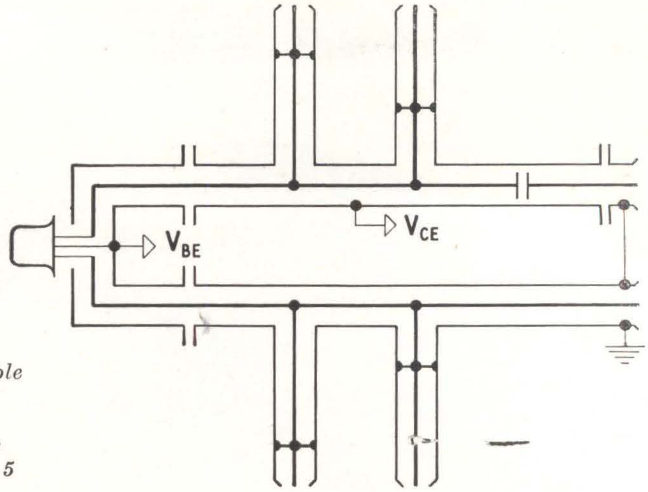

MAXIMUM *available power gain of transistors can be measured using this configuration—Fig. 5*

0.02 μf. The d-c resistance is greater than 10 megohms. The VSWR, plotted in Figure 2, was calculated from measurements of the equivalent series impedance appearing at the center of the component. It is less than 1.1 between 2 and 1,500 Mc., and has a minimum at about 70 Mc., which is the resonant frequency of a single 1,500 pf capacitor with leads of the same length as those in the component. The minimum could be shifted along the frequency axis by using capacitors of a different value. Bandwidth (range between frequencies of equal VSWR, for example 1.1) can be increased by using capacitors all of different resonant frequencies, at the expense of increasing the minimum VSWR.

A component was constructed with the basic silvered ceramic disks, by soldering them directly to the flanges, and then cementing with epoxy resin. The resulting structure was mechanically strong and none of the disks were damaged or cracked; however, piezoelectric effects made it electrically lossy and unstable. To be successful, such a structure must be designed to bring minimum pressure to bear on the disks.

APPLICATIONS — Figures 3, 4 and 5 illustrate circuits in which the outer coupling capacitors have been used.

Figure 3 shows a very fast step generator, using a break-before-make changeover mercury relay. The attenuator pad defines the impedance of the pulse source (50 ohms) and provides a synchronizing pulse, if required; if not, a 50 ohm resistor can be used.

Figure 4 shows a circuit for measuring the charge control parameters of very high speed switching transistors, with provision for variable base-emitter standing bias. A high frequency oscilloscope may be used for charge control measurements, and rise times may be measured using a sampling oscilloscope.

Figure 5 shows a coaxial circuit for measuring maximum available power gain of transistors at frequencies above 100 Mc. The biases are fed to the transistor through the short circuiting stubs which form the input and output matching circuits.

The author's thanks are due to D. L. Hedderly for the circuits of Fig. 3 and 4, and to the Director of Research, British Tele-communications Research Limited, for permission to publish this paper.

Air Force Bibliography Useful to Components Men

NEARLY 300 references on printed circuits and welded modules are contained in an Air Force bibliography just released by Office of Technical Service.[1]

In three sections, the volume cites references to other bibliographies, state-of-the-art summaries, survey articles, printed circuits, micromodule assemblies, high-density packaging, dot components, encapsulation, electrical connections, microcircuits, thin films, integrated circuits, 2-D cir-

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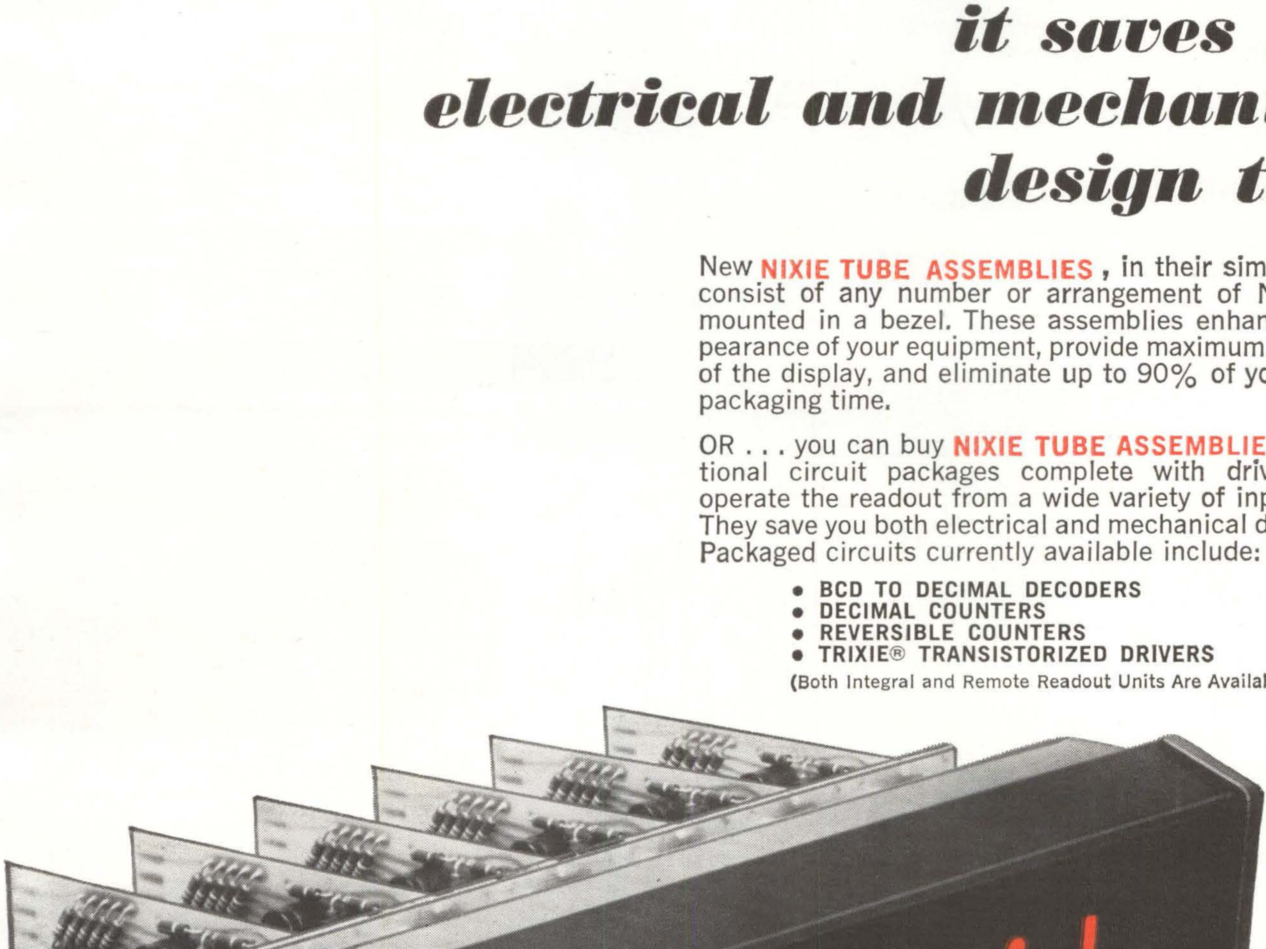

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cuits and solid-state devices.

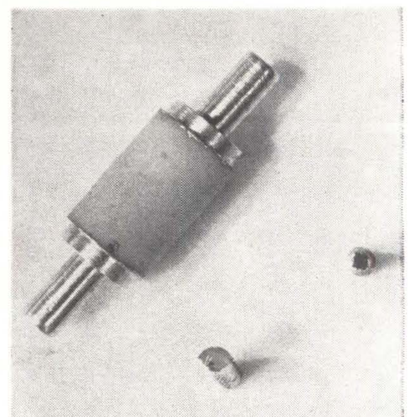
Results of a cursory search on methods of cleaning electronic components and assemblies appear in a separate section.

Subjects also include microminiaturization of circuits and components considered from the manufacturing research standpoint. Bibliographers sought information on design standards and procedures, production methods and techniques, and applications of fabricated compounds.

REFERENCE

(1) G. E. Owens, Printed Circuits and Welded Modules: An Annotated Bibliography, Lockheed Missiles and Space Company for the U. S. Air Force, April, 1962, 100 pgs., AD 278 631 from OTS, U. S. Dept. of Commerce, Washington 25, D. C. ($2.50)

Microwave Diode Overcomes Low-Impedance Problems



MICROWAVE *down-converter construction fits specific amplifier need. Double whisker construction is shown on lower germanium rod*

SEVERAL germanium point-contact diodes have been developed recently by a British subsidiary of International Telegraph and Telephone Corporation. One of these diode types, developed for improving the reliability and performance of microwave diodes, reduces the 70-megacycle intermediate-frequency source impedance to a value of about 100 ohms for the best low-noise match.

The 6-gigacycle down-converter diode, STC type DK-211 was developed to overcome a low-impedance. Now practical silicon mixers have about 300 ohms i-f impedance, and the best germanium diodes are 200 ohms. New approach is to use double whiskers that are placed on a single germanium die to form two small junctions in parallel. The desired i-f source impedance of 100 ohms is obtained with a small forward bias of about 0.1 volt.

Optimum noise figure occurs at a local-oscillator input of about one milliwatt; the average conversion loss is 4.2 decibels. The noise figure obtained is 9 to 10 decibels, but the DK-211 diode is used with an amplifier having a rather high noise figure of 3.3 decibels. Quite a sophisticated range of performance at microwave frequencies can be obtained, according to company.

Some epitaxial layers have been made but the desired control of resistivity has not yet been obtained, according to company. But spokesmen say that from this will come point contact microwave diodes with perhaps only half a db improvement. At this level of consistent improvement, company says this is very important.

Seek Techniques to Sterilize Space Probes

DRY HEAT sterilization will be emphasized as the principal process for space component sterilization at Wilmot Castle Co.

Rather than attempt to sterilize individual components, Castle's work has been geared to discovering general principles which can be used to sterilize all types of space components, including the capsule itself.

The nature of space equipment presents unique sterilization problems. Most electronic components are damaged by temperatures higher than 120 deg C. Little data exists on effectiveness of heat sterilization below 150 C. Thus, with emphasis on dry heat sterilization most of the investigation for NASA has been centered on temperatures around 120 C.

Investigation is aimed at keeping planets free from living organisms from the earth. Program underway is attempting to ensure that space probes will have a probability of less than 1/10,000th chance of landing viable organisms on the space body.

Transfer Process Avoids P-C Open Circuits

Sandwiching techniques used with components in non-rigid substrates

By THOMAS L. ROBINSON
Cornell Aeronautical Laboratory, Inc.
Buffalo, New York

VERSATILE printed-circuit transfer process forms the basis for solving certain problems in the interconnection of microsystem circuit devices. Heat-sink design is also facilitated.

This technique for replacing plugs, sockets and wiring harnesses, which occupy more space than the interconnected components, solves the problem of open circuits resulting from circuit-board flexure.

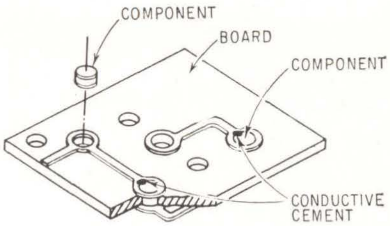
Its application in forming sandwich connections for discrete dot and pellet components and thin-film microsystems is discussed in the following paragraphs.

DOT AND PELLET — Currently, dot and pellet components are pressed into printed-circuit board holes and interconnected with conductive cement as shown in Figure 1. For components mounted in non-rigid substrates, this presents the probability of open circuits at the interface of the component terminal and printed circuit.

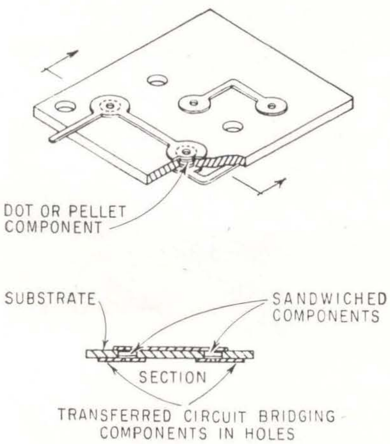
Figure 2 illustrates a solution to this problem. The non-rigid substrate is coated with a pressure-sensitive adhesive on both sides. A paper release sheet is then applied to the adhesive layers, keeping them clean. Next, holes of the proper size are drilled or punched in the substrate for the components that are then pressed into the holes. The plated circuit is transferred first to one side and then to the other. This is done by removing the release paper from the adhesive-coated substrate, pressing the plated-carrier sheet against the adhesive, and peeling off the carrier[1, 2]. The transferred printed circuit which overlays the components may be soldered or spot welded to the terminals.

Another technique using pressure connection is shown in Figure 3. Plated circuits are transferred to only one side of a hole-punched wafer substrate with portions of the conductors overhanging the holes. The component terminals are clad with a soft conductor such as indium-tin or a tin-lead alloy to insure a tight fit when they are pressed into the holes. Interconnecting a number of substrates to form a module can be achieved as illustrated in Figure 4 where soft metal plugs are shown press fitted into the substrates to make wafer-to-wafer pressure contact when stacked. Replacing any of the wafers involves merely the removal of the corner screws and unstacking of the layers, since only pressure contact is employed for electrical contact.

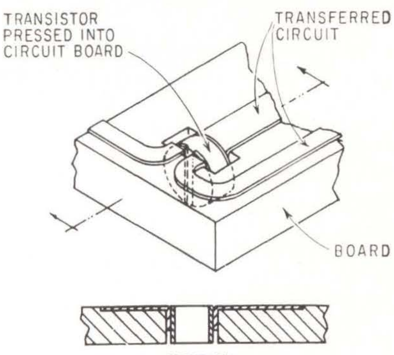
THIN-FILM CIRCUITS — Thin-film circuit elements are vacuum deposited or sputtered on one side of thin mica wafers with wide-area terminations located along the edges. A transferred circuit is sandwiched between two mica circuit wafers and interconnects them by means of free conductor tabs, which are short, unbonded extensions of transferred conductors that can be bent to make electrical contact with wafer conductive areas,



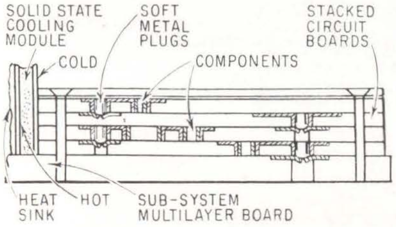
OPEN CIRCUITS *can result when components are interconnected with conductive cement—Fig. 1*



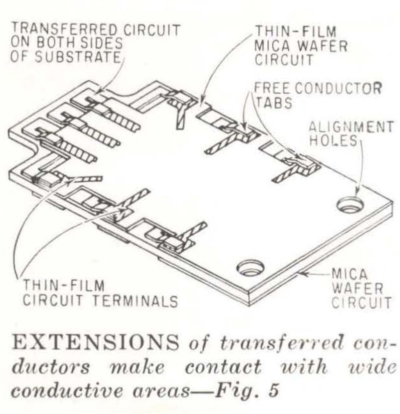
SANDWICHING *of components between plated circuits permits reliable connections—Fig. 2*



PRESSURE-CONNECTION *technique is used for one-sided substrate—Fig. 3*

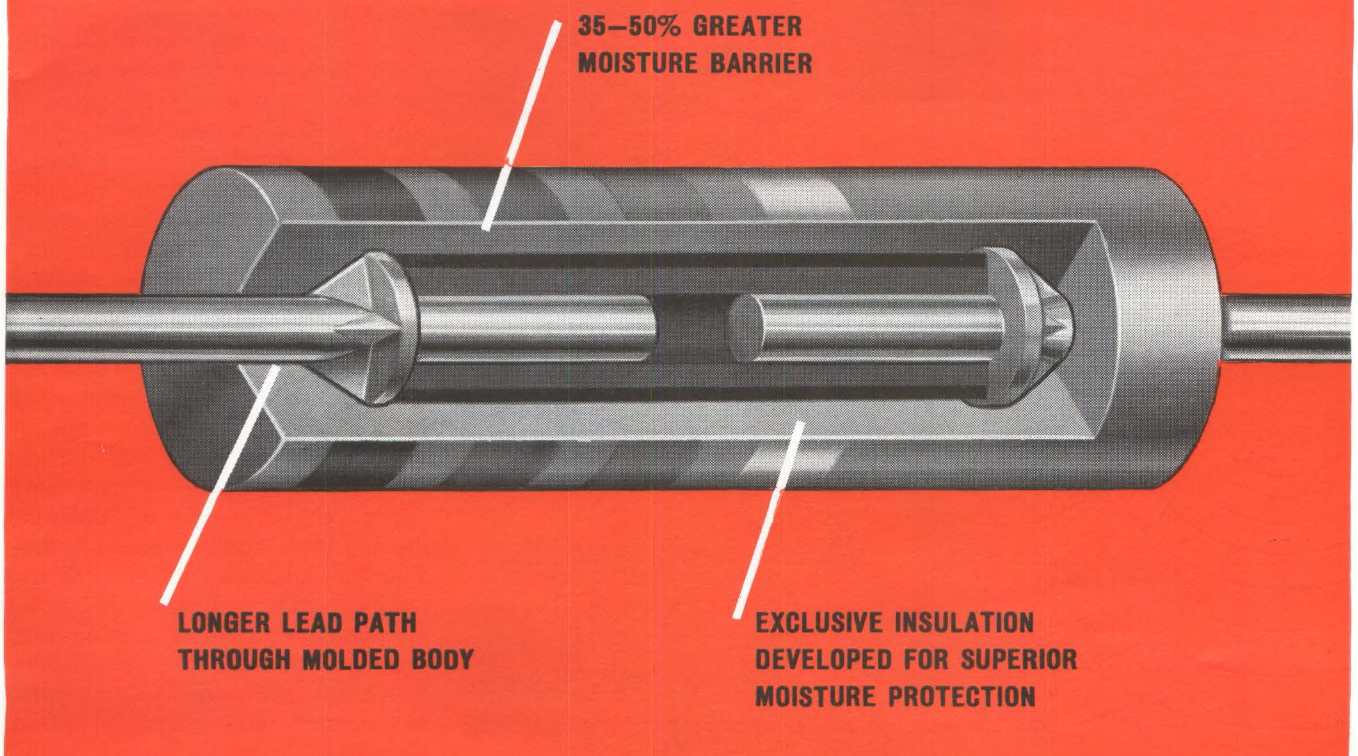


SOFT-METAL *plugs interconnect substrates containing dot and pellet components—Fig. 4*



EXTENSIONS *of transferred conductors make contact with wide conductive areas—Fig. 5*

In FIXED COMPOSITION RESISTORS if it's news, expect it first from IRC



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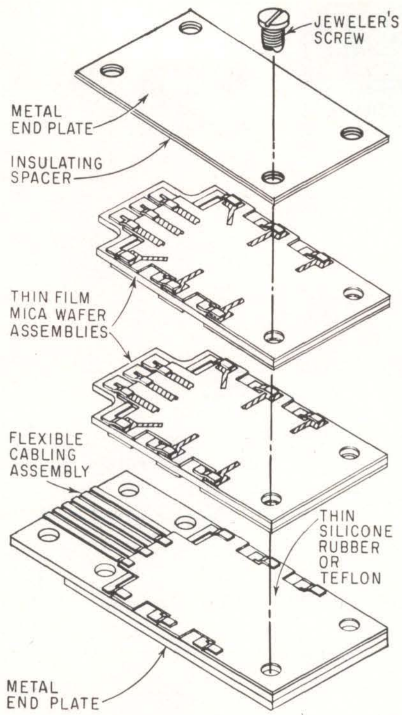
- Outstanding load life
- Ranges to 100,000 megohms
- Stronger termination
- Weldable leads

IRC



THIN-FILM *module assembly uses contract pressure maintained by jeweler's screws—Fig. 6*

(see Figure 5). This sandwich structure thus forms an interconnected wafer assembly.

Figure 6 shows how a number of wafer assemblies are stacked and interconnected to form a module. Contact pressure is sustained on the stack by tightening the jeweler's screws located at each corner. These modules employ short, flexible printed-circuit cabling for connection to a multilayer board in assembling a subsystem.

HEAT SINKS — The foregoing techniques make possible optimum heat dissipation configurations.

Heat sinks in stacked discrete-component wafers (Figure 4) consist of a metallic heat-collecting layer interposed between a heat-producing wafer and an adjacent wafer. This metallic layer (not shown) is a plated pattern transferred to a thin substrate and covers the entire wafer area except where contact is made. Metallic heat sinks also serve as electrostatic shields when connected to ground or other reference.

In thin-film modules, the heat absorbing layer is a copper sheet. Heat flows into the copper mass and is conducted away partly by the assembly screws located at one end of the wafer and partly by interconnecting-lead conduction and radiation to adjacent wafers. Short, flexible, printed-circuit cabling interconnect modules on a subsystem multilayer board. The multilayer board assemblies are then mounted to solid state cooling modules before mounting the whole assembly to a final systems multilayer connector board.

REFERENCES

(1) U. S. Patent No. 3,024,151, T. L. Robinson.

(2) Thomas L. Robinson, "A Novel Solution to the Interconnection Problem in Microsystem Circuits." *Proceedings of the National Electronics Conf.*, 1962, Vol. 18.

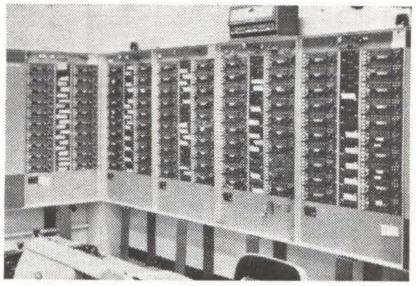
Motors Test Potentiometers

By MORTON H. BURKE
Electronics Associates, Inc.
West Long Branch, N. J.

QUALITY EVALUATION of variable potentiometers requires that some device operate the potentiometers continuously for extended periods of time. The test fixture shown in the accompanying photograph uses synchronous oscillator-type motors manufactured by Cramer Controls that run at a speed of 60 RPM. They have the distinct advantage of reversing themselves as soon as the potentiometer stops are hit. And since motor-torque output is low, there is no possibility of damage to potentiometer under test.

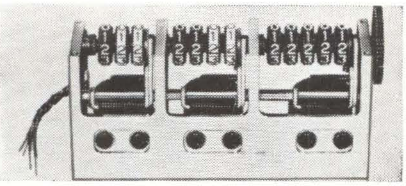
Most potentiometers, single or multi-turn, can easily be turned by these type 117 motors, which have torque capabilities of 1.5 oz-in. Since the motor shaft diameters are $\frac{1}{8}$ inch, it was necessary to drill out some $\frac{1}{4}$ inch aluminum rod to provide a $\frac{1}{4}$ inch to $\frac{1}{4}$ inch coupling surface. The actual coupling between the motor shaft and the potentiometer is made by means of common $\frac{1}{4}$ inch diameter grey plastic tubing (spaghetti).

Before these synchronous motors were utilized, a geared down servo motor employing limit switches for reversing was used. This method



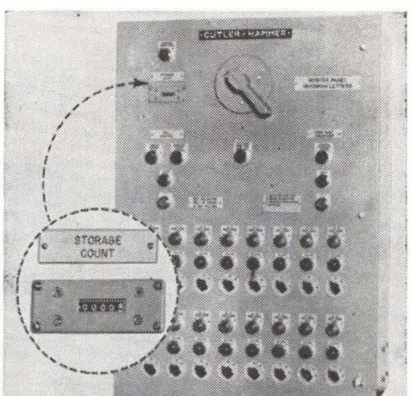
Shoptrol System depends on Durant Counters

DURANT MANUFACTURING CO., Milwaukee, developed two special electric counters for visual readout in the G. E. Shoptrol — a factory production monitoring and data collection system which gives a panoramic view of factory production at a central point. The system uses two Durant electrics, 3-3-5-Y-9965 and 5-Y-9966.



Y-9965 is three counters in a single frame with independent drives—one each for Down Time, On Time, and actual accumulated production from each station and each shift. Fast reset and ease of installation are features.

5-Y-9966 is a predetermined counter — subtracting each unit as produced from a preset total and sends a signal upon reaching total run.



U. S. Post Office "Mail-Flo" System Speeds Processing

DURANT COUNTERS keep mail tray inventory, both in process and temporary storage. Conveyor-mounted switches actuate counters. Each primary side panel uses two 6-Y-1-2-MF models with tumbler lock reset—for trays in storage and in process. 5-Y-8602-MF for incoming and outgoing master panel adds and subtracts for reading of correct number at moment. Selected by Cutler-Hammer Inc. for readability, dependability, long life. Coils totally enclosed in case.

DURANT

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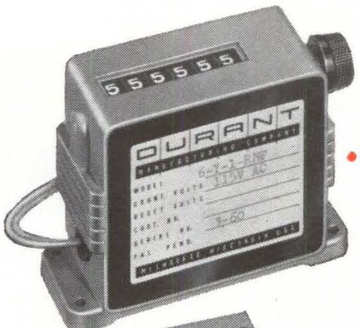
ACCURATE, HIGH SPEED COUNTING by REMOTE CONTROL

ELECTRIC COUNTERS

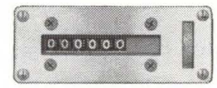
There's a standard Durant Electric Counter to fit practically any OEM application . . . enabling you to build modern electric counting into your PRODUCT, MACHINE or METHOD.

Durant's "HIGH VISIBILITY", with clean-cut legible figures set high up and close to the window, show the exact figure at a glance. Many Durant fully enclosed Electrics have been performing accurately and dependably under varying conditions for years and years — giving the reliability so necessary in a counting operation.

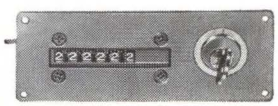


"Y" Electric Series
(Model 6-Y-1-MF)
1000 CPM

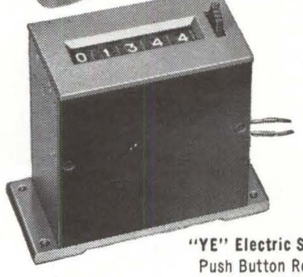
"CS" Electric Series
(larger size — larger figures)



Ideal for PANEL MOUNT
(placed and mounted from front) on machine or at control center



Tumbler Lock Key Reset for "tamper control"



"YE" Electric Series
Push Button Reset
(Model 5-YE-8947-Q)
1500 CPM

"Y" Electric Series
4 figure
(Model 4-Y-9434-B)
600 CPM

"Y" Electric — Small, compact; AC counters equipped with integral rectifier for high speed and long life. Records accurately at high, low, or intermediate speeds.

"CS" Electric — Same external design and features as "Y" Series, but with larger case size and larger figures . . . for more rugged, heavy duty applications.

"YE" Electric — With electric instant reset or finger-flick instant reset.

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Durant offers photo-electric, lever, roller arm, star wheel, or limit switch units for use with Electric Counters.

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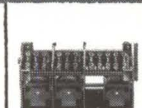
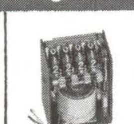
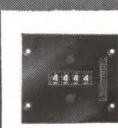


MODEL 3-3-5-Y ELECTRIC COUNTERS ONE FRAME

MODEL 6-Y ELECTRIC PREDETERMINING COUNTER



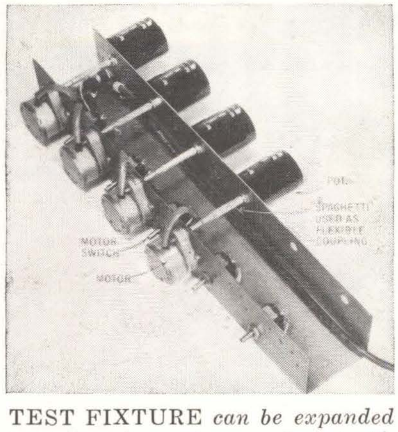
PUSH BUTTON RESET ELECTRIC FOR MILITARY APPLICATION



4 FIGURE "Y" ELECTRIC PANEL MOUNT

"SP-MF" ELECTRIC PREDETERMINED COUNTER

REPRESENTATIVES IN ALL PRINCIPAL CITIES



TEST FIXTURE *can be expanded to take six motors and potentiometers*

always presented the danger of damage to the potentiometer if the motor failed to reverse at the correct time and the wiper was driven into the stop.

The procedure used here for evaluating wire-wound potentiometers is as follows:

(1) Units to be tested are checked for noise by passing 1 milliampere of current through the resistance element and rotating the wiper by hand while viewing the wiper output on an oscilloscope.

(2) Potentiometers are then mounted in the test fixture and rotated for 8 hours.

(3) After each 8 hour period, potentiometers are again checked for continuity, noise, and mechanical bearing wear.

(4) Depending upon the intended usage of the potentiometer, tests are run for periods of time which are equivalent to 100,000; 500,000; or 1,000,000 revolutions.

Machine Serially Labels Parts

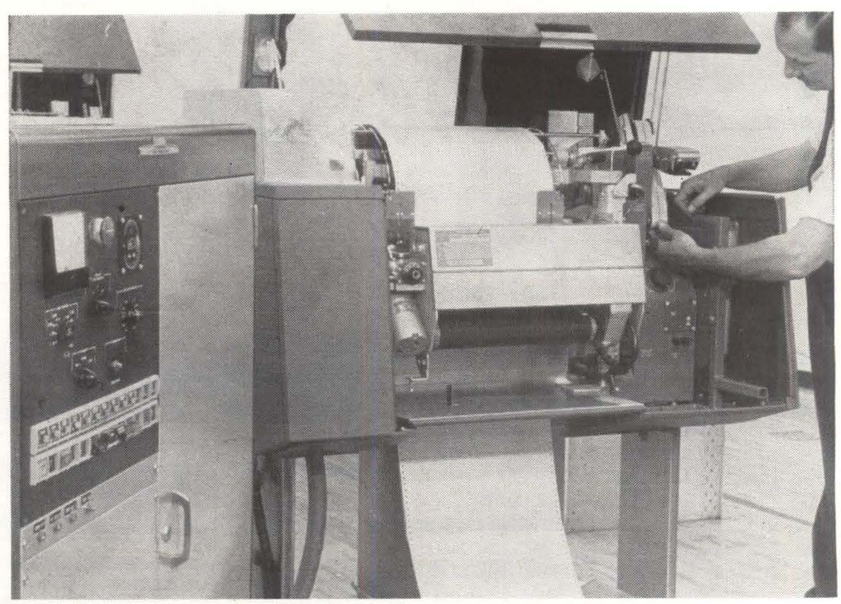
RELIABILITY demands of the Minuteman missile system have spurred development of an automatic sequential numbering machine for electronic components.

The equipment is designed and manufactured by Markem Machine Co., Keene, N. H.

Designated the Markem 162-A, it will print on each component a serial number, company trademark, type number, value and date code, for IBM-card histories.

The machine is basically a special offset printer with metal printing elements. But essence of the Markem solution to the sequential numbering problem is a technique whereby all of the ink needed to imprint a

Printer Tested Automatically



TRANSISTORIZED *tester (left) has several functional tests for checking out assembly of IBM 1403 high-speed printer (right). Tester simulates IBM 1401 central processor to complete printer testing in 96 minutes*

RESISTORS *in rack are each automatically printed with serial number, trademark, type number, value and date*

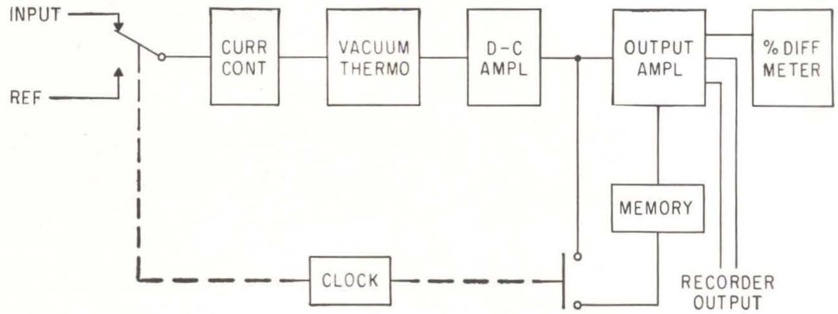
number on a component is used up in that numbering process—and none is left on the offset pad to smudge the next unit. The 100-percent-transfer technique also obviates any need for wiping the offset pad between consecutive imprints.

Critical factors in the process include a special elastomer developed by Markem for the offset pad, ink of a special formulation and the amount of pressure exerted in the imprint.

The Markem device includes a "fail safe" feature. While one component is being marked, a pressure sensor descends upon the next succeeding slot in the production tray. If the unit in that slot is missing—because it had failed to pass an inspection test—the limit switch controlling the sequential numbering will not be tripped, and the numbering cylinder will halt until the tray is moved along to the next slot.

Since each number in a series must be accounted for—and there must be a component for each number—no numbers can be wasted or voided. However, the machine can make a trial imprint on paper without actuating the sequential number unit. Also, a production worker can remove the numbering unit and handset it to "recover" a number.

To keep pace with miniaturization in the electronics industry, the New Hampshire company has developed what are termed the world's smallest automatic numbering units and type. "Minitype" characters can be as small as 0.032 in. high and 0.015 in. wide. Three lines of this type, the middle one being as long as seven digits, can be printed on TO 18 and TO 46 configurations to give trademark, type number and date code.



Voltage Comparator Has Built-In Memory

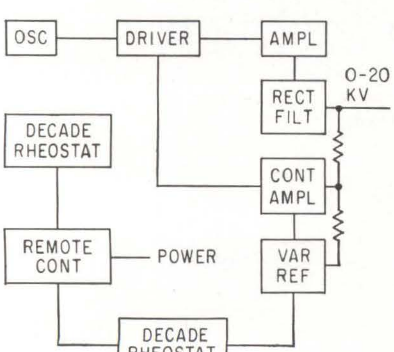
Measures absolute rms between 4 and 1,000 v, from d-c to 10 Kc

MANUFACTURED by North Hills Electronics, Inc., Alexander Place, Glen Cove, N. Y., the model VC-1 true rms voltage comparator permits rms measurements, comparison and recording between 4 and 1,000 v, d-c to 10 Kc with repeatability of 0.01 percent. Input current is 6 to 7 ma, input resistance is 170 ohms per volt and absolute transfer accuracy is ±0.02 percent of reading. Long-term zero drift is ±0.005 percent, resolution of comparison is 0.005 percent and the device supplies 5-0-5 mv, 10-ohm source for servo potentiometer recorders and 0.5 — 0 — 0.5 ma into 0 to 10,000-ohm loads for low-impedance, current-sensitive recorders. As shown in the sketch, the transfer switch, current control and vacuum thermocouple function as a method of precise a-c voltage measurements on a true rms basis involving the use of a vacuum thermocouple as the transfer element between an unknown and an accurately known d-c voltage. The output meter indicates difference between amplified thermocouple voltage and output of a memory circuit. A switch permits equating these two voltages. When the switch is released, the memory circuit will remember the level and the output meter will then indicate differences between this voltage and variations in thermocouple output. With separate sources feeding both reference and input, the meter will indicate differences between the two voltages.

CIRCLE 301, READER SERVICE CARD

Generating 20 Kv With 0.1-Percent Regulation

INTRODUCED by Calibration Standards Corp., 1031 Westminster Ave., Alhambra, California, the model 170 high-voltage power supply delivers 0 to 20,000 v,



between 0 and 5 ma with stability of 0.1-percent per hour or 0.3-percent per day. Regulation versus line is better than 0.1 percent, regulation versus load is better than 0.1 percent zero to full load, resolution is 1 v, accuracy is 1 percent and ripple is less than 1 v rms. As shown in the sketch, an oscillator generates a low-frequency a-c signal that is fed to a driver and then to a high-voltage amplifier. The amplifier generates about 10,000 v a-c unregulated from a high-Q tank circuit. The voltage is then rectified by a voltage doubler and filter circuit. The 20,000 v d-c is applied across a precision resistance divider. At the lower end, a d-c potential is compared to a stable variable d-c reference source. This source is controlled by either front-panel controls or a remote panel. Any error signal from the comparison amplifier is applied to the screen of the driver (at low level) and this in turn controls the high-voltage output amplifier stages. **(302)**

How to Switch C-Band in 30 Nanoseconds

ANNOUNCED by Microwave Associates, Inc., Burlington, Massachusetts, the MA-8305-2C2N is a solid-

CIRCLE 75 ON READER SERVICE CARD→

The Miniature ≠̸ AMERICA KNOWS BEST IS NOW EVEN BETTER

New JFD HI-LIFE® Trimmers Deliver Extra Reliability
Surpass MIL-C-14409A Adjustment Life Requirements by 600%!

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No need any longer to tie yourself down to air variables with their limiting 180 degree tuning. Now you can design into your circuits the **long-lived** adjustment **and** the ultra-sensitive **multi**-turn tuning capabilities of JFD Hi-Life piston trimmers. Add to these the other Hi-Life features of completely sealed (Sealcap) construction . . . ultra linear tuning . . . miniature size . . . panel mount knob tuning . . . shock and vibration-proof ruggedness. Small wonder Hi-Lifes are meeting and beating the test of the most gruelling space age environments.

Panel mount and printed circuit type Hi-Life trimmers may be obtained in four different series, NVC, NMQ, NSC and NQS, offering the same mounting facilities as the already famous and widely used Miniature, Sealcap and Max-C series.

Model NVC 10GW
0.8 to 4.5 pf.
actual size

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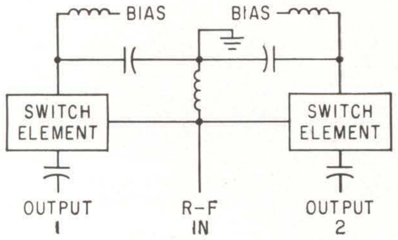
NOUS SERONS TRES HEUREUX DE POUVOIR VOUS ACCEUILLIR AU STAND **JFD** LORS DE VOTRE VISITE AU SIXIEME SALON INTERNATIONAL DES COMPOSANTS ELECTRONIQUES DU 8 AU 12 FEVRIER 1963 DE 9H30A 19H PARC DES EXPOSITIONS. PORTE DE VERSAILLES PARIS FRANCE state, single-pole, double-throw microwave switch for C-band applications. Frequency range is 5.35 to 5.95 Gc, insertion loss is 1 db maximum, isolation is 30 db minimum and input vswr is 1.30:1 maximum. Switching speed is 30 nanoseconds and r-f is 150 w peak. The device is useful in a wide variety of applications such as antenna switching, signal modulation, pulse shaping or time-sharing techniques or any other high-speed r-f switch applications. The sketch shows the bias leads isolated from r-f by low-pass filters while bias voltages are isolated from the r-f circuits by blocking capacitors. In one throw position, the switch is biased in the positive direction while the other bias is set at zero or a slight negative voltage. The r-f is transmitted with small insertion loss to the output terminal connected to the side that has the zero bias. The r-f at the other terminal is attenuated by 30 db. By reversing bias conditions, r-f can be switched back and forth at high rates.



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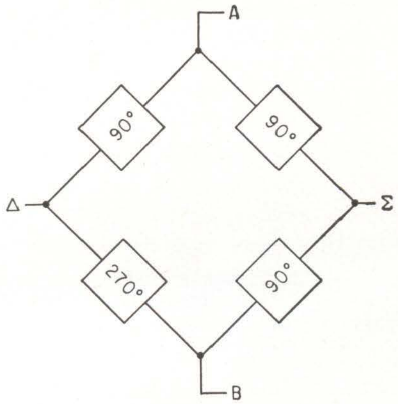
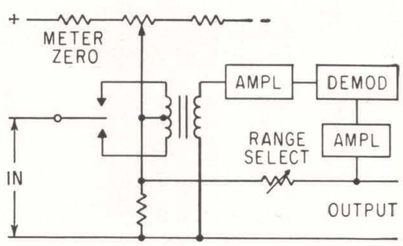


New Approach to H-F Broadband Power Splitting

NEW from Adams-Russell Co., Inc., 280 Bear Hill Road, Waltham 54, Massachusetts, the model H20 h-f hybrid is a balanced-to-unbalanced transformer that offers a solution to broadband power splitting and balun problems. Frequency range is 5 to 32 Mc, with high isolation, low insertion loss and excellent phase balance. Vswr is less than 1.51:1 when all ports are terminated in 75 ohms. The sketch shows operation. Opposite terminals are isolated from each other by the action of the phase shifters, thus except for a constant phase shift, output at Δ is $(A - B)$ and Σ is $(A + B)$. The sums and differences are taken algebraically while A and B are coherent inputs. There is complete reciprocity so that if Δ is energized, the output signals at A and B will be equal and out of phase. The same outputs would be equal and in phase if Σ is energized. In the case of the rat race, useable bandwidth is approximately 10 percent while this unit approaches three octaves bandwidth. **(304)**

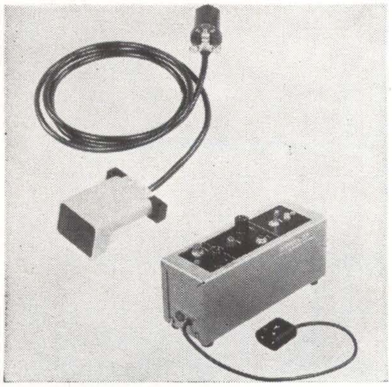


Amplifying 100-Nanovolt Low-Frequency Signals

RECENTLY announced by Astrodata, Inc., 240 East Palais Road, Anaheim, California, the model TDA-120 is a transistorized d-c amplifier that will operate on signals as low as 100 nv. Bandwidth is from d-c to 100 cps, input impedance is constant at 1 megohm on all ranges and noise level is 0.05 μv. Fixed gains of from 3,000 to 100,000 may be selected through front-panel controls. Maximum output voltage is ±5 v peak with maximum output current of ±5 ma. Minimum load resistance is 1,000 ohms and output resistance is less than 1 ohm. Internal batteries permit continuous operation for 24 hours and a built-in charger is provided. Typical uses includes seismographic signals, bolometer signals, cryogenic studies, cell studies, bridge balance amplifier, ultra low-level strain gages, ultra low-level thermocouples and Hall-effect studies. **(305)**

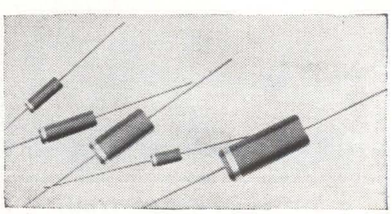
Shrinkable Tubing

ALPHA WIRE CORP., 200 Varick St., New York 14, N.Y. A semi-rigid, irradiated, heat shrinkable tubing that provides maximum strength at stress or connection points has applications in coaxial cable build-up, insulating terminations and connectors, splices, encapsulating components, or wherever extra strength and superior mechanical or electrical insulating qualities are needed. **(306)**



Line Follower Features Flexibility

F. L. MOSELEY CO., 409 North Fair Oaks Ave., Pasadena, Calif. Photoelectric line follower quickly converts almost any trace to electrical energy. Type F-3 is valuable in process of machine program control, graphic data analysis and function generating. It tracks curve slopes up to 85 deg at chart speeds to 12 in./minute and up to 45 deg at 120 in./minute. It will follow a square wave up to 0.1 in. at 6 in./-minute. Instrument features flexibility. Built-in relays for external circuit control are included. Programs can be prepared quickly and changed easily—simply by drawing another line. **(307)**



Film Capacitors Use Mylar Dielectric

ERIE RESISTOR CORP., 644 W. 12th St., Erie, Pa., announces a line of

Said Gaspard de Coriolis: *"A particle which is subject to no forces in a rotating coordinate system experiences a radial acceleration and a tangential acceleration."*

It was around 1840 that Coriolis discovered what has since become known as the Coriolis Effect. He noticed objects above the earth tend to rotate relative to the earth's rotation . . . to the right in the northern hemisphere, to the left in the southern.

The Coriolis Effect is in force in outer space, too. If a space vehicle is rotated in order to establish artificial gravity, the necessarily short radius of the rotation causes a Coriolis force. This creates orientation problems for a human occupant. To eliminate this difficulty, a scientist at Lockheed Missiles and Space Division conceived the idea of connecting the vehicle to an auxiliary fuel tank by a half-mile-long cable. Thus, if the whole system is then rotated at a reduced speed around its center of mass gravity, the longer radius greatly minimizes the Coriolis force. Right now—on the drawing boards at Lockheed—is an enormously advanced space vehicle system which utilizes this concept, in addition to many others.

Fortunately, natural laws are about the only restrictions which circumscribe scientists and engineers at Lockheed Missiles & Space Company. The climate in Sunnyvale and Palo Alto, on the San Francisco Peninsula, is close to perfection. The creative atmosphere—the opportunity to work on such important projects as the AGENA Satellite series, the POLARIS FBM, or even more advanced concepts such as the space system cited above—is the dream of the creative engineer.

Why not investigate future possibilities at Lockheed? Write Research and Development Staff, Dept. M-11B, 599 North Mathilda Ave., Sunnyvale, Calif. U.S. citizenship or existing Department of Defense industrial security clearance required. An Equal Opportunity Employer.

LOCKHEED MISSILES & SPACE COMPANY

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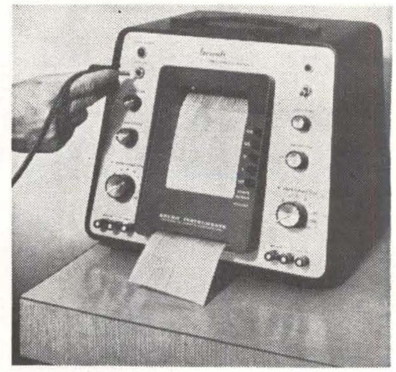
Systems Manager for the Navy POLARIS FBM and the AGENA vehicle in various Air Force Satellite programs. Other current projects include such NASA programs as the OGO, ECHO, and NIMBUS.

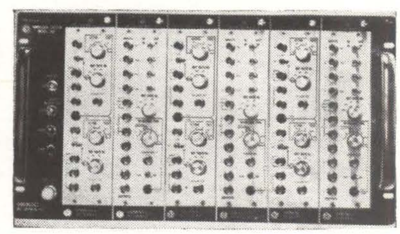
SUNNYVALE, PALO ALTO, VAN NUYS, SANTA CRUZ, SANTA MARIA, CALIFORNIA • CAPE CANAVERAL, FLORIDA • HAWAII polyester film dielectric capacitors developed for applications requiring high capacitance, excellent capacitance stability, superior humidity resistance, and high insulation resistance over a wide temperature range. Wide usage is expected in filter, by-pass, coupling, and blocking applications. Price in production quantities, \$0.0425 each to \$0.345 each depending upon electrical specifications.

CIRCLE **308**, READER SERVICE CARD



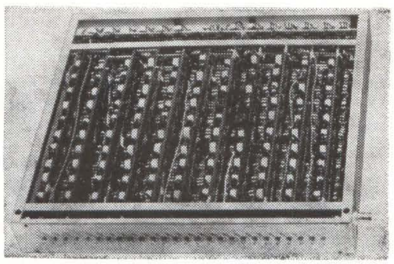
Test Recorder Is Direct Writing

BRUSH INSTRUMENTS, division of Clevite Corp., 37th and Perkins, Cleveland 14, O. Portable two-channel direct writing recorder is ideal for trouble-shooting in telephone, pipeline, and utility systems. It incorporates an accurate 0.1 sec timing marker, provision for remote control, and two analog channel with a frequency response flat from d-c to 100 cps. Self-contained d-c amplifiers are matched to each analog channel to give sensitivities down to 10 mv per mm of pen excursion. Common mode rejection of the recorder is better than 1,000 to 1 at max sensitivity. **(309)**



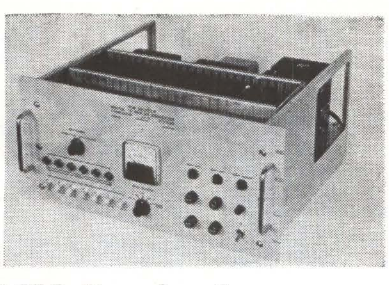
Digital Logic System Features High Speed

CHRONETICS, INC., 9 Elm Ave., Mount Vernon, N. Y. Model 100 Nanologic System is a high-speed asynchronous electronic data processor capable of operating at 10 nsec intervals or at rates up to 100 megapulses per sec. Although the system was designed primarily for use in high-energy physics experiments at accelerators, it is expected to prove equally useful in the study of both nuclear and optical decay schemes, thermonuclear fusion, and high-speed digital communications and telemetry problems. **(310)**



Delay Line Has 25 Available Taps

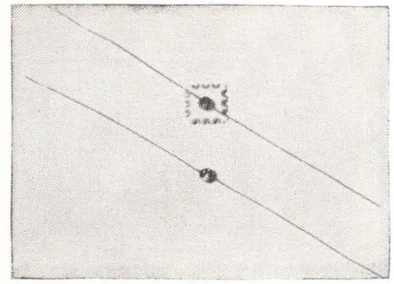
COLUMBIA TECHNICAL CORP., Woodside 77, N.Y. The CTC 1935 was developed for use as a phase converter in an operating radar system. Measuring 11 by 13 by $2\frac{1}{2}$ in., it has 25 available taps. Each tap represents a 360 deg phase conversion at 6 Mc. Accuracy on each tap is $\pm$ 10 deg or 4.6 nsec non-accumulative. Therefore, total delay is 4.166 μsec $\pm$ 4.6 nsec. Temperature coefficient is better than 20 ppm/deg C over a temperature excursion of $-$ 55 C to $+$ 85 C. Phase linearity is $> \pm$ 1 percent up to 15 Mc and attenuation is negligible at impedance of 100 ohms. **(311)**



PCM Decoder Is 0.1 Percent Accurate

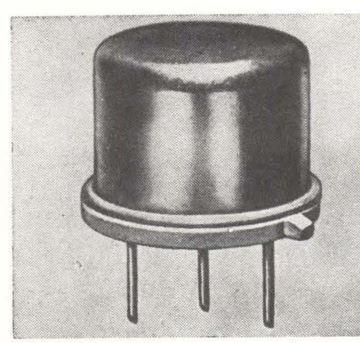
CORRELATED DATA SYSTEMS CORP., 1007 Air Way, Glendale, Calif. Model PCMD-1000 provides ground station telemetry engineers with a convenient way to develop parallel-binary and analog information from a serial digital wave train utilizing the NRZ format. Among its many applications are: as a converter for analog display of selected pcm telemetry words; as an intermediate converter of serial binary data to a computer format; and as a check-out instrument for performance investigation of analog-to-digital converters. Conversion capability is at 5, 6, 7, 8, 9, or 10 bit levels.

CIRCLE **312,** READER SERVICE CARD



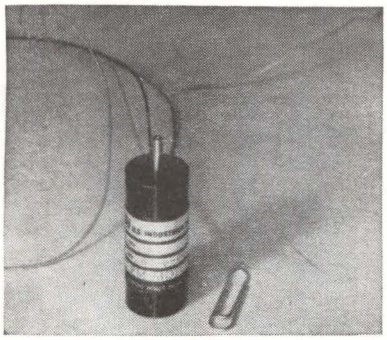
Tantalum Capacitor For Micromodule Use

TANSITOR ELECTRONICS, INC., West Road, Bennington, Vt., offers a disk-shaped tantalum capacitor that has outstanding volumetric efficiency compared to that of other tantalum capacitors. Designed for use in micromodule electronic equipment they eliminate the metal or epoxy case used on standard foil and sintered pellet tantalum capacitors. An invisible moisture resistant coating serves as the case and provides high stability over the operating temperature range of -80 to $+125$ C. Voltage range is 3 to 35 v; capacitance varies from 0.12 to 160 μf, with a standard tolerance of ± 20 percent. **(313)**



Power Transistor Operates at 28 V D-C

CLARK SEMICONDUCTOR CORP., Walnut Ave., Clark, N. J. The 2N2649 is a 130 Mc power transistor that operates at 28 v d-c with 2 w output. It is a triple diffused *npn* mesa device and is available in TO-5 and other packages. Applications include telemetry and mobile communications. **(314)**



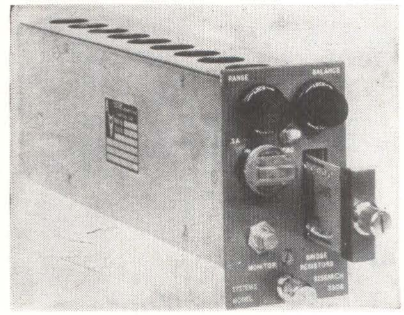
D-C P-M Motor Has $\frac{3}{4}$-In. Diameter

U. S. INDUSTRIES, INC., Engineered Products Division, 6312 Hollister Ave., Goleta, Calif., announces model 20276-001 d-c permanent magnet motor. The governor is capable of maintaining less than ± 1 percent speed regulation over a 25 to 31 d-c voltage range and a -35 F to 160 F temperature range. Unit is able to withstand continuous duty operation with a life of 300 hr. The lightweight compact motor measures only $\frac{3}{4}$ in. in diameter by 1.90 in. long with governor, or 1.37 in. long without governor. Unit can be supplied in 24 standard winding configurations plus special windings to meet customer needs. **(315)**

Frequency Meter And Preset Counter

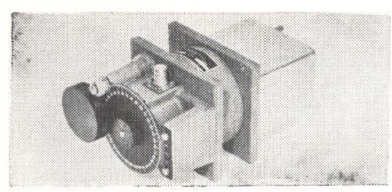
ROBOTOMICS, INC., 4504 N. 16th St., Phoenix 16, Ariz. Combined frequency meter and preset counter is solid state with in-plane display. Model 4202S measures frequency to 100 Kc, contains self-checking circuit, and also operates as an add-subtract preset counter. Miniature thumbwheel switches are used for presetting. Modular construction is used throughout the system. Outputs are optional 10-line coincidence, 1248, relay, or other. Unit is rack mounted with 7-in. panel, with desk top cabinet also available. Power required is 115 v, 50-60 cycles, at less than 100 w.

CIRCLE **316**, READER SERVICE CARD



Strain Gage Supply Has Wide Range

SYSTEMS RESEARCH CORP., 7635 Tobias Ave., Van Nuys, Calif. Model 3506 has front panel plug-in card for quick easy access of signal conditioning resistors. Printed card has four bridge completion resistors, limiting resistor and five calibration resistors. Other front panel controls include range and balance, zero button switch and monitor button switch. Power supply has wide range 0-24 v d-c at 200 ma with regulation of 0.01 percent. Ripple is only 50 μv and noise is less than 2 μv across a 350 ohm bridge. Isolation is better than 10,000 meg to ground. **(317)**



I-F Resolver Controls Signal Phase

MERRIMAC RESEARCH AND DEVELOPMENT, INC., 517 Lyons Ave., Irvington 11, N. J. A precision i-f resolver, for applications requiring control of i-f signal phase, has been developed. It permits choice of any phase angle of an input signal, from 0 deg to 360 deg. Output amplitude is constant. Vernier selector dial permits resolution to 0.1 deg, with a calibration accuracy of ±0.1 deg; a thumbscrew locks the dial at the desired setting. **(318)**

Literature of the Week

CAPACITORS Aerovox Corp., New Bedford, Mass. Technical and operating specifications on Aerofilm type V123G and V423G capacitors are given in a data sheet. **(319)**

EPOXY ADHESIVE Hysol Corp., Olean, N. Y. Bulletin A-402 contains technical data on a high peel strength room temperature curing epoxy adhesive. **(320)**

MOISTURE REGISTER INSTRUMENTS Moisture Register Co., 1510 W. Chestnut St., Alhambra, Calif. Data bulletin describes three new transistorized electronic moisture meters. **(321)**

DATA PRINTERS Clary Corp., 408 Junipero St., San Gabriel, Calif. Form SA 113 is a file folder illustrating the company's standard military and industrial data printers. **(322)**

DIGITAL SYSTEMS EQUIPMENT Packard Bell Computer, 1905 Armacost Ave., Los Angeles 25, Calif. Catalog SP-117A contains new information on a complete line of digital systems equipment. **(323)**

INERTIAL INSTRUMENTS Giannini Controls Corp., 1600 S. Mountain Ave., Duarte, Calif., has published an easy-reference catalog listing specifications of a line of advanced accelerometers and gyroscopes. **(324)**

PHASE COMPARISON RECEIVER Gertsch Products, Inc., 3211 S. LaCienega Blvd., Los Angeles 16, Calif. Brochure covers an all solid-state receiver which calibrates precision frequency standards against vlf radio transmissions. **(325)**

HOT-COLD NOISE SOURCE Watkins-Johnson Co., 3333 Hillview Ave., Palo Alto, Calif. Technical bulletin describes type WJ-190 hot-cold noise source for measuring noise figure in the range of 1-4Gc. **(326)**

DIGITAL LOGIC MODULES Computer Control Co., Inc., Old Connecticut Path, Framingham, Mass. Catalog S-2 covers the full family of S-PAC digital logic modules. **(327)**

VARIABLE RESISTORS CTS of Berne, Inc., Berne, Ind., has released three catalogs on its line of 275C military Cermet variable resistors. **(328)**

CAPACITOR LIFE-TEST RESULTS Arco Electronics, Inc., Community Drive, Great Neck, N. Y. Bulletin 2-62 details results of a 10,000 hr life test on type PJ tubular polystyrene capacitors. **(329)**

TRANSFORMER ENCYCLOPEDIA Aladdin Electronics, Dept. E, Nashville 10, Tenn. A 112-page pulse and wideband transformer encyclopedia may be obtained by requesting on company letterhead.

PUSHBUTTON SWITCHES Dialight Corp., 60 Stewart Ave., Brooklyn 37, N. Y., has published catalog No. L-169 on Dialco subminiature illuminated pushbutton switches and matching indicator lights. **(330)**

PCM TELEMETRY DECODER Correlated Data Systems Corp., 1007 Air Way, Glendale, Calif. Brochure sheet 211-A describes model PCMD-1000 pcm telemetry decoder. **(331)**

LOGIC DESIGN TRANSLATOR Burroughs Corp., Detroit 32, Mich. An 8-page technical information bulletin reprints a paper recently presented on a logic design translator. **(332)**

COUNTERS AND TIMERS Eldorado Electronics, 1832 Second St., Berkeley 10, Calif., has published a bulletin on the 780 series solid-state 100 Mc/10 nsec counters and timers. **(333)**

RELAYS Ohmite Mfg. Co., 3634 Howard St., Skokie, Ill. Bulletin 703 lists various ratings of model DOS a-c and d-c relays approved under the UL Re-examination Service. **(334)**

ACCELEROMETERS Gulton Industries, Inc., 212 Durham Ave., Metuchen, N. J. An illustrated 32-page brochure gives complete information on a broad line of self-generating piezoelectric accelerometers. **(335)**

WATERPROOF PLUGS Cannon Electric Co., 3208 Humboldt St., Los Angeles 31, Calif., has available catalog WP-1 describing the W series of waterproof plugs. **(336)**

INSTRUMENT MOUNT CLAMPS Aeroquip Corp., 11214 Exposition Blvd., Los Angeles 64, Calif. Bulletin covers aircraft instrument panel mounting clamps. **(337)**

TIMER Automatic Timing & Controls, Inc., King of Prussia, Pa. Buletin 320 covers a timer that automatically switches electrical circuits on or off either after a preset time or during the timed period. **(338)**

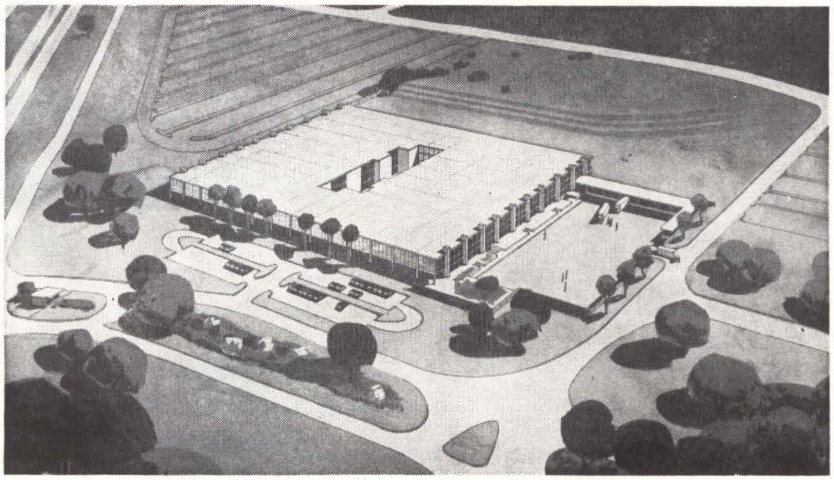
VARIABLE PHASE SHIFTERS Sanders Associates, Inc., 95 Canal St., Nashua, N. H. Bulletin TC-120 covers variable phase shifters which can be used anywhere in the d-c to 4 Gc frequency range. **(339)**

NOISE LIMIT INDICATOR B & K Instruments, Inc., 3044 W. 106th St., Cleveland 11, O., offers a brochure on tht 2211 high-speed noise-limit indicator for production-line noise and vibration analysis. **(340)**

DIGITAL TELEMETER General Electric Co., Schenectady 5, N. Y. Bulletin GER-1798, six pages, discusses a digital telemeter for use with analog telemetering over a single channel. **(341)**

FERRITE SWITCH CORES Electronic Memories, Inc., 9430 Bellanca Ave., Los Angeles 45, Calif. Three 4-page specification sheets feature small, medium and large-sized ferrite switch cores. **(342)**

TI Building $4-Million Plant



TEXAS INSTRUMENTS INCORPORATED announces that construction has begun on a 290,000-sq-ft multi-purpose building to be located on a 350-acre site in Dallas.

President P. E. Haggerty said the cost of the new building, including site preparation and parking lots for 1000 automobiles, will amount to more than $4 million.

The plant is scheduled to be completed in sections, with partial occupancy to begin this fall.

With the addition of this facility, TI will have more than a million square feet of manufacturing, laboratory and office space on this Dallas site. Currently, TI owns or occupies more than 2.5 million square feet of space worldwide, with plants in four U. S. cities and seven other countries.

W. F. Joyce, TI senior vice president—Operations Service & Control, said the new building is of multi-purpose design, suitable for any of the manufacturing activities TI now envisions for the Dallas area. Initially, a major portion of the building will be used to consolidate some of the electronic and electromechanical systems design and manufacture now conducted by TI's Apparatus division in numerous locations in Dallas county. The building also will permit expansion of some of the operations currently housed in TI's 256,000-sq ft Apparatus division plant in Dallas.

Joyce said the building will have extreme flexibility and adaptability to accommodate fast-changing manufacturing technologies. Designed along a modular plan, the building can be expanded in 31,000-sq ft increments. Basic site utilities adequate for a building of 590,000 sq ft will be installed.

Among the advanced functional concepts to be incorporated in the building is a nine foot "space frame" between the lower and upper levels. It will provide space for routing utilities and services to any portion of the building and make it possible to eliminate extensive air-conditioning distribution ducts. This will free production areas from the clutter of distribution pipes and wires and permit flexibility in the placement and relocation of equipment.

Haggerty stated that the start of this construction—along with other projects in various stages in the U.S. and abroad—puts TI underway with one of the most extensive facilities building programs in its 33-year history.

Raytheon Elevates Leopoldo Valdes

LEOPOLDO B. VALDES of Raytheon Company's Rheem Semiconductor Operation, Mountain View, Calif., has been selected as the fifth member of the company's newly established super professional level with the title of consulting engineer.

The appointment was approved by a six-man professional review board and was announced by its chairman, Martin Schilling, vice president-engineering and research. The new level permits specialists to advance their careers without need for accompanying administrative responsibilities.

Indiana General Promotes Just

ROBERT E. JUST has been promoted to manager of manufacturing of the Magnet division of Indiana General Corp., Valparaiso, Ind.

Prior to his present position, Just was chief industrial engineer of the division.

Hopkins Engineering Appoints Lutter

FRED LUTTER has joined Hopkins Engineering Co., San Fernando, Calif., as director of engineering and research. Hopkins, a manufacturer of capacitors and rfi filters, is a subsidiary of Maxson Electronics Corp.

Lutter was formerly with The Potter Co., Skokie, Ill., and its subsidiaries in management engineer-

DATA ACQUISITION WITH DYMEC SYSTEMS

MEASURE AND RECORD DC VOLTS AND MILLIVOLTS, FREQUENCY, AC VOLTS, RESISTANCE WITH DYMEC STANDARD SYSTEMS

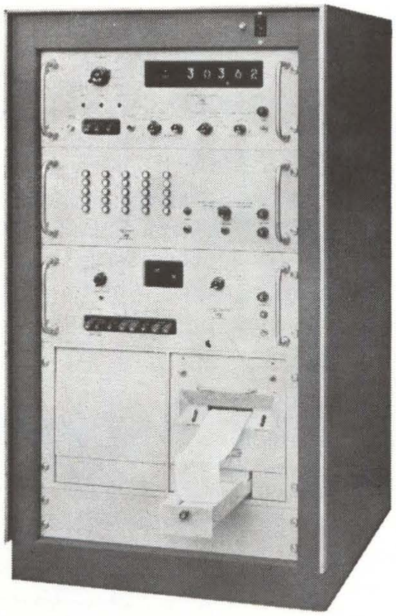
Dymec Data Acquisition Systems are engineered and packaged for a variety of input and output situations. The basic systems measure dc voltage and frequency. Optional equipment permits measurement of ac voltage, 50 cps to 100 kc; resistance, 100 ohms to 10 megohms full scale, and dc measurements of 10 mv full scale.

The measuring element of each Dymec 2010 standard system is the floated and guarded DY-2401A Integrating Digital Voltmeter, which permits accurate low-level measurements even in the presence of severe common mode and superimposed noise.

A family of standard systems has been engineered so you can choose your desired input and output characteristics. Standard input scanners accommodate up to 25 signal sources (expandable to 100 channels with slave scanners), and 200 3-wire guarded inputs or 600 non-guarded 1-wire inputs. Output capabilities include printed tape and punched tape.

The DY-2010A system, pictured here, scans up to 25 3-wire signal sources, programs the digital voltmeter to measure different types and levels of signals, measures the signals and logs measurements on a digital printer.

Advantages common to all systems of the DY-2010 Series are modest cost, fast delivery, high reliability derived from standard design and construction, and proved performance. You get a pre-designed, tested system.



DY-2010A-M2
(includes optional ac and ohms measurement capability)

You don't have to wait—or pay—for "custom" engineering, fabrication or testing time.

Major characteristics of the 2010 Series standard systems are listed in the chart below. Other systems are available to fit many additional requirements.

Check for the system that meets your requirement,
then call or write your Hewlett-Packard/Dymec representative for complete information.

	DY-2010A	DY-2010B	DY-2010C	DY-2010D
Scanner input	Up to 25 3-wire signal sources; to 100 channels with slave scanners; programming capability permits measurement of mixed types and levels of signals		Up to 200 guarded 3-wire inputs; to 600 non-guarded 1-wire inputs	
Voltage Ranges	100 mv to 1000 v full scale; overranging to ± 300% of full scale on four most sensitive ranges; 0.01% stability on four highest ranges			
Frequency Ranges	10 cps to 300 kc; sample period 0.01, 0.1 or 1.0 sec.; accuracy ± 1 digit ± time base accuracy			
Display	5 digits of data, range, function (polarity), channel number, all included in front-panel readout, logged on output recording device			
Measurement Speed	Up to 5 channels per sec	Up to 10 channels per sec	Up to 5 channels per sec	Up to 10 channels per sec
Effective Common Mode Rejection	105 db	105 db	130 db	130 db
Output	Printed paper tape (9 column, alphanumeric)	Perforated tape (10 character, 8-level IBM code)	Printed paper tape (10 column, alphanumeric)	Perforated tape (10 character, 8 - level IBM code)
Price	$8,675	$10,800	$10,965	$12,850
Options	Time of day information, ac voltage and resistance measurements, 10 mv full-scale sensitivity, cabinet			

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

DYMEC
A Division of Hewlett-Packard Company

Dept E-118, 395 Page Mill Road, Palo Alto, Calif. Phone (415) 326-1755 TWX 415-492-9363

8209

ing capacities for 13 years and prior to that with Lockheed at Marietta, Ga.

Aircraft Armaments Advances Gable

WILLIAM H. GABLE has advanced to the post of director of engineering at Aircraft Armaments, Inc., Cockeysville, Md. He will be responsible for the overall management of the company's electronic and electromechanical development and design engineering activities.

The engineering division, now approximately 400 people, is engaged in the development of missile training and simulation systems, test and checkout equipment for electronic systems and sub-systems, special digital and analog computer systems, as well as high frequency and microwave accessory equipment.

Murphy Assumes New Position

BERNARD MURPHY has been appointed to the new position of vice president—international operations for Electronic Associates, Inc.

Formerly vice president in charge of EAI's European division with headquarters at Burgess Hill, England, Murphy will direct international operations from Long Branch, N. J., the company's headquarters. He has been associated with EAI's overseas activities since 1957.

EAI is a diversified instrument and computer manufacturer.

RCA Names Kelly To Fill New Post

APPOINTMENT of R. L. Kelly as administrator, product assurance, RCA Semiconductor & Materials division, Somerville, N. J., has been announced.

Kelly, who joined RCA in 1936 as an application engineer in the Electron Tube division, Harrison, N. J., has served since 1957 as technical coordinator for the commercial manager of that division.

Stancor Electronics Promotes Williams

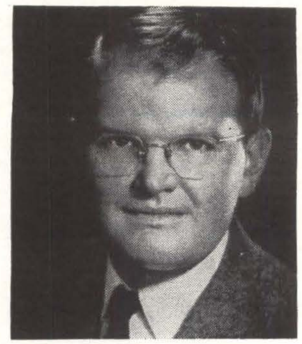
STANCOR ELECTRONICS, INC., Chicago, Ill., has named Oliver Williams as chief engineer, magnetic components. In this capacity he will supervise both the transformer and the filter design groups.

Williams joined Stancor in 1951.

Elektron Standard Hires Hudolin

ELEKTRON STANDARD, INC., South Windsor, Conn., recently appointed Herbert Hudolin as senior project engineer. He assumes project responsibility for continued research in the field of electron beam technology with particular emphasis in the aerospace industry.

Prior to coming to Elektron Standard, Hudolin was with the Hamilton Standard division of United Aircraft Corp. where he was involved in the development of Hamilton-Zeiss electron beam equipment. More recently, his work included the application of electron beam technology to micro electronics.



Appoint Kennedy Velonex Manager

DAN T. KENNEDY has been named to the post of manager of newly formed Velonex of Santa Clara, Calif. Velonex, a manufacturer of electronic instruments, is a division of Pulse Engineering, Inc.

Kennedy was formerly chief engineer of the parent company.

Control Science Appoints Dudley

CONTROL SCIENCE CORP., Alexandria, Va., announces the appointment of H. Lane Dudley to the position of president of the company. He was also elected to the board of directors.

Dudley was formerly manager of

reliability for the Minuteman division of Melpar, Inc.

North Atlantic Names Perlmutter

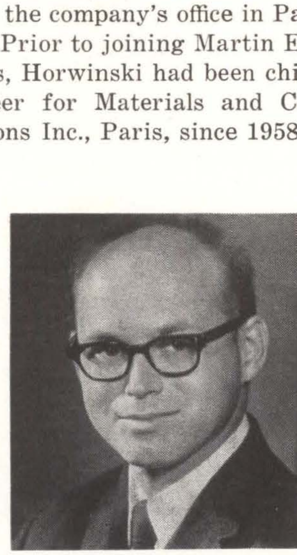
APPOINTMENT of Alvin M. Perlmutter to the position of senior development engineer at North Atlantic Industries, Inc., Plainview, N. Y., is announced. He assumes responsibility for the company's Polaris Program Servo Repeater section.

Prior to his association with North Atlantic, Perlmutter was chief engineer of the Tarc Electronics division of Gotham Broadcasting Co.

Martin Electronics Assigns Horwinski

E. R. HORWINSKI has been appointed director of European special projects for the Electronic Systems and Products division of the Martin Co., Baltimore, Md. He will be located at the company's office in Paris.

Prior to joining Martin Electronics, Horwinski had been chief engineer for Materials and Constructions Inc., Paris, since 1958.



Federal Scientific Appoints Vogel

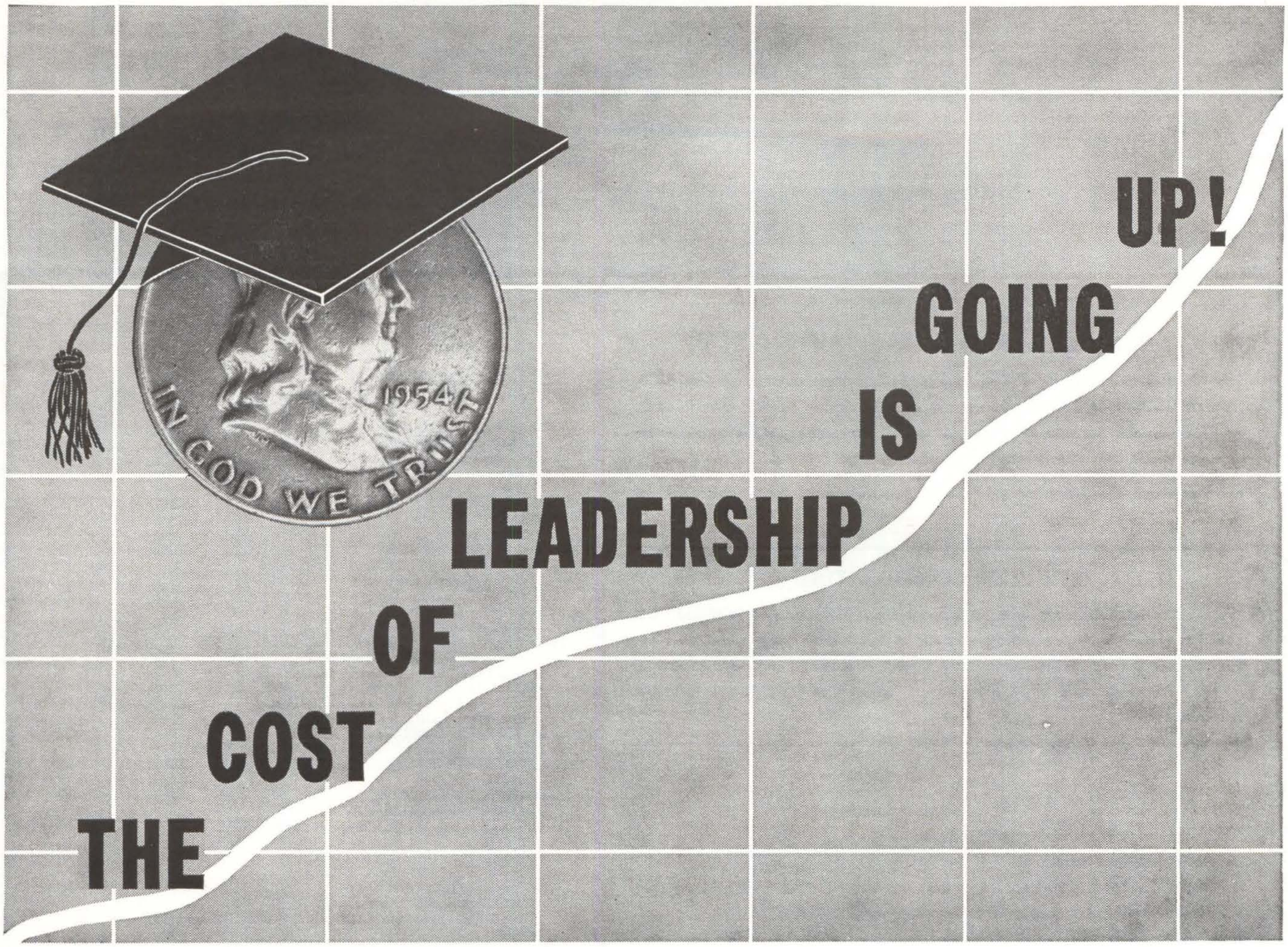
APPOINTMENT of Reinhold Vogel as chief design engineer at Federal Scientific Corp., New York, is announced. He was formerly senior project engineer.

Prior to joining Federal in 1957, Vogel was on the technical staff of the Electronics Research Laboratories at Columbia University, and at the Federal Telecommunications Laboratories.

Federal Scientific Corp., a subsidiary of Polarad Electronics Corp., is engaged in the research and development of advanced electronic systems.

PEOPLE IN BRIEF

George F. Quittner promoted to director of research at Assembly Products, Inc. **G. E. Tralle** moves up to head of the Applications dept. of Sylvania's Microwave Device div. Loral Electronics Corp. advances three men to managerial posts: **Milton Brenner** named chief engineer, development; **Murray Ginsberg** appointed chief engineer, advanced systems; **Harold Sondik** becomes product assurance mgr. **Morris L. Soifert**, formerly with Apogee Electronics Co., now director of engineering for Schaevitz Engineering. **Fred Lorge**, with Kings Electronics Co., Inc., since its founding in 1943, elected president of the company. **Nicholas K. Marshall**, ex-Lockheed Missiles and Space Co., appointed chief engineer for Guidance Controls Corp. Beckman Instruments, Inc. ups **Abe Klein** to product design mgr. for the Spinco div. **James Nicol** leaves A. D. Little, Inc., to join Cryonetics Corp. as director of research. **Donald B. Nason**, recently with Baldwin Military and Industrial Products div., now mgr. of the special programs div. of Sanders Associates, Inc. **E. G. Riley**, previously with Marquardt Corp., named director of advanced planning for the ACF Electronics div. of ACF Industries. **Saul Decker** elevated to director of engineering of Symphonic Electronic Corp. **Ralph R. Ragan**, from MIT's Instrumentation Lab to Raytheon Co. as mgr. of the Sudbury, Mass., operation in its Missile & Space div. **Peter M. Kelly** promoted to director of the Advanced Technology Laboratory of Philco's Communications and Electronics div.



College graduates are penetrating more and more into industry. Now 58% of the graduates of men's colleges land jobs directly on the corporate payroll.

Business gets the lion's share of the college product because business *needs* it and can provide challenge and opportunity to the oncoming classes. About 88% of executive posts in business are held by college alumni, according to a recent study of the 100 largest corporations.

Business always will need the college-trained mind for the *brainpower* that management requires and the *brainwork* that research and development demand. Competition by business for the ablest graduates grows sharper every year.

But the cost of leadership is going up. The upward surge in our birthrate, plus a rapid rise in the percentage of high school students going on to college, has caught colleges in a financial squeeze. Some face serious shortages in classrooms, laboratories, libraries and, above all, in competent teachers.

Corporate support of higher education in ten years has risen substantially to more than $200 million for 1962. By 1970 this investment in educated manpower will need to reach $500 million annually if business wishes to insure the continued effective operation of the sources of supply.

College is business' best friend, certainly. But business recognizes that it must *give* as well as *get*. Higher education needs financial help and needs it now. Business should re-examine its needs and plan its support accordingly.

If you would like factual data on what the college crisis means to you, to business and to the nation, write for the free booklet: "COLLEGE IS AMERICA'S BEST FRIEND", c/o Higher Education, Box 36, Times Square Station, New York 36, N. Y.

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KEEP IT BRIGHT

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The advertisers listed here are seeking professional experience. Fill in the Qualification Form below.

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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.	84*	1
BELL AEROSYSTEMS CO Division of Bell Aerospace Corporation A Textron Company, Buffalo 5, N. Y.	93	2
COLLINS RADIO COMPANY Cedar Rapids, Iowa	22*	3
CURTISS WRIGHT CORPORATION Electronics Division Paterson, N. J.	66, 67*	4
DAYSTROM, INC. Electric Division Poughkeepsie, N. Y.	93	5
DOUGLAS AIRCRAFT CO. Missile & Space Systems Division Santa Monica, California	55*	6
GENERAL ELECTRIC CO. Apollo Support Department Daytona Beach, Florida	83*	7
GRUMMAN AIRCRAFT ENGINEERING CORP. Bethpage, L. I., New York	91, 92	8
HIGH VOLTAGE ENGINEERING CORP. Burlington, Mass.	75*	9
LOCKHEED MISSILES & SPACE COMPANY Sunnyvale, California	77	10
NASA MANNED SPACECRAFT CENTER Houston 1, Texas	80*	11
NATIONAL CASH REGISTER COMPANY Dayton, Ohio	84*	12
NORTHROP CORPORATION Beverly Hills, California	63*	13
PHILCO WESTERN DEVELOPMENT LABORATORIES Palo Alto, Calif.	20*	14
ROME AIR MATERIEL AREA (AFLC) Griffiss Air Force Base, Rome, N. Y.	94	15
U.S.A.F. INERTIAL GUIDANCE Maintenance and Standards Calibration Center, Newark Air Force Station Newark, Ohio	85*	16

• These advertisements appeared in the Jan. 11th. 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)

11863

☐ 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	☐ ....

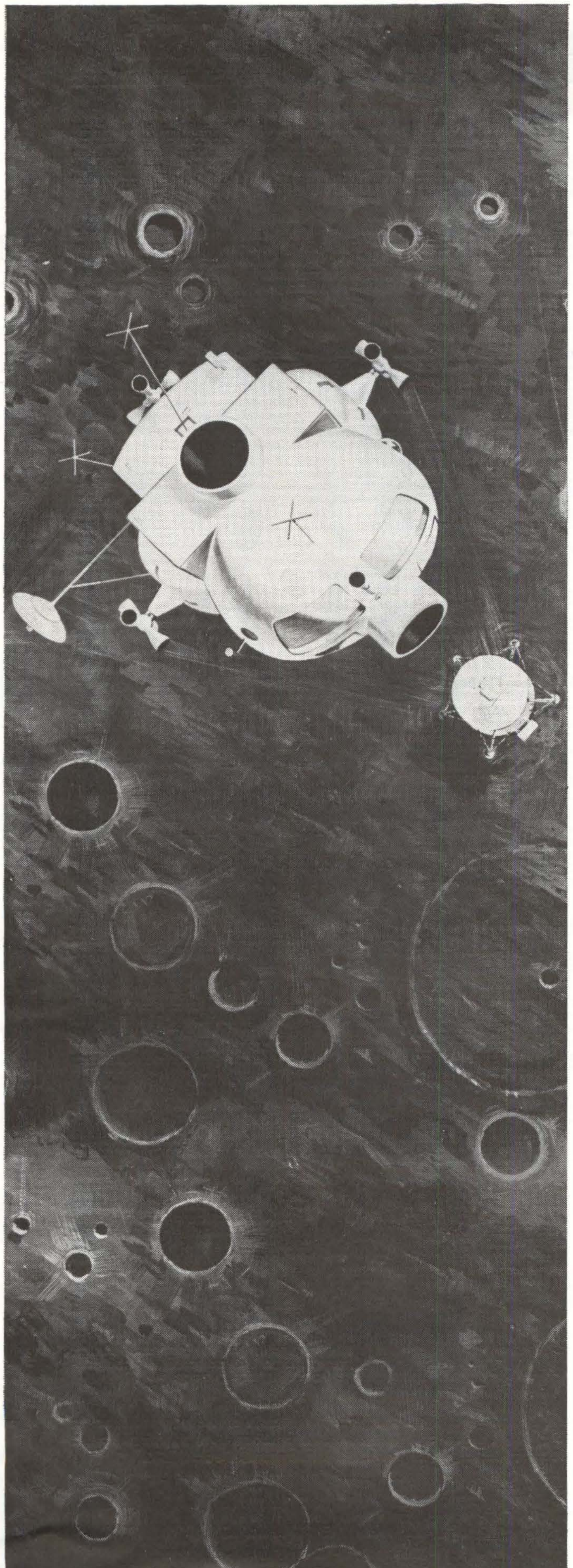
CATEGORY OF SPECIALIZATION

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

Explore these immediately available positions:

Antenna Design Engineers — B.S. in E.E. or Physics with a minimum of 3 years experience in antenna design. Background in classical electro magnetic theory and advanced math essential. Work consists of analysis and synthesis of antennas on current and advanced designs for space applications including the use of the IBM computer facilities to develop design techniques.

Radar Development Engineers — B.S.E.E. with a minimum of 4 years experience in the analysis, design and development of airborne radar systems. Should be capable of analyzing the radar system with the end view of integrating the equipment into a complex space vehicle system. Will fully participate in laboratory and flight development program conducted in the finest facilities available in a professional atmosphere.

Communications Systems Engineers — Electronic Engineers with thorough knowledge of communications techniques who wish to extend their technical background to new challenging areas. Should possess complete understanding of latest modulation techniques, as well as be knowledgeable of data handling requirements. An important phase of this effort will be extensive laboratory development programs in our Electronics Systems Center using the finest of equipment and facilities. B.S.E.E. with a minimum of 3 years experience.

Navigation & Guidance Systems Engineers — B.S. in E.E. or Physics with a minimum of 5 years experience in navigation and systems. Responsibilities involve the design and development of advanced guidance system for spacecraft. Must have demonstrated the ability to synthesize the system and carry it through from analytic concepts to development of hardware.

Flight Control Systems Engineers — E.E. or Physics degree with a minimum of 5 years experience in the design and development of auto-pilot and flight simulators. Work will involve the development of spacecraft flight control systems and the establishment of automatic test equipment requirements.

Space Power Engineers — E.E. or Physicist with understanding of electrical energy generation, thermodynamics and preferably some knowledge of direct conversion of electrical energy from heat and solar energy. To analyze and compare sizes, weights, efficiencies of various means of obtaining electrical energy from solar, nuclear and chemical energy; to perform preliminary design of secondary power systems for satellites and space vehicles; to participate in hardware development programs.

Data Processing Engineers — Background in digital data processing, logic circuit design, memory devices. R-F modulation techniques and related digital techniques required. Opportunity to participate in advanced design of systems concepts and hardware development. B.S.E.E. or B.S. in physics with a minimum of 3 years applicable experience is required.

Digital Circuits Engineers — Experience in logical design and transistor pulse circuit design for work on complex digital data systems. B.S.E.E. or B.S. in Physics with a minimum of 3 years applicable experience is required.

Television Systems Engineers — BSEE or BS in Physics with a minimum of 3 years experience in the fields of television systems. Work involves the analysis, evaluation, design and development of advanced television systems to be integrated into complex space vehicle systems. Considerable portion of effort involves laboratory and flight development programs.

Controls & Displays Systems Engineers — BSEE with 3 years experience in the design of controls and displays systems. A knowledge of the state of the art display techniques is essential. Responsibilities will include design and development of controls and displays systems for space vehicle systems.

Electronic Liaison Test Engineers — BSEE or equivalent with minimum of 8-10 years experience in one or more of the following areas: Inertial navigation, radar, digital computers, communications, power systems, RFI and flight controls. To be assigned, after suitable training, to test teams responsible for test plans as well as for directing factory technicians assigned to vehicle system tests. Expected to resolve technical problems as they arise. Field engineering experience desirable.

Instrumentation Systems Engineers — BS in EE, ME or Physics, with 2 to 7 years experience with either analog or digital instrumentation systems. Areas of particular interest are: Transducers, signal conditioners, commutation and data handling equipment.

Make 1963 a year of personal achievement in an endeavor that ranks among the greatest of all time. Mail the attached inquiry form to Mr. W. Brown, Manager, Engineering Employment, Dept. GR 76.

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Bethpage · Long Island · New York

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PROFESSIONAL PLACEMENT INQUIRY

For your convenience and to facilitate your inquiry, please use this form. It will enable the professional staff at Grumman Aircraft to evaluate your background and experience and arrange for a mutually convenient personal interview. All inquiries will be held in strictest confidence. Enclose in an envelope and send to Mr. W. Brown, Manager, Engineering Employment, **Dept.** GR76, Grumman Aircraft Engineering Corp., Bethpage, L.I., N.Y.

NAME_____

STREET ADDRESS_____

CITY & STATE_____ TELEPHONE_____

NEAREST MAJOR CITY (IF APPLICABLE)_____

COLLEGE GRADUATE: YES___ NO___ Degree Subject Year

Major Speciality_____Yrs.___Other Speciality_____Yrs.___

Applying for position(in)(of)_____

Background and experience (Brief resume of experience, recent history of employment)

To Men Who Can Look Deep Into Tomorrow

SENIOR LEVEL POSITIONS ARE OPEN NOW IN SPACE ELECTRONICS

ADVANCED R&D ENGINEERS
For work beyond the state-of-the-art associated with diversified product lines, involving solid state, controls and communications.

ADVANCED SYSTEMS ENGINEERS
For advanced systems work involving inertial guidance, command and control, radar and data link for application in armed helicopters, lunar landing, earth satellites, weapons and moon excursion vehicles.

LASER DEVELOPMENT ENGINEERS
For project engineering in the investigation of laser applications, and for theoretical analyses involving molecular quantum mechanics.

RADAR DEVELOPMENT ENGINEERS
For R&D work in solid state, circuit design, systems analysis and radar systems integration in both military contracts and company funded programs.

CONTROL SYSTEMS ENGINEERS
For systems and analysis work involving air traffic control, target locator, space electrical, visual simulator and feedback control systems.

OPTICAL SYSTEMS DEVELOPMENT ENGINEERS
For assignment to a variety of programs including visual simulators for space applications, fire control systems, telescopes and digital-to-voice converters.

Top echelon positions are open to men with vision at Bell Aerosystems Co. This growing organization today needs *more* senior scientists and engineers who can perceive where technology should go to meet tomorrow's aerospace requirements – and lead the way to advances beyond the existing state-of-the-art.

Vision coupled with sound engineering judgment has always been characteristic of this Company, as exemplified by such achievements as:

- HIPERNAS (HIgh PERformance NAvigational System), the most accurate, pure inertial, self-compensating navigation and guidance system known, diversely applied in strategic and tactical missiles, aircraft, space vehicles, ships and submarines.
- The FIRST all-weather, automatic aircraft landing system which can touch down 2 planes a minute even through dense fog.

Engineers and Physicists with thorough background in any of the areas listed are invited to inquire about these high level opportunities. Please address Mr. T. C. Fritschi, Dept. G16.

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Are invited to join the Daystrom Electric Scientists and Engineers whose ideas have contributed to new concepts in the field of ASW

The following opportunities offer unlimited professional growth in ASW applied research and systems project engineering:

SENIOR ELECTRONIC ENGINEERS

For research and advanced development in the areas of special study and application in ASW systems, design of electronic instrumentation, analytical and experimental treatment of scientific research problems in acoustics, electronics information theory, sound analysis, signal detection and processing, at sea applied research field trips, transistor circuit design.

MECHANICAL ENGINEER

Broad M.E. background, oceanographic instrumentation experience and knowledge of ship board handling equipment, design of special winches, hydraulic systems and oceanographic equipment. Alternate background acceptable is work experience similar to oil well drilling and logging equipment.

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Manage complete program of sonar transducer research and development. Responsible for project administration, planning, direction of proposals and technical guidance of the transducer engineering group.

ASSOCIATE ELECTRONIC ENGINEERS

Electronic Engineering graduate with one to two years work experience to enter the fields of acoustics, signal detection and oceanographic instrumentation.

COMPUTER SERVICE SUPERVISOR

Physics and mathematics major with Fortran and Format programming experience required. Assignments are in the math area of systems analysis, applied mathematics. Participate in operations research, systems evaluation; give analytical support to advanced R & D programs. Supervise associate mathematicians and programmers.

For additional information about these assignments Write to Mr. P. V. Peters . . . Please enclose resume.

DAYSTROM, INCORPORATED
ELECTRIC DIVISION
229 Manchester Road, Poughkeepsie, N. Y.

An Equal Opportunity Employer

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(Classified Advertising)

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The advertising rate is $27.25 per inch for all advertising appearing on other than a contract basis. Contract rates quoted on request. AN ADVERTISING INCH is measured ⅞ inch vertically on one column, 3 columns—30 inches—to a page. EQUIPMENT WANTED or FOR SALE ADVERTISEMENTS acceptable only in Displayed Style.

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CIRCLE 950 ON READER SERVICE CARD

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Positions Vacant	Civil Service Opportunities	Employment Agencies
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3 & 10 CM. SCR. 584 AUTOTRACK RADARS.
AN/TPS-1D SEARCH. AN/TPS-10 HT. FINDERS.
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AN/APS-15B PRECISION. AN/APQ-35B PRECISION.
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Audited Paid Circulation

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CLASSIFIED ADVERTISING
F. J. Eberle, Business Mgr.

INDEX TO CLASSIFIED ADVERTISERS

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• 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.

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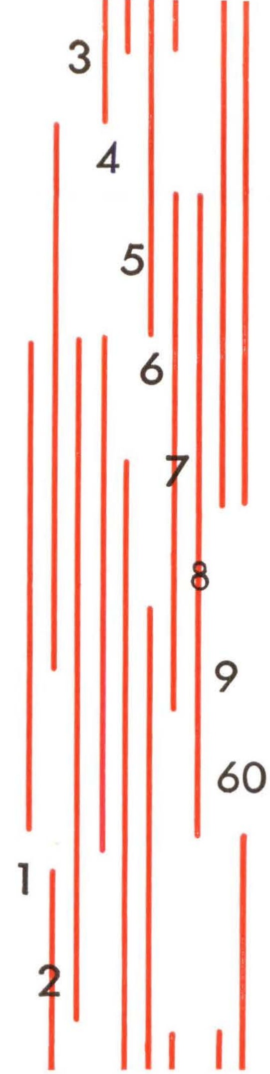

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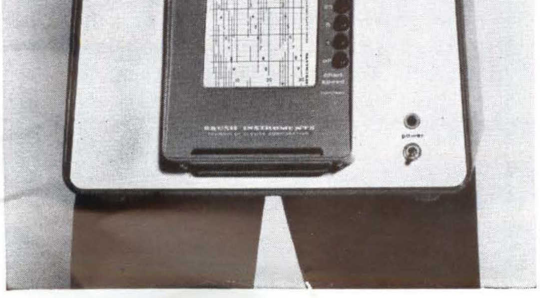

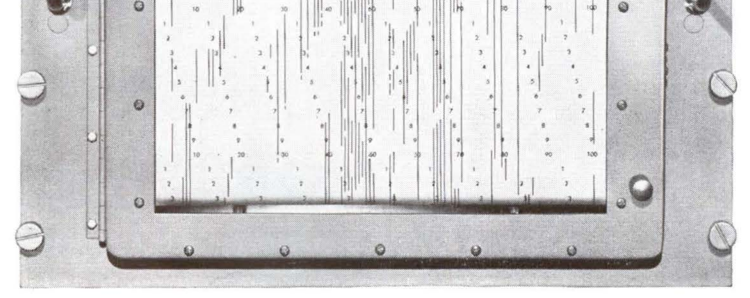

CIRCLE 901 ON READER SERVICE CARD

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RCA MEETS UNPRECEDENTED DEMAND FOR 2N2102, FIRST "UNIVERSAL" TRIPLE-DIFFUSED PLANAR SILICON TRANSISTOR.

RCA now announces mass-production availability of the 2N2102, the "universal" triple-diffused planar silicon transistor designed for widest possible application in military and industrial equipment. It can replace up to 40% of all silicon transistors now on the market and will cover a vast majority of your Small-Signal and Medium-Power Applications.

The RCA 2N2102 features high switching speed, high pulsed beta (h_{FE}) at $I_C = 1$ amp, and controlled beta from $I_C = 10\mu a$ to 1 ampere. It has high breakdown-voltage ratings, high dissipation ratings, low saturation voltages and low output capacitances.

RCA's line of triple-diffused silicon planar transistors now includes the 2N699 and 2N1613.

Call your RCA Representative today or write RCA Semiconductor and Materials Division, Commercial Engineering, Section IN 1-3, Somerville, N.J.

RCA-2N2270, New Economy Version of RCA "Universal" Triple-Diffused Planar Silicon Transistor Now Available in Production Quantities.

Now you get many of the performance and versatility features of RCA's 2N2102 in a new economy version, the RCA 2N2270. The 2N2270 offers one of the greatest price/performance values in transistors today. The 2N2270 features operation at high junction temperatures—up to 200°C...very low output capacitance—15 pf max...high minimum gain bandwidth product—60 Mc...useful in applications from dc to 20 Mc...JEDEC TO-5 package.

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