June 2, 1961

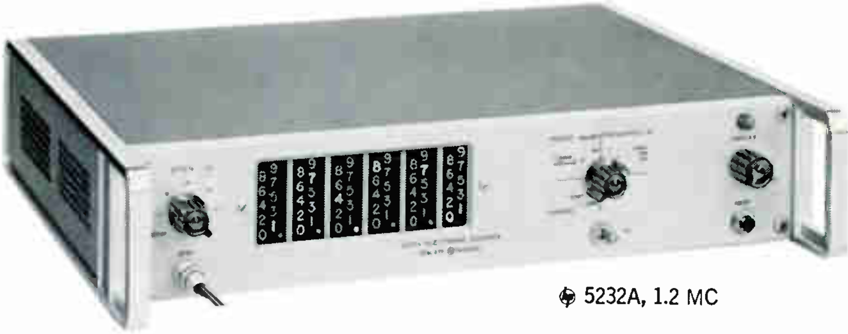
electronics

A McGraw-Hill Publication 75 Cents

Ultrasonic velocimeter being lowered from fantail of research vessel (right) measures speed of sound in sea water, p 41

Staggered-tuned f-m discriminator offers low distortion, p 44

hp 5212A, 300 KC



hp 5232A, 1.2 MC

COUNTERS!

sensitivity! Higher sampling rate! Unique low frequency accuracy! Operation −20° to +65° C! Prices comparable to vacuum tube counters!

Measurement		Frequency Measurement				Ratio Measurement			
Reads in	Periods Averaged	Range	Accuracy	Reads In	Gate Time	Reads	Range	Accuracy	Price
Millisec- onds with positioned decimal	1, 10, 10^2, 10^3, 10^4, 10^5	2 cps to 300 KC	± 1 count ± time base accuracy	KC with positioned decimal	10, 1, 0.1, 0.01 sec.	(f_1/f_2) x period multiplier	f_1:100 cps to 300 KC (1 v rms into 1,000 ohms) f_2: same as period	± 1 count of f_1 ± trigger error of f_2	$ 975.00
									1,175.00
Milli- seconds or microsec- onds with positioned decimal		2 cps to 1.2 MC					f_1: 100 cps to 1.2 MC (1 v rms into 500 ohms) f_2: same as period		1,300.00
									1,550.00

curacy in lower frequency ranges, even for noisy signals. Self-check is provided for both frequency and period measurement modes.

Only 3½" high, these counters are housed in the new hp modular cabinets ideal for both bench use and easy rack mounting. Routine maintenance is simple with snap-out decade/readout units and circuit cards. Readout drive directly from photoconductors eliminates a complete stage of complex circuitry, to effect genuine cost and reliability advantages. Compact design and construction and servicing ease are illustrated at the left.

Solid state design and construction gives you the advantages of low heat dissipation with minor heating effect on adjacent equipment, fast warm-up, low power consumption and new standards of reliability.

The new counters include a four-line BCD code output. This output, with assigned weights of 1-2-2-4, is available for systems use or to operate devices such as the hp 562A Digital Recorder. Front panel controls include Input Attenuation, Display, Reset and Function.

Call or write your hp representative or call us today for information and a demonstration!

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

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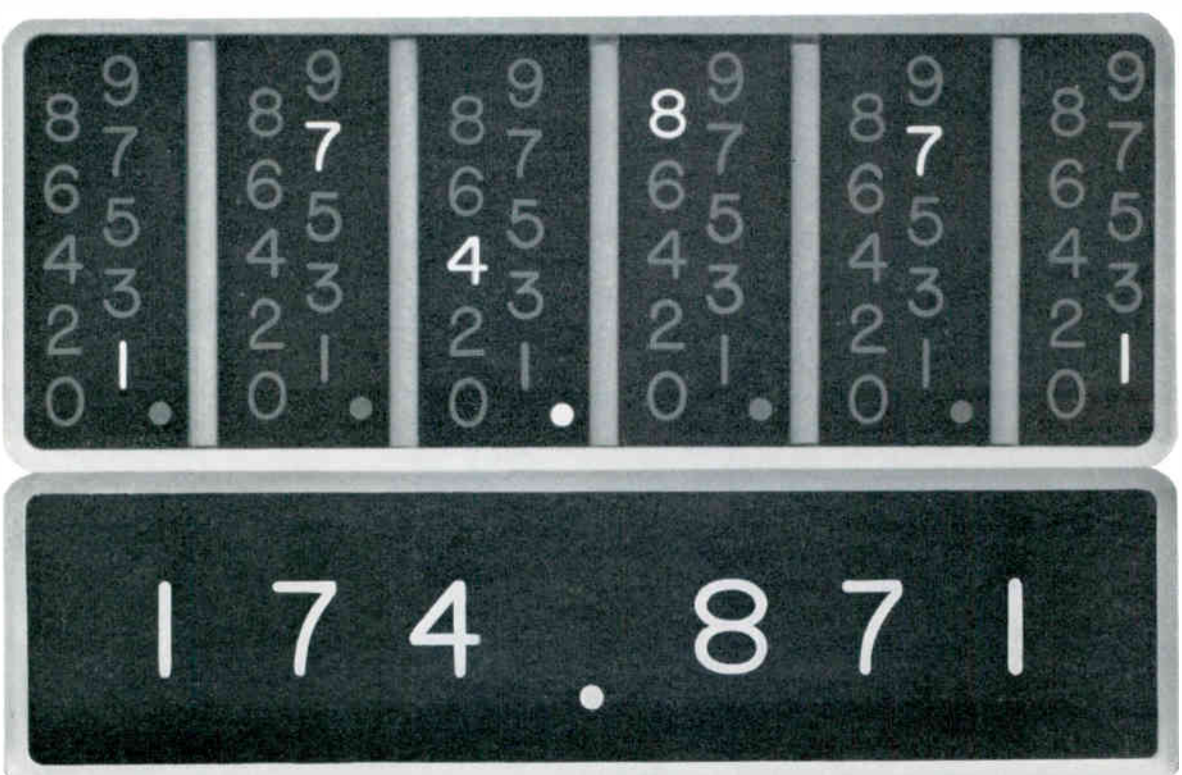
7061

Easier reading continuous display
Higher sampling rate
Multi-period average
Wide temperature range
Low-frequency accuracy
Versatile new modular design
Measurement flexibility, moderate cost

IN 4 NEW hp SOLID STATE COUNTERS!



Turn the page to learn about new measuring convenience, dependability from hp.

a pleasure to measure with these...

hp 5512A, 300 KC

hp 5532A, 1.2 MC

4 NEW SOLID STATE

Measure frequency, period, ratio, quickly, accurately. Compact, easy-to-use instruments provide continuous display, no "blinking"! Solid-state dependability! 0.1 volt

All the advantages of solid-state design are now yours in these new hp solid state counters—offered at prices comparable to those of today's vacuum tube counters. And you get the *plus* advantages of greater readability, faster measurements, easier routine maintenance, rack-and-stack convenience of the new hp universal module instrument cabinets.

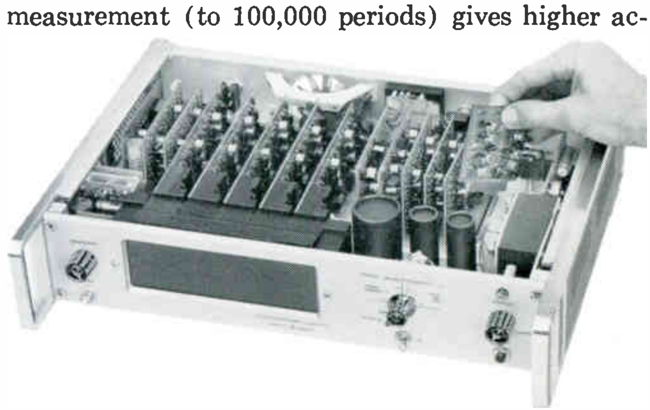
Offered in four models, these new counters have maximum counting rates of 300 KC or 1.2 MC, with a choice of Nixie or columnar readouts. The high-intensity neon readouts are stacked in compact columns for faster, easier reading. On the in-line readouts, hp-pioneered standard incorporation of the new long-life, wide-viewing Nixies gives you many extra hours of lamp life and heretofore unknown readability even at extreme angles. Polarized screen provides maximum readout brilliance with freedom from reflections.

A unique display storage feature of these new counters produces a continuous visual readout of the most recent measurement, even while the instrument is making a new measurement. Only if the new count differs from the previous count will the display change, in which case it will shift directly to the new reading. The fatigue and error possibility of a "blinking" display is eliminated. The storage feature may be disabled with a rear panel switch.

The counter's "inactive time" (when not making a new measurement) is independent of gate time and adjustable from 0.2 to 5.0 seconds, thus permitting a higher sampling rate.

Counter	Max. Counting Rate	Registration	Period	
			Range	Accuracy
5212A	300 KC	5 digits columnar	2 cps to 10 KC in single period; up to 300 KC in multiple period average	± 10 μs ± time base accuracy ± trigger error/ periods averaged
5512A	300 KC	5 digits Nixie		
5232A	1.2 MC	6 digits columnar	2 cps to 10 KC in single period; up to 1 MC in multiple period average	± 1 μs ± time base accuracy ± trigger error/ periods averaged
5532A	1.2 MC	6 digits Nixie		

High sensitivity permits low level measurement without accessories, and multiple period average measurement (to 100,000 periods) gives higher ac-



Note clean, compact, easy-to-service physical arrangement of new hp solid-state counters.

June 2, 1961

electronics

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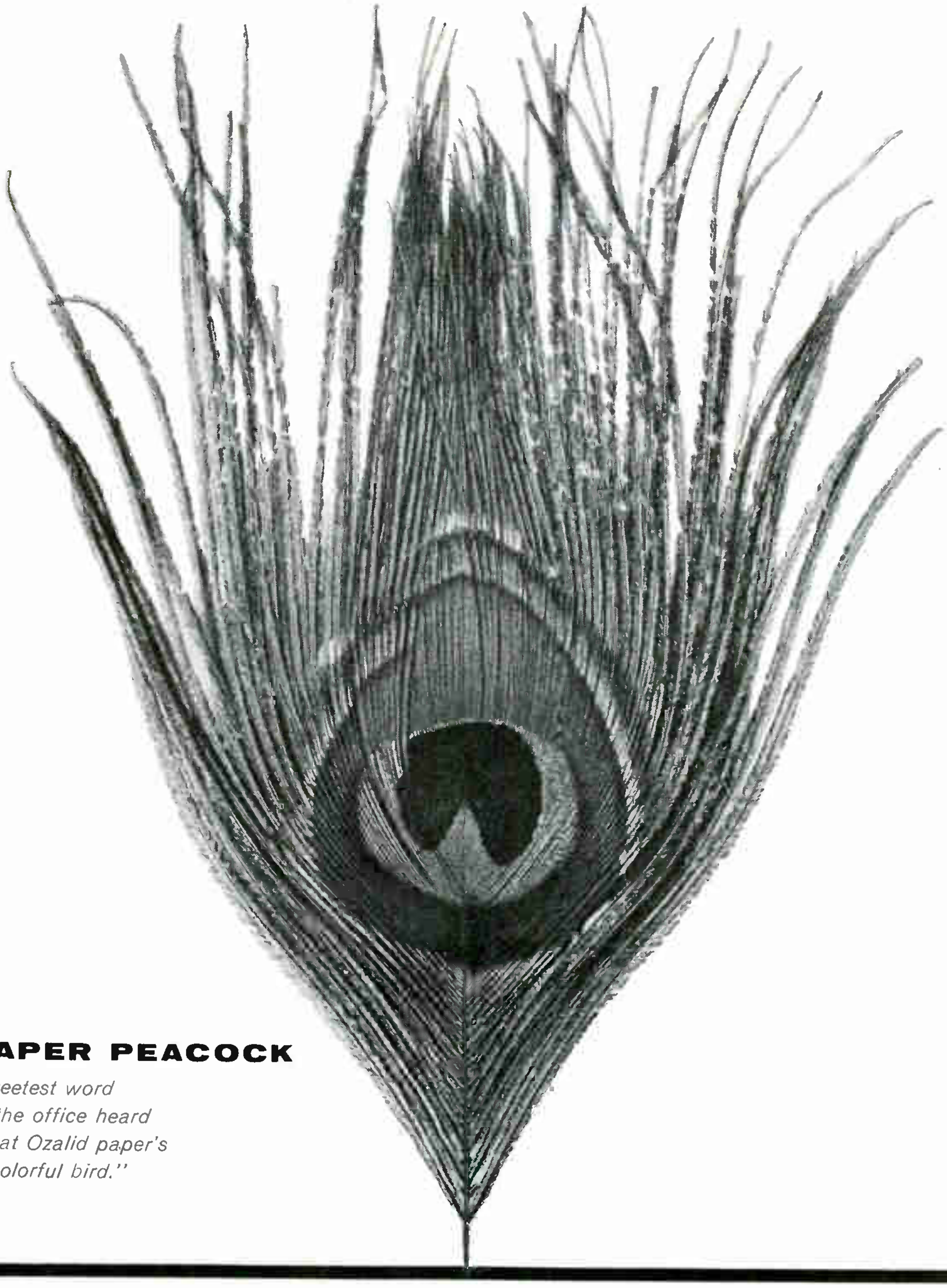
W. W. MacDONALD, Editor

BUSINESS

ENGINEERING

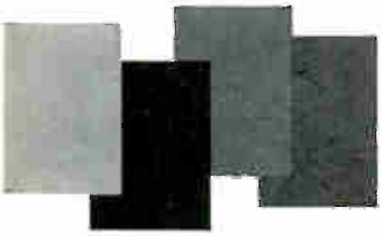
DEPARTMENTS



PAPER PEACOCK

Sweetest word
in the office heard
"that Ozalid paper's
a colorful bird."

The peacock, they tell us, flaunts color to win attention. (From lady peacocks, we presume). You, too, can attract attention with color. But in a more businesslike way. With Ozalid Sensitized Papers you can color-code any engineering or business system. Speed and simplify paperwork. Eliminate routing errors. Make sure important or top secret documents get instant action when needed. In engineering, for example, "blueprints" no longer need be blue. Office systems—production control, order-invoicing, income tax returns—can be coded by function, status, time or destination. Sales bulletins, charts, graphs, presentations can be brightened... made more effective by color. Want to simplify, error-proof your office system? Show your colors! Our booklet "Color says so much . . . so much faster" tells you how. Send for it today. Ozalid, Dept. 184, Johnson City, N.Y.



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DIVISION OF GENERAL ANILINE & FILM CORPORATION

SIGNAL SOURCES

direct reading, self contained...

X772A

- 4 MODELS COVER RANGES FROM 0.95 KMC TO 11.0 KMC
- MODULATED AND CW OUTPUT
- AMPLE POWER FOR NORMAL REQUIREMENTS

SERIES 772 SIGNAL SOURCES

- Single control tuning
- ±1% frequency accuracy
- Pulse or square wave modulation, internal or external
- 10 mw to 100 mw max. CW power output
- Regulated internal power supply

Truly unique in the industry, the FXR family of signal sources provides full coverage from 0.95 KMC through 11.0 KMC. Power output is more than ample for most test requirements. The sources provide for the use of internal or external modulation, either pulse or square wave, or external FM. Design features include an internal, regulated power supply and frequency tuning dial accuracy of ±1% throughout the range. This frequency tuning accuracy is always assured by automatic variation of the klystron reflector voltage simultaneous with positioning of a broadband, non-contacting tuning plunger within the oscillator cavity. Each model is a compact self-contained unit ready for laboratory or field use.

DELIVERY FROM STOCK

	FREQUENCY RANGES	PRICE
MODEL L772A MODEL S772A MODEL C772A MODEL X772A	0.95 to 2.0 KMC 1.9 to 4.0 KMC 3.95 to 8.2 KMC 7.0 to 11.0 KMC	$1340. $1340. $1340. $1340.
FREQUENCY ACCURACY	±1%, all models	
POWER OUTPUT	10 mw to 100 mw max CW output power variable by front panel control through use of an internal level-set attenuator	
MODULATED OUTPUTS	Internal: CW, pulse or square wave External: Pulse, square wave or FM	
EXTERNAL MODULATION REQUIREMENTS	Pulse: positive pulse of 30 v. amplitude across 100 K ohms. Pulse width from 1 microsecond to square wave Reflector: sine wave or sawtooth FM, sensitivity from 100 to 200 kc/v	
CONNECTORS	RF Output—Type N jack External Pulse—Type BNC jack Reflector Modulation—Type BNC jack	
POWER REQUIREMENTS	115/230 v. AC, 50 or 60 cycles, 150 w.	
DIMENSIONS	11" high x 16" wide x 15" deep	
NET WEIGHT	45 lbs.	

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electronics
June 2, 1961 Volume 34 Number 22

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CROSSTALK

SPECIAL REPORT. The conference photographed above took place some weeks ago. But you can tune in on it next week by reading Chief Editor MacDonald's special report about "Electronics In Europe".

The picture was taken at Siemens in Germany, where MacDonald (fifth from right) had a lengthy talk with the company's top engineers and executives.

This scene was duplicated time and again as he visited scores of plants, talked with hundreds of industrialists, picked up novel schematic diagrams and informative photographs, and lived—day and night—with electronics in Europe.

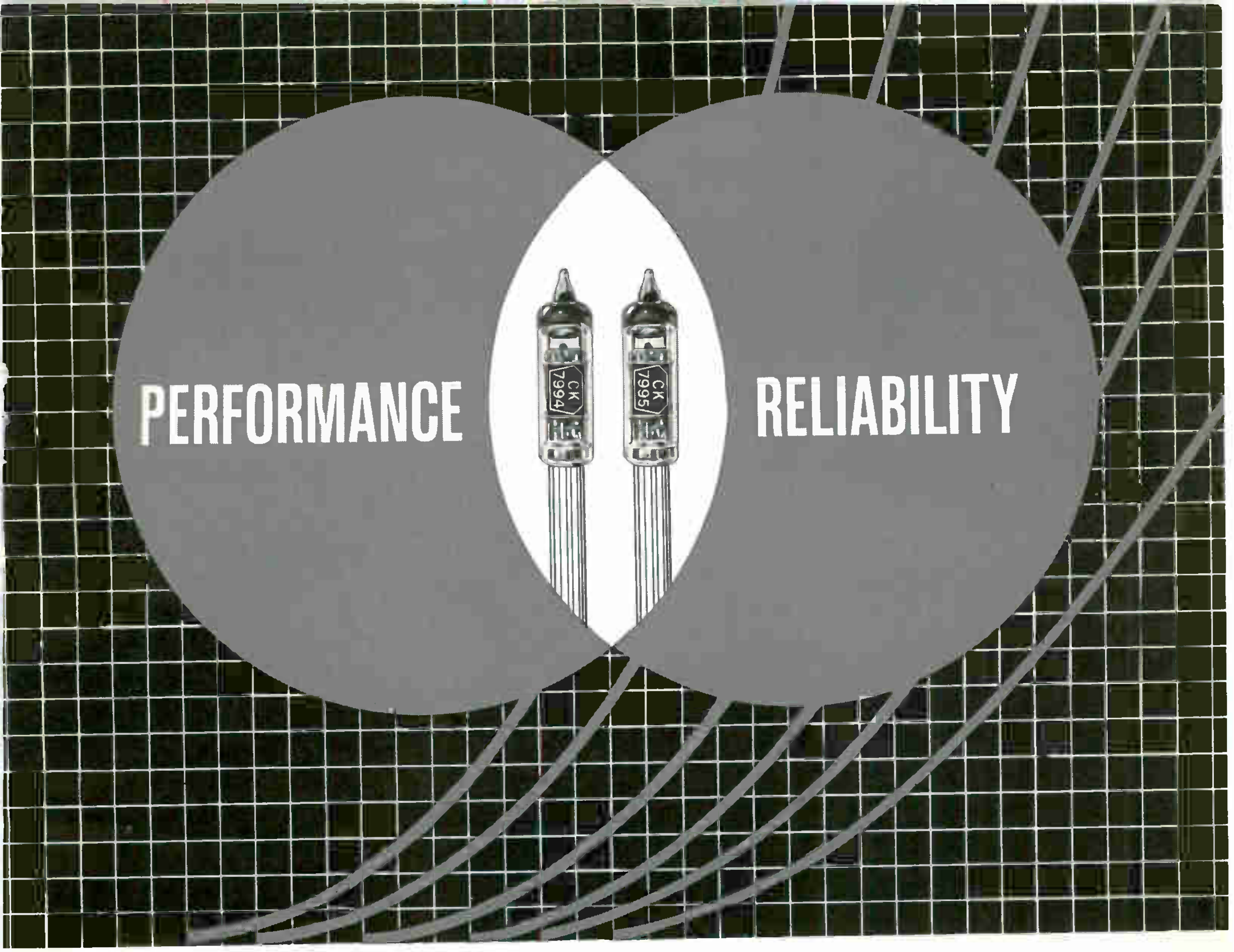
HARMFUL PATENT LEGISLATION. The subcommittee on patents, copyrights and trademarks of the Senate Committee on the Judiciary is currently considering two bills which could do a great deal of harm to the electronics industry—and might just backfire on the government as well.

The two bills (S. 1084 and S. 1176) are sponsored by John L. McClellan (D., Ark.), who is chairman of the subcommittee, and Russell B. Long (D., La.). They have the common aim of requiring federal agencies to take title to patents on any inventions developed in the performance of government contracts. Senator Long's S. 1176 is the more extreme bill; it would jeopardize the rights of the inventor to any invention made during the term of a contract, whether the invention was related to contract performance or not, since judgment of the relationship between an invention and a contract would be at the discretion of an Administrator of Federal Inventions.

The clear injustice of the proposed legislation is that it can grant to the government property for which the government has not paid. Federal agencies rarely contract for an invention; they usually contract for goods or services. In these cases, if inventions are made by a supplier to provide the goods or services more efficiently, that is contractually none of the government's business; in the philosophical sense of the word, it is an accident. Throughout the long history of letters patent, they have traditionally been privately held, although sometimes assigned to corporate or public entities.

Reaction to the proposed legislation so far indicates that the government could hurt itself by being thus acquisitive. Some British firms (see Electronics Newsletter, p 12, May 19) have already indicated that they will hesitate to take on projects in which they may be working for the U. S. government—as in NATO contracts, for instance. Undoubtedly there will be U. S. companies who will react identically. The result may be a net reduction in the brainpower and manpower made available to federal agencies.

It would be healthier if this legislation were killed before it emerged from its committee hearings. If our republic is to be based on free enterprise, this keystone of free enterprise—the right to own and exploit the product of one's inventiveness—must be kept safe. Your senators should be speedily informed of your reaction to these bills.



New Raytheon Frame Grid Subminiatures

fill the gap with highest Gm / Ip / size available

CHARACTERISTICS AND TYPICAL OPERATION

	CK7794	CK7795
HEATER VOLTAGE	6.3 Volts	6.3 Volts
HEATER CURRENT	0.3 Amps	0.3 Amps
PLATE VOLTAGE	100 Volts	150 Volts
GRID #2 VOLTAGE		150 Volts
CATHODE BIAS RESISTANCE	82 Ohms	160 Ohms
GRID #1 VOLTAGE	0 Volts	0 Volts
PLATE CURRENT	15 mA	8.0 mA
GRID #2 CURRENT	—	2.0 mA
PLATE RESISTANCE	25 K Ohms	0.1 Meg Ohms
TRANSCONDUCTANCE	18,000 μmhos	13,000 μmhos
AMPLIFICATION FACTOR	43	—
Ecl for Ib = 10 A	−6 Volts	−6 Volts

There's no longer any need to sacrifice performance and reliability for small size. Raytheon frame grid subminiatures now fill your design needs with extremely compact tubes of higher gain bandwidth product, lower noise figure, and greatly increased reliability. Two subminiatures with exceptionally high transconductance to plate current ratios are immediately available.

The CK7794 is a triode with a transconductance of 18,000 μmhos at a plate current of 15 mA. The CK7795, a sharp cutoff pentode, features 13,000 μmhos at 18 mA. Both types are precisely fabricated with perfect pitch frame grids of high uniformity of spacing and characteristics. Maximum reliability is assured through the excellent mechanical rigidity of the grid structure.

Raytheon frame grid subminiature tubes remove the limitations imposed upon your designs by tubes with conventional grid construction. For optimum performance consider the many advantages offered by the growing line of frame grid tubes from Raytheon, leading manufacturer of subminiature tubes.

Full technical data may be obtained by writing to: Raytheon, Industrial Components Division, 55 Chapel Street, Newton 58, Massachusetts.

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COMMENT

Computers Today

I was delighted to receive a copy of your special report on computers ("Computers Today," p 63, Apr. 28). It certainly contains a wealth of information regarding the present status of this industry, and suggests the general directions toward which we are pushing. Articles such as this serve as useful reviews for members of the electronic data-processing industry and for others in engineering management who wish to stay abreast of dynamic technologies.

E. R. PIORE
INTERNATIONAL BUSINESS MACHINES CORP.
NEW YORK

I've just received my copy of the April 28 issue of ELECRONICS, and in glancing through the feature "Computers Today" my first reaction was to compliment you on a most comprehensive story. However, the section on Data Communication refers to a dozen different companies which market data-transmission systems, but fails to mention the Digitronics Dial-o-verter. The Dial-o-verter system is truly functioning hardware; it was introduced and demonstrated seven months ago. It is transmitting and receiving data over the regular telephone dial network at the rate of 1,000 words per minute, complete with error detecting and correcting facilities.

The equipment functions with any of the business-machine media: paper tape, punched cards or magnetic tape; it can transmit in one medium at one point and have it received in another medium at the other point—paper tape to magnetic tape, punched cards to paper tape, and so forth . . .

LESTER KRUGMAN
DIGITRONICS CORP.
ALBERTSON, N.Y.

There were naturally some aspects of the computer technology that were not covered as deeply or completely as we would have liked. Just listing all producers and their products would have taken up more space than we devoted to the report, and would have left us no room for the interpretive analysis that we set out to do.

I am writing to tell you that the people here at Wellesley's electronic data-processing division were very much impressed with the special report on computers that appeared in the April 28 issue of ELECTRONICS.

Many of the people here feel that this is one of the best undertakings of its kind that has ever been done . . .

F. A. WESTBROOK JR.
MINNEAPOLIS-HONEYWELL REGULATOR CO.
WELLESLEY HILLS, MASS.

Discriminator Without Coupling

I am working on the subject of a discriminator without magnetic coupling for an M.Sc. project at Israel Institution of Technology.

In the course of this project, I came across the article "Camera Control System for Rocket-Sled Tests" (p 63, Apr. 1 '60), and had difficulty in understanding the exact operation of the discriminator included there.

I would be grateful to you if you could refer this to the right people in order to get a more detailed explanation of the operation of that discriminator.

JOSEPH SHAPIRA
TEL AVIV, ISRAEL

We referred the request to the author of the article, who wrote:

. . . The people who did the work on the discriminator adapted the circuit from published material. I believe the configuration originated at RCA, but I am not certain. As a suggestion, you might find it helpful to redraw the circuit in the form of a bridge; this expedient might aid in the analysis . . .

FLOYD M. GARDNER
GARDNER RESEARCH CO.
ORANGE, CALIF.

Rectifier Circuits

I find a drafting error in "Improving Rectifier Circuits," p 88, Apr. 7. The filter inductor has been omitted from part (F) of the published figure. Without it, the circuit will not work as described.

G. FRANKLIN MONTGOMERY
NATIONAL BUREAU OF STANDARDS
WASHINGTON, D. C.

The inductor should be between the junction of D_1 and D_2 and the capacitor.

SILICON RECTIFIERS

Higher ratings in smaller packages . . . that's what Motorola's new 1N3282 series offers the design engineer for simpler, more reliable circuitry. These all-new high-voltage glass, silicon rectifiers eliminate the need for using several lower-voltage units in series. Thus, circuit engineering is easier . . . circuits cost less . . . reliability is increased . . . space requirements are reduced.

Packaged in subminiature, hermetically-sealed glass packages, these economical new rectifiers offer dramatically increased voltage ratings of 1000 to 3000 PIV, with a current rating of 100 mA @ 25°C, low forward voltage drop, and 150°C junction temperature. Sealed glass packaging accomplished in a closely controlled, high pressure gaseous atmosphere, provides a high dielectric constant. Being similar in size to a ¼ watt carbon resistor, the 1N3282 series is small enough to be ideal for printed circuit design.

RATING	SYMBOL	1N3282	1N3283	1N3284	1N3285	1N3286
Peak Inverse Voltage DC or Recurrent	PIV	1000	1500	2000	2500	3000
Sine Wave RMS Input Voltage	V	700	1050	1400	1750	2100
Average Half-Wave Rectified Forward Current (25°C Ambient) mA (100°C Ambient)	I_F	100 50	100 50	100 50	100 50	100 50
Peak Forward Current @ 25°C (½ Cycle Surge, 60 cps) (Recurrent) Amps	I_{surge} I_{rec}	2.5 0.50	2.5 0.50	2.5 0.50	2.5 0.50	2.5 0.50
Maximum Ambient Temperature	T_A °C	150	150	150	150	150

Immediately Available — Motorola's new 1N3282 series rectifiers are available from your Motorola Semiconductor Distributor.

MOTOROLA DISTRICT OFFICES: Belmont, Mass. / Burlingame, Calif. / Chicago / Clifton, N. J. / Dallas Dayton / Detroit / Glenside, Pa. / Hollywood / Minneapolis / Orlando, Fla. Silver Spring, Md. / Syracuse / Toronto, Canada.

For complete technical information on the 1N3282 series request data sheet #DS6009 from your Motorola Semiconductor District Office or write: Technical Information Center, Department HR, Motorola Semiconductor Products Inc., 5005 East McDowell Road, Phoenix 10, Arizona.

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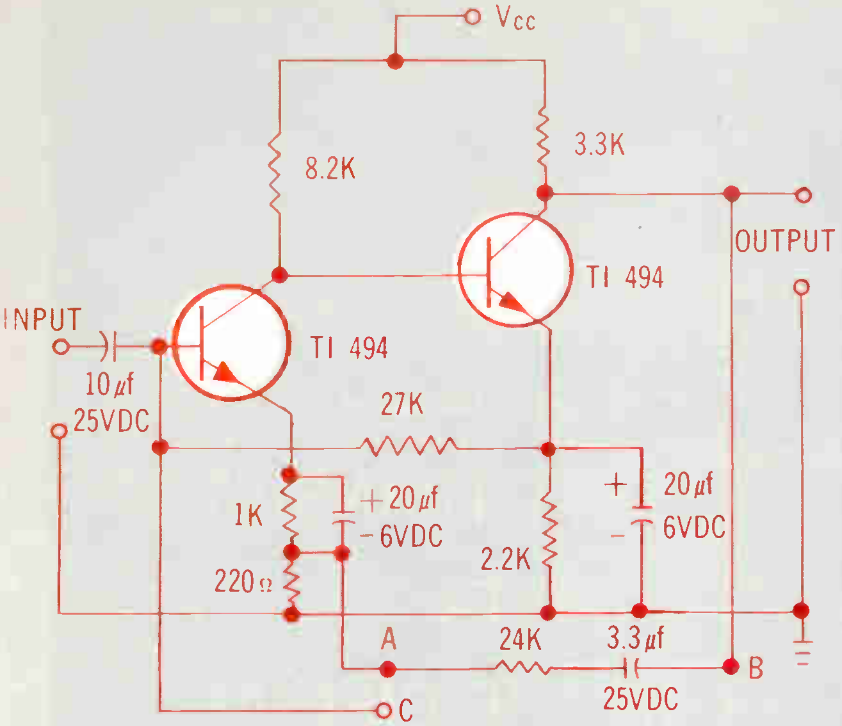
CIRCLE 7 ON READER SERVICE CARD



Multipurpose Industrial Amplifier

Typical Characteristics:

Voltage Amplification	40 db (nominal)
Frequency Response	±3 db from 10 cps to 1 mc
Input Impedance	20KΩ @ 1 kc
Output Impedance	less than 50 ohms @ 1kc
Max Input Voltage	80 mv (rms)
Supply Voltage	10 to 25 volts dc
Temperature Range	−20°C to +100°C

Versatility—

The basic amplifier circuit also may be utilized as a sensitive a-c voltmeter, tuned amplifier or tuned oscillator simply by employing different networks between terminals A and B or C and B.

HOW TO GET HIGH TEMPERATURE STABILITY AND INDUSTRIAL ECONOMY

With New TI Low-Cost Silicon Industrial Transistors . . .

You can assure your customers optimum circuit performance up to 125°C when you design-in new, low-cost TI silicon industrial transistors. Priced comparable to lower-temperature industrial devices, these new TI silicon industrial units provide the high performance your industrial designs require.

Get greater margins of operational safety by applying these new silicon industrial transistors to your process control, communication, aviation system, electronic instrumentation, and computer applications today.

CHARACTERISTICS					APPLICATIONS					
TYPE	MIN BV_{CBO}	DC Beta Range	MAX I_{CBO} @ 100°C	$f_{\alpha b}$ (typ)	Servo and Relay Driver	Audio Amplifier Medium Speed Switches †	Audio Amplifier Medium Speed Switches ‡	High Speed Switches	RF Amplifier (to 40 mc)	VHF Amplifier (to 100 mc)
TI 480	50 v	9—36* @ 5 ma	50 μa @ 30 v	1 mc	TI 480					
TI 481	80 v	9—36* @ 5 ma	50 μa @ 30 v	1 mc	TI 481					
TI 482	20 v	>20 @ 30 & 150 ma	50 μa @ 10 v†	60 mc			TI 432		TI 482	
TI 483	40 v	20—60 @ 150 ma	50 μa @ 30 v†	60 mc			TI 483		TI 483	
TI 484	40 v	40—120 @ 150 ma	50 μa @ 30 v†	60 mc			TI 484		TI 484	
TI 485	20 v	15—60 @ 10 ma	20 μa @ 15 v†	200 mc				TI 485		TI 485
TI 492	40 v	15—45* @ 1 ma	50 μa @ 30 v	8 mc		TI 492				
TI 493	40 v	15—45 @ 10 ma	50 μa @ 20 v	20 mc		TI 493				
TI 494	40 v	40—125 @ 10 ma	50 μa @ 20 v	20 mc		TI 494				
TI 495	40 v	120—250 @ 10 ma	50 μa @ 20 v	20 mc		TI 495				

*AC Beta   † I_{CBO} @ 125°C   †100 μa to 20 ma   ‡20 ma to 300 ma

ELECTRONICS NEWSLETTER

Thin-Film Sandwich Produces Multiple-Interface Amplifier

METAL-INTERFACE AMPLIFIER developed as a new means for achieving electronic amplification was demonstrated last week by scientists of Philco's research center. New Philco research v-p Donald Fink said "experimental devices have been successfully tested, leading the way to a family of active components which theory indicates will outclass the transistor in substantially all respects."

The MIA is a room-temperature thin-film device. Common-emitter current gain of about 20 and common-base current gain of 0.9 have been measured. Power gain has not been disclosed. In measurements of common-emitter current gain against frequency, conducted on first unit, cutoff occurred at 100 Kc.

As described by Philco scientists, the structure was fabricated by evaporation of aluminum film about 100 angstroms thick on the etched surface of a 1 ohm-cm *n*-type of germanium. A 20-A oxide film was then formed on the surface of the aluminum film, and a gold film evaporated over the oxide to serve as the electron source.

Another series of Philco experiments is studying the use of electroquenchable phosphors for displays. Devices are made of doped sulfides, would be subjected to ultraviolet radiation and then selectively quenched by application of a few volts of d-c to selected areas. Electrical contacts have been developed that are said to be thin, highly conductive, and capable of being deposited on phosphor film with high definition. Crosstalk between channels is low, indicating that high packing densities are possible.

Davis Reelected President Of Industry Association

ELECTRONICS INDUSTRIES Association board of directors, meeting in Chicago at the close of the 37th Annual EIA Convention last Friday, reelected L. Berkley Davis, a GE vice president, as president. L. F. Muter, president of the Muter Co., was named to his 26th term as treasurer. Also reelected were: James D. Seacrest, executive vice president; John B. Olverson, general counsel; Robert S. Bell of Packard-Bell, senior vice president; Sidney R. Curtis, General Dynamics/Electronics, vice president; Ben Adler, Adler Electronics, vice president; and W. S. Parson, Centralab division of Globe Union, vice president. George W. Keown, a Tung-sol vice president was elected to his first term as EIA vice president.

Inspection Satellite May Orbit In Two Years, Air Force Says

AIR FORCE is now officially saying it may have its SAINT (satellite inspection) satellite operating within "a couple of years." The SAINT is one of three or four programs designed to orbit a satellite for tracking down and possibly destroying hostile satellite vehicles.

SAINT will weigh between one and two tons, will go aloft on an Atlas-Agena B booster. It is designed to home on other satellites by radar and inspect them with a small television camera.

Navy is working on two similar countersatellites. One program, dubbed Dog Leg, would use a small nuclear charge to destroy satellites. The other, called Notsink, would launch a countersatellite from high-flying aircraft. Advanced Research Projects Agency is also believed to be considering a countersatellite called Somnium.

Budget Increases Favor Space, Limited-War Arms

ADMINISTRATION REQUESTS for increased spending authority last week stressed conventional arms and equipment on the one hand, and space exploration on the other.

Pentagon's pending appropriation request for Army procurement was boosted $100 million to speed up modernization of combat units. Defense Department also reshuffled its procurement plans by setting aside another $100 million to buy tactical equipment for guerrila and other limited-war military forces. Much of this money will go for advanced types of long-range radio gear. $1,885 million was asked for the Military Assistance Program.

To get a man on the moon before 1970 will cost an additional $531 million this year and $7 to $9 billion more over the next five years, the President said.

Highlights of proposals for additional appropriations for 1962 included $376 million for R&D and $143 million for construction. The R&D money includes $130 million for the three-man Apollo spacecraft; $56 million for lunar and planetary exploration; $50 million for communications satellites; $75 million for weather satellites ($22 million of this goes to NASA to keep the Tiros satellite going up until the high altitude Nimbus is ready, and $53 million to the Weather Bureau for operational ground systems to support Tiros); $8 million for scientific satellites; $12 million for launch vehicles and orbital rendezvous studies; $15 million for liquid propulsion; $48½ million for airframe design for the 1½-million-pound-thrust F-1 engine; and $30 million for the Rover nuclear rocket.

The $143 million for construction and facilities includes $5 million for tracking stations; $28 million for Nova launch facilities development; $60 million for a new manned space flight lab. Also proposed: NASA hire 3,300 more employees.

Garnet Oscillator Developed As Frequency Translator

GARNET OSCILLATOR developed at the USAF Cambridge Research Labs generates pulsed microwave in the millimeter band from lower frequency inputs. Unlike a maser, the device operates at room temperature. Air Force thinks of it as a frequency translator rather than an amplifier. Oscillator design is based on the physics of electron spin coupled with magnetic field effects, rather than on the shift in energy levels.

The device was developed by F. C. Morgenthaler and M. Stiglitz; their design has been adopted by Stanford Research Institute scientists, who have built an oscillator to convert S band inputs to 60-Gc outputs. Inventors told ELECTRONICS that there is no theoretical limit to output frequency, but the design of the cavity and other parameters set practical engineering limits.

In the first models, yttrium iron was used as a cavity material. Low-power r-f is used to start the spin. Pulsed currents are sent through a coil surrounding the cavity. The output frequency varies with the strength of the magnetic field which biases the cavity to resonance.

Favor Mercury Funds For Booster Development

MINORITY VOICE on the importance of Mercury and other astronaut programs was heard in Chicago last week. C. Stark Draper, head of MIT's instrumentation lab, commented at the National Telemetering Conference that funds now being channeled into repetitions of Alan Shephard's flight would be more scientifically useful in producing giant boosters of the type that already exist in the Soviet Union, for future Saturn, Nova and other U. S. space programs.

He noted that Shepard's ride gave the U. S. taxpayers a psychological lift that was valuable, but that the U. S. should bypass present plans to put six or seven more astronauts through similar flights. Instead, the U. S. should develop craft capable of carrying crews of men, able to move around, make decisions and operate controls.

Telemetry Conference Discusses European Systems

NATIONAL Telemetering Conference held last week in Chicago included a workshop on Telemetry in Europe at which latest uses of telemetering systems in seven European countries were discussed.

G. Y. Fokkinga, Amsterdam, described a gyrostabilized system to measure movements of the tides and height and frequency of waves. System puts out 2 w on 158 Mc from the open sea, is augmented by a 170-Mc stakeout closer to shore to warn of possible floods. Netherlands engineers have also developed an optical reducer for demultiplexing telemetered information from positive copy recorded on 35-mm film.

Italian distance-measuring equipment which integrates many time delays reduces error of usual radar-type system, says F. A. Pentini of Rome. A. E. Dorsimont, Brussels, described a solid-state pulse-coded railroad security system using a two-counter matrix decoder. He also discussed a radioastronomy effort to sample hundreds of discrete points on the solar surface and also to measure temperatures on rockets in flight.

Most United Kingdom effort is concentrated on prototype aircraft and pilotless target craft for testing missiles, according to A. Cowie, London. UK uses eight conventional f-m/f-m subcarriers at about 400 Mc. With 10 Mc being sliced from the band in 1962, crystal frequency controls will be needed, Cowie said.

Satellite Communications Said to Be Worth High Cost

FIRST GENERATION communications satellite system to be launched by the U. S. within the next five years will cost $250 million, including ground network and maintenance, over the following decade—but it'll be worth it. So said vice-president G. Mueller of Space Technology Labs at the Globecom V symposium luncheon in Chicago last Wednesday.

Mueller said that the system will help meet the need for trunkline communications, expected to expand an order of magnitude over the next decade, at a thirtieth the cost of equivalent cable service today. Future improvements in cables may reduce the satellite advantage to one third cable cost. First half dozen or so satellites will resemble Advent, fitted with solar cells and storage batteries for active relay in the 1-to-10-Gc range.

Air Agency Starts New Control Center

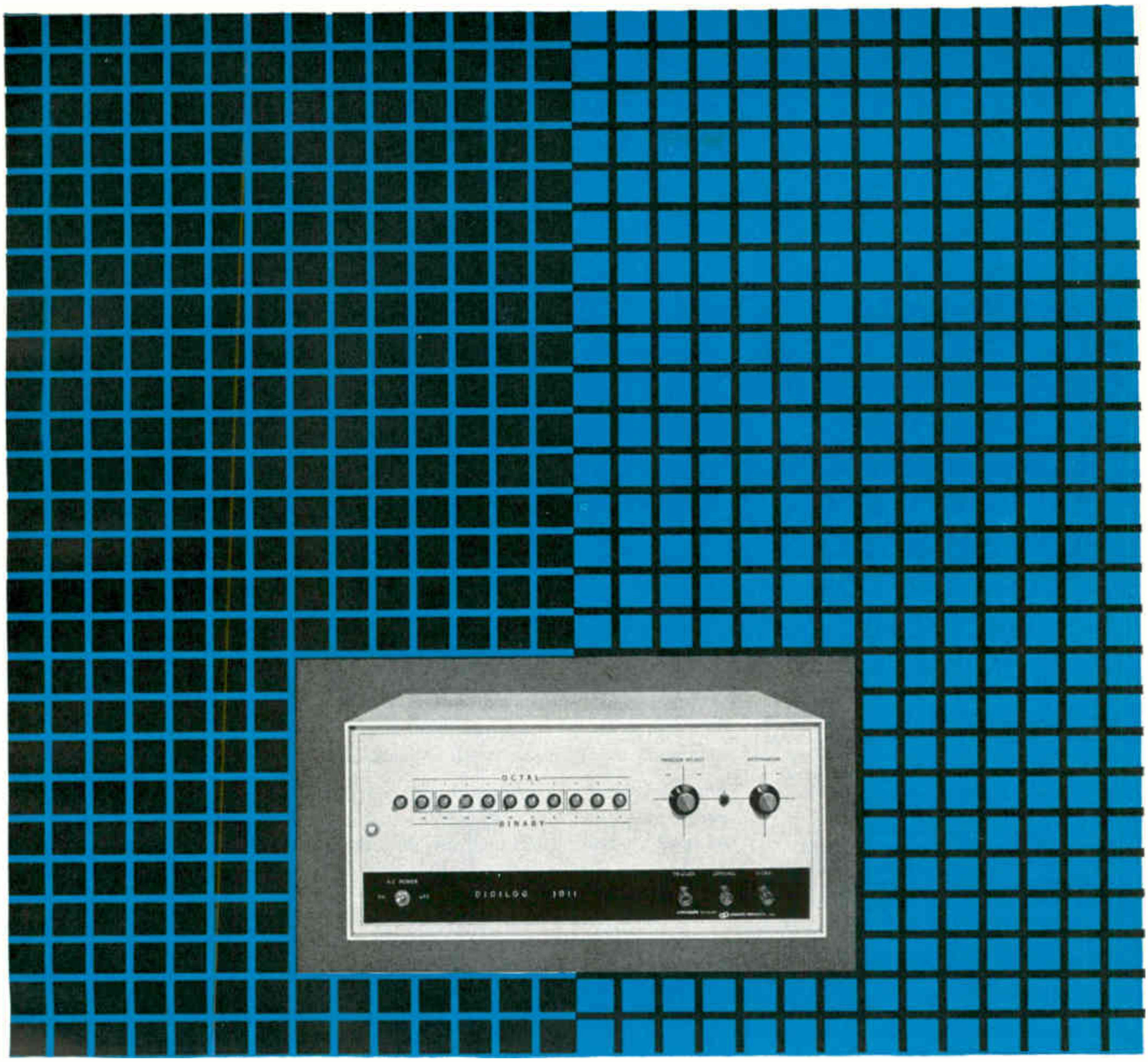
FEDERAL AVIATION Agency starts work tomorrow on a new air-route traffic-control center for its Northeast Region. The center will be built on a 14-acre tract in Nashua, N. H., taking over control operations now located at Logan International Airport, Boston. Centers will have two of Librascope's air-traffic control computers, one operational and one standing by. Flight-strip printer and loader are under development for the new center. Microwave system will be installed to relay flight data from FAA radars 40 miles away in Winthrop, Mass.

FAA also announced last week that joint use of long-range radar by the air agency and the U. S. Air Force Air Defense Command has saved more than $15 million in equipment costs since 1957. The joint use program, first suggested by the Congress several years ago, adapts long-range equipment to serve functions of both users. Fifteen radars are now in joint use, each saving about $1 million in establishment costs. Present programs call for 33 more systems to be used jointly by December, 1963; 17 will be FAA radars, 13 will be ADC systems, and the other three will be radars of other Air Force organizations.

Japan May Abandon Parametron Computers

JAPAN's computer industry may be abandoning its reliance on the parametron as a basic computer element. In a recent article in the *Nihon Keizai* (Tokyo's leading business newspaper), a government scientist commented that the capabilities of the human brain could be more easily approached by increasing the speed rather than the population of elements. In discussing this, he noted that tunnel diodes and parametrons in the microwave range, which share high-speed capability, are both two-terminal devices needing special circuits to ensure unilateral signal propagation. This fact, he said, was causing renewed interest in transistors, especially in high-speed mesa units with the prospect of 10-nanosecond cycle times.

The scientist, M. Takahashi, was advisor to Eiichi Goto when Goto developed the parametron.



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WASHINGTON OUTLOOK

THE LABOR DEPT. has set a tentative minimum wage of $1.23 an hour for production workers in plants producing electronic component parts for sale to the government. This is the second minimum pay rate established for the electronics industry under the Walsh-Healey Public Contracts Act. The law authorizes the determination of minimum wages for employees working on government supply contracts of at least $10,000. An earlier determination was made for electron tubes; another case is pending for electronic end-items.

(Note too that the Kennedy administration's newly-passed $1.25 minimum wage law goes into effect in September. At that time, those presently covered by $1 minimum will be raised to $1.15 for a two-year period, going to $1.25 in Sept., 1963. Walsh-Healey determination would go into effect much sooner than that at the $1.23 figure.)

The Labor Dept. based the tentative decision on a wage survey of the industry made in October 1958. EIA has challenged the tentative ruling, claims $1 is a more widely paid minimum rate in the industry. Labor union interpretation of the wage data is that $1.24 to $1.25 is the prevailing minimum rate.

Producers can file for exceptions to the tentative rate until June 13. A final ruling will be made in mid-July. The case covers "those parts of an electric end product which affect the current characteristics within its circuit . . . " Examples: resistors, capacitors, relays, connectors, switches, transformers, coils, reactors, chokes, inductors, vibrators, filters.

Government purchases of these products run about $75 million annually. The components industry includes about 65,000 production workers employed in 450 plants with at least eight persons each.

CONGRESS wants the Air Force to continue production of manned bombers, preferably the B-52. Present schedules call for phasing out production of both Convair B-58 medium and Boeing B-52 heavy bombers in 1962; neither the Eisenhower nor Kennedy defense budgets earmark new funds for additional procurement.

But in voting a $12.5-billion authorization bill for procurement of aircraft, missiles and naval vessels, the Senate tacked on authority to buy $525-million worth of strategic bombers—or another wing of 45 planes. The House okayed an additional $337 million for bomber aircraft.

So far, there's no sign of what the Pentagon would do with additional bomber money, assuming an appropriation bill is voted to back up the authorization. For the first time, military procurement is going through two legislative cycles this year: first, an authorization bill, then the regular appropriation legislation.

Many lawmakers feel the Defense Dept. is making the strategic transition from bombers to ICBMs too rapidly. The innate conservatism of congressional defense experts, Sen. Richard Russell (D., Ga.), chairman of the Senate Armed Services Committee, for example, shows up in his talk that while manned bombers are proven weapon systems, the reliability of ICBMs is still an uncertain factor.

There are many Air Force leaders who would like to buy more B-52s. The new Chief of Staff, Gen. Curtis Lemay for instance, has been plumping for greater bomber production ever since he commanded SAC.

FOR YEARS, congressional small business proponents have demanded that the Pentagon increase the volume of advertised bidding on procurement and cut the rate of negotiated contracting. They said this would afford small business a bigger chunk of defense orders.

But Sen. Henry Jackson (D., Wash.) has released a University of Washington study, financed by AIA, which shows that the overwhelming majority of small defense contractors prefer negotiated procurement. The survey covered over 1,000 firms. About 90 percent of them said negotiated contracting is more profitable for suppliers, affords greater protection of proprietary data, and favors neither large nor small suppliers.

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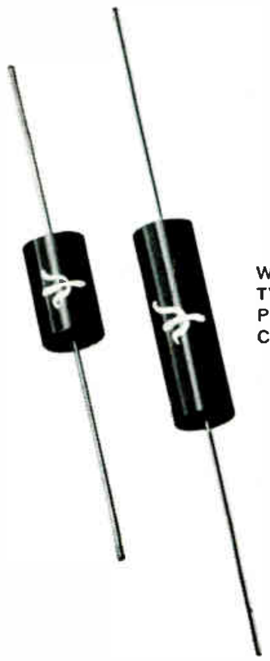

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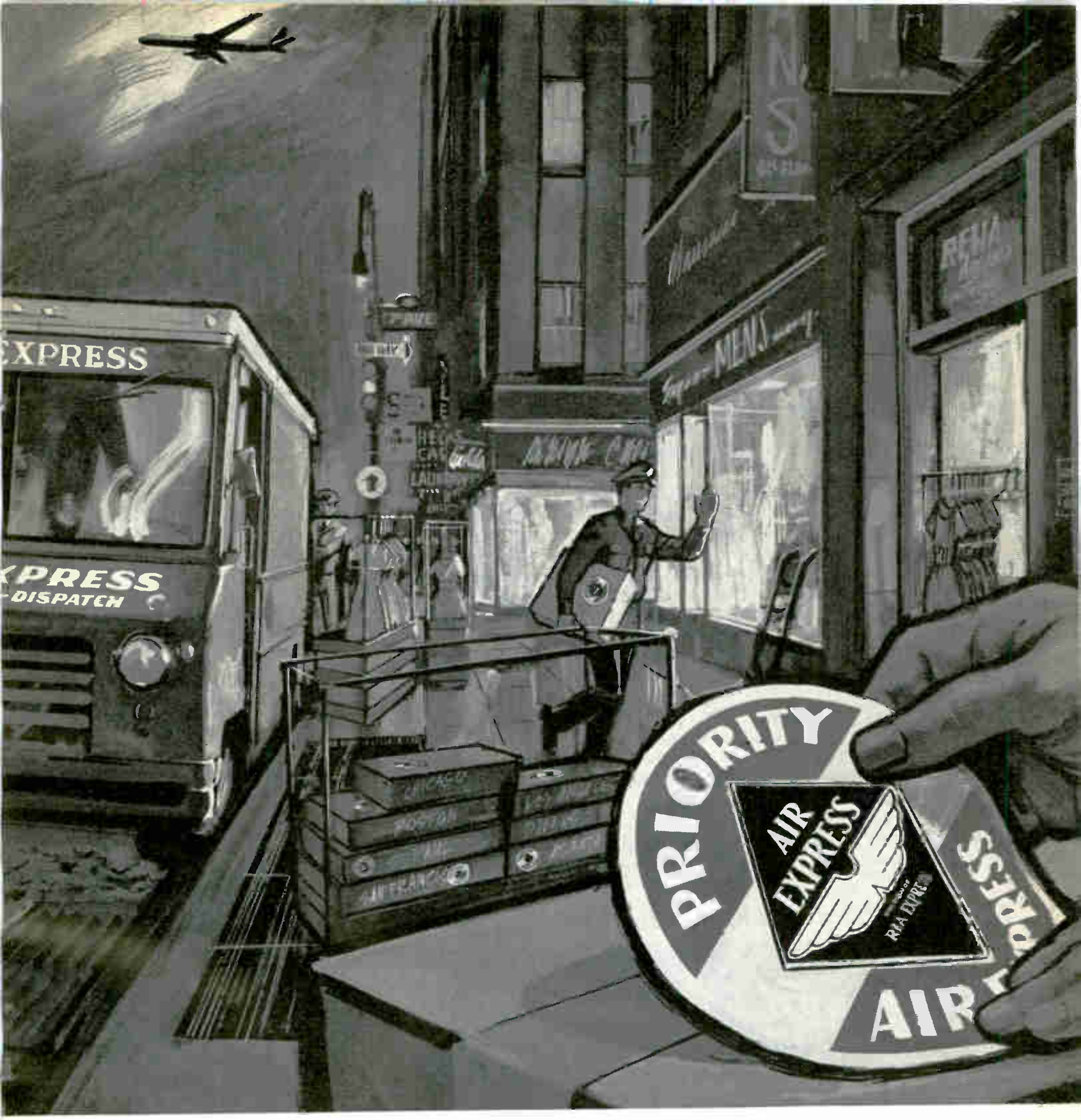

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Industry-Military Program

Contractors Trading Reliability Data

By LEON H. DULBERGER
Assistant Editor

PRIME CONTRACTORS for military missile and related efforts are now exchanging data in a rapidly growing program of component and parts reliability testing designed to cut down test duplication; thus save time and expense. Over 70 firms are active in the nearly one-year-old operation, which is jointly sponsored by the Air Force, Navy and Army. The combination military-industry endeavor is called IDEP, for Interservice Data Exchange Program, and is modeled after Navy's components testing program set up for the Polaris weapon system.

The Air Force Ballistic Systems Div. was first to begin interchanging data within IDEP.

The program supplements the slower to prepare, more general, MIL specs, in many cases provides the only guide to high-reliability component applications.

Improved standards of military system reliability are expected when the program has been in operation for an extended period.

Individual companies prepare reliability test reports on components purchased from vendors, and these reports are distributed to all IDEP members by the program centers. Tests are made on transistors, diodes, resistors, capacitors, relays, connectors, valves and other electronic and mechanical items; roughly ninety types in all.

The report format used by the IDEP centers is an 8½-by-11-inch card containing up to 50 microfilm insets, each equivalent to a page of printed data. The file card carries information on component type, tests performed and highlights of the results. The microfilm supplies detailed information.

Reports are circulated to all IDEP members. Test results can often be used directly by recipients.

The vendor of each tested component is usually given a copy of the report by the firm making the tests before the card is made up, and he is free to point out exceptions to the test results. These may be added to the report if deemed valid. However, IDEP cannot order a contractor to do this.

James Draughon is chairman of the IDEP coordinating group at the Army Ballistic Missile Agency, Redstone Arsenal, Huntsville, Ala.

There are three IDEP centers, one for each military service. Martin Barbe of Aerospace Corp., El Segundo, Calif, serves the Air Force Ballistic Systems Division. IDEP Data Distribution Center.

R. A. Ham is Chief, IDEP Distribution Center, Army Ballistic Missile Agency at Huntsville.

Tom Carswell heads the IDEP Data Distribution Center, Naval Ordnance Lab., Corona, Calif.

Major Vincent Bracha of Air Force Ballistic Systems div. has pointed out some of IDEP's aims: besides saving testing time and money, the program will give designers insight to the component state-of-the-art. It will make available handbook-type data for new designs, and provide information needed to prepare reliability analysis on new systems. Data for such an analysis is put into a mathematical model, and worked out for submission with the prototype model of a new military system.

Plans include use of IDEP for circulating general reliability studies, and other information to improve contractor's reliability performance. Boiling down IDEP data into statistical results in the future will give life information to implement systems engineering in early stages of design.

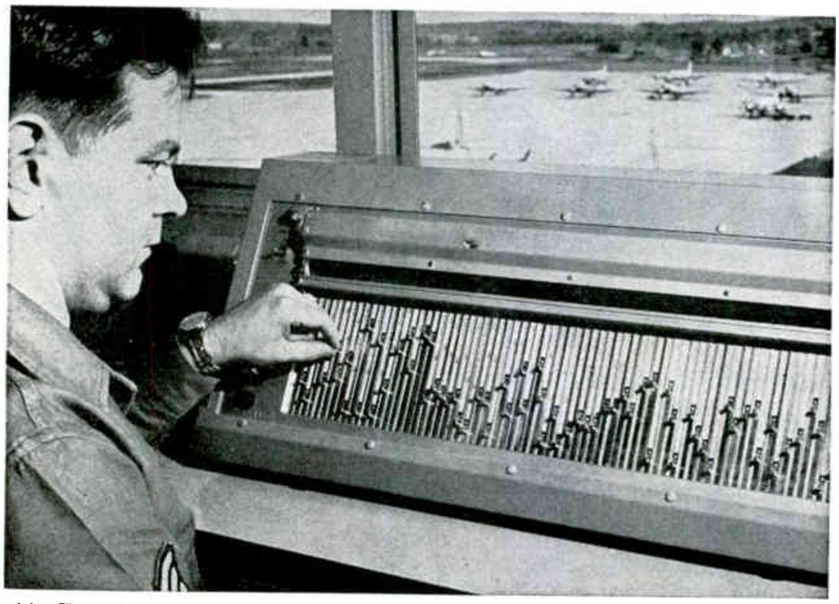
Opinions in industry show much favor for IDEP, though there have been some dissenting voices.

Various firms have declined to comment on the program. Others will only release information after careful consideration. One company required that a lawyer be present if the subject were discussed. Another firm refused to cover the subject except by mail.

One question that has been raised, but is apparently resolved, is the legality of IDEP.

Since it is publicly funded, through the military, and informa-

Weather Transmitted By Pushbutton



Air Force's new telecode weather transmitter under test. Temperature, wind direction, other variables are set on 72 metal slides. On pushbutton command, data is sent to remote weather stations tion is made public, it could not be classed as restraint of trade, proponents say.

A few vendors feel an IDEP report could show their product in an unfavorable light if the tests made on it were in excess of intended design limitations, or the system application were incorrect. In answer, it is pointed out every effort is made to prevent this and, in addition, vendors can submit comment when a forthcoming report is shown to them.

The possibility that a large contractor who also owns a component manufacturing division would have an inside track on design has been mentioned by vendors. The argument is that the contractor (and thus the vending division) would see all reports on one type of component, while those out of the IDEP group would only see reports pertaining to their product.

However, it has been pointed out that all reports are nonclassified, and available to any vendor from Armed Services Technical Information Agency in Washington, D.C.

There is no attempt to make IDEP a closed circle, its backers say, but rather to aid the input and final perusal of reliability information to the advantage of all.

The use of automated data processing methods to handle the growing accumulation of data is anticipated, though there are no active plans at this time.

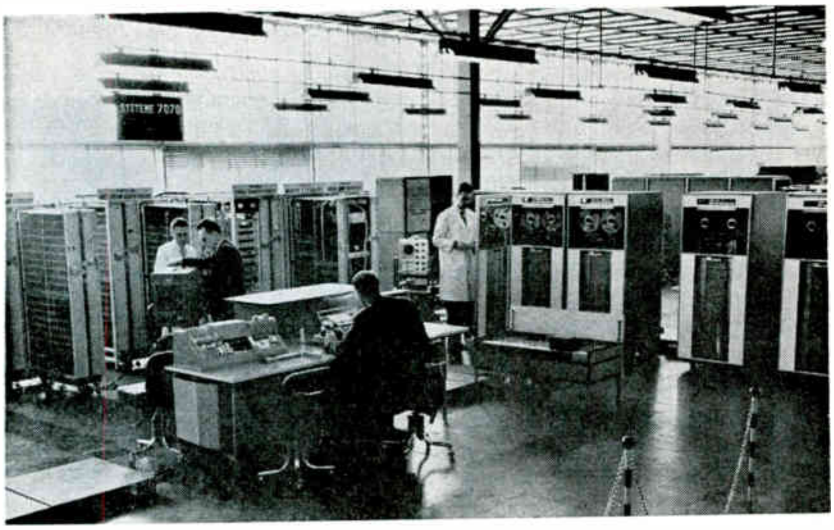
IDEP has produced a specification on the format to be followed in writing an IDEP report, designed to produce uniformity of testing and ease in report.

A large contractor in Long Island, N. Y., an IDEP member, is much in favor of the program, feels that the firm gains in many ways by participating. When a component type is new to the firm, or being used in a new application, an initial survey can be made using IDEP information, he says.

Kurman Electric Co., Brooklyn, N. Y., manufacturer of relays, favors IDEP, observes that it is faster and cheaper than MIL specs.

The firm feels that a vendor is not placed at a disadvantage by the circulation of reports on his product among his competitors, points out that anyone can write for sales, and often design data from a competitor and receive it.

Computer for French Auto Manufacturer



Engineering research, plant control and payroll at Renault will be done by this 7070 unit being readied at IBM's Corbeil-Essones, France plant

Transistor Sales Increase Over 1960

SALES UPTURNS in several electronics categories is noted by the Electronics Industries Association.

Factory sales of transistors showed a healthy gain in March of 1,858,845 more units above the number of units sold in the preceding month. Total number of transistors sold during March was 15,129,273 as compared with the February total of 13,270,428. The dollar values for the two months were $29,815,291 and $25,699,625, respectively.

This year so far has been a better one for transistor sales than the comparable period of 1960. In 1960's first three months 31,155,798 transistors valued at $78,246,279 were sold. In the comparable period this year, unit total was 40,583,632, while dollar value was $78,470,083.

Television picture tubes and receiving tubes also registered increases in sales during March this year. Units sold amounted to 941,215 tv picture tubes valued at $18,771,363, and 36,635,000 receiving tubes valued at $30,719,000.

In February the number of tv picture tubes sold was 728,989 valued at $14,395,981. Receiving tubes sold that month totaled 25,803,000 units worth $21,865,000.

Despite this monthly climb, cumulative totals for the 1961 first quarter were below those of the comparable period of 1960 for receiving tubes. In the first three months of 1960, 100,417,000 receiving tubes valued at $86,013,000 were sold. In this year's first quarter the figures were 88,781,000 units at $74,811,000.

Television picture tubes showed slight gains in the first three months of this year as compared with the same period of 1960. This year 2,378,039 tubes worth $47,598,099 were sold in the January-March interval as compared with 1960 three-month figures of 2,330,858 units at $54,981,191.

Phonograph factory and retail sales rose in March after declines during January and February, but still failed to measure up to figures for the first quarter of 1960. Stereophonic phonographs in both intervals outstripped monaural.

During the first quarter of 1960 factory sales of monaural units were 274,313, while stereo factory sales were 908,518. In this year's first quarter the respective figures were 193,472 and 643,490. Retail sales figures showed improvements in both periods over factory sales. In the first quarter of 1960 they were: monaural, 315,125; stereo, 965,196.

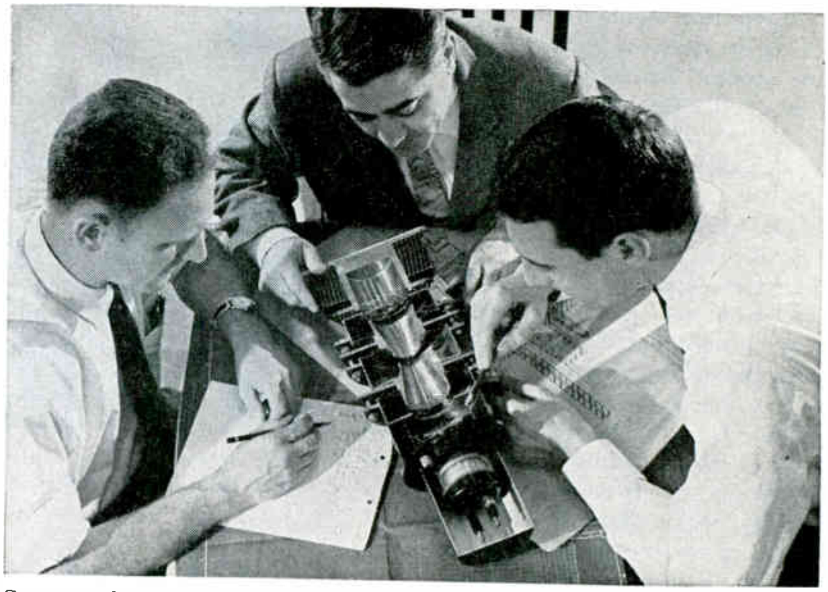
In the first quarter of this year, the equivalent figures were 231,537 and 734,383.

Training Programs Broaden Value Analysis

By ROY J. BRUUN
Assistant Editor

VALUE ANALYSIS is now becoming a meeting ground for engineers and purchasing people. Basically it means taking a second hard look at an engineering design to see whether it can be modified or simplified to bring down costs, seeing if parts should be made or bought and finding the best source of supply.

At some firms, value analysis is becoming a specialty within the purchasing operation. At others, value analysis is performed by engineering at the request of purchasing. In either case, large-scale value analysis requires cooperation between engineering and purchasing as well as top management support.



Sperry value analysis team studies klystron tube design

RCA's Industrial Electronics Products activity feels that if value analysis is to be performed competently, purchasing must have value analysts who are business-oriented engineers able to work with design and development engineers.

At RCA-IEP, value analysts may study engineering designs before purchasing makes up orders for production quantities of components and materials. They make change recommendations to design engineers that are intended to result in cost savings while retaining the essential design. Recently, changes recommended by value analysts resulted in a 40 percent cost reduction on magnetic heads.

After helping in determining design, value analysts decide on the monetary value of design—specified components and parts. On the basis of this evaluation, purchasing personnel establish what are called standard costs that allow for expected losses of individual items thorough pilfering, breakage, etc.

Value analysts at RCA-IEP also have the responsibility of inspect ing and evaluating potential vendors' plants to determine their capability of delivering desired products on time, at cost, and with the required reliability. They also advise and help vendors in their technical and business operations if quality and delivery is not up-to-par. Thus, they acquire a background that enables them to know how effectively individual vendors can follow through on engineering design specifications, what they can and can't do.

The value analysts plan to conduct seminar courses in value analysis for buying personnel and engineering personnel.

Technical experts from outside IEP will be invited to lecture and join the seminar discussions. Conferees will evaluate and make changes in design examples and then will be shown how it can be done even better. This provides an incentive not to be topped.

A value analysis contest is planned for May through the end of the year to stimulate cost-saving practical ideas for going projects.

Top management at IEP is endorsing the value analysis program as one means of increasing the organization's margin of profit.

Value analysis at Huyck Systems Company is not done on as elaborate a scale. During the prototype stage, purchasing personnel take note of components and materials that approach engineering design specifications but are considerably less expensive. They bring this to engineering's attention recommending that they make design changes to include the nonspec items. Engineering is free to accept or reject the recommendations, but often finds that acceptance pays.

Sperry Gyroscope Company uses a one-man approach to value analysis. David Fram is administrator of the value analysis program and its only full-time employee. He is assisted by engineers, quality control experts, and buyers who have other assignments at the company.

When Sperry decides to study one of its products (ideally, before it's off the drawing board) each expert looks at it from his own approach and makes recommendations. If changes are not made early enough, however, a good idea can go down the drain because the cost of making the change is more than price savings, says Fram.

Sperry claims it has saved $2 million since the start of the year. The value analysis program is aiming to cut costs 25 percent without affecting quality.

Range of cost saving efforts at Sperry include: trimming nearly $1.7 million from a ballistic missile program by replacing some parts in the missile power supply unit to cut the unit price from $15,000 to $8,000. The less-expensive version may perform even better than its predecessor, says Fram.

At the other end of the scale,

Sperry replaced a $2.22 soldering iron with a $5.35 model. Maintenance costs of the new iron ran to $9.51 a year versus $189.22 for the old iron.

Sperry value analysis reduced the cost of a radar klystron tube to the point that an engineering proj- a savings of $81,000.

An indicator device was successively reduced in price from $4,300 to $3,200 to $2,898 and finally to $2,523. In total, Sperry realized a savings of $81,000.

A clearing house for value analysis ideas is the Value Engineering Committee of the Electronic Industries Association. This group meets periodically in different parts of the country to swap ideas on how to get the best possible products at the best prices.

Arma division of American Bosch Arma has used the training program technique to coordinate purchasing with engineering and other company operations to save money. Semiweekly sessions are held for all buyers in the purchasing department. Lectures are given by purchasing management and also by people from engineering, finance and product reliability. Topics include: price and value analysis, solicitation of bids, review of quotations, negotiations techniques, accounting terminology.

A natural complement or extension of value analysis at Arma is the checking of vendors for improvements in product art and manufacturing processes that might reduce costs, thus making sure that savings realized by the vendor are passed on to Arma.

This check is performed by representatives from purchasing and engineering, who also witness the manufacturer's high-reliability testing process spelled-out for him by Arma.

Written data must be made on these tests and submitted to purchasing so that savings may be realized by the assurance that only satisfactory items are accepted on delivery.

Even small manufacturs must invest $50,000-$70,000 and up in capital equipment, such as shake tables, to meet Arma's test requirements, which reportedly are above and beyond those specified by government source inspection regulations.

Services Step Up Frequency Compatibility Plan

FREQUENCY COMPATIBILITY program of the Department of Defense moves ahead with award of $2-million contract to Armour Research Foundation for technical support of the triservice Electromagnetic Compatibility Analysis Center at Annapolis, Md. (ELECTRONICS, p 9, Mar. 17, '61.)

Mutual interference of military electronic equipment ranging from hand-carried transceivers to giant radars is a serious problem, though specific examples are rarely revealed.

In some cases, the interference involves classified equipment. In others, it's just considered impolitic for the military to point the finger publicly at whose side lobes are saturating whose receivers.

Ironic example, however, is seen at the newly established center itself. To protect computers and other equipment, the center has to be shielded from a nearby Navy installation which puts out a half-megawatt of low frequency power.

Contract awarded to Armour by the AF Electronics Systems Division at Bedford, Mass., calls for electronics and mathematical specialists to develop methods for analyzing interference problems.

Work has been started at temporary analysis center in Chicago, is expected to move to Annapolis in November with 100-man staff. AF Col. Charles C. Woolwine is head of the center.

Although compatibility effort is initially a DOD program, it is hoped that eventually it will involve FCC and FAA as well as industry.

Need for triservice compatibility program is dramatically seen in projection of a brush-war situation where units of Army, Navy, Marines pour into battle area—each setting up carloads of electronic communications and control equipment. Turn them all on at once and chaos would result. It would take days of fixes, time-sharing and band-sharing agreements to bring any semblance of compatibility.

Also, an AF official points out, about one-half of service test cost of today's military electronic equipment goes into debugging to eliminate interference. Goal of DOD program is to design compatibility into equipment in the first place.

Analysis center will set up procedures for measurement of antenna patterns, power distribution, field strength, side lobes, spurious emissions.

Program will start with pulse-type equipment, particularly radars in the higher bands, and will eventually encompass all electronic equipment.

Parallel research program will investigate best types of fixes for existing equipment, also look into such things as tube design for frequency stability, side-lobe suppression techniques.

Military services will furnish operational information to the center, such as precise location, hours of operation, spectrum signature—including every type of radio frequency energy emitted.

Many emitters, Col. Woolwine points out, produce incidental radiation in addition to the energy for which they were designed. These can include wider bandwidth, side lobes, leakage from signal-generating equipment.

Analysis center will examine characteristics of equipment under development to insure conformity with standards, also the spectrum signatures of equipment in specific operational environments, and the operational environment itself in problem areas.

Also planned are development of mathematical models and simulators for use as frequency management tools and for R&D. Center will operate as clearing house for information on compatibility.

When interference problems are uncovered involving equipment under development, DOD will take remedial measures through its Radio Frequency Compatibility Program. When problems develop among existing equipment, corrective action may include phase-out and replacement.

Center is expected to become fully operational by first of next year with estimated $3 million needed to finance the 1962 program.

Computer Imitates Famous Music Composers

EXPERIMENTAL electronic system (photo) that can help a composer create new music by suggesting variations and tone combinations based on his original ideas was described recently to the National Academy of Sciences.

The unit, a random probability computer developed by Radio Corporation of America, forms part of equipment devised in studies on communications theory, especially in relation to sounds and music.

The computer has produced original tunes in the style of Stephen Foster guided by melodic and rhythmic characteristics typical of his compositions.

The computer's principle of operation may be applied, according to RCA, by styling designs where a definite and limited range of characteristics and functions must be encompassed; color combination selections and word sequences.

Harry F. Olson, director of RCA lab in Princeton, N.J., changes arrangement of control circuit in experimental electronic system

Microwave Ovens Find Market In Company Cafeterias

ELECTRONIC OVENS have yet to attain any significant sales volume in the consumer markets but now they are making impressive strides in institutional cafeterias and restaurants. One market estimate places the number of ovens in use at somewhat under 10,000.

Manufacturers say the technique of using microwave radiation to cook food still needs two keys to unlock the home market: consumer education and reduction in price.

Companies report they are working along both these lines and point to the way early television sets gained consumer acceptance after being seen and used in public places.

One hopeful indicator for manufacturers seeking a mass market has been a fairly consistent decline in price. During the past three years the average cost of a microwave oven has gone from about $1,200 to about $800.

Main advantage of microwave cookers in company cafeterias is the way they permit serving hot meals at low cost without requiring heavy investment in steam tables, and the conventional ovens, pots, pans and other restaurant equipment.

Frozen food caterers now are able to supply a wide variety of menus. Complete frozen meals available include meats, vegetables, stews, curries and many other dishes.

The meals come in self-contained trays or dishes that are selected from the freezer by employees and placed in the microwave oven. Color-coded pushbuttons are pressed to control cooking time. Average time from freezer to table is about one minute.

In 1946 Raytheon had made and tested an experimental microwave oven. In 1954, a commercial unit was demonstrated.

Development since then has been aimed mainly at styling and cost reduction. Also included among suppliers are Tappan, Westinghouse and Hotpoint.

Two other manufacturers closely watching the market are Kelvinator and General Electric. GE tells ELECTRONICS it has an electronic oven in the development stage.

A report from Japan describes

Frozen dinners are cooked in seconds by Nuclear Metals Corp. employees with Raytheon's microwave oven a $2,800-microwave oven by Hayakawa Electric (ELECTRONICS, p 34 May 12). It operates at 2,500 Mc.

A Tappan spokesman describes his company's microwave oven: 60-cycle 220-volt power is changed by the high-voltage power supply to 4,800-volt, 120-cps pulses. Pulses are applied to the cathode of the grounded-anode cooking magnetron causing it to oscillate at 2,450 Mc.

During warmup the oven requires about 11 volts for the magnetron filament and 2.5 volts for the filaments of the power rectifier. After warmup, magnetron filament voltage is reduced to about 8 volts, dropping to 6.3 volts during cooking.

A waveguide directs the microwave power to the oven. The unit has interlocks that turn it off when the oven door is opened. Filters reduce radio interference to negligible minimums.

The oven consumes about 0.7 Kw on standby and approximately 3.5 Kw while cooking. An electric heating unit to brown roasts, poultry and other foods needs an additional 4 Kw.

Although present major users of microwave ovens are institutional cafeterias, restaurants are finding the new method useful in saving work and reducing labor costs. Of primary interest to restauranteurs is the saving in time.

A 22-pound rib roast may be cooked in 45 minutes, a three-pound chicken in nine minutes, a one-pound lobster in three minutes.

Cleanup time is reduced since foods may be placed uncooked on dishes, put in the oven and brought out ready for the customer.

Facsimile System Uses Transistors and P-Cs

FACSIMILE SYSTEM introduced recently by Fairchild Camera & Instrument is designed for transmission of graphic data. It has two transmission speeds, one for high-definition reproduction, a faster rate when less highly defined copy is tolerable.

Blueprints can be formed into strips and continuously fed into the system; a switch control permits skipping portions of the material fed in. System is all solid-state, uses printed-circuit cards.

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Lafayette Radio	1	2	3			6	Boston, Mass.
Radio Shack		2					Boston, Mass.
Radio Specialties		2					Detroit, Mich.
Northwest Radio	1	2		4			Minneapolis, Minn.
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Walters Radio		2				6	Kansas City, Mo.
Interstate Indus. Elec.				4			St. Louis, Mo.
Olive Electronics	1				5		St. Louis, Mo.
General Radio		2				6	Camden, N. J.
Eastern Radio		2				6	Clifton, N. J.
Atlas Electronics	1	2				6	Perth Amboy, N.J.
Federated Purchaser	1	2				6	Mountainside, N. J.
Aaron Lippman & Co.		2					Newark, N. J.
Lafayette Radio	1					6	Newark, N. J.
State Electronics		2		4		6	Whippany, N. J.
Federal Electronics	1	2				6	Binghamton, N. Y.
Acme Electronics		2				6	Brooklyn, N. Y.
Radio Equipment		2					Buffalo, N. Y.
Wehle Electronics	1					6	Buffalo, N. Y.
Greylock Electronic		2					Kingston, N. Y.
Peerless Radio						6	Lynbrook, L.I., N.Y.
Bruno-New York		2				6	New York, N. Y.
Electronic Center		2				6	New York, N. Y.
Harrison Radio	1	2	3	4		6	New York, N. Y.
Harvey Radio	1	2				6	New York, N. Y.
Lafayette Radio	1	2	3			6	New York, N. Y.
Milo Electronics		2				6	New York, N. Y.
Terminal Hudson Elec.	1	2				6	New York, N. Y.
Higgins & Sheer Elec.		2					Poughkeepsie, N. Y.
Morris Electronics						6	Syracuse, N. Y.
Valley Indus. Elec.		2					Utica, N. Y.
Westchester Electron.	1	2		4			White Plains, N. Y.
Dalton-Hege Radio	1						Winston-Salem, N.C.
Akron Electronic Sup.		2					Akron, Ohio
United Radio	1		3	4			Cincinnati, Ohio
Pioneer Electronics	1					6	Cleveland, Ohio
Thompson Radio		2		4			Columbus, Ohio
Whitehead Radio			3				Columbus, Ohio
Allied Supply	1		3	4			Dayton, Ohio

Man-In-Space Simulator, Data Links Described At Telemetering Sessions

CHICAGO—Equipment to simulate Mercury-capsule flights and data links for the DynaSoar suborbital coast-glide vehicle were featured recently at the National Telemetering Conference here.

Discussions centered on a clearing house for biological telemetry information, status of standards, a student-information program and telemetering in Europe.

More than 1,500 scientists, engineers and management people attended 15 technical sessions ranging from r-f components and techniques and industrial telemetering through underwater measurements and biomedical telemetering. More than 50 manufacturers set up more than 70 exhibits.

A system capable of simulating and conditioning data from both normal and abnormal Mercury missions was discussed by Burton S. Ritter of Bendix. The system supplies real-time simulation of capsule data and communications.

Initial design of a pulse-code-modulated/frequency - modulated data system as a low-frequency, high-accuracy data link and an f-m/f-m link for high-frequency, low-accuracy reporting to share a total of 1,270 different measurements of flight safety, failure analysis, design verification and operation of special subsystems was described as instrumentation for DynaSoar by Moore and Mace of NASA.

A clearing house to uncover requirements for new bioastronautical and biophysiological measurements was proposed during the biomedical session by H. T. Fiertag of Martin, Denver, as a move to clear up duplication among new agencies entering the field.

Described was a self-contained multichannel personal telemetry system using pulse-position modulation of multivibrator or sawtooth carriers to transmit heart and respiration rates, body temperatures on a single radio frequency over a range of 100 feet. The equipment was described by A. R. Marko of Wright Patterson AFB.

A telemetry package for electrocardiograph telemetry was discussed by Boreen, Shandelman and Berman of Vector, Southhampton, Pa.

Remote telemetry of a radioisotope setup for measuring the water equivalent of snow in California and Idaho watersheds was described by Sidney Rosenberg, Sierra Electronic division of Philco.

Soviets Court Japan For Electronics Trade

TOKYO sources hint that Russo-Japanese trade in electronics may step up due to Russian reactions to the recent Tokyo International Trade Fair. The Soviet electronics mission reportedly found Japanese electronics far advanced.

The four-member mission, headed by Nicolai N. Strelichenko, chief of engineers of the Soviet National Science and Technology Committee, visited Japan for the Tokyo fair and to prepare for the Soviet trade show in Tokyo this summer.

"We are prepared to buy Japanese know-how on electronics and a good deal of electronic products from Japan," he said, "provided Japanese ties with the U.S. and West Germany are not stumbling blocks for such deals."

Stock Quoted By Dial

Unit by Teleregister gives bid-asked stock figures on 800 stocks

MEETINGS AHEAD

June 6-8: Instrument-Automation Conf. & Exhibit, ISA; Royal York Hotel, Toronto, Ontario, Canada.

June 8-9: National Electrical Manufacturers Assoc., NEMA; Biltmore Hotel, Los Angeles.

June 11-16: Electronic Representatives Management Inst., ERA & Univ. of Ill.; Robert Allerton Park, Urbana, Ill.

June 12-13: Radio Frequency Interference, PGRFI of IRE; Sheraton-Park Hotel, Wash., D. C.

June 12-17: Components & Materials Conf., Institution of Electrical Engineers; London.

June 14-15: Product Engineering & Production, PGPEP of IRE; Sheraton Hotel, Philadelphia.

June 19-20: Broadcast & Tv Receivers, B&TVR of IRE; O'Hare Inn; Des Plaines, Ill.

June 22-23: Computers & Data Processing, Univ. of Denver; Elkhorn Lodge, Estes Park, Colo.

June 22-23: Air Lines Communications Administrative Council. AEEC; Saxony Hotel, Miami Beach, Fla.

June 26-27: Vacuum Metallurgy Conf., American Vacuum Society; New York Univ., Heights Campus, New York City.

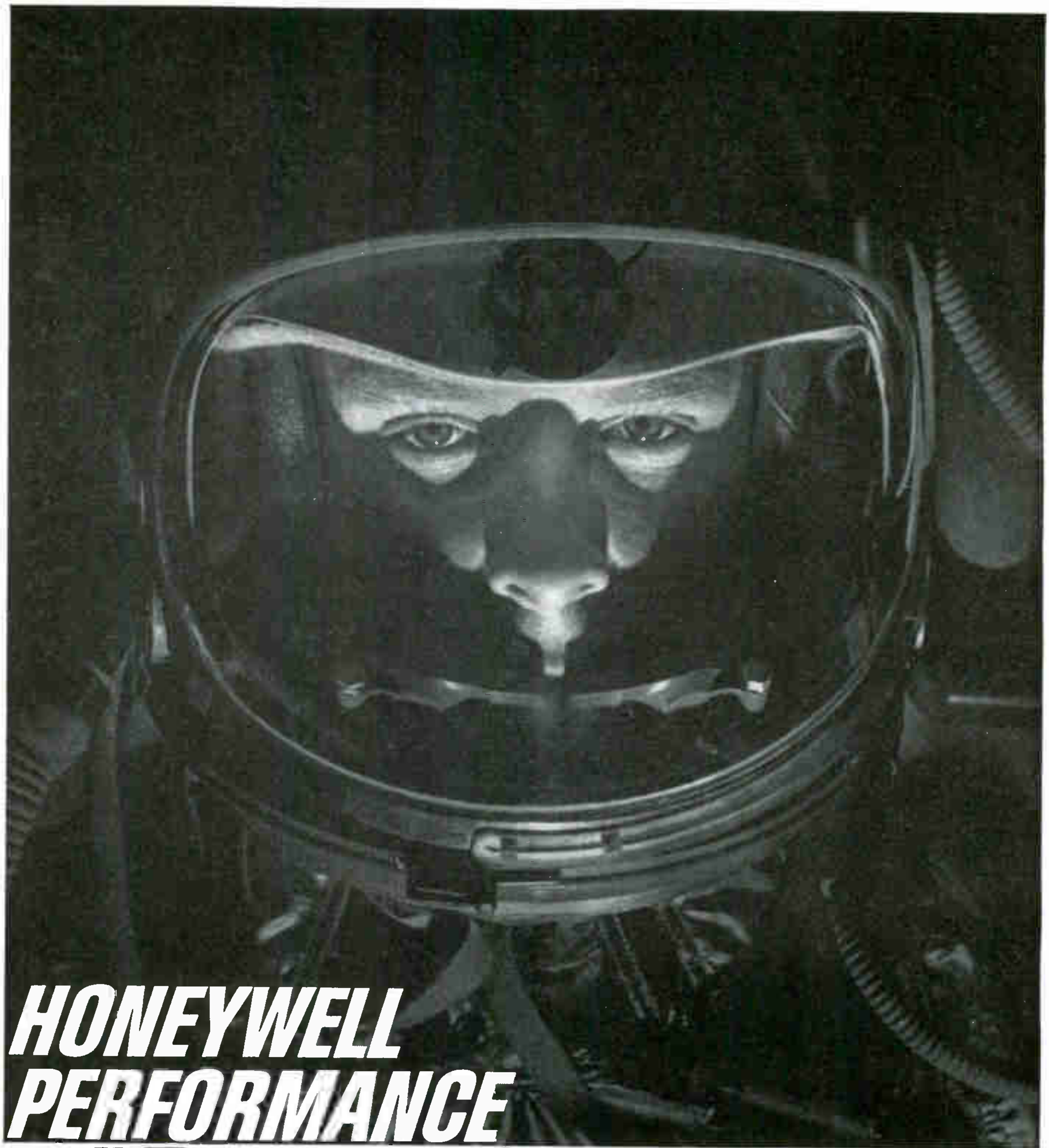
June 26-28: Military Electronics, National Convention, PGME of IRE; Shoreham Hotel, Wash., D. C.

Aug. 22-25: WESCON, L. A. & S. F. Sections of IRE, WCEMA; Cow Palace, San Francisco.

Sept. 11-15: Instrument-Automation Conf. and Exhibit, ISA; Sports Arena, Los Angeles.

Oct. 9-11: National Electronics Conf., IRE, AIEE, EIA, SMPTE; Int. Amphitheatre, Chicago.

Nov. 14-16: Northeast Research and Engineering Meeting, NEREM; Commonwealth Armory & Somerset Hotel, Boston.



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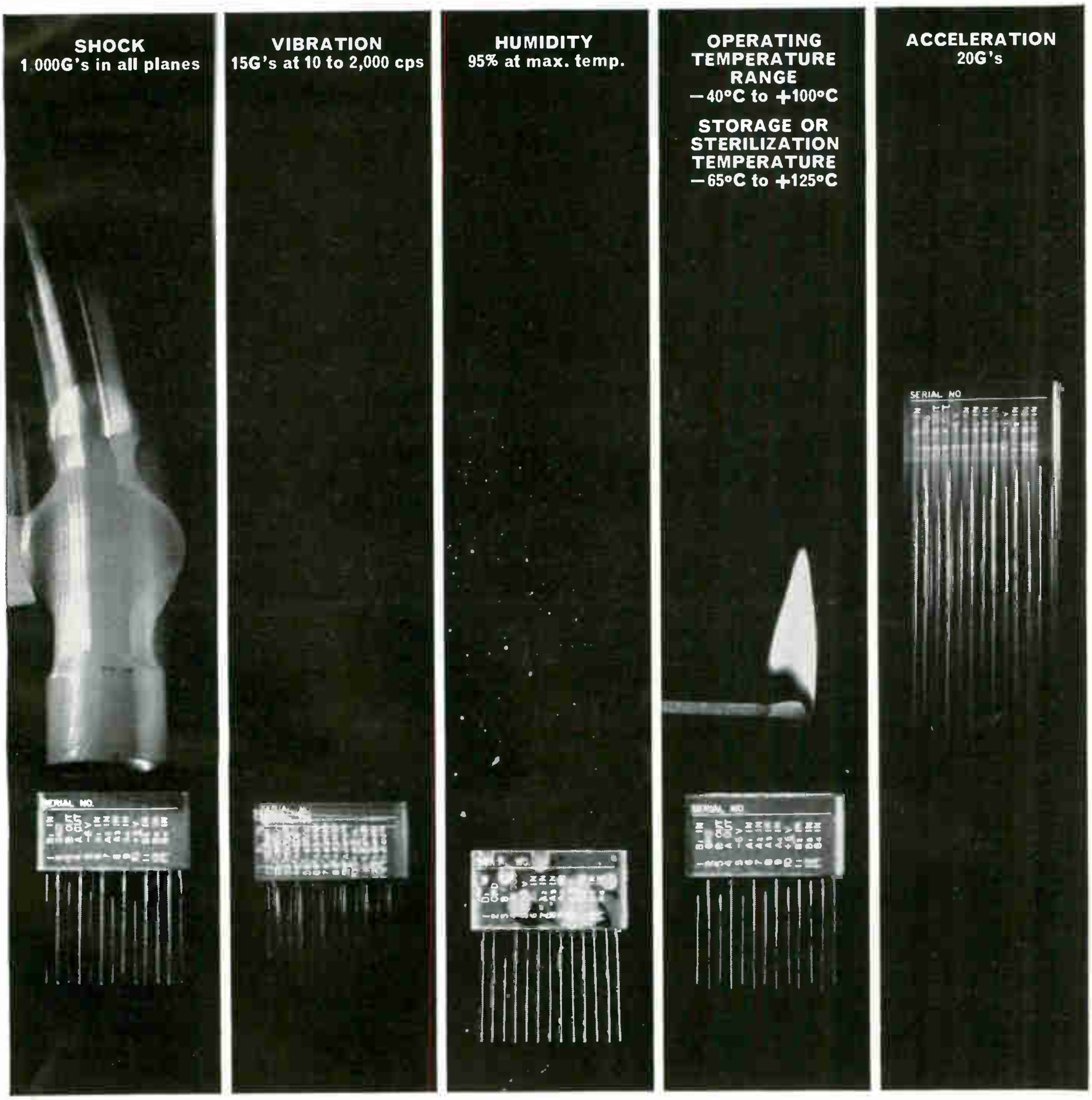

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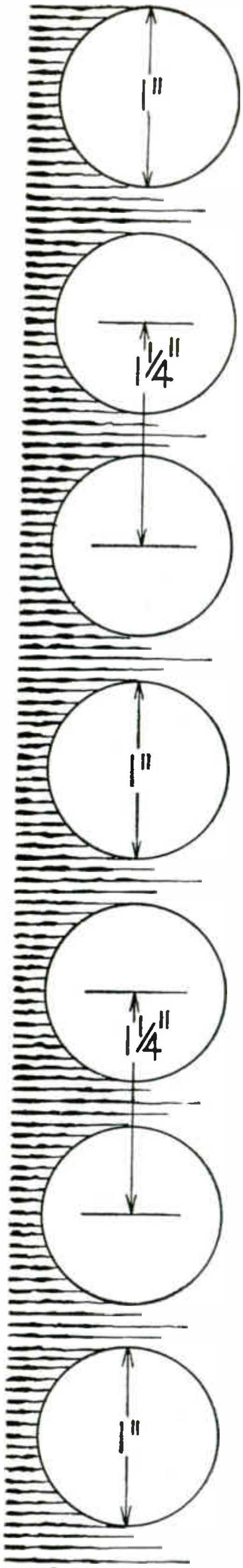

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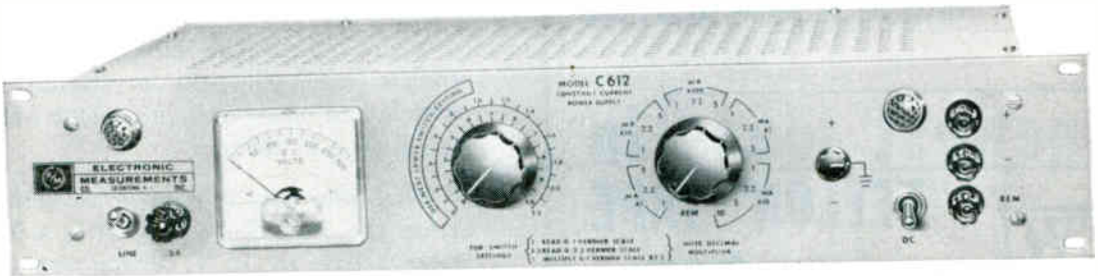

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C621A	5 uA to 500 ma	100 V	5¼	19	15	$479
C620A	5 uA to 500 ma	50 V	5¼	19	15	$449

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NOTICE TO READERS

FREE REPRINT OF THE MONTH

Each month the editors of *electronics* are selecting a significant article and offering it in reprint form —FREE—to readers.

The June free reprint is an article from the June 2nd issue. It is a one page article by L. V. McNamara entitled—Letter Code Designations For Microwave Frequency Bands.

Though there is some disagreement among parts of the industry about how certain microwave frequency bands should be designated, ELECTRONICS' Reference Sheet, compiled from manufacturers' literature and other unofficial sources, is a guide to the most common band letter designations in actual use today.

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electronics

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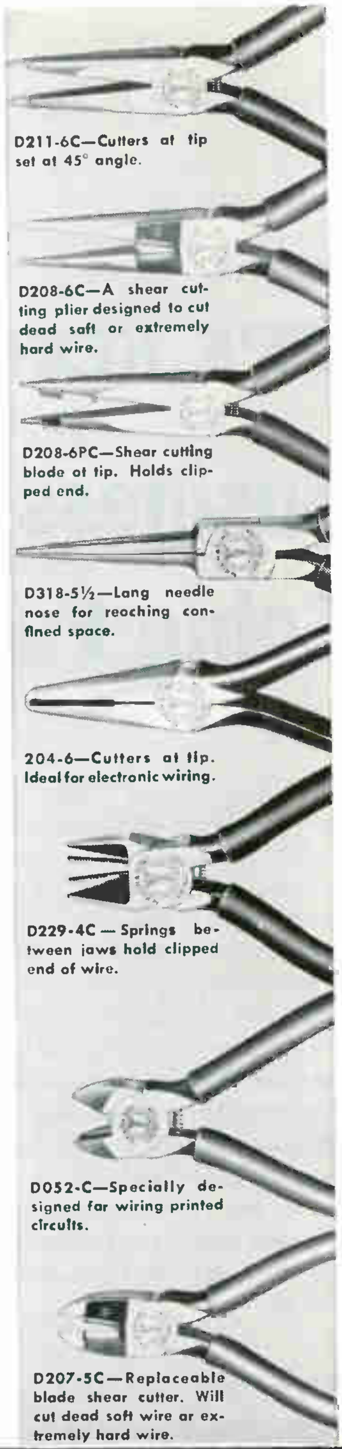

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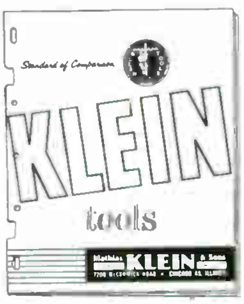

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LET'S KEEP

Business Help For Our Colleges Going Full Speed Ahead

"Should our company fold up its program of financial help for higher education now that the Kennedy Administration plans to have the federal government provide this kind of help in a big way?" It is clear why, in the light of campaign promises and plans announced since, this question is being raised in many business firms at this juncture.

What seems far clearer, however, is the right answer to the question. It is a resounding NO! **This is no time for the business community to ease up in what have been its notably successful efforts to help our colleges and universities get out of the deep financial hole in which they are operating. On the contrary, this is the time to put more steam than ever behind the drive of business to increase its financial help for higher education.**

Massive Help Needed

It is easy to understand why any individual businessman or firm might have a rather despairing feeling about the prospect of competing with the federal government, with its almost all-embracing tax arm, in providing financial support for higher education or almost anything else for that matter. But this is not a case of competition. It is a case where our colleges and universities must have massive help all along the line if they are to be put squarely back on their feet financially—a goal of crucial and perhaps decisive national importance. **The business community will continue to have both the opportunity and the obligation to keep on increasing its help for higher education as rapidly as possible.**

To underline this proposition take a look at the chart at the top of the next page. It shows how far the salaries of college and university faculty members continue to lag behind those of other occupational groups in the U.S.A. There has been some relative improvement in the average of faculty salaries in recent years. And the salary improvement in some fields, such as those of science and mathematics, has been very pronounced. But the chart makes clear how badly the average salary of college and university faculty members still lags.

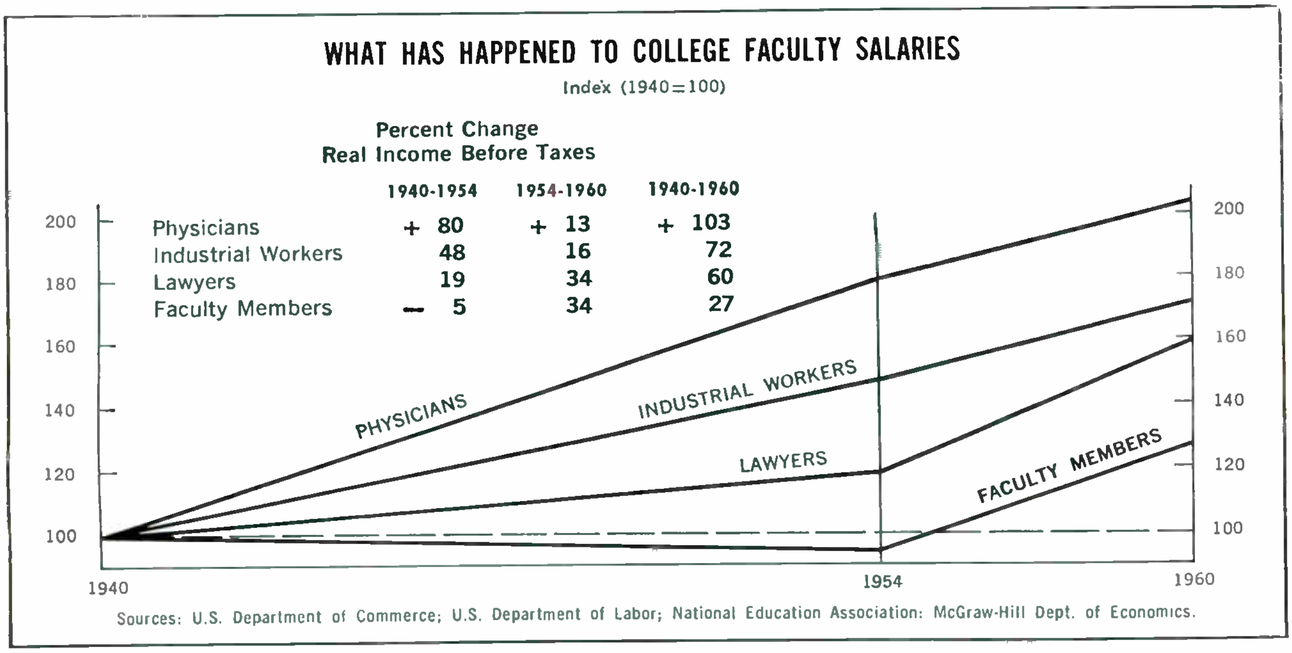
No Federal Funds For Salaries

The plans for increased financial aid for higher education, proposed by President Kennedy, do not contemplate increased expenditure for faculty salaries. This, we believe, is wise whether or not you feel, as many do, that resort to this kind of federal financing would inevitably carry with it federal controls that would ultimately undermine academic independence. The fight over federal appropriations for faculty salaries would be so long and bitter that it would be destructive to the aid program as a whole.

However, what the federal government will not be doing to remedy the deplorable condition of faculty salaries, as reported by the chart, is one indication of the tremendous scope that remains for crucially important help for higher education from business. Manifold other indications are available.

Disaster Escape Route

One of these indications is provided by the careful calculation that the annual income of our colleges and universities must be increased by about \$4½ billion (from about \$4½ billion to about \$9 billion) over the next eight years if the tremendous wave of students



now gathering to descend on these institutions is not to wind up in both a financial and an educational disaster. This wave promises to add more than 2.5 million, or 75%, to college enrollments by 1970.

Thus far, the program for financial help for higher education by business, spearheaded by the Council for Financial Aid to Education, has been a remarkable success in all dimensions. The dollars contributed have increased rapidly—from about $100 million five years ago to about $150 million this year. Contributions of $500 million a year by 1970 are a clear possibility.

One of the inspiring developments increasing this possibility stems out of Cleveland, Ohio. There through their chief executives, an imposing group of business firms have established one per cent of their profits before taxes as their minimum goal for contributions to higher education, to be reached within three years. General acceptance of this goal by business would go most of the way toward getting our colleges and universities firmly on their feet financially.

Mutual Respect Increased

The mutual esteem of the academic community and the business community, an element of enormous importance to a free society, has been increased by the manner in which the program of financial aid has been carried out. In making its contribution, there has been no attempt whatsoever on the part of business to encroach upon the academic freedom of the institutions financially benefited. And the program of financial aid has greatly increased the knowledge, understanding and respect which the colleges and universities and business have for each other.

The Kennedy Administration's program to enlarge federal financial support of higher education is certain to arouse strenuous controversy. As proposed by its Task Force, it avoids some of the most controverial areas of principle. However, the very magnitude of the proposed extension of the federal government's already vast program of financing higher education involves fighting issues.

But if the enlargement of federal aid were to be deeply discouraging to the continued expansion of private aid for higher education, it would be a national misfortune of major proportions. There is no good reason why it should be. On the contrary, there is compelling reason for the business community to continue giving higher education all the financial help it possibly can, thus speeding onward a program that has been and continues to be a major constructive force for our colleges and universities, for business and for the nation.

This message was prepared by my staff associates as part of our company-wide effort to report on major new developments in American business and industry. Permission is freely extended to newspapers, groups or individuals to quote or reprint all or part of the text.

Donald C McGraw

PRESIDENT

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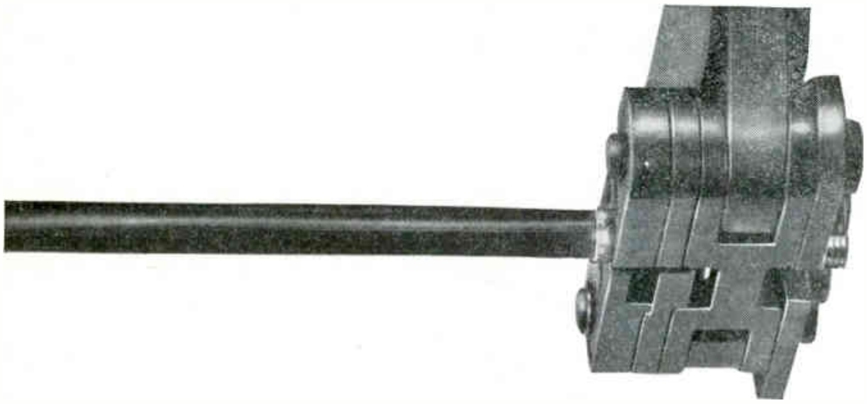

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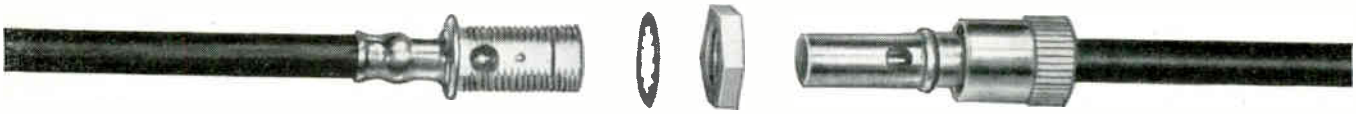

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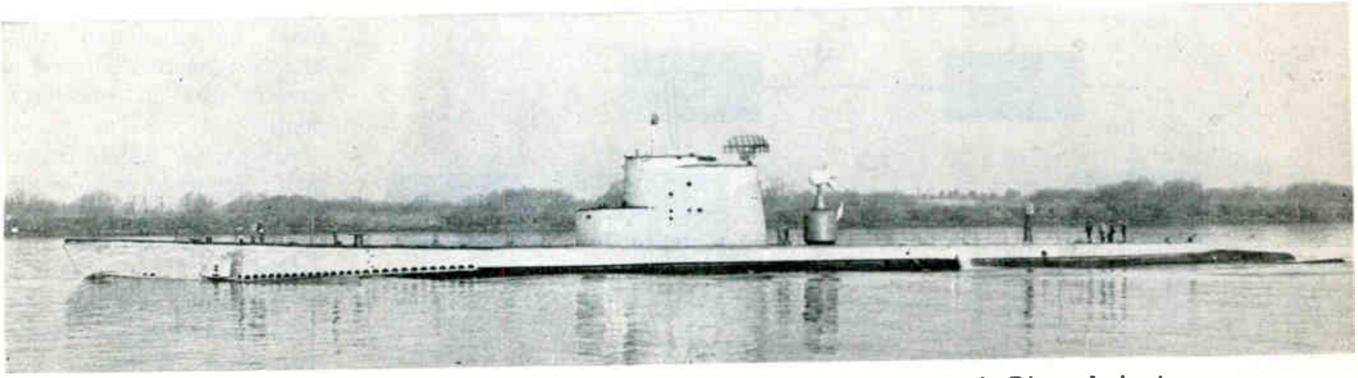
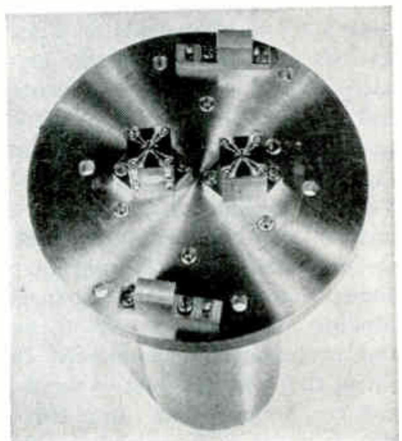


Navy's USS Redfin, *equipped for electronic research, is fitted with a Daystrom Electric Div. velocimeter*

Deep-Ocean Velocimeter Aids Sonar Systems Design



Transmitting and receiving transducers (center) and reflectors of velocimeter built by ACF Electronics Division

Transistor instrument operates at maximum ocean depths, supplying speed-of-sound-in-water information to surface by cable. Supersonic pulse sent along fixed-length water path is fed back as generator trigger. Repetition rate change is read out

By LEON DULBERGER, Assistant Editor

PHYSICAL OCEANOGRAPHERS AND NAVY scientists are now able to measure the speed of sound in water to extreme depths, using self-contained transistor instruments of high accuracy, pressurized for deep-ocean operation.

Last summer, the Navy's bathyscaphe, *Trieste*, equipped with a transistor velocimeter (instrument for measuring speed of sound in water) descended to 18,800 feet, off Guam. The velocimeter, designed and fabricated by National Bureau of Standards, was mounted externally on a hull platform, operated reliably at the extreme pressures encountered. The *Trieste* is now being prepared for dives equal to its seven-mile record of last February, will carry a velocimeter to depths over 35,000 feet.

These dives provide checks to confirm depth dependance of formulas developed for calculation of speed of sound in water from temperature, depth and salinity. There is a backlog of data on these three variables gathered by ocean researchers working throughout the world. It can be converted into sound speed information right now, while velocimeter surveys are being made.

Sonar weapon system design will be implemented by the study of undersea sound propagation in such surveys[1].

Ocean sound channels several

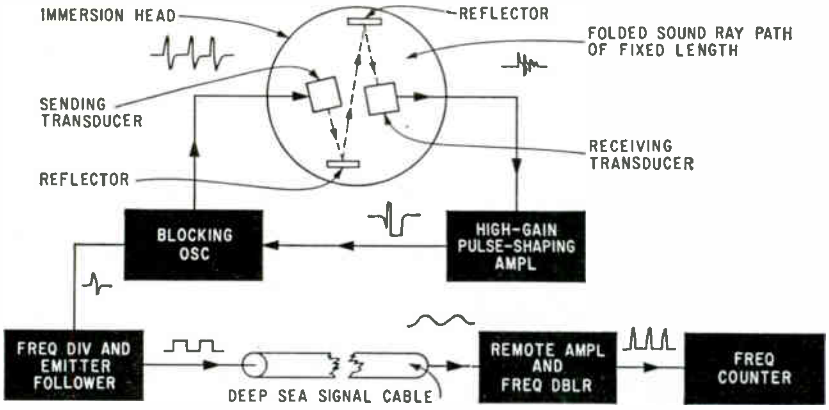


FIG. 1—Block diagram of National Bureau of Standards designed deep-ocean velocimeter for measuring speed of sound in water. Transmission cable may be several miles in length

thousand feet below the surface are capable of multithousand-mile propagation at low frequencies, and may be located by sound velocity meter surveys. A system of ship distress signals, whereby vessels drop an explosive charge adjusted to detonate at the depth of a long distance channel local to the incident, has gained attention. Receiving stations thousands of miles away can triangulate on the explosion. Thus, knowledge of exact sound propagation rates in these channels can provide accuracy in fixing the vessel's position.

Velocity of sound in water varies primarily with temperature, pressure and salinity. Temperature changes rapidly near the surface, producing the major effect on sound propagation encountered in the first few hundred feet of depth. Pressure becomes an important factor as depth is increased, due to leveling off of temperature variations. Salinity is assumed constant when its lesser effect is not the limiting factor in accuracy of calculations.

Sound velocity variations in water produce channeling of sonar signals near the surface. Reflection and refraction of sound rays disrupt sound propagation generally. Submarines seeking to escape detection from surface vessels hide beneath thermoclines, layers of unequal water temperature. They bend sonar rays and render a sub undetectable.

When sonar transducer location can be controlled, as in the case of a submarine-mounted unit where the craft is free to maneuver, a sound velocity meter will allow tactical positioning for maximum range.

A mechanical instrument, the bathythermograph, has been relied on for years to measure temperature against depth. Lowered into the ocean, it makes a graphical record of these two variables on a smoked glass slide. With the bathythermograph, speed of sound must be calculated, the instrument's response is slow and it is usually used at relatively limited depths.

An earlier all-electronic instrument, designed to provide temperature and pressure is available, but does not read out directly in sound velocity[2].

Operating principle of the National Bureau of Standards velocimeter design is based on delay of an ultrasonic sound pulse sent along a fixed length path through the water sample[3,4]. A crystal transducer, driven by a free-running blocking oscillator (see Fig. 1), transmits the pulse along the ray path. This path is folded by using reflectors; this prevents errors due to liquid movement which causes Doppler shift in the rep rate; and also unwanted multiple echoes.

The pulse is picked up by a receiving crystal transducer, amplified and reshaped to a steep rise again. The output is fed back to the blocking oscillator and synchronizes it at a repetition rate determined by the delay time of the sample. This method is the "sing-around" system. Referring to Fig. 2, output from the oscillator is divided in frequency by a multivibrator, which also supplies a high-energy low frequency component at the repetition rate, to overcome attenuation of the signal in transmission. It is next applied to an emitter follower to obtain low impedance and driving power to accommodate long cables with high capacitance.

At the remote end of the cable, the signal, which approaches a sinusoidal waveshape due to the cable's filter action, is amplified to restore the leading edge, and doubled in frequency for ease of counting.

Output frequency is a function of speed of sound in water, and is calibrated for each instrument built. Distilled water is used as the standard calibrating fluid on velocimeters intended for ocean operation.

EVOLUTION OF THE DEEP-SEA VELOCIMETER

Design of a vacuum-tube velocimeter was started in 1955 by Greenspan and Tschiegg at the National Bureau of Standards. The early instrument was useful to depths of several hundred feet. It employed the sing-around principle described in a 1937 patent by Shepard. The NBS scientists chose this system because it provided simplified instrumentation through measurement of frequency as the variable. Readout is accomplished on a counter, or a frequency meter, able to run a recorder.

By 1957, Tschiegg had developed a transistorized version of the velocimeter, operating on self-contained batteries, and packaged to resist high pressures. Tests were made to 6,000 feet at sea by Woods Hole Oceanographic Institution under the direction of Earl Hays. Sound velocity readings were made to an accuracy of less-than 1 ft per sec, and were reproducible in the field to 0.5 ft per sec.

WHOI has since used the velocimeter as a standard instrument in basic oceanographic studies. They may develop a system using several units to obtain continuous profiles of sound speed, at various depths simultaneously

Time delay introduced by path-length variations in the electronic circuits are accounted for in calibration.

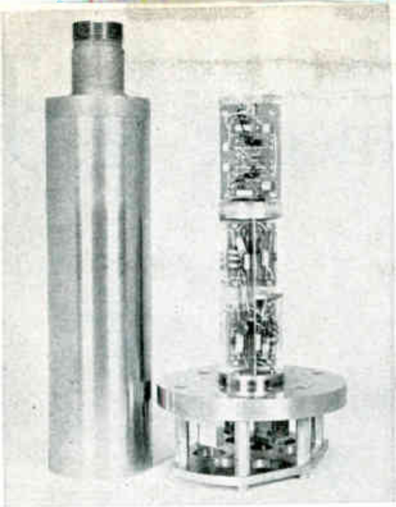
The velocimeter's submersible section[5], called the "fish" includes transducers and sound path reflectors mounted on an end plate. Electronic sing-around circuits, cable-driving amplifier and mercury batteries are in a stainless steel case.

The remote transistor unit at the other end of the cable accepts the signal from the fish and readies it for counter readout. The device includes: preamp which feeds the full-wave rectifier and frequency-doubler, and output inverter-amplifier. An audio frequency meter at the output allows direct calibration on the meter scale of speed of sound in water. This type of output also provides the basis for a strip chart recording version of the velocimeter.

Design drawings of the NBS-developed, Tschiegg high-pressure model were made available to industry by the Navy and commercial units are now on the market. Daystrom, Inc., Electric Div., Poughkeepsie, N. Y. is one firm now producing the velocimeter. They make calibrated units able to operate at 10,000 psi. The Navy Hydrographic Office has installed several aboard submarines such as the *USS Redfin* which is used for electronic instrumented oceanographic and military marine research. The submarine *USS Archerfish*, now on survey, also carries a unit.

A chart is supplied with each calibrated instrument to convert output frequency directly into speed of sound in water.

Another firm, ACF Electronics Div., ACF Industries, Inc., Paramus, N. J., also produces velocimeters based on the NBS design. The firm supplies Navy Hydrographic Office with instruments.



Watertight housing (left) shown removed from velocimeter built by ACF Electronics Div. Plate on spacers (bottom, same photo) protects transducers and reflectors from damage. Picture at right shows velocimeters undergoing tests at firm's laboratory. Readout is obtained on frequency counter

REFERENCES

(1) G. Rand, Determining Sonar System Capability, ELECTRONICS, Feb. 10, 1961.

(2) J. Snodgrass and J. Cawley, Bathythermometer Telemeters Ocean Data, ELECTRONICS, May 1, 1957.

(3) *NBS Technical News Bulletin*, Dept. of Commerce, 39, No. 7 July, 1955.

(4) M. Greenspan and C. Tschiegg, Sing-Around Ultrasonic Velocimeter for Liquids, *Rev. of Scientific Instruments*, 28, No. 11, Nov., 1957.

(5) C. Tschiegg and E. Hays, Transistorized Velocimeter for Measuring the Speed of Sound in the Sea, *Jour. of the Acoustical Soc. of America*, 31, No. 7, July, 1959.

BIBLIOGRAPHY

W. Wilson and D. Taylor, Sound Velocity Measurement in Liquids, ELECTRONICS, Sept. 9, 1960.

R. Forgacs, Precision Ultrasonic Velocity Measurements, ELECTRONICS, Nov. 18, 1960.

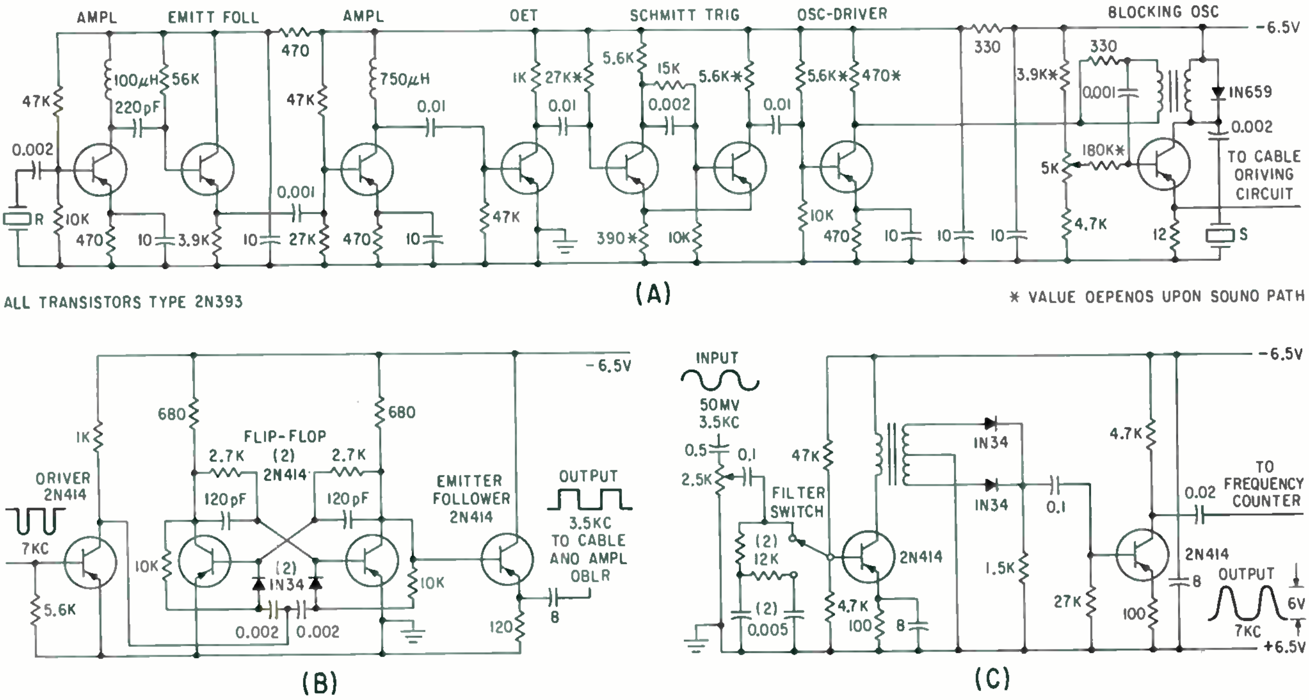


FIG. 2—Complete schematic of Daystrom's velocimeter. "Sing-around" circuit (A) and cable driving circuit (B) are in "fish." Amplifier and frequency doubler (C) are located at far end of cable. R-C filter may be switched in to shape waveform for short cable lengths

Staggered-Tuned F-M Discriminator

By RUDOLPH FEDERMAN,
Electronics Research Laboratories, Columbia University, New York, N. Y.

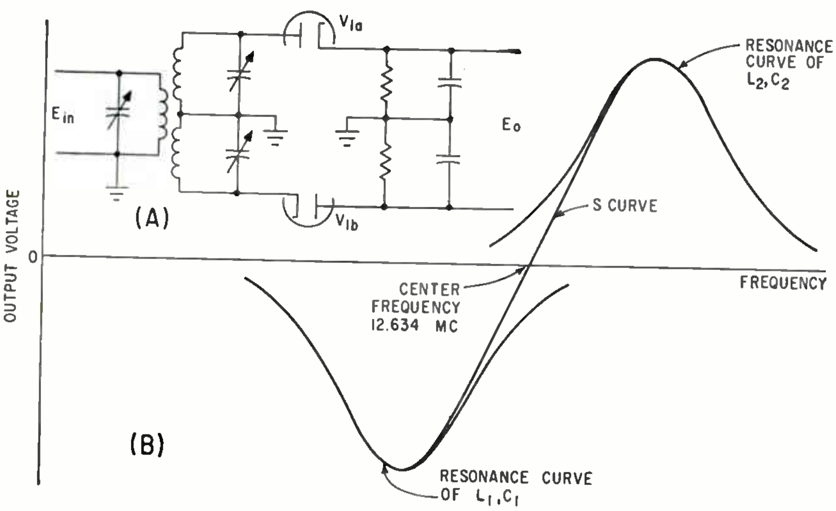


FIG. 1—Circuit of discriminator is shown in (A); the resonance S curve resulting from subtracting secondary tank resonances is in (B)

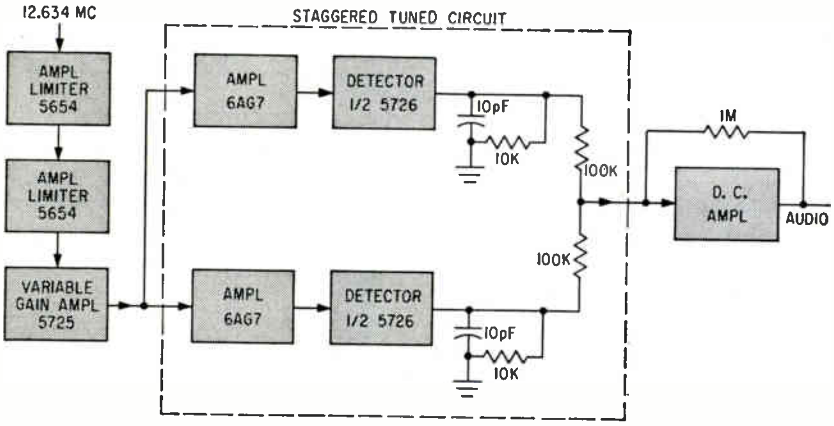


FIG. 2—Block diagram of discriminator indicates two limiting stages, one variable-gain amplifier stage, and individual driver amplifiers for each half of circuit

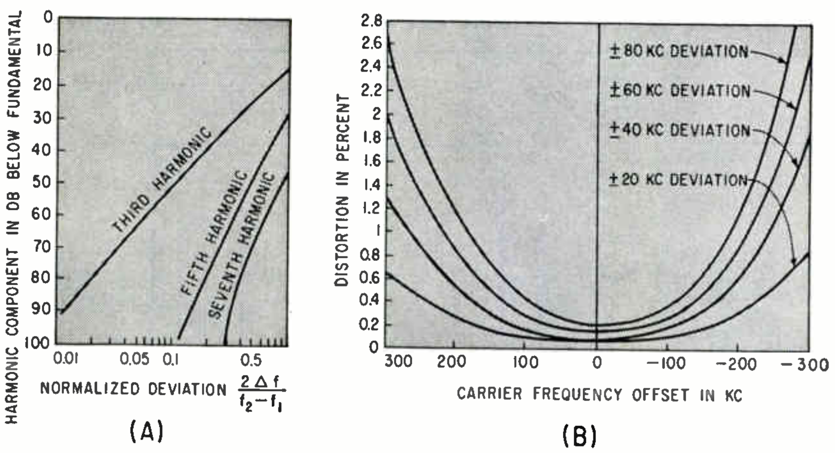


FIG. 3—Distortion curves of important harmonic components are plotted against the normalized deviation for a discriminator in (A); the percent distortion against offset in carrier frequency with frequency deviation as a parameter is plotted in (B)

IN THE DESIGN of frequency modulator systems the discriminator plays a major role in over-all performance. If the main objective is linearity, a wide-band discriminator is used; if the important characteristic is gain, a narrow-band discriminator is employed.

In this application, low distortion was of primary importance: 0.25 percent for a frequency deviation of ±40 Kc at a center frequency of 12.6 Mc; therefore a wide-band, low-sensitivity approach was taken.

This discriminator was used in a corrective feedback loop around a frequency modulator. When the discriminator output is compared with the modulating signal, any dissimilarities are interpreted as errors in the output frequency and a correction is made. Therefore, even though all other components are perfect, the lower limit of distortion performance of the modulator with feedback is determined solely by the discriminator.

Since this discriminator is linear, it can be used to determine the distortion contributed by signal generators, or as an error sensing device in other feedback arrangements where the conversion of an f-m signal into a voltage signal must be accomplished with a minimum of distortion.

The staggered-tuned circuit, shown in Fig. 1A, uses two identical secondary tank circuits. One of these is tuned above the center frequency of the primary tank circuit, and the other is tuned below the center frequency. This offset is usually the same for both circuits, but an assymetrical condition sometimes gives lower distortion. In Fig. 1B, the resonance curves of the individual secondary tank circuits and the *S* curve are shown for the symmetrical case.

The ideal *S* curve indicates that the output voltage is zero for an unmodulated carrier. When the input frequency changes from the center frequency, the secondary tanks become unbalanced and pro-

Has Low Distortion, Wide Bandwidth

duce a voltage across the load resistor. This circuit will reject some types of amplitude modulation, but amplitude modulation introduced at a frequency other than center frequency of the discriminator will cause an output. This discriminator therefore must be preceded by several stages of limiting.

Use of two individual secondary tank circuits results in an extremely linear *S* curve. Because all even-harmonic components are cancelled, the *S* curve is linear over a wide range, and this is the main reason for the low distortion.

Third-harmonic distortion can arise because the linear region at the origin is degraded if separation between the resonant peaks of the two tuned-secondary tank circuits becomes large compared with the bandwidth of the individual tank circuits. In a wide-band discriminator, this will occur only if the mistuning is severe.

A block diagram of the discriminator is shown in Fig. 2. Two stages of amplification and limiting reject any amplitude modulation on the carrier and insure adequate signal level to drive the circuit. The next stage, a variable-gain amplifier, restores the sinusoidal waveform after clipping, and further amplifies the signal. To reduce distortion, these circuits have a bandwidth of almost 3 megacycles.

Given the distortion requirements, the problem was to determine the over-all bandwidth of the staggered-tuned circuit and the individual bandwidths of the secondary tanks. The following symbols were used: f_o = center frequency, 12.6 Mc, Δf = zero-to-peak deviation, 40 Kc, f_2 = resonant frequency of upper secondary tank circuit, f_1 = resonant frequency of lower secondary tank circuit, $f_2 - f_1$ = separation between peaks, BW = bandwidth of an individual secondary tank circuit, $\alpha = f - f_1/BW$; the ratio of separation between peaks to the bandwidth of an individual secondary circuit, and $2\Delta f/(f_2 - f_1)$ = normalized deviation, or (peak-to-peak deviation)/(separation between peaks).

Over-all bandwidth of the staggered-tuned circuit was calculated using the graph[1] in Fig. 3A. Although the curves are for a phase-shift circuit, they may be used in this case since the two circuits have virtually the same variation in harmonic content for the same bandwidth. It was assumed that all harmonics except the third would be negligible.

To allow a safety margin, distortion of 0.1 percent was used as the design goal instead of the target of 0.25 percent. From Fig. 3A, a distortion of 0.1 percent (60 db on the ordinate axis) corresponds to a normalized deviation of 0.066 or 1/15. Thus, $2\Delta f/(f_2 - f_1) = 1/15$. Solving for $(f_2 - f_1)$ yields, for an 80-Kc peak-to-peak deviation ($f_2 - f_1$ = 1.2 Mc, the required bandwidth of the over-all staggered-tuned circuit.

To determine the bandwidth of the secondary tuned circuits, the following relations are obtained from Argimbau's analysis:[2] $\alpha \times BW = f_2 - f_1$; let $\alpha \cong \sqrt{3}/2 \cong 1.25$; $1.25\ BW = 1.2 \times 10^6$, and BW = 960 Kc for each secondary circuit.

This value of BW and a 12.6-Mc center frequency determines the Q, $Q = f_o/BW = 12.634 \times 10^6/960 \times 10^3 = 13$ for each secondary circuit.

This Q cannot be obtained directly without loading the coil with a damping resistance. Therefore, it is necessary to determine the values of all circuit elements that will achieve this value of Q.

Although a low Q is desired, the impedance of the tank circuit should be high enough to maintain high gain. The L/C ratio is therefore chosen as high as possible. The highest possible value of L is about 2.4 μh. Further increase in inductance will decrease the fixed capacitance necessary for a sufficient value of tuning. With L = 2.4 μh, the value of capacitance, for resonance is 70 pf. The unloaded Q of this coil is about 100.

Distortion readings for different frequency deviations and for various carrier-frequency offsets from the center-frequency of the discriminator are plotted in Fig. 3B.

Staggered-tuned discriminator, shown with author, brings distortion below 0.25 percent for a frequency deviation of 40 Kc

Over-all sensitivity is 7 volts for every 10 kilocycles. Referred to the detected output of the staggered-tuned circuit, the sensitivity is 0.7 volts per 10 Kc, since there is a gain of ten in the d-c amplifier.

The author thanks A. F. Sciorra and Professor J. H. Bose for their many technical suggestions, and C. P. Walsh for his assistance and comments.

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REFERENCES

(1) W. G. Tuller and T. P. Cheatham, Jr., Adjustable Bandwidth FM Discrimination, ELECTRONICS, p 117, Sept. 1947.
(2) L. B. Argimbau, Discriminator Linearity, ELECTRONICS, p 142, March 1943.

Designing

Step-by-step design of a fundamental transistor circuit is detailed showing methods of designing for maximum reliability under worst-case conditions

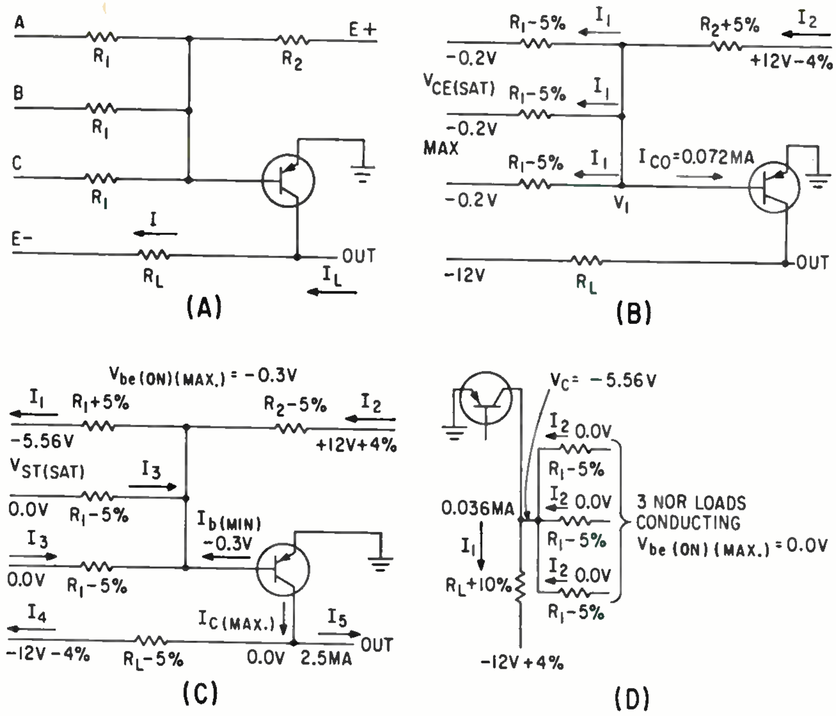


FIG. 1—Typical pnp NOR circuit (A) showing 50-degree C worst case (B), room temperature worst case (C) and worst case OFF loading (D)

By K. M. TRAMPEL,
IBM Corp., Poughkeepsie, New York

EXTREMELY COMPLEX logical functions can be built up from a few simple operations. All logical relations can be expressed by the use of the three connectives AND, OR and NOT (for negation). By using either one of two methods of logic, the Sheffer stroke or the NOR, all logical statements can be implemented with the NOR circuit to be described. Since all logical expressions can be derived with the NOR circuit, an entire digital switching system can be constructed with a single type of circuit.

A *pnp* NOR circuit is shown in Fig. 1A. Three input resistors R_1 provide the logical function while the transistor inverts the base (input) signal establishing a well-defined on level (level setting) and supplies power.

The *pnp* NOR circuit is a saturating voltage mode circuit. The terminology of voltage-mode operation stems from the method of transmitting information. The state of the information (up or down) in the NOR application outlined in this article is defined by a voltage level. This voltage level is either ground or a negative potential.

The voltage mode output of the *pnp* NOR circuit is at the collector of the transistor and has two output states. In operation, the transistor is switched between its saturation (on) state and its cut off (off) state. When the transistor is in saturation, the output voltage is at ground potential minus the collector-emitter drop across the transistor (−0.1 v is typical). When the transistor is cut off, output voltage V_{off} is given by the equation $V_{off} = IE^- + IR_L$ where I is the current determined by the addition of collector leakage current I_{co} and the current I_L drawn by the load.

The transistor is turned on (saturated) when any of the three inputs is at a down level (negative voltage). To cut off the transistor, all three inputs must be at ground level (up level or 0 v). Adopting the convention the 0 volts (up level) is 1 and negative voltage (down level) is 0, the circuit performs the Sheffer stroke function. Adopting the opposite convention produces the NOR function.

To assure reliable circuit operation, the circuit should operate satisfactorily under end-of-life conditions. Worst-case circuit design takes into consideration the degeneration of circuit components, device specifications and purchase tolerances. A circuit in which all parameters deviate simultaneously in the worst direction by a maximum expected amount is called the worst case. Taylor design criteria is one method of designing circuits with a high degree of reliability. This approach requires that when the effects of circuit parameters are considered, all parameters are taken at worst-case purchase tolerances and the most critical parameter is taken at worst-case end-of-life tolerance. The most critical parameter can be determined by extensive analysis where, for a condition, each parameter is considered in turn as the critical one. Circuit experience reduces the extent of the analysis and only a few parameters need be considered.

Independent variables of the NOR circuit can be assigned values based on engineering knowledge and the environment in which the circuit is intended. For the alloy junction *pnp* NOR design, the transistor specifications are shown in Table I. Power supplies $E+$ and $E-$ are +12 v and −12 v respectively, both ±4 percent and all resistors are ±5 percent with ±10 percent at end of life.

A knowledge of the design limitations and logic gives the value of the number of inputs and the output drive capability. The maximum number of inputs and the output drive is assigned a value of three. These values are assigned

NOR Circuits for Maximum Reliability

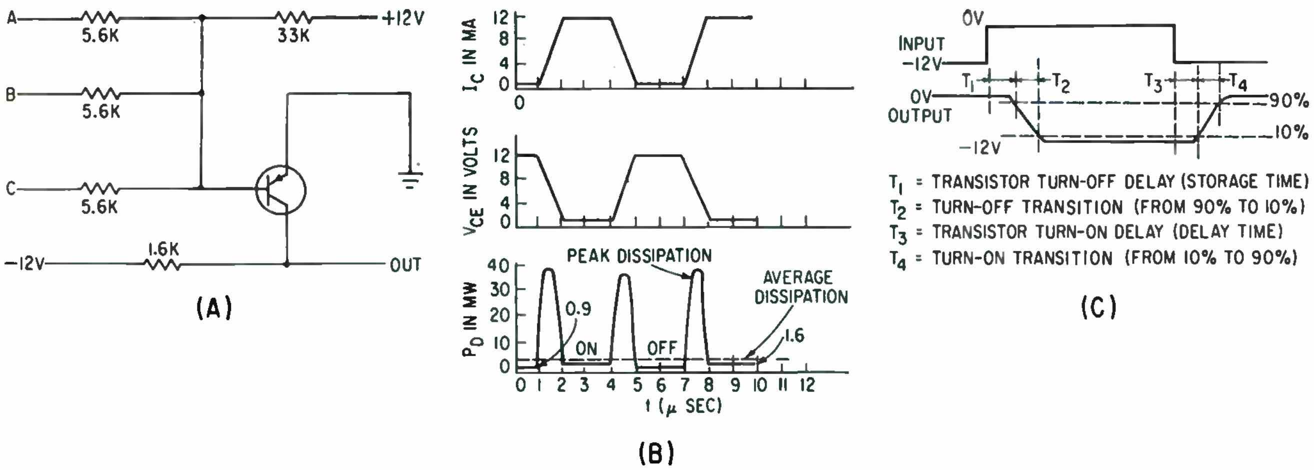


FIG. 2—Completed NOR circuit (A) showing power dissipated during switching period (B) and characteristics affecting output signal (C)

to facilitate description of the basic design. They could be assumed as variables and an optimum solution can be obtained by programming a small digital computer.

The *pnp* NOR is to be designed so that when all inputs are at ground level, the transistor is not conducting (off). For this worst-case condition, the most critical parameter is transistor leakage current. Under this condition, the criterion to be satisfied is that V_{be} (off) maximum must be equal or greater than +0.2 v, therefore V_{be} (off) = $V_1 \geqq +0.2$ v.

Figure 1B shows the worst-case off conditions with the significant circuit parameters deviated in the direction to make it difficult to satisfy the off case. Junction V_1 is made as negative as possible which tends to turn the transistor on

$$V_1 \geq +0.2 \text{ v (OFF criteria)} \quad (1)$$

$$I_2 = 3I_1 + I_{co} \quad (2)$$

$$(11.52 - V_1)/(1.05\,R_2) = 3\,(V_1 + 0.2)/(0.95\,R_1) + 0.072 \quad (3)$$

Current is in milliamperes and resistors R_1 and R_2 are in thousands of ohms. Simplify Eq. 3 and solve for V_1 by

$$V_1 = [10.95\,R_1 - R_2\,(0.63 + 0.072\,R_1)]/(3.15\,R_2 + 0.95\,R_1) \quad (4)$$

Substitute Eq. 4 into Eq. 1 and simplify

$$1/R_1 \leq (8.47/R_2) - 0.057 \quad (5)$$

The transistor can always be guaranteed off as long as this equation is satisfied and none of the parameters deviate more than their maximum expected deviations. When a EIA value of R_2 is selected, the value of R_1 becomes established. Any EIA value greater than R_1 can be used to satisfy the off case. For satisfactory circuit operation, the worst case on condition has to be considered.

To complete the *pnp* NOR design, transistor saturation has to be satisfied. The most positive down level to the *pnp* NOR has to be compatible with the output of a finalized voltage mode trigger. Since the most positive down level from the voltage mode trigger is −5.56 v, the *pnp* NOR must operate with this as a possible input signal. When any one or more inputs are at −5.56 v (or more negative), the transistor will saturate (on). All parameters are deviated in the direction to make it most difficult to satisfy the on condition.

For this worst-case condition the most critical parameter, determined by experience and analysis, is the transistor current gain. Under this condition the criterion to be satisfied is that the minimum base current is equal to or greater than I_c (max)/α_{fe} (min) therefore I_b (min) $\geqq I_c$ (max)/α'_{fe} (min). If this criterion is satisfied then any transistor having a current gain equal to or greater than α'_{fe} (min) can be saturated for collector current from 0 to I_c (max).

Figure 1C shows the worst-case on condition with the significant circuit parameters deviated in the direction to make it difficult to satisfy the on case. The junction V_{be} (on) is made as negative as possible to determine the minimum available base current.

Available on current I_5, used to drive additional circuits, has to be sufficient to supply the crosstalk current (other inputs of succeeding stage). Specifying this available current simplifies design. From knowledge of the loading circuits, maximum available current I_5 of 2.5 ma is a realistic current to guarantee. If this circuit is to be used only with the same type circuit (*pnp* NOR), then this loading current would be too great. Restricting the loading to only NOR circuits would also simplify the design. To clarify the presentation, the maximum loading current is specified. The on criteria is

$$I_b\,(\text{min}) \geq I_c\,(\text{max})/\alpha'_{fe}\,(\text{min}) \quad (6)$$

solving for I_b (min)

$$I_b\,(\text{min}) = I_1\,(\text{min}) - I_2\,(\text{max}) - 2I_3\,(\text{max}) \quad (7)$$
$$= [(5.56 - 0.3)/(1.05\,R_1)]$$

$- [(12.48 + 0.3)/(0.95 R_2)]$
$- [2 (0.3/0.95 R_1)]$ (8)
$= (4.38/R_1) - (13.45/R_2)$ (9)

solving for I_c (max):

$$I_c(\text{max}) = I_4(\text{max}) + I_5(\text{max}) \quad (10)$$
$$= (12.48 - 0.0)/(0.95 R_L) + 2.5 \quad (11)$$
$$= (13.15/R_L) + 2.5 \quad (12)$$

substitute Eq. 12 and 9 into Eq. 6

$$(4.38/R_1) - (13.45 R_2) \geq 1/30 [(13.15/R_L) + 2.5] \quad (13)$$

Drive capabilities of the NOR circuit depend on the value of load resistor R_L. The NOR circuit should be capable of driving three other NOR circuits in the off condition. Figure 1D shows the worst-case off loading. Since the NOR should operate with an input at −5.56 v during the down level, the collector should not become more positive than −5.56 v when the transistor is off.

For this worst-case condition, the most critical parameter is the load resistance of the NOR circuit. Under this condition, the criterion to be satisfied is that the collector never becomes more positive than −5.56 v. Therefore

$$I_1(\text{min}) \geq I_{co}(\text{max}) + 3I_2(\text{max}) \quad (14)$$
$$[(11.52 - 5.56)/1.1 R_L] \geq 0.036 + 3 [(5.56 - 0.0)/(0.95 R_1)] \quad (15)$$
$$5.42/R_L \geq 0.036 + (17.6/R_1) \quad (16)$$

A unique solution of the equations is not possible because of the inequality of the relationships. To facilitate design, a value of R_L is selected. Selection can be aided by the compatibility with existing circuits. Here the *pnp* NOR circuit has to be compatible with the IBM CTRL (complementary-transistor-resistor logic) circuit family. To common the output of a NOR circuit to the output of a CTRL circuit, a load resistor of 1.6 K (value of the CTRL resistor) should be used.

If the load resistor is chosen as 1.6 K, design of the NOR circuit can be completed. An optimum design can only be accomplished if the particular logical application is defined. This means that the logical system must be available before the electrical circuit design can be undertaken. For conventional versatile circuits, generalizations must be made to complement the majority of logical applications

$$R_L = 1{,}600 \text{ ohms} \quad (17)$$

substituting Eq. 17 into Eq. 16 and solving for R_1

$$R_1 \geq 5{,}270 \text{ ohms} \quad (18)$$

the next higher EIA value is 5,600 ohms therefore

$$R_1 = 5{,}600 \text{ ohms} \quad (19)$$

Substitute Eq. 19 into Eq. 5 and solve for R_2

$$R_2 \leq 35{,}900 \text{ ohms} \quad (20)$$

Substitute Eq. 19 and 17 into Eq. 13 and solve for R_2.

$$R_2 \geq 31{,}500 \text{ ohms} \quad (21)$$

From Eq. 20 and 21, the EIA value of 33,000 ohms satisfied the two equations. If no EIA value were overlapped by Eq. 20 and 21, then a larger value of R_L would have to be used. Figure 2A shows a completed NOR circuit.

The design of the NOR circuit did not consider the effects of power dissipation because of the advantages of operating the transistor in saturation. Since V_{ce} (saturation) and I_{co} are small, there is low power dissipation when the transistor is on or off. High dissipation results only during the transition from one state to the other (in the active region). Figure 2B gives the power dissipated in the transistor as it is switched from one state to the other in the NOR circuit.

$$P_{on}(\text{max}) = V_{ce}(\text{max})\, I_c(\text{max}) = 0.2 [(12.48 - 0.2)/(0.95 \times 1.6)] \approx 1.6 \text{ mw}$$
$$P_{off}(\text{max}) = V_c(\text{max})\, I_{co}(\text{max}) = (12.48 - 0.072 \times 0.95 \times 1.6)\, 0.072 \approx 0.9 \text{ mw}$$

From Fig. 2B, the average dissipation is much less than the peak dissipation. Since the average dissipation is low, it is possible to operate the transistor at power that exceeds the maximum rated dissipation during the switching transient, but does not exceed it in the steady state.

The possibility of the reverse bias voltages exceeding the breakdown specifications of the transistor must be checked. The maximum reverse bias voltage occurs when the driving circuits are removed and all the NOR inputs float. Under this condition, the maximum reverse collector-base bias is 12.48 + 12.48 = 24.96 v when both the +12 v and −12 v supplies increase to the maximum of +4 percent. The maximum reverse emitter-base bias is 12.48 v. These values are within the breakdown specifications shown in Table I.

The major disadvantage of the NOR circuit is low operating speed. The speed is limited by the small amount of base overdrive and the high degree of saturation (heavy minority carrier storage) when two or more inputs are very negative.

Figure 2C shows the output waveform with a signal applied to one input with the other inputs grounded. The minority carrier storage in the base and the transit time through the base affect turn-off delay T_1. Transit time is the time required for emitter current to cross the base region. Differences in minority carrier velocity and path length affect the arrival time of the carriers influencing T_2, the turn-off transition. Several factors affect T_3, the turn-on delay with transit time and base-emitter junction capacitance being important. Since the NOR is reverse biased, time is required to discharge the capacitance across the base-emitter and to charge it forword biased. The greater the reverse bias, the longer the delay. At small emitter currents, α_{fe} and the frequency response are low and emitter current must increase to a reasonable value before the transistors response is fast.

As with turn-off transition, velocity and path length affect T_4, the turn-on transition. Rise time is also a function of transistor frequency response. Turn-on delay and transistion are also a function of the base current (turn-on current). The greater the turn-on current, the shorter the delay and transition.

TABLE I—END OF LIFE (EOL) TRANSISTOR SPECIFICATIONS

α'_{fe} (min) = 30
I_{beo} (max) = I_{ceo} (max)
= 72 μa at 50 C (EOL)
= 36 μa at 50 C (acceptance)
$V_{ce\,(sat)}$ (max) = −0.2 v
$V_{be\,(off)}$ (max) ≥ +0.2 v at 50 C
K = 0.35 mw/degree C
T_j (max) = 75 C
T_a = 50 C
$V_{be\,(on)}$ (max) ≤ −0.3 v at 25 C
$P_{max} = (T_j - T_a)/K = (75 - 50)/0.35 = 71.4$ mw
Breakdown: V_{bc} = 25 v, V_{be} = 13 v

BIBLIOGRAPHY

(1) J. J. Ebers and J. L. Moll, Large Signal Behavior of Junction Transistors, *Proc IRE*, 42, p 1761, Dec 1954.
(2) R. A. Henle and J. L. Walsh, The Application of Transistors to Computers, *Proc IRE*, 46, p 1240, June 1958.
(3) N. T. Grisamore, L. S. Rotolo and G. V. Vychara, Logical Design Using the Stroke Function, *Trans IRE*, EC-7, p 181, June 1958.
(4) L. P. Hunter, "Handbook of Semiconductor Electronics," McGraw-Hill Publishing Co., New York, 1956.

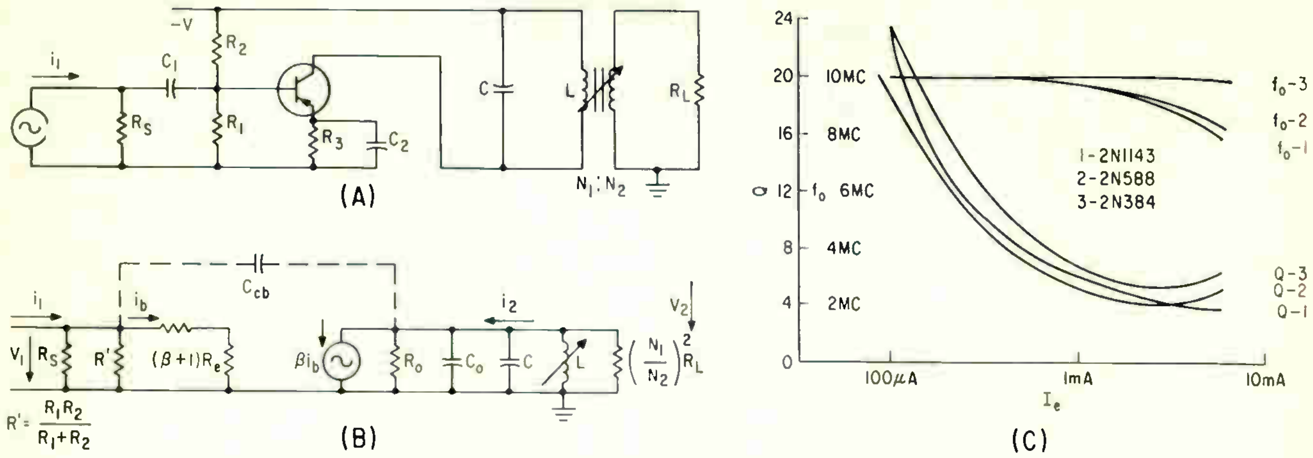


FIG. 1—Typical tuned i-f amplifier, unneutralized (A); high-frequency equivalent circuit (B); and graph of center frequency f_o and circuit Q plotted against emitter current (C) for three different transistors

Transistor Cascode Circuit Improves Automatic Gain Control in Amplifiers

By J. F. PERKINS, Jr.,

Mgr., Circuit Techniques Section, Techniques and Components Dept., Raytheon Co., Sudbury, Mass.

THE PROBLEM of providing automatic gain control for tuned i-f amplifiers, without degrading the frequency response of the amplifier, is common to both transistor and vacuum-tube circuits. The problem is especially acute with transistor amplifiers, due to the larger changes in transistor parameters with changes in operating point.

A review of the effects of transistor parameter changes upon the Q and center frequency of a tuned circuit demonstrates the need for isolating the tuned circuit from these changing parameters.

This article presents an improved method of applying agc to transistor i-f tuned amplifiers that overcomes, to a great extent, the problems that have plagued previous agc circuits. It is hoped that this material will be of value in the application of transistors to superhetrodyne receivers and amplifiers.

A simple one-stage, grounded-emitter tuned transistor i-f amplifier without neutralization, is shown in Fig. 1A. The high-frequency equivalent circuit of this stage is shown in Fig. 1B. From the equivalent circuit, note that transistor output impedance R_o is in parallel with the reflected load impedance of the transformer. As the Q of the stage is a function of the transistor output impedance, the reflected load impedance, and the characteristic impedance of the inductance-capacitance combination, any change in transistor output impedance will affect the Q of the circuit.

One method commonly used for minimizing the effect of the output impedance upon the Q of the circuit is to mismatch the reflected load and output impedances. Mismatch-

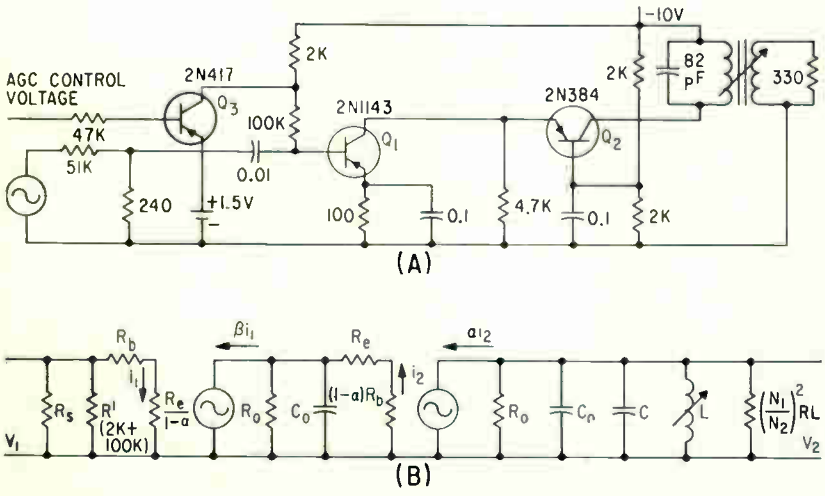
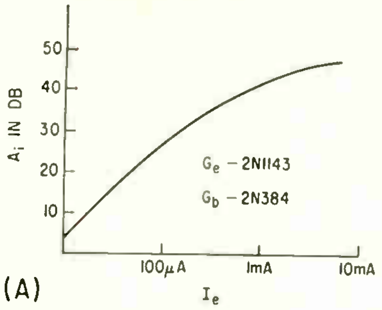


FIG. 2—Schematic of cascode i-f amplifier stage with agc (A); and high-frequency equivalent circuit (B)



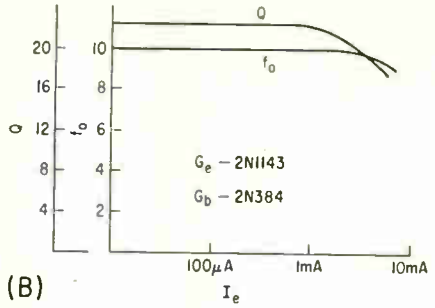


FIG. 3—Graphs of current gain plotted against emitter current in Q_1 (A); and circuit Q and center frequency against emitter current for cascode 10-Mc stage

ing is difficult to achieve in transistor circuits, as the output impedance of a high-frequency transistor in the grounded-emitter configuration is relatively low.

Another problem is the effect of output capacitance C_o on f_o, the tuned-circuit center frequency. This output capacitance is in parallel with capacitance C, used to tune the inductance of the transformer primary, and unless $C >> C_o$, any change in C_o will change the center frequency of the tuned circuit. Unfortunately, the value of transistor output capacitance when used in the grounded-emitter configuration is not small in comparison with the value of capacitance needed to tune the primary of an i-f transformer at higher frequencies. Therefore, output capacitance has considerable influence on the tuned circuit center frequency.

In the circuit of Fig. 1A, there will be a change in voltage from collector to emitter with a change in bias current, due to the change in voltage across emitter resistor R_3. As the output capacitance of a transistor is a function of the voltage from collector to emitter, this will produce a change in the output capacitance, thus producing a shift in the center frequency of the tuned circuit.

Among the various methods of gain control that are possible in transistor circuits, those most often employed use the change in transistor parameter β, or input resistance R_{in}, against the change in bias current I_E, or a combination of both. It is also possible to allow the input impedance of the transistor stage to remain constant, but vary the impedance of a shunt element comprising the forward resistance of a diode or the collector resistance of a shunt transistor. This article is concerned with the methods using the effect of changing the emitter current upon the parameters of the transistor. Specifically considered is the 2N1143 germanium diffused base, 2N384 germanium alloy junction, and 2N588 germanium microalloy diffused base transistors, because of their potential applications to i-f amplifiers at high frequencies.

A plot of center frequency against emitter current and of the circuit Q against emitter current for the amplifiers stage of Fig. 1A is shown in Fig. 1C. The numbers on the curves indicate the transistor used for that plot. All three types have a large change in Q and drift in center frequency, although there is a larger deviation in f_o between types than for the circuit Q.

The large variation in Q against I_E for this circuit configuration is understandable when the extent of the change in R_o against I_E for a grounded emitter transistor is noted. It will be shown that the output resistance R_o changes by 10 to 1 or more over the range of emitter current. As the Q of the tuned circuit is $Q = R/\sqrt{L/C}$ where R is output impedance R_o in parallel with the reflected load impedance $(N_2/N_1)^2 R_L$, it is difficult to mismatch the output impedance and load impedance enough to compensate for a change of that magnitude. Therefore, if the overall current gain A_i of a grounded-emitter transistor stage is controlled using the relationship of the transistor current gain β to emitter bias current I_E, some change in Q and f_o

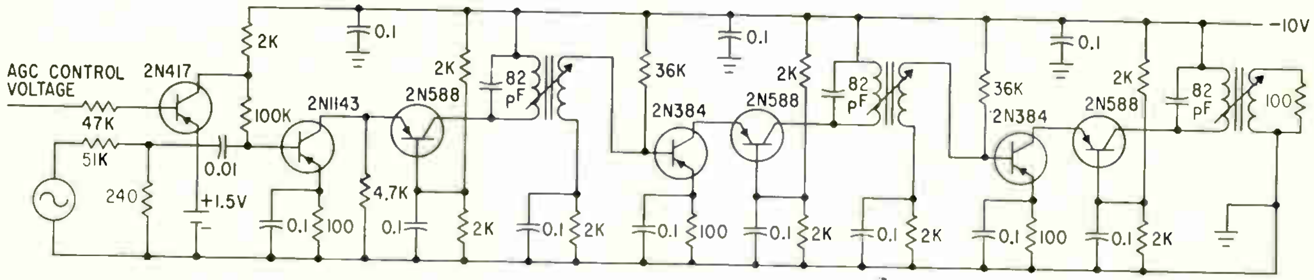
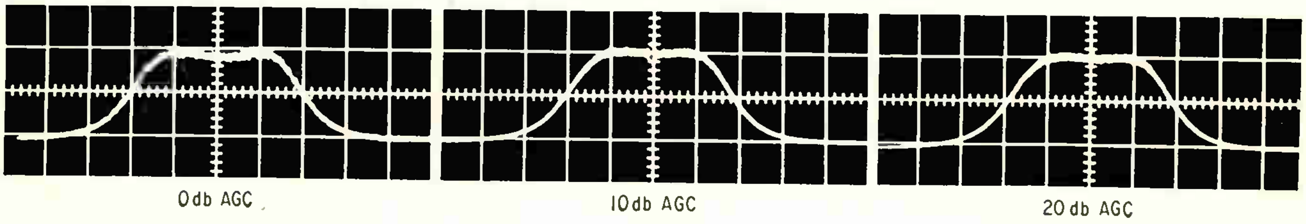


FIG. 4—Schematic of 10-Mc i-f amplifier with agc



will be encountered unless the circuit can be modified to minimize the effect of R_o and C_o on the tuned circuit.

The main cause of variations in Q and f_o are the R_o and C_o of the grounded-emitter transistor. Because of the low value of output impedance in high-frequency transistors, mis-matching is impractical. Because of the small amount of capacitance needed to tune the primary of the i-f transformer, changes in output capacitance with V_{ce} are significant. Therefore, some form of buffer between the grounded-emitter transistor and the tuned circuit is indicated.

Plots of the input and output impedances of both grounded-emitter and grounded-base transistor stages were made for the three transistor types under investigation. Comparison of the plots shows that there is much less variation in the output impedance of a grounded-base stage than there is for a grounded-emitter stage for the same change in emitter current I_E. Therefore, there should be much less change in the Q of the tuned circuit due to the influence of the output impedance of a grounded-base stage.

The input impedance of the grounded-base stage is much less than the output impedance of a grounded-emitter stage, and the change in output impedance of the grounded-emitter stage will have much less effect upon the overall performance of the circuit if the input impedance of a grounded-base stage is in parallel with a grounded-emitter stage.

The circuit of Fig. 2A provides the buffer stage between the grounded-emitter stage and the tuned circuit. The equivalent circuit for this stage is shown in Fig. 2B. The output impedance and the output capacitance of the grounded base stage are now in parallel with the tuned circuit at the output. The output impedance of a grounded-base stage is much less subject to variation than the output impedance of a grounded-emitter stage and the value of output capacitance of a grounded-emitter stage is, due to the circuit configuration, much less subject to variation. The variations in output capacitance of the grounded-emitter stage are now isolated from the tuned circuit at the output by the grounded-base buffer stage and contribute little to a shift in the center frequency of the tuned i-f amplifier stage.

The high-frequency transistors investigated provide excellent gain-control elements due to the variation in the gain of the transistor with changes in the bias current I_E. Because of the isolation of the grounded-base stage, this characteristic can now be fully exploited. If the grounded-base stage is biased so as to assure a minimum value of bias current, that is, if the bias current in the grounded-emitter stage is varied over a wide range of values yet the bias current in the grounded-base stage is varied over a much smaller range, then a further improvement in isolation can be seen.

A 10-Mc i-f amplifier stage using the cascode configuration of Fig. 2A was constructed. Transistor Q_3 is the gain control element for the cascode combination of Q_1 and Q_2. A change in control voltage changes the collector current of Q_3, which in turn changes the bias current in transistor Q_1.

The test results of current gain against emitter current in transistor Q_1 are plotted in Fig. 3A. These results demonstrate that it is possible to achieve a 40-db range of gain control in one cascode stage.

The effect of agc on the Q and the center frequency of the i-f amplifier stage is shown in Fig. 3B. The test results show that over a range of 37 db of gain control, there is no change in the Q or center frequency of the stage, illustrating the effectiveness of the cascode configuration in an i-f amplifier using agc.

An experimental i-f amplifier having a center frequency of 10 Mc, a bandwidth of 1.25 Mc and a maximum gain of 91 db was constructed (Fig. 4).

The flatness in the passband region was obtained by triple stagger tuning the cascode stages. As a shift in f_o would tilt the passband noticably, the flatness was used as an indication of any shift in the center frequency of any of the tuned stages.

The gain of the amplifier was changed in 10-db steps, and at each step the frequency response of the amplifier was plotted using a frequency generator and measuring the 3-db-down points. A photograph of the frequency response, as shown using a sweep generator and oscilloscope, was also taken at each step in order to present the flatness in the passband information.

The passband characteristics over a 40-db range of agc are shown in Fig. 5. There is no shift in center frequency indicated in the oscillograph, which is in keeping with the results predicted.

This work was extended to include a 30-Mc i-f amplifier with similar results. The agc circuit was also modified to extend the dynamic range and signal-handling capabilities of the stage by using a forward-biased diode as a shunt element, as well as the transistor gain characteristic.

The author appreciates the assistance of F. Gibson and J. D. Harmer.

BIBLIOGRAPHY

AGC of Silicon Tetrodes, Texas Instruments Application Notes, Dec. 1959.
J. R. James, Analysis of the Transistor Cascode Configuration, *Electronic Engineering* (British), p 44, Jan. 1960.
R. F. Shea, "Transistor Circuit Engineering," Ch. 11, Sect. 2.6, J. Wiley & Sons Inc., New York, NY, 1957.

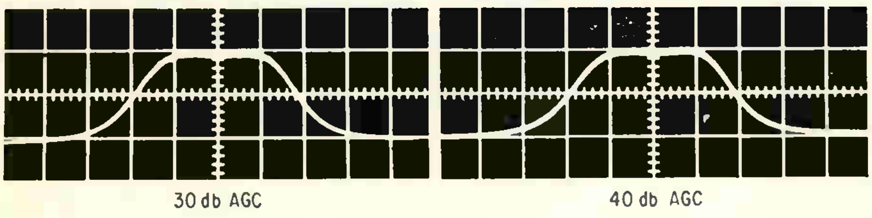


FIG. 5—Bandpass characteristics of 10-Mc tuned i-f amplifier over a 40-db range of agc, with horizontal scale of 312 Kc per cm

Determining Phase Shift and Gain

Instrument makes highly precise measurements of phase shift and voltage

By WALTER C. ACHA,
Project Test Engr.,
Hughes Aircraft Co., Tucson, Ariz.

DETERMINING THE PHASE shift and voltage gain of a differential amplifier at subaudio frequencies to accuracies of better than 1 degree and 1 percent has been a requirement in missile servo systems for many years. This has posed many problems. Difficulty in measuring phase at subaudio frequencies is encountered because of the large coupling capacitors, drift and instability of conventional d-c amplifiers, and poor sensitivity and frequency response of the null-detecting device. Most commercially available phase-measuring equipment has a lower frequency limit of about 20 cps and a phase accuracy of 1 degree. Indirect methods have been used, such as modulating an audio frequency with the subaudio frequency. The audio frequency is demodulated and fed to the amplifier under test. Phase measurements are then made by phase shifting the audio frequency and measuring its phase change. However, this method gives relatively poor accuracy and requires complex demodulating and filter circuits.

Figure 1 shows an instrument that emphasizes simplicity, ease of operation, readability and flexibility in making null ratio and phase shift measurements on a differential amplifier. Differential amplifier *A*, the amplifier under test, may be one or a number of amplifiers.

Alternately adjusting the phase shift and the null ratio controls will produce a null on the indicator across points *a* and *b* of the summing network. To obtain a null, the phase and voltage relationship of the signals at these points must be

$$-AV_2 \angle\alpha = +V_1 \angle\beta$$

and

$$+AV_2 \angle\alpha = -V_1 \angle\beta$$

respectively, where $-\angle\alpha = \angle\beta$. Assuming the amplifier under test is noiseless and utilizing a low-frequency-response a-c vtvm or cro as the null indicator, the null will theoretically be zero; that is, the differential signal between *a* and *b* will be zero. The values of phase shift and null ratio of amplifier *A* are read directly from the two dials.

Hereafter, null ratio will be designated as N/R, where

$$N/R = 1/\text{Gain}$$

Blocks V_1 and V_2 (Fig. 2) must possess certain characteristics. Block V_1 must have a constant voltage and adjustable phase with respect to V_2, and V_2 must have an adjustable voltage and constant phase with respect to V_1.

The adjustable-phase constant-voltage characteristics of V_1 are obtained from a 10-turn quarter (90 deg) cosine-sine potentiometer having a dual dial that consists of an outer and inner scale. The outer scale is divided into 10 parts, each of 9 deg. The inner scale is divided into 9 major parts of 1 deg and each part is subdivided into 10 parts, giving a readability of 0.1 degree.

The adjustable-voltage constant-phase characteristics of V_2 are obtained from a 10-turn linear potentiometer having a dual dial. A total of 1,000 divisions is equally divided giving a readability of 1/1,000 of the total voltage across the potentiometer or 0.1 percent.

Consider now the generation of V_1. The zero-reference signal, which is the output of amplifier 2 of the 4-cps oscillator, is fed to the + *E* terminal of the cosine section of the cosine-sine potentiometer.

EXPANDED N/R SCALE FEATURE

This feature obtains increased accuracy and readability from the N/R circuit. Scale expansion is accomplished by inserting the N/R potentiometer into any quarter of any coarse N/R range output, thereby expanding the readability of the N/R dial by a factor of 4.

The position of the coarse N/R switch will determine one of 3 independent gain levels, ×1, ×5 or ×10, for isolation and booster amplifiers 7 and 8. These gain levels determine the coarse N/R ranges, 0-1, 0-5 or 0-10, with respect to the signal amplitude of V_1*. Any quarter of any coarse N/R range may be expanded over the entire N/R dial by the fine N/R switching circuit. For example, if the 0-1 coarse N/R range is being used, the 0.50 to 0.75 portion of this range may be expanded over the N/R dial by positioning the fine N/R switch to 0.50—0.75. When using the expanded N/R scale feature, any N/R can be calculated by using*

$$N/R \text{ dial reading} = (N/R - L_1)\left(\frac{1{,}000}{L_2}\right)(a)$$

where N/R *= desired null ratio,* L_1 *= lower limit of fine N/R control (zero if no expansion is used) times upper limit of course N/R control,* L_2 *= upper limit of coarse N/R control,* $a = 4$ *when expansion is used and one if* $a = 1$ *for no expansion.*

The voltage across the N/R potentiometer is summed into the inverter adder amplifier 9. The output amplitudes $+V_2\angle\phi$ *and* $-V_2\angle\phi$ *are directly related to the settings of the coarse and fine N/R switches.*

# of Subaudio Differential Amplifiers

null ratio at subaudio frequencies. Tests servo amplifiers of a missile

Output of amplifier 3, which is an integrator, and output of amplifier 4, which is an inverter, will be minus or plus 90 degrees out of phase with respect to the zero reference signal. The position of S_1 will select the phase relationship. Since the signals applied to the cosine-sine potentiometer are equal in magnitude, their vector sum gives a constant-amplitude and adjustable-phase-angle signal. Thus the output of amplifier 5 is a signal having constant magnitude but adjustable phase. Amplifiers 5 and 6 are inverter adders having unity gain, whose outputs $+V_1\angle\beta$ and $-V_1\angle\beta$ are equal in magnitude but opposite in phase.

The variable-voltage constant-phase signal, V_2 originates from the zero reference signal. The zero reference signal is fed through the coarse N/R switching circuit, through the isolation and booster amplifiers 7 and 8, and into the fine N/R switching circuit. The signal at the arm of the N/R potentiometer is summed into amplifier 9. Since amplifiers 9 and 10 are inverter adders having unity gain, their outputs, $+V_2\angle\phi$ and $-V_2\angle\phi$ are equal in magnitude but opposite in phase.

Six design requirements are fulfilled in achieving the accuracy, readability and simplicity of this instrument. These requirements involve: generation of the subaudio signal, signal V_1 and of signal V_2; obtaining accuracy and readability of phase-shift and N/R measurements; and adding d-c bias levels to the V_1 and V_2 signals.

Amplifiers 1, to 4 generate the subaudio frequency and obtain the phase relationship of this signal. To sustain oscillation in the oscillator, which consists of amplifiers 1, 2 and 3, the total loop gain of these amplifiers must equal one. Fixing feedback resistors R_1 and R_2 in the oscillator and inverter,

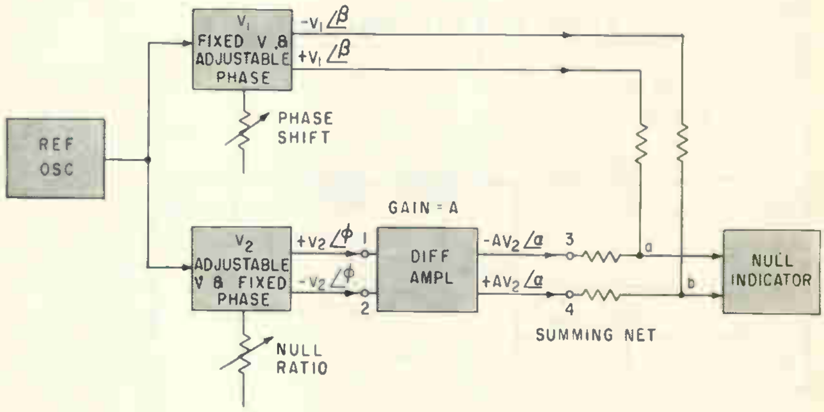
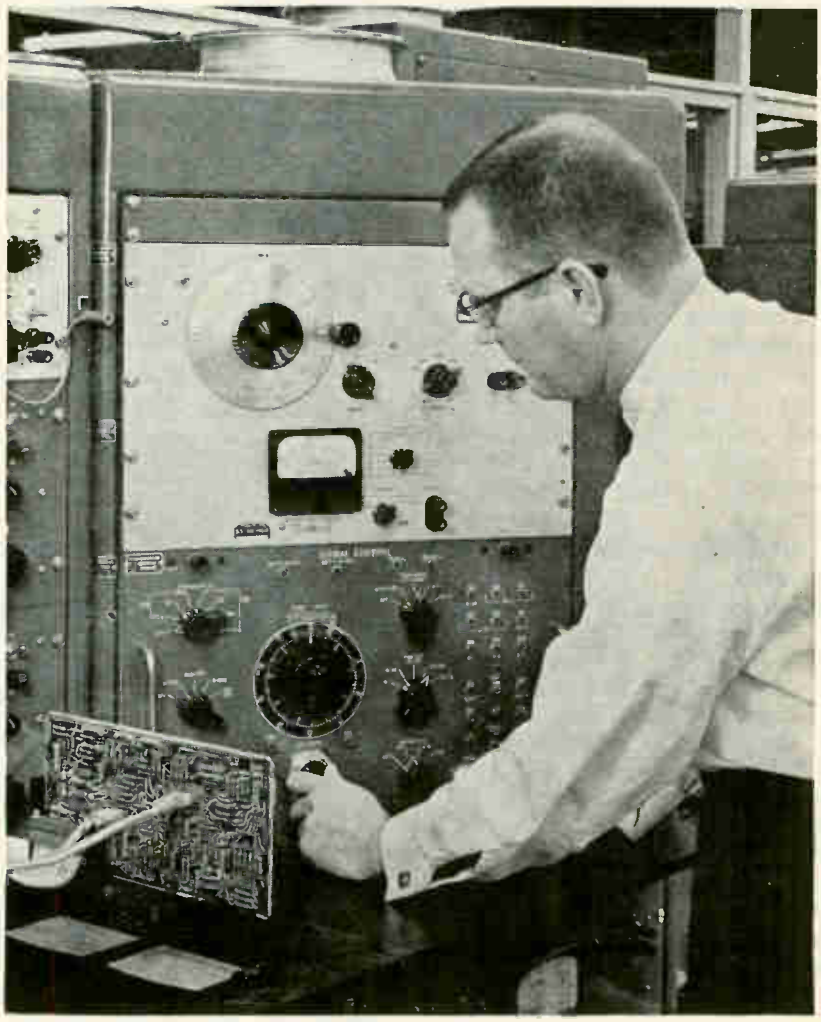


FIG. 1—Null-ratio and phase-shift measuring setup



Author and his instrument. Instrument is part of a test console used to test servo amplifiers of a missile

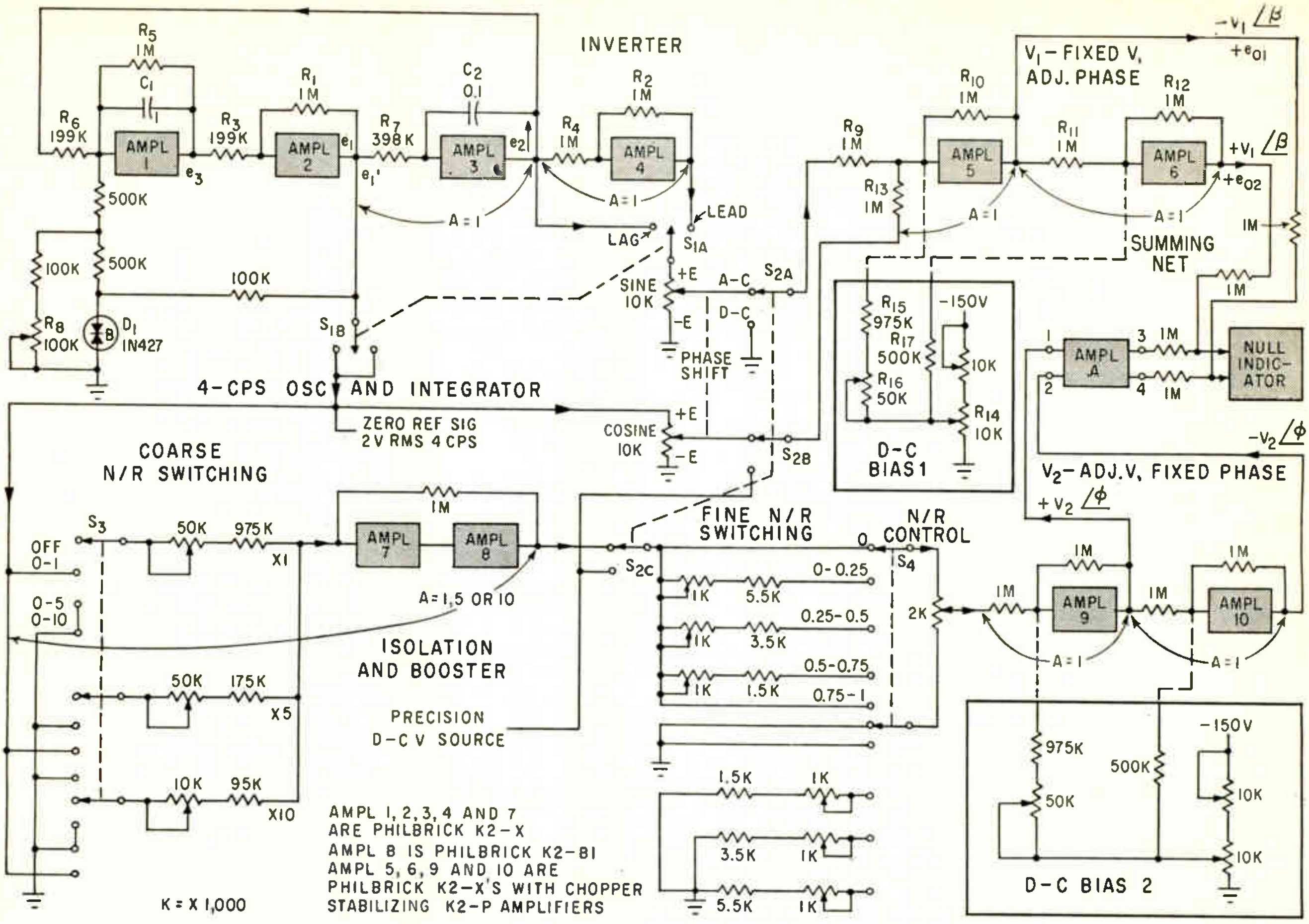


FIG. 2—Drawing shows how measuring instrument is hooked up to differential amplifier under test. Broken-lines from d-c bias blocks indicate that these connections may or may not be made

respectively, at 1 Megohm establishes the magnitude of summing resistors R_3 and R_4, these magnitudes being large enough to cause negligible loading on amplifiers 1 and 3, respectively. Capacitors C_1 and C_2 may be selected for convenient and practical values, but damping resistor R_5 must be at least 20 times X_{C1} at the frequency of oscillation.

Therefore R_5 can be neglected in the analysis.

Writing the total loop equation

$$\left(\frac{e_2}{e_1'}\right) \times \frac{e_3}{e_2} \times \frac{e_1}{e_3} = 1 \qquad (1)$$

relationships can be determined for R_6, R_3 and R_7. To establish the same signal amplitude applied to the sine and cosine sections of the cosine-sine potentiometer, the gain of the integrator stage, amplifier 3, must be fixed at unity. Let $R_7 = 1/\omega\ C_2$ at the desired frequency. Then

$$e_2/e_1' = 1 \qquad (2)$$

If the conditions of Eq. 2 exist, then Eq. 1 becomes

$$(e_3/e_2) \times (e_1/e_3) = 1$$

From Fig. 2

$$e_3/e_2 = X_{C1}/R_6 = 1/\omega C_1 R_6$$

since $X_{C1} << R_5$. Also from Fig. 2 $e_1/e_3 = R_1/R_3$. Therefore

$$\frac{e_3}{e_2} \times \frac{e_1}{e_3} = \frac{1}{\omega C_1 R_6} \times \frac{R_1}{R_3} = 1$$

or $R_6\ R_3 = R_1/\omega C_1$.

The feedback loop of Zener diode D_1, a double-anode diode, resistor R_8 and the associated circuitry govern the output voltage level. The zener voltage of D_1, divided by 2, will establish the approximate magnitude of the zero-reference-signal amplitude. This voltage can be varied approximately ±50 percent by R_8, the oscillator amplitude control. Accuracy and stability of the frequency depends critically upon the tolerance and stability of the components in the oscillator.

With respect to generating V_1: if amplifiers 5 and 6 have unity gain, the differential output between $+V_1\angle\beta$ and $-V_1\angle\beta$ will be twice the zero reference signal; amplifier 6 must always retain unity gain, and resistors R_9 through R_{13} must have a ±0.1 percent tolerance to obtain a ±0.1 percent tolerance of the output signal levels, with respect to V_2.

As to generating V_2, the same conditions apply for increasing or decreasing the differential output signal level of V_2 as for V_1. However, output will be limited by the output characteristics of the operational amplifiers in the V_2 circuit.

Phase-shift accuracy is directly dependent upon the conformity of the cosine-sine potentiometer. To avoid destroying some of this conformity by other circuit components, the cosine-sine potentiometer resistance value must be carefully chosen. The value must be high enough to avoid loading the output of amplifiers 2, 3, and 4 but it must also be low enough to minimize the shunting effects of R_9 and R_{13}. Readability of phase shift depends upon the type of cosine-sine potentiometer and type of dial. A quarter cosine-sine potentiometer gives twice the readability with the same dial when compared to a half cosine-sine potentiometer.

The problem of obtaining good N/R accuracy is similar to obtaining good phase-shift accuracy. A high linearity (±0.05 percent) multiturn potentiometer should be chosen for the N/R control. Readability of N/R's is excellent due to the use of a dual dial, a 10-turn potentiometer, and the expanded-scale feature of the fine N/R switching circuit.

The expanded-scale feature of this instrument is discussed in detail in the editorial box on the first page of this article.

The d-c bias blocks can be used to add d-c bias levels to the a-c signals of $+V_1\angle\beta$, $-V_1\angle\beta$, $+V_2\angle\phi$, and $-V_2\angle\phi$. Consider the effect of connecting d-c bias block No. 1, which is shown in Fig. 3. The setting of R_4 is directly reflected at $+e_{01}$ and $+e_{02}$. The resistance of R_{15} + R_{16} must be equal to R_{10}. Output of amplifier 5 will therefore always be equal in magnitude to the input $-e_1$, that is $|-e_1| = |e_{01}|$. Amplifier 6 now has two signals summed into it, the output of amplifier 5, and $-e_1$. The circuit of amplifier 6 acts as a one-to-one inverter with respect to the output of amplifier 5 since $R_{11} = R_{12}$, but it acts like a one-to-two inverter with respect to $-e_1$, since $R_{17} = R_{12}/2$. The voltage gain through the circuit of amplifier 5 is

$$e_{01} = (-R_{10}/R_T)(-e_1)$$

where $R_{10} = R_T$, and $R_T = R_{16} + R_{15}$.

Determine voltage $+e_{02}$ from

$$e_{02} = \frac{-R_{12}}{R_{12}} \times e_{01} + \frac{-R_{12}}{R_{17}} \times -e_1$$

The operational amplifiers in amplifiers 5, 6, 9 and 10 are chopper stabilized to minimize off-set d-c levels at the outputs.

The null ratio calibrator (Fig. 4) which is a voltage-summing device using high-quality resistors to obtain good stability and accuracy, is used to calibrate the instrument.

The null ratio calibrator has two functions: it determines the voltage ratio between two signals that are opposite in phase and it can determine the variable signal voltage needed to arrive at any ratio

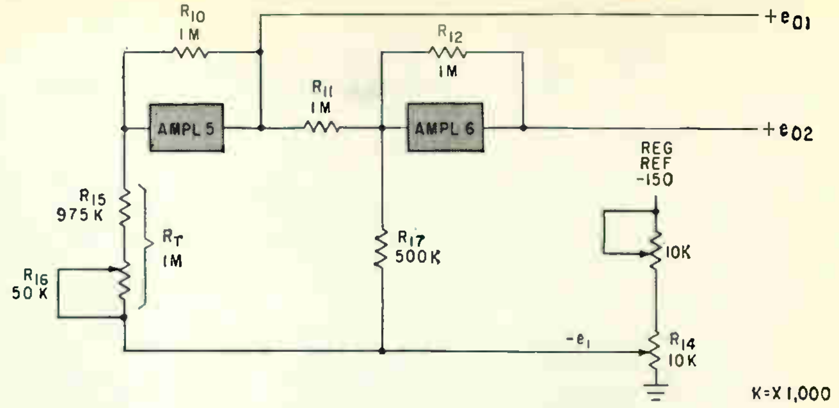


FIG. 3—Connection of d-c bias block to fixed-v adjustable-phase section of Fig. 2

with respect to a reference signal of opposite phase.

Calibration of the null ratio calibrator consists of accurately measuring, to at least ±0.05 percent the value of R_1 with R_1 set to a maximum. Since ratios are desired and not actual values, the values of R_{T1}, R_{T2} and R_{T3} are adjusted to 0.1 R_1, 1 R_1 and 10 R_1 respectively. All values must be adjusted to an accuracy of ±0.05 percent.

Calibration of the instrument consists of: d-c balancing the operational amplifiers, calibrating the zero reference signal amplitude, the d-c bias, the phase-shift dial, and performing N/R circuit adjustments.

The d-c balancing consists of adjusting the amplifier bias control for minimum off-set voltage at the output of the amplifier. Each amplifier may be adjusted separately before the chopper stabilizing amplifier is connected.

The zero reference signal amplitude is adjusted by R[illegible] (Fig. 2) to the design value. Since ratios, not voltage magnitudes, are important, the accuracy of the instrument used for this measurement is relatively unimportant.

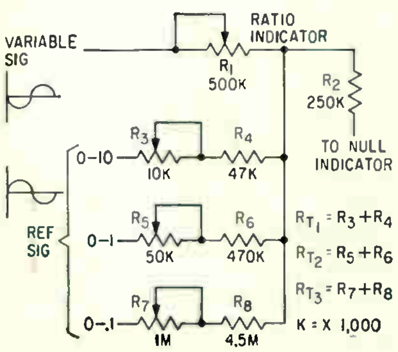
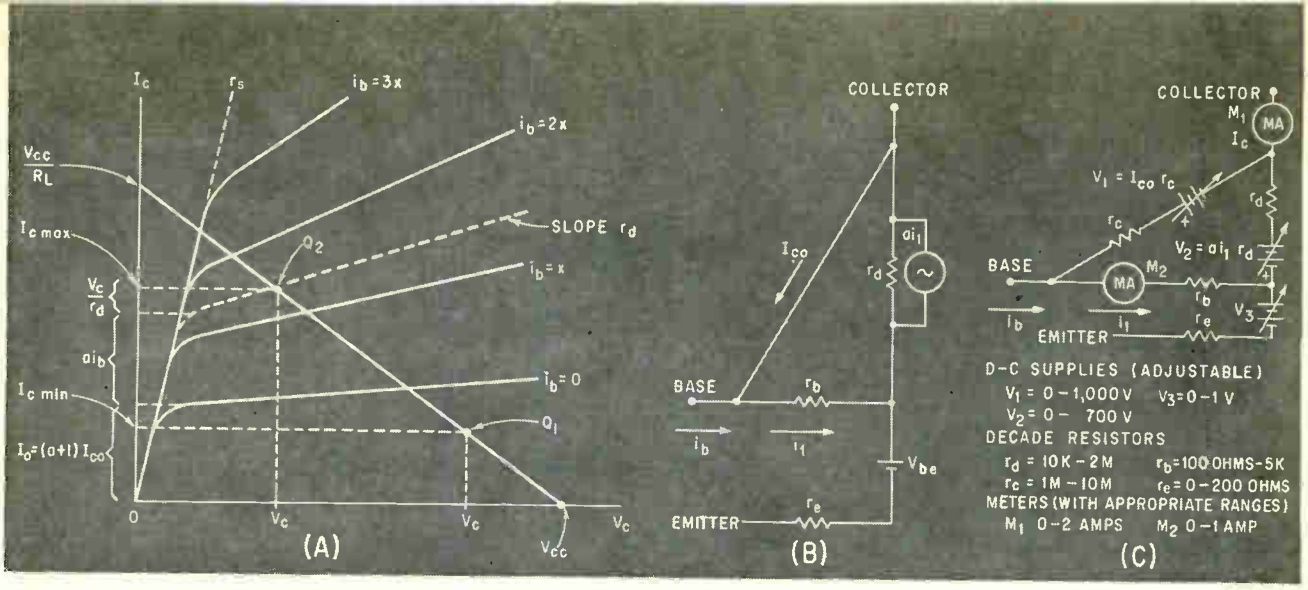


FIG. 4—Null-ratio calibrator

In calibrating the d-c bias, the trimming potentiometers used in the d-c bias circuit are adjusted. These adjustments compensate for errors in the tolerance of components used in amplifiers 5, 6, 9 and 10 and reduce off-set voltage that may exist in the output of these amplifiers.

One method of calibrating the phase shift dial's zero point is to connect a short between points 1 and 3, and another short between points 2 and 4 of Fig. 2, with the amplifier under test removed. Since the V_1 and V_2 signals are opposite in phase, they can be fed, at a one-to-one ratio, to the summing network inputs. Adjustments of the phase shift dial will result in a null on the indicator, thereby establishing the zero phase shift setting on the phase shift dial.

The N/R circuit adjustments are made with the null ratio calibrator. The procedure is to set the phase shift dial to zero and connect the reference signal, the final voltage level at the output of $+V_1\angle\beta$, to the desired N/R range of the reference input of the null ratio calibrator. The variable signal input, $-V_2\angle\phi$, is fed to the variable-signal input of the null ratio calibrator. The ratio indicator dial of the calibrator is set to the ratio value. With the coarse and fine N/R switches and the N/R potentiometer set to the N/R reading, the calibration controls in these circuits are adjusted until a null is achieved on the null indicator connected to the null ratio calibrator.



Collector characteristics with bias points (A); d-c r-equivalent circuit (B); and simulator circuit for solving simultaneous equations (C)

Simulating Transistor Amplifiers

Uses resistor network to save time in determining optimum design

By A. R. BERDING
R. H. BREEDLOVE,
IBM Federal Systems Div.,
Owego, N. Y.

DESIGN of class A transistor amplifiers for operation over a range of temperatures is complicated by transistor parameter variations and bias point stability. Parameter variations between transistors with temperature and with life make it impractical to attempt circuit evaluation using limit transistors. This article describes a transistor circuit simulator for determining bias point limits for amplifier stages, a-c gain and input impedance.

In the past, bias limits have been approximated using the stability factor $S = \delta I_c/\delta I_{co}$ where I_c = collector current, and I_{co} = collector cut-off current. However, this approach assumes I_{co} to be the only variable appreciably affecting bias point, and inadequate results have been obtained for silicon transistors at higher temperatures because parameters other than I_{co} vary with temperature.

For d-c operation of transistors (A) bias points are Q_1 and Q_2 and $I_{cmax} = I_o + ai_b + V_c/r_d$ where: I_c = collector current; I_o = collector current with zero base current; a = current gain; i_b = base current; V_c = collector voltage; and r_d = slope of collector characteristics. Note that Q_1 is in the negative base-current region. Transistors operate normally in the negative base-current region as long as Q_1 does not swing to cutoff. Cutoff occurs approximately where $i_b = -I_{co}$.

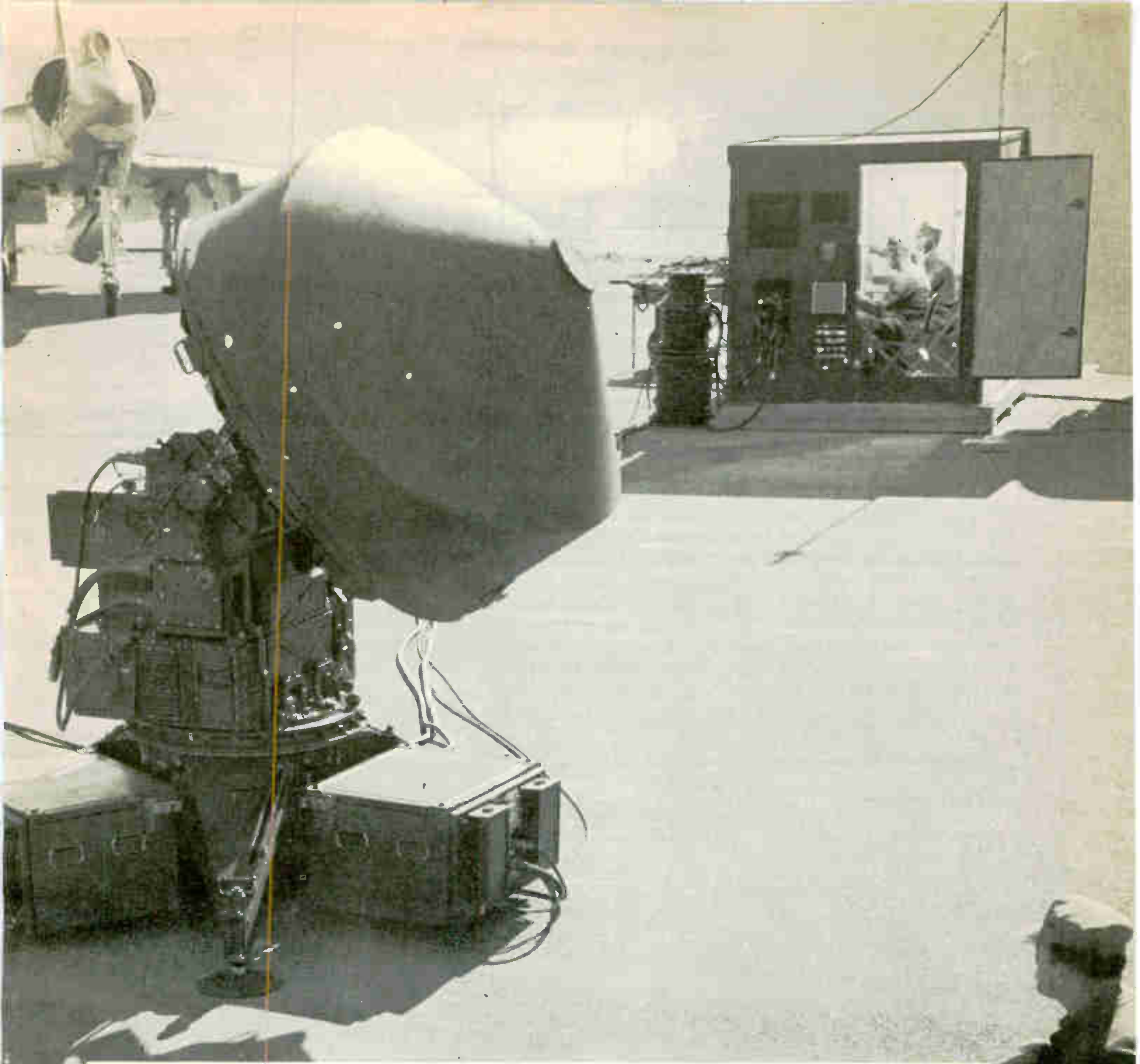
Operation in the negative base current region can be better understood in the r equivalent circuit (B) where $I_c = 0$ when $ai_1 = 0$ and $i_1 = 0$ when $i_b = I_{co}$. Here $I_c = I_{co} + ai_1 + V_c/r_d = I_{co} + a(i_b + I_{co}) + V_c/r_d = (a + 1)\ I_{co} + ai_b + V_c/r_d = I_o + ai_b + V_c/r_d$. The emitter circuit used in this d-c equivalent circuit can be justified by a sketch of a transistor's emitter current versus base to emitter voltage.

The d-c equivalent circuit can be used for analysis of the operating bias point stability in circuit design. This involves drawing the circuit, writing the loop or nodal equations, and then solving them for the collector current. Bias point limits I_{cmin} and I_{cmax} are obtained by substituting each set of extreme transistor parameters into the equations and solving simultaneously.

However, the complexity of solving simultaneous equations for a two-transistor stage led to the laboratory construction of another equivalent circuit (C). Here the I_o limits are read directly from milliammeter M_1 when $V_2 = ai_1 r_d$. Thus, manual adjustment of V_2 simulates transistor action. Values of I_c agree with the computed values within the accuracy of the meter used. The two-transistor stage amplifier was redesigned with each component change requiring only a short setup time to obtain maximum and minimum I_c limits.

A permanent self-contained model of the equivalent transistor circuit was then built including the capability of d-c stability determination, a-c gain and input impedance measurement, the latter two being derived from an a-c equivalent circuit.

Although the measured limits of the qualities of interest were close to those that were hand calculated, neither the calculations nor the simulator can duplicate the operation of a limit transistor since the limit transistor is a nonlinear device.



AN ACHIEVEMENT IN DEFENSE ELECTRONICS

New Transportable Radar Directs Precision Air Support

Front-line ground forces can now obtain all-weather, close air support, —when and where needed—with the new lightweight AN/TPQ-10. This is the first helicopter-transportable, high-accuracy control radar for precision air support. Developed for the U. S. Marine Corps by General Electric's Heavy Military Electronics Department, the versatile new system can also provide aircraft control for emergency supply airdrops, paratroop placements and aerial mapping.

176-07

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Letter-Code Designations for Microwave Frequency Bands

By LEO V. McNAMARA,
Applied Dynamics Division,
Atlee Corp.,
Waltham, Mass.

SEVERAL standards for designating microwave frequencies have been adopted by governmental, industrial and professional groups. These vary from a band number designation based on powers of 10 to a descriptive designation such as vlf, l-f, m-f, h-f, etc. signifying very low frequency, low frequency, medium frequency, high frequency and so on.

Microwave engineers have largely ignored these systems, and use instead letter designations for the various frequency bands. These band code letters were originally military project security codes, and have since drifted into common use.

A sampling of manufacturers' catalogs reveals that only three of the many waveguide ranges are designated consistently: the S, X and K bands, representing, respectively, 2.6 to 3.95 Gc, 8.2 to 12.4 Gc, and 18.0 to 26.5 Gc. In another instance, waveguide range 26.5 to 40.0 Gc (WR28) is called V band by two manufacturers, while three others name it U, R or K_a.

This chart, compiled from the best available sources, is offered as a useful reference. The data, however, is not necessarily official.

P BAND

FREQ.	λ
0.225	133.3
0.390	76.9

UHF TELEVISION BAND Channels 14 thru 83 0.470 to 0.890 Gc

L BAND

SUB	FREQ.	λ
P	0.390	76.9
	0.465	64.5
C	0.465	64.5
	0.510	58.8
L	0.510	58.8
	0.725	41.4
Y	0.725	41.4
	0.780	38.4
T	0.780	38.4
	0.900	33.3
S	0.900	33.3
	0.950	31.6
X	0.950	31.6
	1.150	26.1
K	1.150	26.1
	1.350	22.2
F	1.350	22.2
	1.450	20.7
Z	1.450	20.7
	1.550	19.3

S BAND

SUB	FREQ.	λ
E	1.55	19.3
	1.65	18.2
F	1.65	18.2
	1.85	16.2
T	1.85	16.2
	2.00	15.0
C	2.00	15.0
	2.40	12.5
Q	2.40	12.5
	2.60	11.5
Y	2.60	11.5
	2.70	11.1
G	2.70	11.1
	2.90	10.3
S	2.90	10.3
	3.10	9.68
A	3.10	9.68
	3.40	8.83
W	3.40	8.83
	3.70	8.11
H	3.70	8.11
	3.90	7.69
Z	3.90	7.69
	4.20	7.15
D	4.20	7.15
	5.20	5.77

C BAND Designation includes S_Z thru X_Y from 3.9–6.2 Gc

X BAND

SUB	FREQ.	λ
A	5.20	5.77
	5.50	5.45
Q	5.50	5.45
	5.75	5.22
Y	5.75	5.22
	6.20	4.84
D	6.20	4.84
	6.25	4.80
B	6.25	4.80
	6.90	4.35
R	6.90	4.35
	7.00	4.29
C	7.00	4.29
	8.50	3.53
L	8.50	3.53
	9.00	3.33
S	9.00	3.33
	9.60	3.13
X	9.60	3.13
	10.00	3.00
F	10.00	3.00
	10.25	2.93
K	10.25	2.93
	10.90	2.75

K BAND

SUB	FREQ.	λ
P	10.90	2.75
	12.25	2.45
S	12.25	2.45
	13.25	2.26
E	13.25	2.26
	14.25	2.10
C	14.25	2.10
	15.35	1.95
U	15.35	1.95
	17.25	1.74
T	17.25	1.74
	20.50	1.46
Q	20.50	1.46
	24.50	1.22
R	24.50	1.22
	26.50	1.13
M	26.50	1.13
	28.50	1.05
N	28.50	1.05
	30.70	0.977
L	30.70	0.977
	33.00	0.909
A	33.00	0.909
	36.00	0.834

Q BAND

SUB	FREQ.	λ
A	36.00	0.834
	38.00	0.790
B	38.00	0.790
	40.00	0.750
C	40.00	0.750
	42.00	0.715
D	42.00	0.715
	44.00	0.682
E	44.00	0.682
	46.00	0.652

V BAND

SUB	FREQ.	λ
A	46.00	0.652
	48.00	0.625
B	48.00	0.625
	50.00	0.600
C	50.00	0.600
	52.00	0.577
D	52.00	0.577
	54.00	0.556
E	54.00	0.556
	56.00	0.536

K1 BAND Designation includes K_U thru K_Q 15.35 to 24.5 Gc

LEGEND: SUB = Identifying subletter.
FREQ. = Band limits in Gigacycles.
λ = Equivalent wavelength in centimeters.

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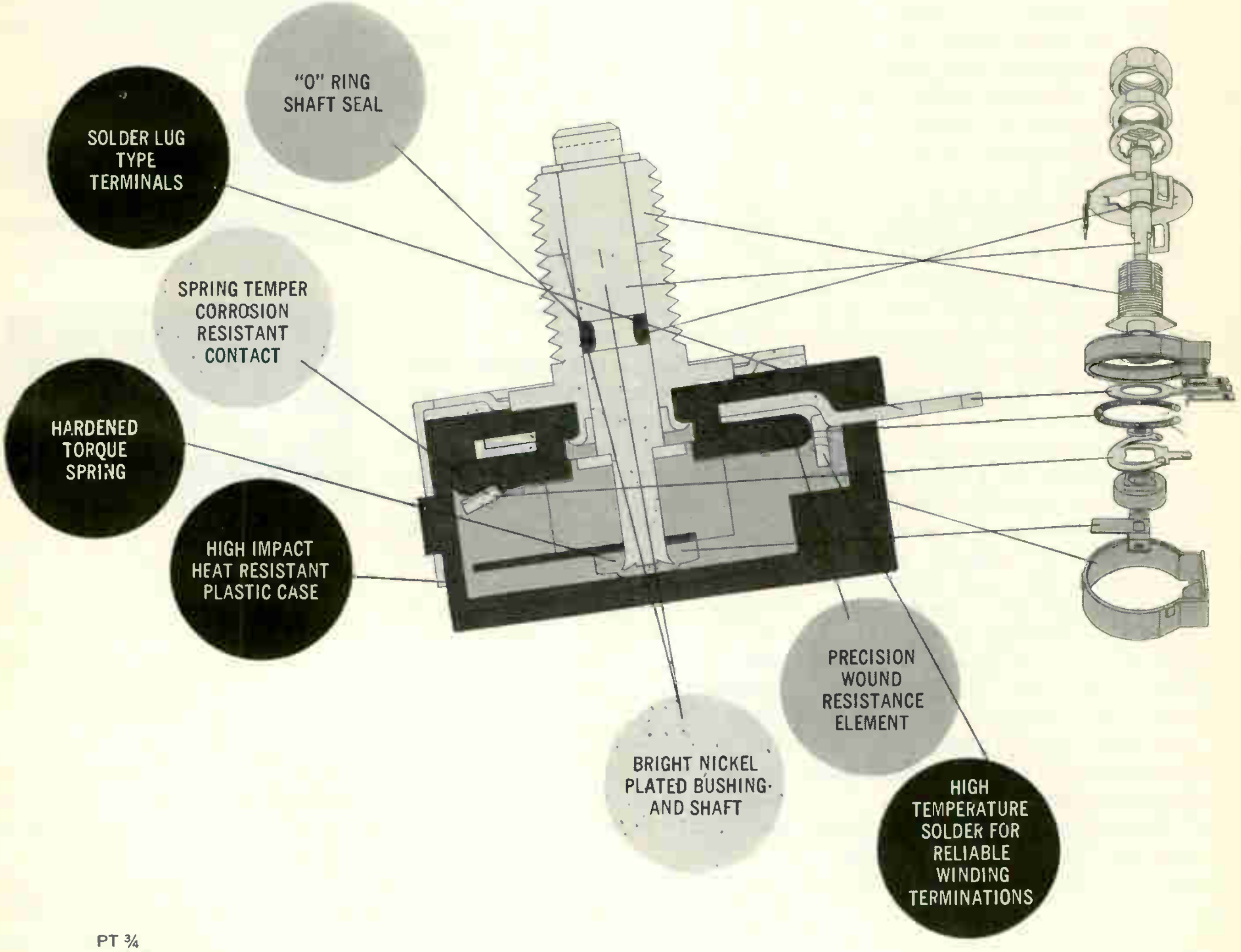
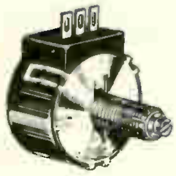


PT ¾



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CIRCLE 59 ON READER SERVICE CARD

Semiconductor Diode Circuit Provides Gain

By S. RITTERMAN,
Picatinny Arsenal, Dover, N. J.

AMPLIFICATION can be achieved using the voltage-current characteristic of semiconductor diodes. Considerable attention has been given recently to amplification based on other diode properties such as tunneling[1] and capacitance changes.[2] However, little attention has been given to diode forward-reverse characteristics as a means of amplification.

Using this characteristic of diodes to amplify was originally investigated by A. W. Holt at the National Bureau of Standards[3] and the principle was patented.[4] The aim of these studies was to use diode amplifiers in digital computer circuits such as pulse repeating stages and flip-flops.

In this type diode amplifier, the low resistance of a semiconductor diode when biased in the forward direction permits current flow. When bias is suddenly reversed, carriers in the diode continue to permit current flow for a finite time after bias has been reversed. During this time, a reverse transient current flows until the steady-state reverse-bias condition has been established. By controlling this phenomenon with an input signal, gain can be achieved.

The power supply for the diode amplifier in the figure provides a half-wave rectified voltage. The input signal is also a half-wave rectified voltage having a frequency equal to or lower than that of the power supply.

When input voltage is at zero, there is no output across the load because power supply voltage is either zero or is blocked by the diode. If input voltage becomes positive while power supply voltage is zero, signal current can flow either through the load resistor or through the diode and power supply. If combined diode and power supply impedance is much lower than load resistance, most signal current will flow through the diode and power supply and carriers will be produced in the diode.

As power supply voltage increases beyond the level of signal voltage, the diode is reverse biased. During the interval that carriers remain in the diode, power supply voltage appears across the load. The input signal thus controls an output of greater magnitude through the diode and gain is achieved in the circuit.

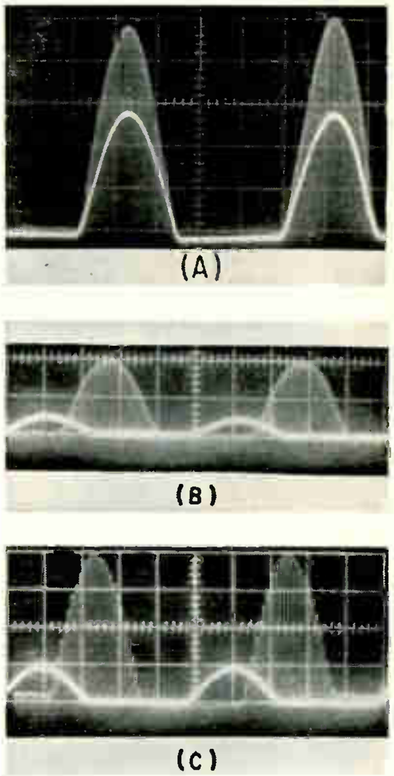
One condition for operation of the circuit is that maximum power supply voltage cannot exceed peak inverse breakdown voltage of the diode. In addition, impedance of the power supply when its output is zero must be much lower than that of the diode so that most signal voltage is developed across the diode.

A half-wave rectified input signal is required. However, all input information can be retained if a bandwidth-limited signal is sampled at least at equally spaced intervals of twice the product of bandwidth and time duration.

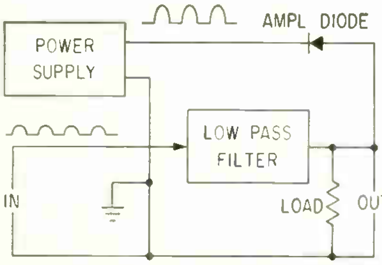
In the work of Holt, input and power supply frequencies were the same. However, in the present experiments using an electronic switch, power supply frequency was considerably higher than signal frequency. Oscilloscope photographs of input and output waveforms were made. Deflection of both the single bright line representing the input waveform and the higher frequency envelope of the output wave was 0.5 volts per division.

With the half-wave rectified 100-cps input signal at (A) and a half-wave rectified power supply frequency of 0.5 Mc, voltage gain was slightly more than 1.5. With 1-Kc input and 50-Kc power supply frequencies, gain of almost 4 was obtained, as shown at (B). Gain of about 4 was also obtained with the 100-cps input signal shown at (C) in the figure using a power supply frequency of 5 Kc.

No attempts have yet been made to achieve maximum gain or to design an optimum circuit. Applications of the diode amplifier are not

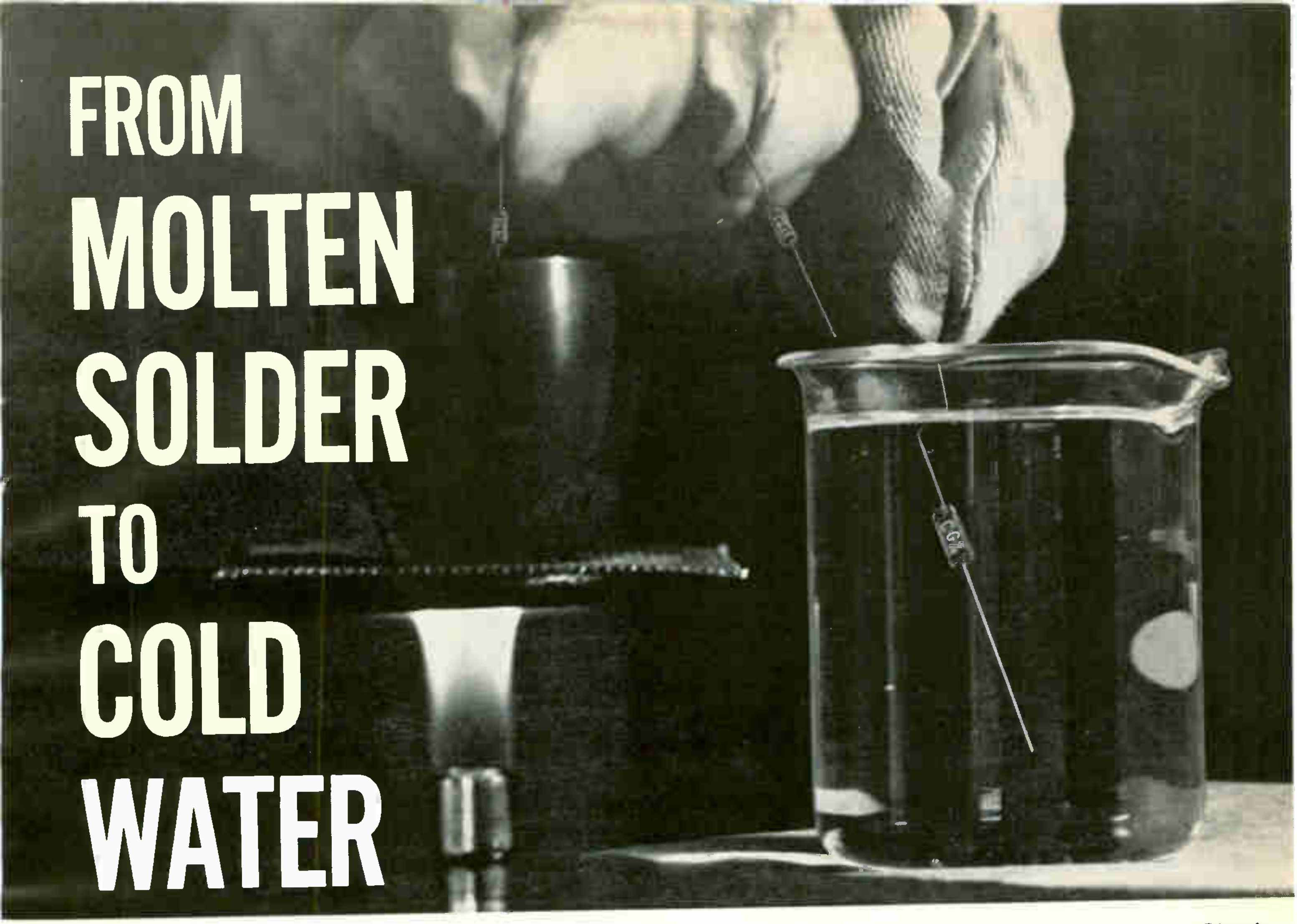


Gains of about 1.5, 4 and 4 were achieved at (A), (B) and (C), respectively with different signal-power supply frequency combinations



Half-wave rectified input signal is amplified using half-wave rectified voltage for power supply

FROM MOLTEN SOLDER TO COLD WATER



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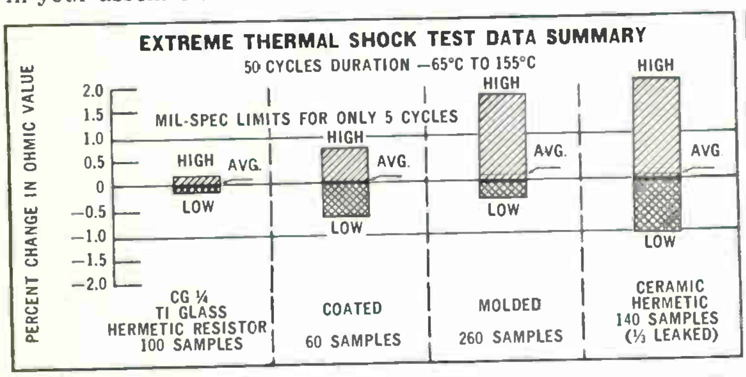

SPECIFICATIONS

ACTUAL SIZE

TI type number	wattage rating	MIL designation	standard resistance ranges	maximum recommended voltage
—	watts	—	—	volts
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CG⅛	⅛	None	10Ω to 100k	250

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presently being investigated. However, it is hoped that further work with the circuit will bring applications to light for which the circuit will be well suited.

REFERENCES

(1) H. G. Dill and M. R. MacPherson, Tracing Tunnel Diode Curves, ELECTRONICS, p 62, August 5, 1960.
(2) W. W. Mumford, Some Notes on the History of Parametric Transducers, *Proc IRE*, May 1960.
(3) Diode Amplifier, *NBS Tech News Bulletin*, 38, October, 1954.
(4) U. S. Patent 2,879,409 to U. S. represented by Secy of Comm.

Gear Measures Lifetime Of Minority Carriers

ZURICH—Lifetime of minority carriers in semiconductor materials can be determined with a newly developed instrument. The apparatus was designed so that it can be operated by unskilled personnel or can be made fully automatic.

The test equipment was developed by Associated Electrical Industries Ltd. and is described in British Patent specification 860,433. Operation is based on the fact that when a semiconductor material is illuminated with a light of varying intensity, photoconductivity lags the change in illumination. The angle of lag of photoconductivity relative to the change in illumination is a function of minority carrier lifetime.

In the test instrument, the semi

High-Power Uses Studied For Silicon Trinistors

Feasibility of using experimental silicon-Trinistor controlled rectifiers for high power applications is studied in Westinghouse prototype rectifier that will supply 1,200 amp at 250 volts conductor material under test is illuminated by one pulsating light beam. A second pulsating light beam illuminates a photocell simultaneously. Illumination from the two light sources is varied so that a fixed phase relationship is maintained between them.

The signals from the photocell and from the semiconductor sample are amplified and then combined in a phase-sensitive detector. Output from the detector is then used to determine minority carrier lifetime in the semiconductor material.

Fast Electron Dose From Narrow Beam Is Calculated

PENETRATION in air of fast electrons from a beam source has been calculated. Possible applications of this information include determining spacial distribution of the dose in therapy involving electron beams and estimating the resolving power of large single crystals in high-energy radiography.

The work, sponsored by the Atomic Energy Commission, was carried out by the National Bureau of Standards.[1] It was part of a program to develop methods of calculating dose from a source geometry involving two spacial variables.

The calculation was based on a collimated beam of monoenergetic electrons originating at a point in the medium. As the electrons move about, their energy is dissipated. The objective of the experiment was to determine the energy dissipated in a small volume described in terms of specified distances from the point source and from the center line of the initial beam.

Calculated energy dissipation distributions for fast electrons in infinite and homogeneous media have been reported for the simplest source geometries.[2, 3] The new calculation is an extension of this effort. It is a special application of the moment-fitting techniques developed at NBS. This approach was initially applied to x-ray penetration.[4, 5]

REFERENCES

(1) J. E. Crew, Calculated Energy Dissipation Distribution in Air by Fast Electrons from a Gun Source, *J Res NBS*, 65A, 113, 1961.
(2) L. V. Spencer, *Phys Rev*, 98, 1955.
(3) L. V. Spencer, *NBS Mono*, 1, 1959.
(4) L. V. Spencer and U. Fano, *J Res NBS*, 46, 1951.
(5) Fano, Spencer and Berger, *Encyc Phys*, Springer-Verlag, 38, Part 2, 1959.

Radiation Reports Aid Circuit Designer

THE VITAL NEED for knowledge of the effects of space radiation on the electrical characteristics of materials, components, and systems used in the payloads of space vehicles will reduce the need for costly irradiation testing of many components of the same class.

The results of one recent study on radiation behavior was recently obtained from a paper given by J. W. Kallander and J. F. Weller of the U. S. Naval Research Laboratory, Washington, D. C[1]. Also, the results of a nine months study of the status of radiation damage research, awarded to E. E. Conrad of Diamond Fuze Ordnance Labs, will be wrapped up in a paper Conrad will deliver during the coming MIL-E-CON session to be held at the Shoreham Hotel, Washington, D. C. on June 27[2]. At the same session, J. D. Meyer of Lockheed will present a paper on the attenuation of electromagnetic radiation from Polaris[3].

The effects of high intensity pulsed nuclear radiation exposure on selected parts and materials used in critical, high-speed electronic circuits has been conducted at IBM under a project sponsored by USASRDL[4]. At IBM, an environment simulating the radiation effects of a nuclear weapon detonation is used. And measurements are made of the change in electrical characteristics during exposure and for such a period of time as required for the part to stabilize.

At Stanford Research Institute[5], a program has been underway to determine radiation effects in magnetics and dielectrics that are the most sensitive to neutron radiation, and how this sensitivity is related to the compositional and structural perfection of the specimens. Rates of recovery of useful magnetic and dielectric properties are also being established.

At the University of Pittsburgh[6], a program has been underway to investigate the effect of irradiation and subsequent annealing on the electrical and mechanical properties of pure crystal whiskers as compared to amorphous materials in wire and single polycrystalline materials. Interpretation of data is directed towards the role played by crystal imperfection on electrical and mechanical properties of various materials.

The damage mechanism in a number of elements carefully chosen to reveal the underlying essential features of the radiation damage process is being investigated at General Electric[7]. Work on this includes the experimental determination of thresholds for the onset of damage and the nature of the imperfection content, crystal habit and crystal orientation. A quantitative model of radiation damage will be formulated and its application tested.

As pointed out in the paper by Kallander and Weller[1], the purpose of the U.S. Naval Research program on radiation behavior studies is threefold: to correlate the known space radiation information in such a manner that the radiation environment can be determined for any specified satellite or space-probe orbit; to investigate all effects on components and materials; and to furnish consulting services in the space-radiation field.

An accurate picture of the radiation environment has been compiled from the standpoint of its use in determining the radiation fluxes to which satellites will be exposed. This picture is being kept up to date as additional data is compiled.

Semiconductors present the major radiation problem. To date, an emphasis has been put in the field of solar cells and their associated materials, also giving due attention to electrical insulation problems. Before the complete answers to the radiation problem can be uncovered, it is necessary to devise a practical simulation of the solar spectrum. Thicker shields for the solar cells are not the complete answer, since they will lower the efficiency of the cells. And in some cases even a thin shield may be more harmful from a radiation point of view.

The Kallander, Weller paper presented data of the effect of electron irradiation on solar cell efficiency, load characteristics, and the effects of shielding discoloration. This paper also presented data on epoxy adhesives used to cement the solar cells to the satellite skins, with relationships given for surface resistivity in ohms cm plotted against radiation dosage in megaroentgens.

E. E. Conrad of DOFL was awarded a Secretary of the Army Research Fellowship to investigate the status of radiation damage research both in this country and in Europe, and his MIL-E-CON paper should be of considerable interest to electronic designers.

REFERENCES

(1) John W. Kallander and J. F. Weller, Radiation Behavior of Electrical Materials and Components for Space Vehicles, U. S. Naval Research Labs., Washington, D. C.; paper presented at Fifth Navy Science Symposium, Annapolis, Maryland, 18 April, 1961.

(2) Edward E. Conrad, The Status of Radiation Damage Research, Diamond Ordnance Fuze Labs., Wash., D. C.; paper to be presented at the National Convention on Military Electronics, Shoreham Hotel, Wash., D. C., 27 June, 1961.

(3) J. D. Meyer, Attenuation of Electromagnetic Radiation from Polaris, Lockheed, paper to be presented at same session as above.

(4) Radiation Effects on Selected Parts and Materials, International Business Machines Corp., Contract DA36-039 SC-85395, USASRDL.

(5) Radiation Effects in Magnetics and Dielectrics, Stanford Research Institute, Contract AF 19(604)-4141, AFCRC.

(6) Radiation Effects on Solids Using Cyclotron Irradiations, Univ. of Pittsburgh, Contract AF 19(604)-3906, AFCRC.

(7) Radiation Damage Thresholds of the Elements, General Electric Co., Contract AF 19(604)-5557, AFCRC.

New Image Orthicons Roll Off Lines

PRODUCTION MODELS of RCA's new 4½-inch image orthicon television camera, now being shipped commercially, were demonstrated at the recent National Association of Broadcasters convention.

C. H. Colledge, Division Vice President and General Manager, Broadcast and Television Equipment Division, described the TK-12 as the first all-new studio camera since the advent of television and said it would further upgrade tv pictures.

Compared with standard 3-inch

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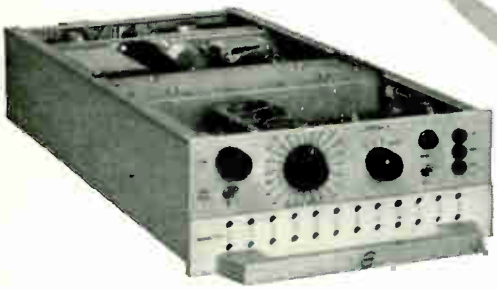

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Color image orthicon developed in Japan

tube studio cameras currently in use, the 4½-inch eye has greater stability and is capable of producing pictures of increased resolution and better gray scale rendition.

The significant difference lies in the larger area of the glass target scanned by the electron beam. This larger area accounts for the camera's ability to give increased resolution, or more importantly, increased contrast in fine detail by a factor of almost two to one.

The TK-12 eliminates the need for circuit adjustments during normal operation, and built-in feed circuits compensate for changes occurring during warm-up and for most of the drifting sometimes experienced with television cameras.

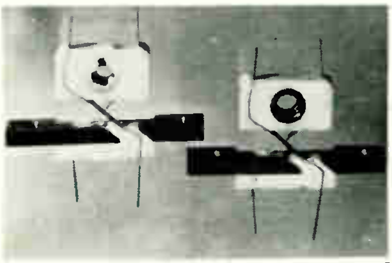
The first color tv camera tube to be developed in Japan was recently announced by Tokyo Shibaura Electric Company, Ltd.

The new image orthicon tube, Toshiba 7513, will replace USA tubes previously imported for use in color television cameras in Japan.

Development of the new tube was termed by Toshiba officials a major step forward in making the Japanese television industry a self-contained entity, capable of manufacturing domestically all equipment necessary for color as well as black and white television transmission and reception.

Abrasive Particles Clean Molded Mica

MOLDED, glass-bonded mica flexural pivots are deburred, deflashed and cleaned with gas-propelled abrasive powder at Electronic Mechanics, Inc., Clifton, N. J. The method removes flashes and loose particles of



Flexural pivots before (left) and after cleaning. The entire part is about one-half inch long.

the dielectric at the same time metal inserts are deburred. Cleaning time, which took 30 minutes with a hand pick, has been reduced to 90 seconds per part, the firm reports. The equipment used, an Airbrasive unit (S.S. White Industrial Division, New York, N. Y.), is generally used for cutting and abrading semiconductors, tungsten and other hard materials.

Offers Special Thyratron

A NEW 3.2 ampere d-c thyratron has been added to the National Electronics, Inc., Geneva, Ill., line of industrial tubes. This tube, the NL-734/5544 was designed especially for welding control, motor control and other industrial applications. The tube is quick starting and operates reliably within wide temperature limits, and is available with the lug base under the type number NL-734/L. Other ratings of the tube are: filament volts, 2.5; filament amperes, 11.5; peak anode current, 40.

Thermionic Converter

A VAPOR thermionic converter with a 15 to 17 percent efficiency has been produced by General Electric. The converter produces 4.6 watts per square centimeter of cathode surface.

Cast Waveguide: Select the Best Process

By R. S. GORDON,
E. I. GOTTHOLD,
Pickard & Burns, Inc.,
a subsidiary of Gorham Mfg. Co.,
Needham Heights, Mass.

AS WAVEGUIDE COMPONENTS and system designs become increasingly complex, attaining predicted performance in production becomes more difficult. Any shape can be made to extremely close tolerances by prototype machining and fabrication techniques. But practical manufacturing processes are limited in their abilities to produce complex shapes in acceptable tolerances.

The manufacturing problem can be solved by a proper choice of processes and by recognition of process limitations by the designer. Component performance can be predicted by waveguide theory if the nature and geometry of mechanical discontinuities are known and related to electrical parameters. The last four items in the bibliography discuss such analyses.

This discussion is limited to the selection of casting methods, since comparable data on fabrication methods are widely available. The various manufacturing methods are listed in Table I. Complex components are generally produced by a primary method to which other methods are added as secondary or finishing operations. The primary method can be selected by sequential application of process capability data to the problems.

First: Obtain an initial screening from the chart of process size ranges (Fig. 1A), showing characteristic lengths for each process. For example, only sand and plaster casting should be used to produce a part 36 inches long, but all might be used for a part 10 inches long. The darker portions of the bars indicate optimum size.

Second: Determine and apply the significant tolerances to the chart of process tolerances (Table II). Although several processes have relative capabilities (inches per inch) which are quite low, their total minimum allowance in practical production are fixed values regardless of length. If maximum capability is required, cost and production time will be greater.

Table III notes, for comparison, recommended EIA standards on waveguide tolerance. The casting processes do not, in production, meet this standard. While the individual process may be capable of meeting these tolerances, to specify them for any particular design may cause reject rates of 40 to 60 percent and the time required to pro-

TABLE I—MANUFACTURING METHODS

Fabrication:	machining, extruding, forging, sintering, electro forming
Assembly:	hot joining, cold joining, fastening
Casting:	sand and shell (mold is sand), plaster and investment (plaster or calcium sulphate), permanent mold and die (metal)

TABLE III—TOLERANCES FOR ALUMINUM AND MAGNESIUM

Guide Size	EIA	Actual	Band
0.140×0.280	±0.0015	±0.002	KA
0.311×0.622	±0.0025	±0.003	KU
0.400×0.900	±0.003	±0.004	X
0.497×1.122	±0.004	±0.005	XL
0.872×1.872	±0.005	±0.007	C
3.250×6.500	±0.005	±0.008	L
10.50×21.00	±0.020	±0.020 −0.040	

TABLE II—PROCESS TOLERANCES

Process	Capability (In./In.)	Minimum (Inches)
Sand Casting (Prec. Core)	±0.0025	0.004
Shell Casting	±0.007	0.010
Plaster Casting	±0.0025	0.004
Investment Casting	±0.0040	0.005
Permanent Mold	±0.010	0.020
Die Casting	±0.007	0.012
Brazed Fabrications	E I A tolerances maintained	

TABLE IV—CASTING ALLOYS FOR MICROWAVE COMPONENTS

Alloy	Company	Heat Treat	Brazability	Weldability	Dimensional Stability	Applicable Casting Processes
356	Alcoa	T6	poor	excellent	good	all except die
356	Alcoa	T51	poor	excellent	good	all except die
40E	Frontier Bronze	aged	excellent	good	fair	all
Tenzalloy	Federated Metals Div.	aged	excellent	good	fair	all
Ternalloy	Apex Smelting & Refining	aged	excellent	good	fair	all
612	Alcoa	aged	excellent	good	fair	all
Beryllium Copper	any	solution annealed and aged	good	——	good	all except die
Silicon Brass	any	——	——	——	poor	all except die
Magnesium AZ91	Dow	T6	poor	good	good	all
Magnesium AZ63	Dow	T6	poor	good	fair	all

duce even this quantity successfully becomes prohibitive. Experience has shown that meeting the "best" or EIA recommended tolerances does not guarantee required performance regardless of process. The experienced designer generally provides for enough adjustment to avoid a critical system.

Third: Check the surface requirements against the chart of surface finishes (Fig. 1B). Only plaster, investment and die casting yield finishes as fine as 36 microinches. Die casting is infrequently used due to the generally small quantities involved in microwave production. In practice, finishes of 63 through 125 microinches are satisfactory at frequencies through 20 Gc for operational components. Instrument components requiring higher accuracies are often hand-finished. Tolerable surface finishes at higher frequencies are indicated by experience with various designs.

Fourth: Check individual requirements such as internal shape (core) tolerances, alloy selection (Table IV), and secondary assembly or finishing operations against the overall process capabilities and limitations. Accessibilities and rigidity of the cores is an important consideration. When very precise inside dimensional control is required, the cores must be measured just before the molten metal is poured. Only rigid, firm cores can be measured by contact pressure instruments.

There are other considerations which follow these in importance. Some are: wall density, conductive and protective finishes, adjustability and corner radii.

Finally: If the above steps still

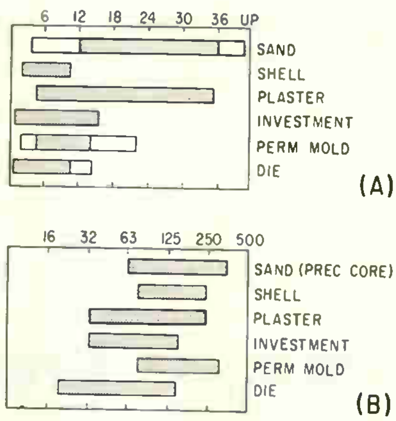
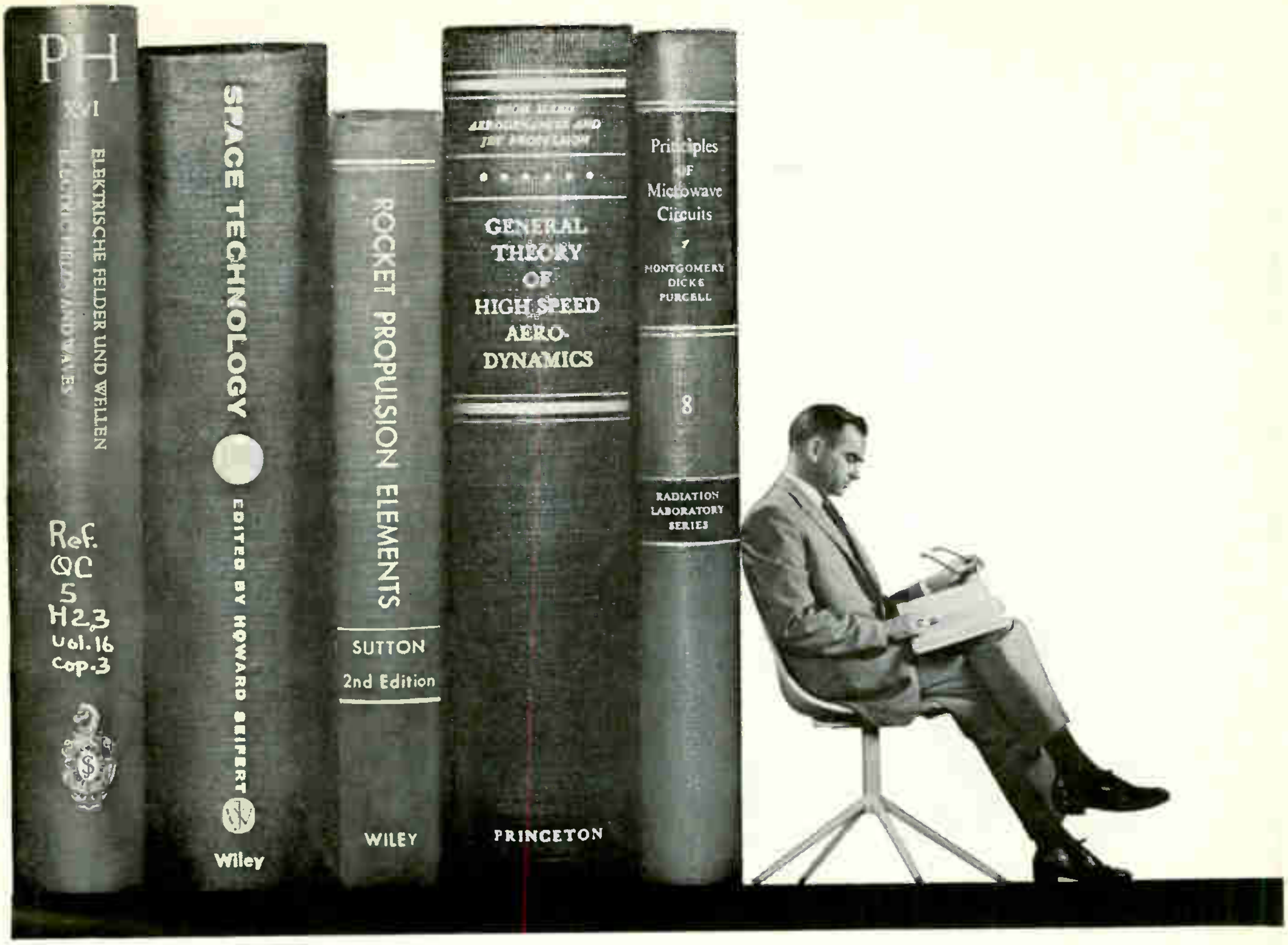


FIG. 1—Process size range in inches (A) and surface finishes in microinches-rms (B)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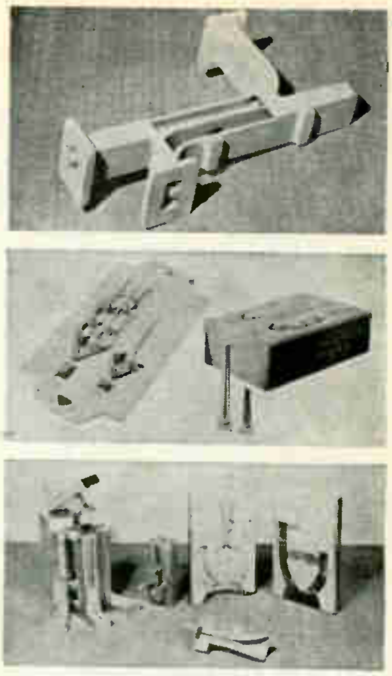

Cutaway view of coupler made as plaster casting (top), match plate for cored sand casting of antenna feeds (center) and patterns and molds for investment casting

leave a choice of more than one process, check tooling time and relative process costs.

The broadband directional coupler shown cutaway in the photo offers an example of process selection. Dip brazing was ruled out because of the need for ±0.004 symmetry in the over and under guide passages and alignment of the coupling slots with the ridges. Length is 13 inches, waveguide opening is 1.465 by 1.690 with tolerances of ±0.005 inches. Aluminum alloy 356 was specified.

Screening with Fig. 1A. Table II and Fig. 1B showed that either sand or plaster casting could be used. However, the requirements dictated precise core measurement before pouring. Only plaster casting allows such measurements.

BIBLIOGRAPHY

"Cast Metals Handbook", Third Edition, American Foundrymen's Association, Chicago, Ill., 1944.

"Metals Handbook", ASM, Cleveland, Ohio, 1944.

L. W. Brown, Problems and Practice in the Production of Waveguide Transmission Systems, *Proc. IEE*, p 639, Vol 93A.

J. A. Mullen and W. L. Pritchard, The Statistical Prediction of Voltage Standing Wave Ratio, *IRE Trans MTT*, p 127, April, 1957.

C. E. Nelson, Analysis of a Waveguide Reflection Problem by Statistical Methods, Internal Report TIS53E270, General Electric Co., Nov. 2, 1953.

R. S. Gordon and F. I. Gotthold, Design Considerations in the Manufacture of Microwave System Components and Assemblies, Gorham Electronics, Providence, R. I., 1960.

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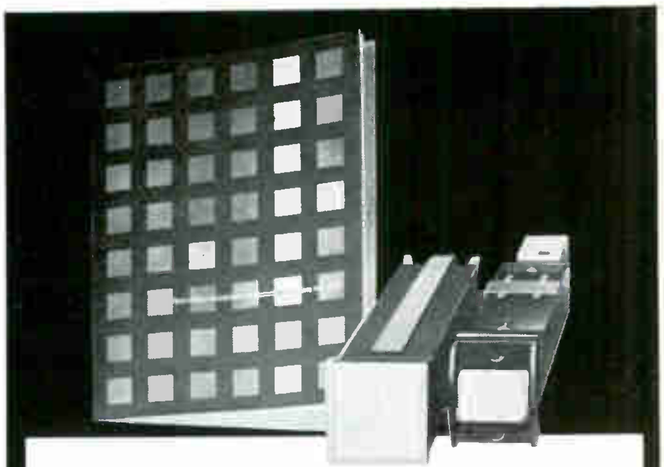

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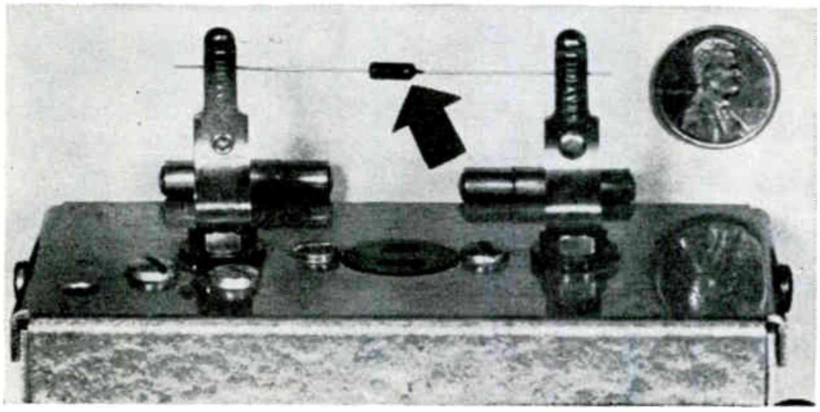
New On The Market



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SUBMINIATURE diffused junction silicon rectifiers operate at 1,000 to 3,000 piv. Sealed in glass packages 0.1 inch in diameter, diodes are rated at 100 ma at 25 C. A high dielectric constant is achieved by sealed-glass packaging in a closely controlled, high-pressure gaseous atmosphere. The 1N3282 through 1N3286 series of low cost diodes are available in quantity from Motorola Semiconductor Products Inc., 5005 E. McDowell Rd., Phoenix, Ariz.

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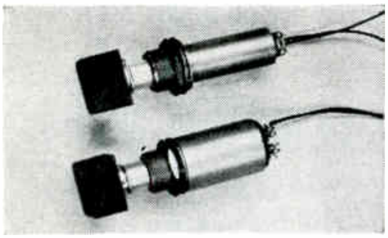

Solenoid Switch-Lights
LATCHING ACTION

SERIES OF solenoid hold-down switchlights have contacts from spst to 8pdt, with independent lamp circuits. When the solenoid hold-down switch is actuated, the coil is energized and holds the push-button in the IN position. The pushbutton remains in until the coil is remotely deenergized. When the coil is not energized, switching action is momentary. Switches are rated at 28 v d-c, 50 ma to 2 amp resistive with silver contacts, and 1 to 50 ma with gold contacts. Switching mechanism and coil are enclosed in a gold-anodized aluminum case; moisture-proof units are available. Delivery in 3 to 4 weeks; prices on request, from Pendar, Inc., 14744 Arminta St., Van Nuys, Calif.

CIRCLE 302 ON READER SERVICE CARD

Ultrasonic Shake Table
20 TO 100 KC; 4,000 G's

ULTRASONIC vibration table is for destructive and nondestructive testing of electronic and mechanical components, semiconductors, and missile hardware. Variable-frequency variable-power ultrasonic shake table operates from 20 Kc to 100 Kc, with approximately constant amplitude of motion through the range. Accelerations to 4,000 g can be obtained. DiSONtegrator model-160 shake table is now available from Ultrasonic Industries, Inc., Plainview, L. I., N. Y., at $750 each.

CIRCLE 303 ON READER SERVICE CARD

Sensitive Image Orthicons
FOUR TYPES

FOUR SENSITIVE camera tubes are announced by General Electric Co., CRT Dept., Syracuse, N. Y. The most sensitive, GL-7967, uses a trialkali photocathode, a magnesium-oxide semiconductor target, and can operate with photocathode illumination of 10^{-6} foot-candle or less. At low light levels the tube is capable of resolution in excess of 300 lines, with resolution in excess of 1,200 lines at higher light levels. Another type, GL-7969 image orthicon, is super sensitive in the ultra violet region, is expected to find use in blood and cell studies and in X-ray work. The third tube, Z-5395, with near-ir spectral response, has application in the commercial and military fields. The tube can penetrate hazy atmospheres for mapping and surveillance, and can be used in passive detection systems. The fourth tube, GL-7409, features ruggedized construction and high sensitivity for military applications such as missiles, satellites, fire control and drone guidance.

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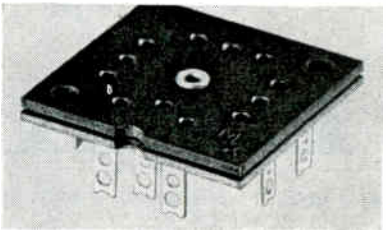

Module Socket
ACCEPTS CIRCUIT STACKS

SOCKET ACCEPTS module resistor and capacitor stacks. Insulating wafers are NEMA grade XP chocolate. Brass contacts are barrel-type, cadmium plated, and are designed to remain firmly in place when module is engaged to socket. Details and prices are available from Mandex Mfg. Co., Inc., 2614 W. 48th St., Chicago, Ill. Sockets can be furnished in production quantities.

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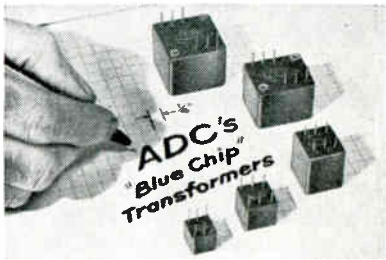
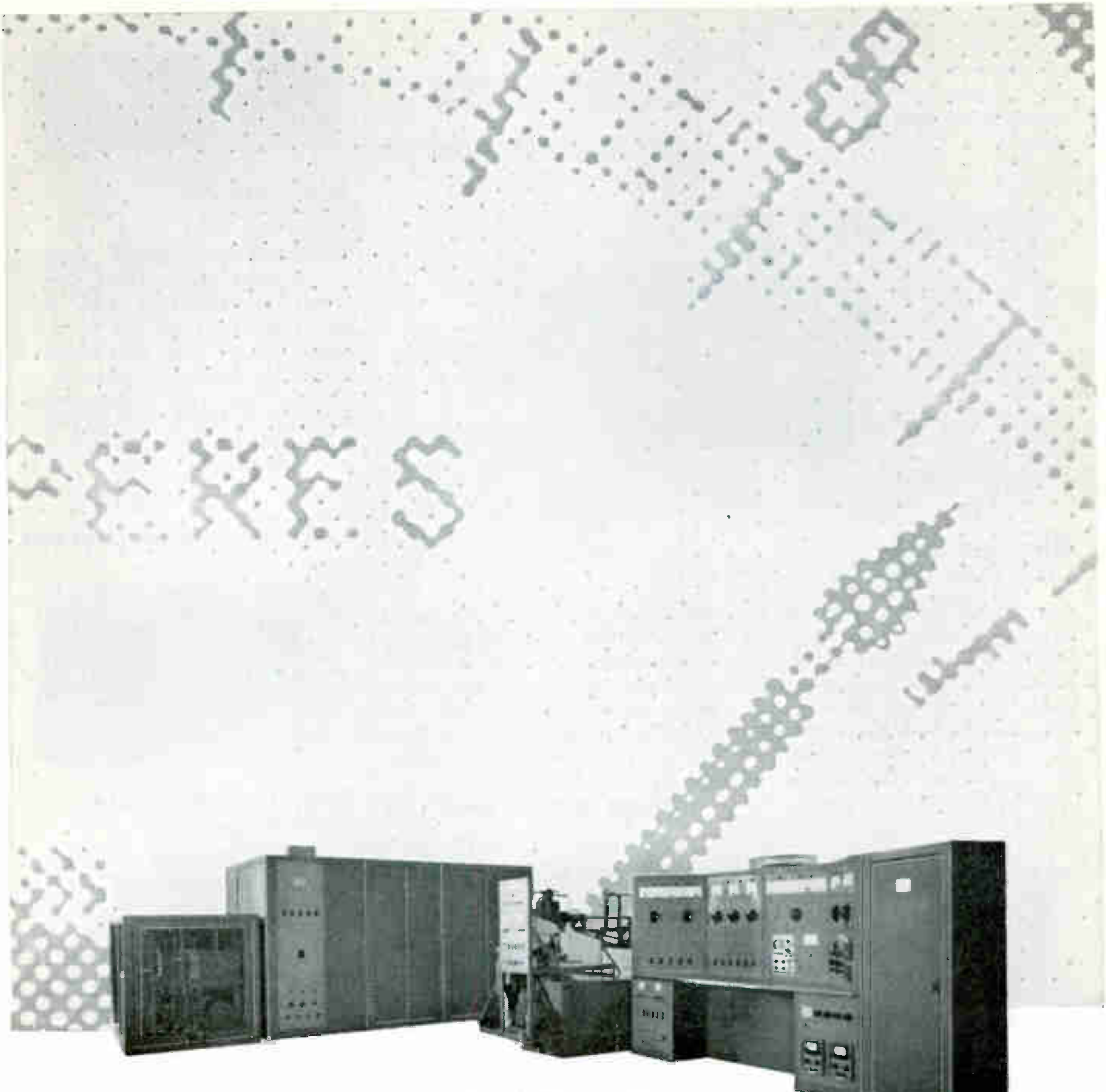


Line of Transformers
PRINTED-CIRCUIT USE

LINE OF small encapsulated transformers for printed-circuit applications is announced by ADC Inc., 2833 13th Ave. So., Minneapolis 7,



THEY RELY ON RADIATION FOR MEGAWATTS AT MEGACYCLES

Radiation at Stanford (formerly Levinthal) designs and builds high-power radar and communications transmitters, modulators and power supplies. This 30 megawatt transmitter for radar and component testing is typical. It demonstrates a unique capability for solving the special problems of superpower RF.

Two major design considerations in superpower RF equipment are performance *and* safety. In this unit—as in other Radiation-built systems with peak power to 100 megawatts and frequencies to 40,000 megacycles—special circuitry operates at miscrosecond speeds to prevent damage to the equipment. It includes five sub-assemblies with remote console containing all controls, interlock indicators and monitoring oscilloscope.

This capability of Radiation at Stanford is being utilized today by many prime contractors for advanced defense systems, and by makers of high-power commercial equipment. If you work with megawatts at megacycles, you can rely on it, too, for comprehensive solutions to your problems. Write Radiation at Stanford, Dept. EL-6, 3180 Hanover Street, Palo Alto, California, for detailed information.

RADIATION
INCORPORATED

CIRCLE 77 ON READER SERVICE CARD

Minn. Transformers are available in five different sizes, from 0.08 to 1.2 cubic inches. Sixty-four models offer a choice of power levels for voice and extended frequency operation.

The units meet MIL-T-27A, Grade 5, Class S requirements. Engineering data and prices available on request.

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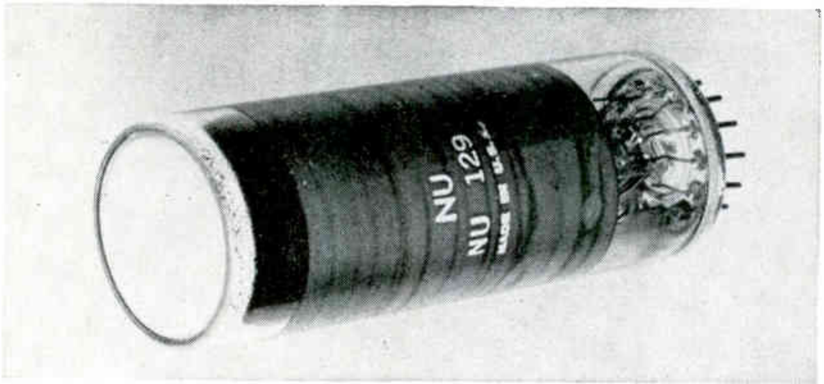

Miniature CRT
LOW-COST MONITOR

TYPE NU129 miniature crt is 1 5/16 inches in diameter and 4 inches long, has electrostatic focus and deflection with an isolated cathode lead. The tube has 12-pin E11-22 stem and the bulb has a flat face with excellent display for visual or photographic use. The tube may be operated at 1,000 volts, providing a brilliant display with a spot size of less than 0.01 inch. Available in most phosphors, the tube can be incorporated at low cost for equipment manufacture and inspection. The tube will be available for June delivery from National Union Electric Corp., Bloomington, Ill.

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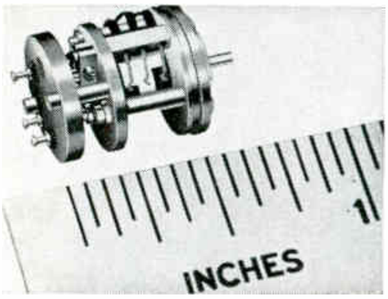


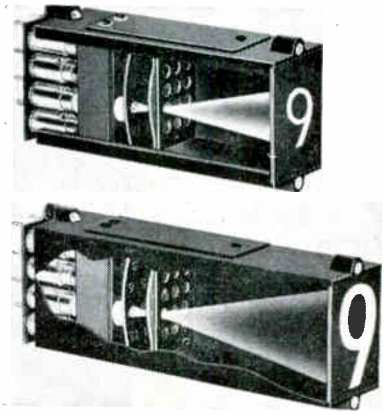
Commutating Switch
SIZE 5 HOUSING

HOUSED IN a size 5 can, miniature rotary commutating switch weighs less than 3.35 grams and occupies less than 1.28 cubic centimeters. Designed for missile application, the unit will pass rigorous specification of shock and vibration. Unit illustrated is single-pole, 8-position, make-before-break. Commutating surfaces are 18 karat gold, and brushes are multiple strand precious metal with current rating to 250 ma. Manufacturer is Airflyte Electronics Co., 535 Ave. A, Bayonne, N. J.

CIRCLE 308 ON READER SERVICE CARD

Digital Readout
SELF-DECODING

INDUSTRIAL ELECTRONIC ENGINEERS, INC., 5528 Vineland Ave., N. Hollywood, Calif. Slide plate readout accepts any BCD or teletypewriter code up to six bits, does its own translating, and displays the proper character. There are no auxiliary



translators, relays, or diodes required. Price of the basic unit is $50.

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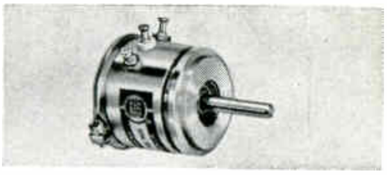

Miniature Pot
SINGLE-TURN

BORG EQUIPMENT DIVISION, Amphenol-Borg Electronics Corp., 120 S. Main St., Janesville, Wisc. The 2440 series Micropot is 7/8 in. in diameter. It is linear over specified resistance ranges of from 10 to 50,000 ohms. Resolution ranges from 229 to 900 turns. Maximum power rating is 3 w. Temperature extremes from − 55 to + 125 C. Gangable up to six units on a common shaft.

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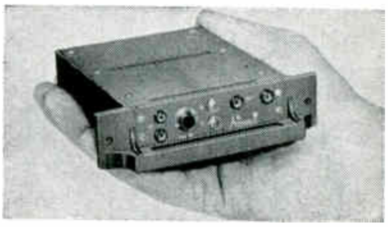

Pulse Rate Integrator
MINIATURIZED

ANADEX INSTRUMENTS, INC., 14734 Arminta St., Van Nuys, Calif. Model PI-300-J77 pulse rate integrator is used in missiles and aircraft for converting frequency to voltage for telemetering. It is highly accurate and features a self-contained calibrating circuit as well as high-input and low-output impedances. It has a full scale output of 5 v and is adjustable over a 4 to 1 frequency range. Input sensitivity is adjustable from 10 mv to 1 v.

CIRCLE 311 ON READER SERVICE CARD

Deflection Yokes
FOR SQ-CORNER TUBES

F. W. SICKLES DIVISION of General Instrument Corp., Chicopee, Mass., announces deflection yokes for square-corner, 114 deg picture tubes. Company claims they will provide equivalent focusing quality and, possibly, even superior pattern rectangularity, as compared with earlier 110 deg systems using spherical face plate tubes.

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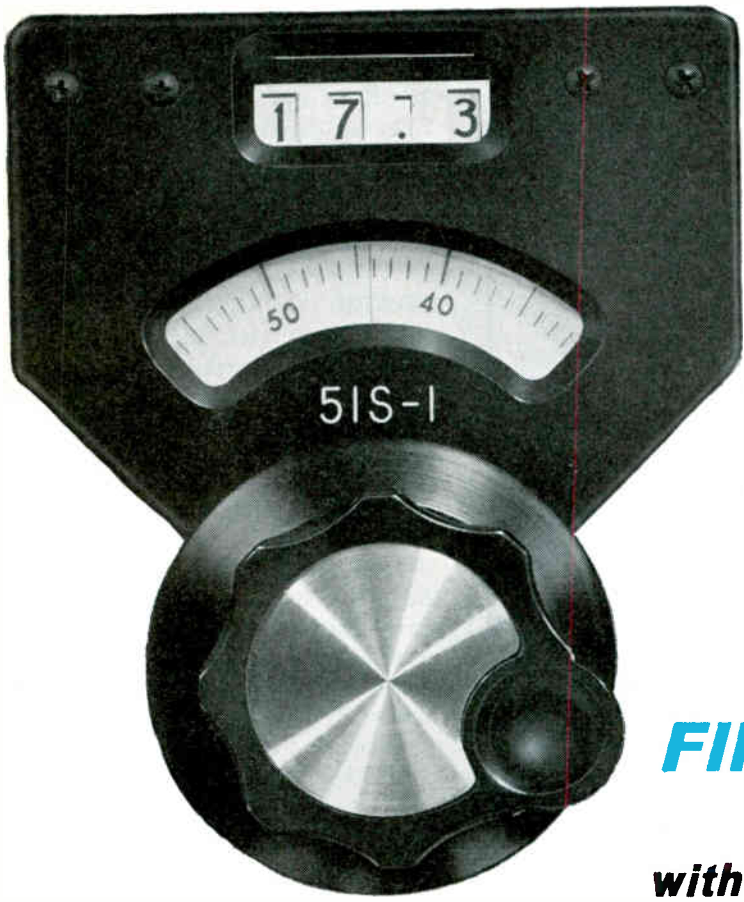
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Literature of

MICROWAVE POWER FILTERS General Electric Co., Schenectady 5, N. Y., has available booklet PT-52, entitled "Microwave Power Filters: Theory and Application."
CIRCLE 313 ON READER SERVICE CARD

POWER PACKS Electronic Research Associates, Inc., 67 Factory Place, Cedar Grove, N. J. Catalog No. 122 describes recent additions to the company's line of high current miniaturized solid state power packs.
CIRCLE 314 ON READER SERVICE CARD

WIRE-WOUND RESISTORS Reon Resistor Corp., 155 Saw Mill River Road, Yonkers, N. Y. A four-page catalog covers a line of encapsulated precision wire-wound resistors for military and industrial applications.
CIRCLE 315 ON READER SERVICE CARD

DECADE LINE CORRECTOR The Superior Electric Co., Bristol, Conn. Loose-leaf perforated sheet illustrates and describes type DLC1005 Powerstat decade line corrector.
CIRCLE 316 ON READER SERVICE CARD

RECORDER / REPRODUCER Consolidated Electrodynamics Corp., 360 Sierra Madre Villa, Pasadena, Calif., announces a four-page bulletin describing the features of the GL-2510 continuous-loop recorder/reproducer.
CIRCLE 317 ON READER SERVICE CARD

SWITCHING TRANSISTORS Texas Instruments Inc., Semiconductor-Components Division, P. O. Box 5012, Dallas 22, Texas. Germanium bilateral switching transistors are covered in a recent issue of *Application Notes*.
CIRCLE 318 ON READER SERVICE CARD

FIXED STATION ANTENNAS Mark Products Co., 5439 Fargo Ave., Skokie, Ill. "Beacon" fixed station antennas for the 25-50 Mc region are covered in bulletin 613.
CIRCLE 319 ON READER SERVICE CARD

DIODE CLOSURE Metalizing Industries, Inc., 338 Hudson St.,

the Week

Hackensack, N. J. Bulletin M-103 lists specifications and advantages of its ceramic diode closure that meets MIL Specs.
CIRCLE 320 ON READER SERVICE CARD

SILICON RECTIFIERS Solitron Devices, Inc., 500 Livingston St., Norwood, N. J., has available a 6-page catalog on the double diffused axial type silicon rectifiers, medium type.
CIRCLE 321 ON READER SERVICE CARD

TRITIUM VACUUM GAGE Radiation Research Corp., 1150 Shames Drive, Westbury, N. Y. Bulletin RRT-E101 contains technical data on the company's wide range radiation-free tritium vacuum gage.
CIRCLE 322 ON READER SERVICE CARD

DATA ACQUISITION SYSTEM Datex Corp., P. O. Box 667, Monrovia, Calif. A six-page folder gives an illustrated summary of the flexible, low cost DL-210 data acquisition system.
CIRCLE 323 ON READER SERVICE CARD

SYSTEMS & INSTRUMENTS Dymec, a division of Hewlett-Packard Co., 395 Page Mill Road, Palo Alto, Calif., has available a 16-page catalog of digital and r-f systems and instruments.
CIRCLE 324 ON READER SERVICE CARD

D-C POWER SUPPLIES Kepco, Inc., 131-38 Sanford Ave., Flushing 52, N. Y. The 32-page 1961 catalog provides complete data on more than 150 standard models of regulated d-c power supplies.
CIRCLE 325 ON READER SERVICE CARD

PREFORM ALLOYS Accurate Specialties Co., Inc., 345 Lodi St., Hackensack, N.J., offers a semiconductor alloy preform selector chart.
CIRCLE 326 ON READER SERVICE CARD

SERVO AMPLIFIER Kearfott Division, General Precision, Inc., Little Falls, N.J. An advance technical data sheet gives features and typical characteristics of a wide band semiconductor servo amplifier.
CIRCLE 327 ON READER SERVICE CARD

IBM Computer Center Exploring 6 Areas

INTERNATIONAL BUSINESS MACHINES CORP. recently opened its new Thomas J. Watson Research Center in suburban Yorktown Heights, 40 miles north of New York City. Company says it is the most advanced center in the world for the study of computer science. The crescent-shaped structure, which stretches 1,091 feet, will house some 1,500 scientists and supporting personnel.

The Center has a floor space equal to eight football fields—all of it divided into laboratory, office and service areas. It is traversed by more than half a mile of glass-walled corridors. A total of 56 aisles intersect the 146-ft wide structure from front to back on its three levels.

Work in the new center will be divided into six broad fields of exploration:

General Science — investigation into magnetics, low temperature and semiconductor phenomena.

Solid State Science—probing the mysteries of solid materials which might find application in computers.

Experimental Systems—studying new systems for the machine translation of languages, for information retrieval and for control of chemical and other industrial processes.

Experimental Machines — development of advanced concepts for super-speed computers out of newly-evolving techniques.

Engineering Science — research into voice and printed character recognition by machine, and studies of the properties of paper and ink to meet the demands of advanced computers.

Mathematical Sciences — investigation into new logical approaches to computer design and computer problems to improve both the machines and the ability to use them.

The Center becomes not only IBM's largest research installation, but also acts as a national and international clearing house for new thinking in computer science.

Today, IBM also conducts research at the Watson Scientific Computing Laboratory at Columbia University in New York City; the San Jose Research Laboratory in California; and the Zurich Research Laboratory in Switzerland. Findings from these laboratories are applied to industrial practice at 22 IBM development laboratories here and abroad.

Heading up the new Center is Gilbert W. King, IBM director of research. He reports to Emanuel R. Piore, vice president for research and engineering.

John Locke Assumes New Hughes Position

JOHN E. LOCKE has been appointed manager of diode operations for the semiconductor division of Hughes Aircraft Co., Newport Beach, Calif.

Before joining the semiconductor division, Locke was director of administration and assistant to the vice president of the company's components group and, previously, manager of planning and industrial engineering in Hughes' Tucson, Ariz., plant. He has been with Hughes since 1949.

Donald Caverly Joins General Time Corp.

APPOINTMENT of Donald P. Caverly as director of engineering of General Time Corp., Stamford, Conn., is announced. He was president and a director of Barth Engineering and Mfg. Co., Meriden, Conn. and will remain a director of that firm.

Reevesound Co., Inc. Hires Chief Engineer

APPOINTMENT of Michael W. Chitty as chief engineer for Reevesound Co., Inc., a subsidiary of Reeves Soundcraft Corp., Long Island City, N. Y., is announced.

Chitty was formerly associated with Canadian Marconi, Ltd., as division manager.

Daystrom Vice President Takes Additional Post

LOUIS H. ARICSON has been named chief executive officer of the Weston

Instruments Division of Daystrom, Inc., Murray Hill, N.J. He retains his post as corporate vice president, a position he has held since July, 1960.

Industrial Timer Corp. To Get New Facility

INDUSTRIAL TIMER CORP., Newark, N. J., recently broke ground on a 14.3 acre plot near Parsippany, N. J., for construction of a new facility to be occupied later this year.

Company is engaged in design, development and manufacture of timing and control devices for industrial, research, military and commercial application. It presently occupies a 22,000 sq ft building in Newark.

Tensor Electric Names Ballaine to Board

FRANCIS K. BALLAINE, executive vice president of Adelphi Research Center, Inc., Adelphi College, has been named to the board of directors of Tensor Electric Development Co., Inc., Brooklyn, N.Y. He will also act as an advisor on management problems.

Loral Electronics Hires L. F. Jones

LORAL ELECTRONICS CORP., New York, N. Y., has appointed Lawrence F. Jones as staff scientist.

Jones was formerly chief of the digital branch of the Norden Division of United Aircraft Corp. and prior to that, advisory engineer in charge of the digital computer group at the Air Arm division of Westinghouse Electric Corp.

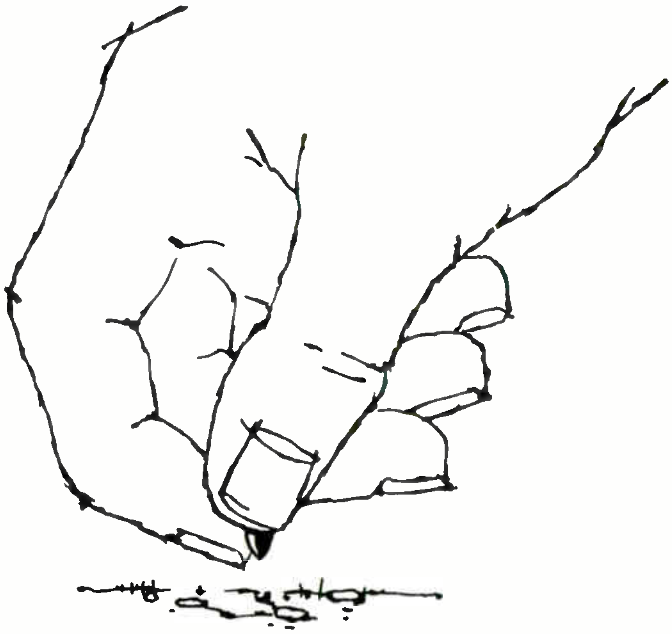
Electrada Corp. Elects Vice President

ROBERT W. LANDEE has been elected a vice president of the Electrada Corp., Culver City, Calif., and general manager of the firm's electronics division.

For the past three years, Landee has been director of research and development for the western division of the Collins Radio Co. Prior to that, he was for 12 years in charge of all electronic projects for Gilfillan Bros.

PEOPLE IN BRIEF

Donald Wahl, formerly with Convair Electronics, appointed engineering manager at the San Diego branch of General Dynamics/Electronics' military products division. **Erich A. Herold** leaves Republic Aviation to join Sanders Associates as manager of manufacturing planning. **Arthur D. Hughes** of Auerbach Electronics Corp. chosen technical staff senior member. **James R. Pepper**, ex-General Electric, joins Microwave Electronics Corp. as production engineer. **Frederick Shuh** promoted to general manager of General Instrument-F. W. Sickles of Canada. **Robert J. Sullivan** advances to manager of liaison engineering in Europe for Fairchild Controls Corp. **John G. Sinclair, Jr.**, previously with Hughes Aircraft, joins the microwave labs of Quantatron Inc. as senior engineer. **L. D. Brown** moves up to chief engineer at Aerotest Laboratories. **James C. Alemanni** transfers from Teleflex to International Resistance Co. as manufacturing engineer. **T. S. Torian** promoted by Bendix Corp. to director of contracts and planning for the Mishawaka Div. **Earl H. Blaik** of Avco Corp. and **W. R. Persons** of Emerson Electric elected to the board of directors of Gulton Industries.



planting for tomorrow

You've heard of the "hard sell" and the "soft sell" — but many of our advertisers are also interested in the "long sell".

This is *planned* advertising. You might call it "planting for tomorrow".

The sales seed in an advertising message bears abundant fruit if sown in fertile ground . . . readers of this publication, for example, who, in *buying* this issue, have demonstrated their interest in what we have to say.

As a member of the Audit Bureau of Circulations*, our circulation records have been audited and the facts published — by this impartial organization of advertisers, advertising agencies, and publishers. These bedrock facts about our circulation audience can help you to plan more productive advertising.

Is your own planned selling based on circulation facts? You can be ABC-sure. Ask to see a copy of our latest circulation report.

AUDITED PAID CIRCULATION ABC

electronics

A McGRAW-HILL PUBLICATION • 330 W. 42nd ST. • NEW YORK 36, N. Y. ABP

* Through the reports issued by the Audit Bureau of Circulations, this publication, along with other publisher members of ABC, voluntarily and regularly give the buyers of advertising more verified factual information than is available for any other advertising media at any time.

EMPLOYMENT OPPORTUNITIES

electronics

WEEKLY QUALIFICATION FORM FOR POSITIONS AVAILABLE

ATTENTION: ENGINEERS, SCIENTISTS, PHYSICISTS

This Qualification Form is designed to help you advance in the electronics industry. It is unique and compact. Designed with the assistance of professional personnel management, it isolates specific experience in electronics and deals only in essential background information.

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

STRICTLY CONFIDENTIAL

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

WHAT TO DO

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

COMPANY	SEE PAGE	KEY #
AIRCRAFT ARMAMENTS INC. Cockeysville, Maryland	88	1
THE BENDIX CORPORATION Kansas City Division Kansas City, Missouri	88	2
BROOKHAVEN NATIONAL LAB. Upton, New York	80	3
CORNELL ASSOCIATES Chicago, Illinois	88	4
ERIE ELECTRONICS DIV. Erie Resistor Corp. Erie, Pa.	88	5
ESQUIRE PERSONNEL Chicago, Illinois	104*	6
FIDELITY PERSONNEL OF PHILADELPHIA Philadelphia, Pa.	104*	7
HEATH COMPANY Benton Harbor, Michigan	88	8
LABORATORY FOR ELECTRONICS Boston, Massachusetts	87*	9
McGRAW-HILL PUBLISHING CO., INC. New York, New York	104*	10
REPUBLIC AVIATION Farmingdale, L. I., New York	103*	11
WHO'S HIRING WHO Washington, D. C.	88	12
P-6754	88	13

* These advertisements appeared in the 5/26/61 issue.

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electronics WEEKLY QUALIFICATION FORM FOR POSITIONS AVAILABLE

Personal Background

NAME ....

HOME ADDRESS..

CITY.......................... ZONE...... STATE............

HOME TELEPHONE..

Education

PROFESSIONAL DEGREE(S)..

MAJOR(S) ....

UNIVERSITY ....

DATE(S) ....

FIELDS OF EXPERIENCE (Please Check)

621

☐ 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

POSITIONS OPEN FOR INQUIRING MINDS IN MANUFACTURING ENGINEERING!

Engineering Special Projects

Bendix of Kansas City, Missouri needs three Manufacturing Engineers to do original work with new materials, and close, more exacting work with ordinary materials—minds that will inquire into the many branches of technology and bring together that combination of techniques capable of producing a unique product. As a Prime Contractor for the Atomic Energy Commission, our function is to give the Weapon Designer the greatest possible latitude in exploiting new materials and techniques. We do this by paralleling his design work with advanced development of manufacturing processes during the design phase. The control of processes must frequently be so precise that automation is required for that reason alone—production quantity notwithstanding.

Engineers who can fill these positions must combine original thought with solid training in the basic physical sciences. They must be able to combine the reasoning of several disciplines in the development of a solution. Minimum requirements include:

- Bachelor's Degree in Mechanical, Chemical or Electrical Engineering.
- Strength in one or more of the following fields: subminiature transformer and toroid production, fabrication and assembly of precise and delicate electrical and electronic assemblies requiring special environmental facilities.

These are responsible positions for engineers who are qualified to do original and creative work, and who can demonstrate by a record of past professional accomplishment that they possess this ability. Ours is one of the nation's most vital industries. We offer unusually generous company benefits in a Midwestern community which is famous for its beauty and low cost-of-living. All replies will be strictly confidential.

For Personal Interview Send Resume to
Mr. K. L. Beardsley
Box 303-VI

All qualified applicants will receive consideration for employment without regard to race, creed, color or national origin.

THE Bendix CORPORATION

KANSAS CITY DIVISION

95th & Troost, Kansas City 41, Missouri

A stimulating challenge to

COMPETENT ENGINEERS

AAI's continued growth offers exceptional opportunities to qualified engineers who want the freedom of creative thinking and have the ability to work as a team. Right now we're looking for this kind of talent to add to our staff:

ELECTRONIC ENGINEERS

...with experience in digital systems design, digital analysis and design, pulse circuitry, simulation and telemetry.

...to work on computers, test equipment and instrumentation.

ELECTROMECHANICAL ENGINEERS

...with experience in servos, relays, switches and analog computers.

...to work on trainers and simulators.

If your experience is in any of these areas and you are interested in moving ahead with us, send your resume to Mr. D. J. Wishart.

AIRCRAFT ARMAMENTS, INC.
Cockeysville, Maryland
(Suburban Baltimore)

All qualified applicants will receive consideration for employment without regard to race, creed, color or national origin.

20,000 JOBS

U. S. A. & WORLDWIDE

WHO'S HIRING WHO (Fifth Edition) identifies job vacancies in all states, all continents (plus Caribbean & Pacific islands.) Includes more than 10,000 jobs with interview & moving expenses paid!

FULL GUIDES ON HOW TO PREPARE A SUPERIOR RESUME ARE INCLUDED PLUS FREE RESUME REPRODUCTION & REFERRAL TO EMPLOYERS FOR ELECTRONIC ENGINEERS & TECHNICIANS.

All only $1 postpaid and yet WHW is the most complete report of job openings publicly available in the U. S.

Full refund if not satisfied.

WHO'S HIRING WHO (E-2)

2020 M St. N.W. Washington 6, D. C.

CHIEF PROJECT ENGINEER

Minimum—B.S.E.E. or Physics, for Inertial Guidance Systems Design and Development group. Should have Inertial Systems, or Airborne Electronic Systems background and administrative qualities.

SALARY TO 17,500

Write or Wire

MICHAEL BASS, Vice President

Cornell Associates

14 East Jackson Blvd. Chicago 4, Illinois
WAbash 2-7580

ELECTRONIC COMPONENT DEVELOPMENT ENGINEER

Experienced in the design and development of Capacitors and/or Resistors for Commercial and Military applications.

Ideal opportunity for ambitious man to develop to limit of his ability. Salary—Open. Location—Erie, Pa. Call or send resume to: Chief Engineer

Erie Electronics Division
ERIE RESISTOR CORPORATION
645 West 12th St., Erie, Pa. (GL 6-8592)

ELECTRONIC ENGINEERS

to design and develop

HEATHKIT AUDIO PRODUCTS

If you have circuit design experience with high fidelity components . . . Heath Company can offer you excellent salary and benefits plus the opportunity and security unique to a fast-growing consumer products manufacturer. Ideal conditions in a modern plant on the shores of Lake Michigan, 2 hours from Chicago. Send complete resume including salary requirements to:

D. J. McNamara

HEATH COMPANY
A Subsidiary of Daystrom, Inc.
BENTON HARBOR, MICHIGAN
Telephone GA 4-2411

Wanted: Electronic Meter Engineers

Young and aggressive meter manufacturing firm has opening for two experienced meter engineers. Design and development and production background important. Salary open. Advance with this dynamic firm in its all new plant. All replies will be held in strictest confidence.

P 6754 Electronics
645 N. Michigan Ave., Chicago 11, Ill.

PERSONNEL MANAGERS

Looking for
EXPERIENCED ENGINEERS . . .
TECHNICAL PERSONNEL?

Write for a free copy of:

"HOW TO ATTRACT ENGINEERS"

This file-size booklet is designed for personnel people faced with the problem of recruiting engineers and technical people.

The top-flight engineers and technical personnel you want are at a premium . . . as this twenty page booklet points out. How you can reach and influence these men is the story told.

This booklet describes the McGraw-Hill publications best suited to reach the specific type of engineer you want . . . how you can make contact . . . channel and concentrate your employment advertising to just the men with the job qualifications you want . . . helpful hints to consider and pitfalls to avoid when you prepare your copy and layout for an "Employment Opportunity" advertisement . . .

Write for your free copy to . . .

B. A. Feher
Classified Advertising Division
McGraw-Hill Publishing Co., Inc.
Post Office Box 12
New York 36, New York

INDEX TO ADVERTISERS

Audited Paid Circulation

* See Advertisement in the July 20, 1960 issue of Electronics Buyers' Guide for complete line of products or services.

* See Advertisement in the July 20, 1960 issue of Electronics Buyers' Guide for complete line of products or services.

■

CLASSIFIED ADVERTISING
F. J. Eberle, Business Mgr.

ADVERTISERS INDEX

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

electronics

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NEW!

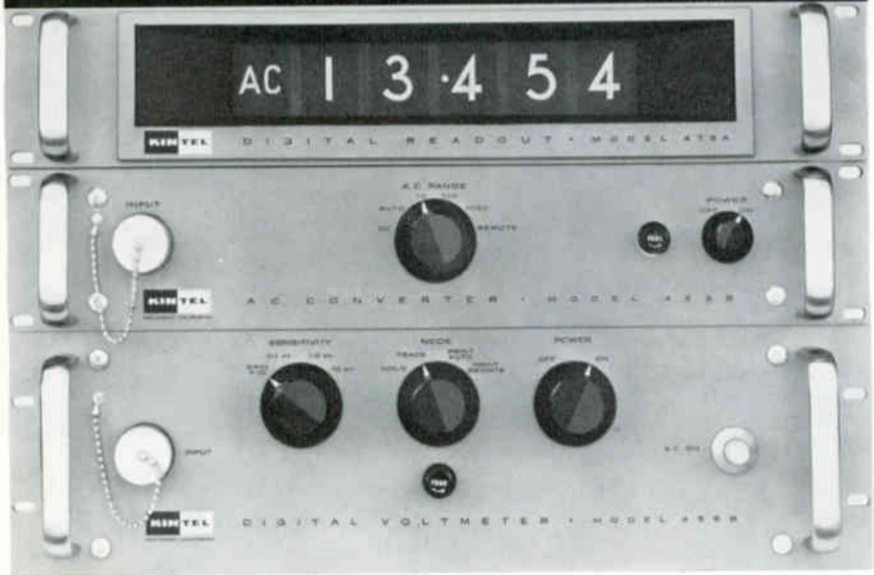
AC/DC digital voltmeter

EXCLUSIVE FEATURES:

remote (programable) control

up to 10 times more AC and DC resolution

industry's highest AC accuracy



The Model 502B AC/DC Digital Voltmeter measures DC between ±100 microvolts and ±1000 volts, AC from 30 cps to 10 kc between 1 millivolt and 1000 volts. The readout displays 4 digits plus a 5th over-ranging digit (0 or 1) that gives 10 times greater resolution at the decade points (1, 10, 100 volts). The 502B is unique among digital voltmeters in providing AC over-ranging on the two lower manual range scales—00.000 to 19.999 volts and 000.00 to 199.99 volts.

DC measurements are accurate within 0.01% of reading ±1 digit. AC accuracy is the highest in the industry—within 0.1% of reading or ±3 digits from 30 cps to 10 kc for inputs up to 10.000, 100.00, or 1000.0 volts on the respective range scales, within the same tolerance for signals from 50 cps to 7 kc up to 15.000 and 150.00 volts on the respective scales.

The 502B is the only digital voltmeter controllable by remote contact closures. With the AC converter control set to REMOTE, contact closures can select any of the following ranges (1) 10-volt range, AC; (2) 100-volt range, AC; (3) 1000-volt range, AC; (4) auto-range, AC; or (5) auto-range, DC.

Write for detailed literature or a demonstration of this outstanding instrument.

Price $4245.00. Delivery from stock.

Representatives in all major cities.

5725 Kearny Villa Road, San Diego 11, California • BRowning 7-6700

KIN TEL
A DIVISION OF
COHU
ELECTRONICS, INC.

RCA Microwave Devices

The RCA Microwave facility has recently received the "Reduced Inspection Quality Assurance Plan" award—by U. S. Army Signal Supply Agency—for a number of outstanding tube types. Here are additional types that will be of interest to you.

REPRESENTATIVE RCA MICROWAVE TUBES, SOLID-STATE OSCILLATORS AND AMPLIFIERS

LOW-NOISE SOLENOID AND PPM TRAVELING-WAVE TUBES (listed by Power-Frequency Ratings)

Type No.	Frequency Range (Mc)	Min. Power Output (Watts)	Min. Small-Signal Gain (db)	Max. Noise Factor (db)
A-1217*	1100-1400	0.0005	20	4.5
A-1217-V4*	1700-2000	0.0005	25	5
A-1119*	2000-4000	0.001	20	12
A-1207-V5*	2190-2310	0.001	20	4.5
A-1207-V10*	3500-4000	0.001	25	5
A-1139*	1000-2000	0.01	20	12
4019	1000-2000	0.01	28	17
4017	2000-4000	0.01	30	16
4020	4000-7000	0.01	28	18

PPM POWER TYPE TRAVELING-WAVE TUBES (listed by Power-Frequency Ratings)

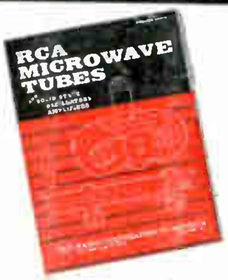
Type No.	Frequency Range (Mc)	Min. Power Output (Watts)	Min. Small-Signal Gain (db)	Max. Noise Factor (db)
4009	2000-4000	0.01	33	—
A-1140*	8000-12000	0.01	33	—
A-1215*	12000-15000	0.01	30	—
A-1189*	4000-7000	0.1	30	—
4021	1000-2000	1	27	—
4010	2000-4000	1	33	—
A-1205*	4000-7000	1	30	—
4015	8000-12000	1	33	—
A-1225*	12000-15000	1	30	—
A-1093*	1700-2300	15	27	—
A-1160*	2000-4000	10#	25	—
A-1181*	7500-11200	25#	27	—
A-1136*	5000-6000	50#	30	—
A-1179*	2000-4000	80#	23	—
A-1134*	2000-4000	1000#	30	—

PENCIL TUBES (including Integral-Cavity Types)

Type No.	Description	Max. Dimensions (in.) Length	Diam.
A-15131*	CW integral-cavity type for fixed-tuned oscillator service—300 mw useful power output. Variants available to cover 50 Mc intervals, 975-1225 Mc.	4.6**	0.98▲
A-15132*	Similar to A-15131, but for pulsed-oscillator service—500-watts peak useful power output.	4.6**	0.98▲
A-15227*	CW integral-cavity type for fixed-tuned oscillator service—300 mw useful power output. Variants available to cover 100 Mc intervals, 1800-2250 Mc.	2.5**	1.0▲
A-15228*	Similar to A-15227, but for plate-pulsed oscillator service—300 watts peak useful power output.	2.5**	1.0▲
A-15235*	CW integral-cavity type for fixed-tuned oscillator service—50 mw useful power output. Variants available to cover 100 Mc intervals, 3000-3450 Mc.	5.5**	1.0▲
A-15236*	Similar to A-15235, but for plate-pulsed oscillator service—50 watts peak useful power output.	5.5**	1.0▲
7552	For low-noise, Class-A service at altitudes up to 100,000 ft. without pressurization. 13 db min. power gain for 5 Mc Bw.	1.62	0.557
7553	Similar to 7552, but has additional performance and environmental features. 14 db min. power gain for 5 Mc Bw.	1.62	0.557
7554	For low-noise, class-C service at altitudes up to 100,000 ft. (at reduced ratings without pressurization). 1.6 watts power output at 500 Mc.	1.62	0.557
A-15205*	Similar to 7554, but for plate-pulsed oscillator service—250 watts peak useful power output.	1⅝	9/16

Solid-State Oscillators		Solid-State Amplifiers		Magnetrons (Pulsed-Oscillator Service)			
Type No.	Description	Type No.	Description	Type No.●	Frequency Range (Mc)	Min. Peak Power Output (kw)	Tuning
SS-100*	L-Band, mechanically tunable tunnel-diode type	SS-500*	L-Band, tunnel-diode type	6521	5400 ±20	75	None
SS-104*	L-Band, electronically-tunable tunnel-diode type	SS-1000*	S-Band helix-type parametric amplifier	7008	8500-9600	200	Servo
SS-107*	UHF and into S-Band, fixed-tuned tunnel-diode type	SS-1001-V1*	S-Band helix-type parametric amplifier	7111	8500-9600	200	Hand
		SS-1002*	L-Band mechanically tunable low-noise parametric amplifier				

*Developmental type
**Excludes flexible leads
#Peak
●With integral permanent magnet
▲Excludes frequency adjustment screws and rf connector



Now Available! A 16-page booklet filled with technical data on nearly 100 different RCA Microwave Tubes and Solid-State Amplifiers and Oscillators. For your free copy, write on company letterhead to Section F-19-Q-1, Commercial Engineering, RCA Electron Tube Division, Harrison, N. J.

RCA Electron Tube Division, Harrison, N. J.

RCA®

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