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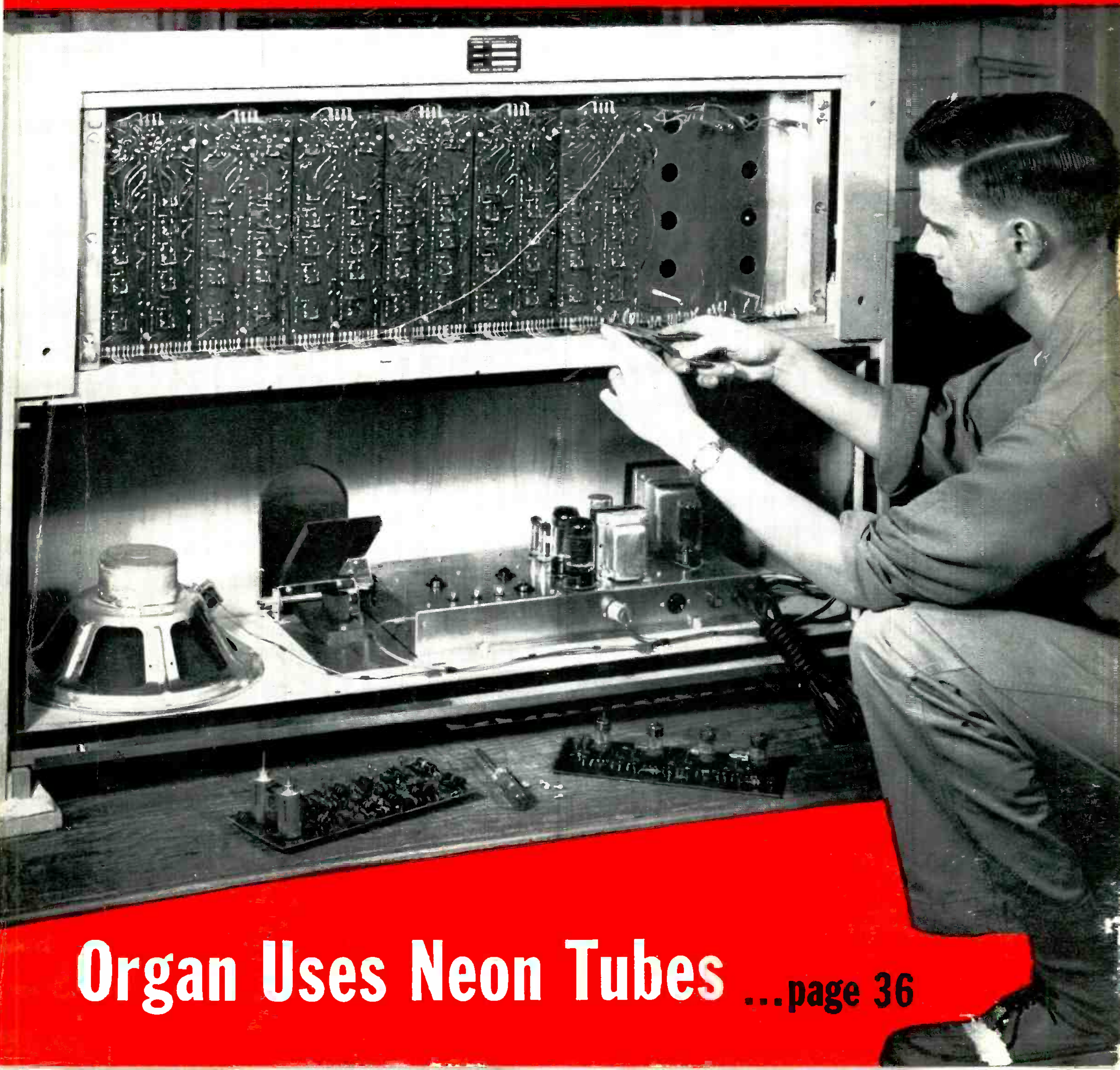
AUGUST 29, 1958

electronics

engineering issue

Photoflash Power Packs ...p 29

Meteors Create Radio Paths ...p 42



Organ Uses Neon Tubes ...page 36

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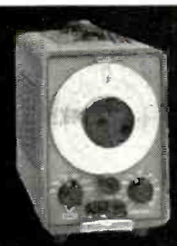
each designed to do a specific job best
stable RC circuit pioneered by -hp-

201C—designed for high quality audio tests. Covers 20 cps to 20 KC. Output 3 watts/42.5 volts. $225.00



200J — extreme accuracy for interpolation and frequency measurements. Covers 5 cps to 6 KC, output 160 mw/10 volts; 20 volts open circuit. $275.00

202C — replaces famous 202B for low frequency measurements 1 cps to 100 KC. Output 160 mw/10 volts; 20 volts open circuit. $300.00

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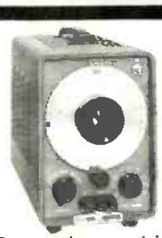
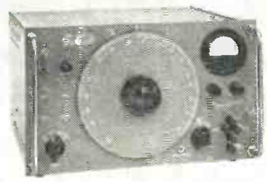


200CD—popular precision instrument for audio and ultrasonic tests. 5 cps to 600 KC; output 160 mw/10 volts; 20 volts open circuit. $160.00



233A — carrier test oscillator covering frequencies 50 cps to 500 KC. Output 3 watts/600 ohms. $475.00

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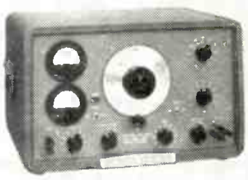
200AB—for audio tests, 20 cps to 40 KC. Output 1 watt/24.5 volts. Simple to use, compact, rugged. $130.00



205AG — time-tested convenience for high power tests, gain measurements. 20 cps to 20 KC, 5 watts output. $475.00

206A — widely-used for high quality, high accuracy audio tests. Very low distortion. Covers 20 cps to 20 KC, output + 15 dbm. $6[illegible]5.00

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A McGRAW-HILL PUBLICATION • VOL. 31, NO. 35 • AUGUST 29, 1958

Issue at a Glance

Organ Uses Neon Tubes. Use of two neon lamps in voltage-divider relaxation-oscillator circuit gives organ, made by the Kinsman Company, wide latitude in electronic tone selection techniques. See p 36.....**COVER**

Business Briefs .... p 7

Electronics Newsletter 7
Figures of the Week 7
Subs Use Navaho's Guidance 8
Magnetics Papers Reveal Trends 8
Latest Monthly Figures 8
Reactor Control Is Transistorized ... 12
Washington Outlook 12
Attitude Display for Helicopter 14
Military Electronics 14
Instruments Get Space Tests 14
Meetings Ahead 16
Financial Roundup 16
MIT Reactor Aids Components R&D .. 16

Photoflash Transistor Power Converters. Electronic photoflash unit power supplies use transistors to increase efficiency and to decrease size and weight .... p 29
By Haig A. Manoogian

Ultrasonics Tests Undersea Propagation. Variations in attenuation and propagation time of an ultrasonic signal through sea water are determined by sensitive instrumentation .... p 32
By Willis C. Gore

Electronic Organ Uses Neon Tone Generators. With unusual relaxation-oscillator circuits, tone generators in electronic organ provide twelve notes of chromatic scale .... p 36
By Richard H. Dorf

Meteor Bursts Provide Communications Path. Showers of meteor particles, entering E-layer of atmosphere, leave ionized trails that reflect vhf radio waves providing 700-mi communication path .... p 42
By B. M. Sifford and W. R. Vincent

Meter Measures Midfrequency Phase Shift. With double mixing process, unit linearly transposes phase shifts at 30-mc down to 2-mc reference for comparison .... p 46
By Allen Nirenburg

DIGEST CONTINUED ON NEXT PAGE

DIGEST continued

Designing Noisefree Enclosure Openings. Interference radiated from equipment enclosure openings is reduced by designing apertures as waveguides .... p 48
By Arnold L. Albin

Electrons At Work .... p 50

High-Frequency Phase Detector 50
Override Circuits Are Simplified 50
By Ronald L. Ives
Long-Range X-Rays 52
100 Disks Store 10 Million Units 55

Component Design .... p 56

Klystron Uses Capacitive Tuning 56
By Robert G. Rockwell
Neon Lamps Display Numerals 56
Reverse-Twist Cable 60
Dials Are Self-Illuminating 61

Production Techniques .... p 62

Peg Board Harness Guide 62
Wiring Pattern on Film 62
Fixture For Wire Assembly 64
Sensitized Metal Name Plates 66

New Products .... p 68

Literature of the Week .... p 76

Plants and People .... p 78

New Books .... p 84

Comment .... p 85

Index to Advertisers .... p 91

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August 29, 1958 Vol. 31, No. 35

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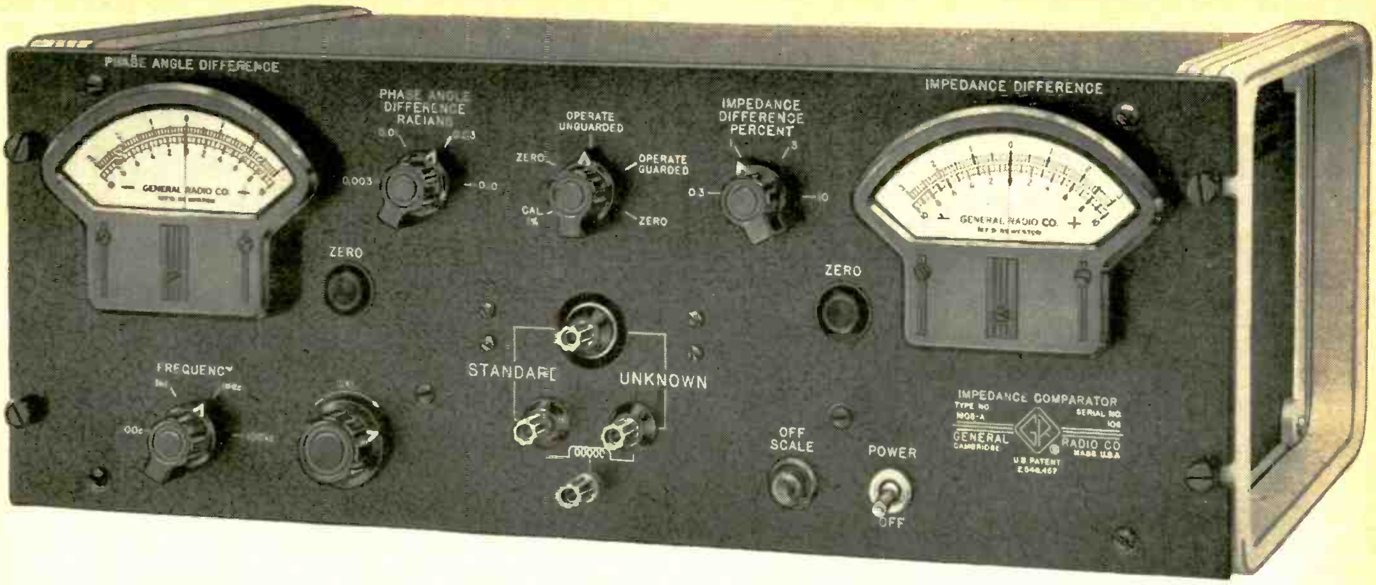
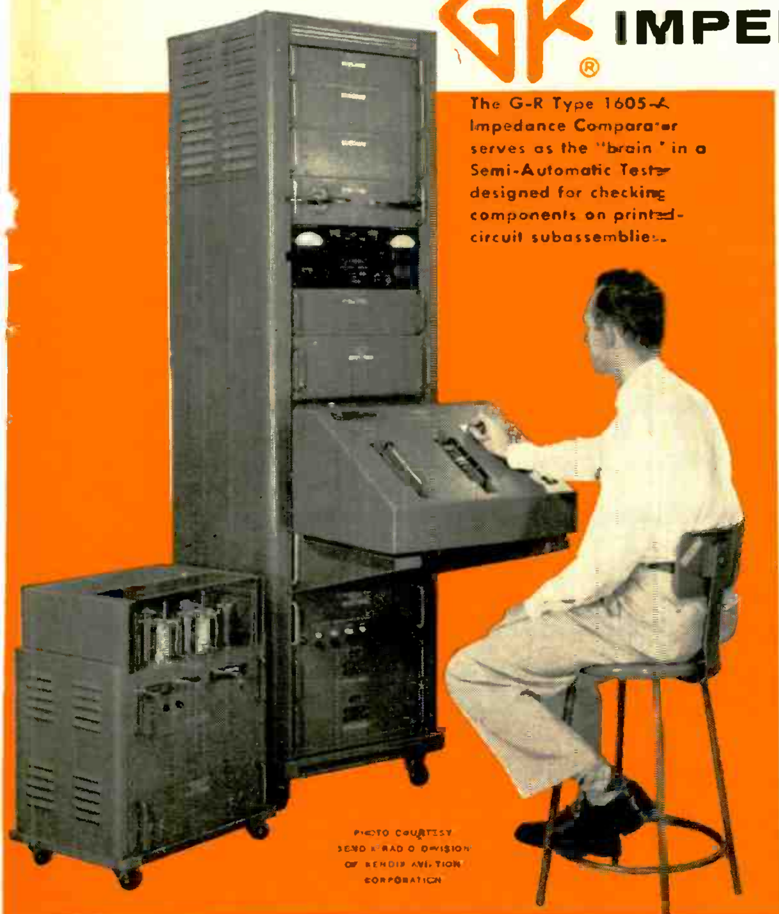


A Measurement Once Every Second with the GR® IMPEDANCE COMPARATOR



The G-R Type 1605-A Impedance Comparator serves as the "brain" in a Semi-Automatic Tester designed for checking components on printed-circuit subassemblies.

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The Comparator indicates directly on two panel meters the differences in magnitude and phase angle between unknown and standard impedances. No manual balancing is required.

As used with the Semi-Automatic Tester, the Comparator's panel meters are disconnected. Comparator metering voltages, proportional to impedance-magnitude difference (in per cent) and phase-angle difference (in radians), are amplified by the Tester and compared against d-c reference voltages which correspond to allowable tolerances. Printed-circuit components which produce voltages in excess of pre-set tolerances are automatically rejected.

Relays have been added in the Tester so that Comparator impedance ranges can be switched automatically by a remote punched-card programmer. Since programs are switched every second, three continuously running oscillators are used as fixed-frequency sources for the Comparator.

The Unit was constructed by Bendix Radio Division under sub-contract for IBM and the United States Air Force.

Why The GR Impedance Comparator Was Selected For Automatic Sorting:

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- ★ Wide impedance range, high measurement accuracy.
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Resistance: 2 ohms to 20 megohms
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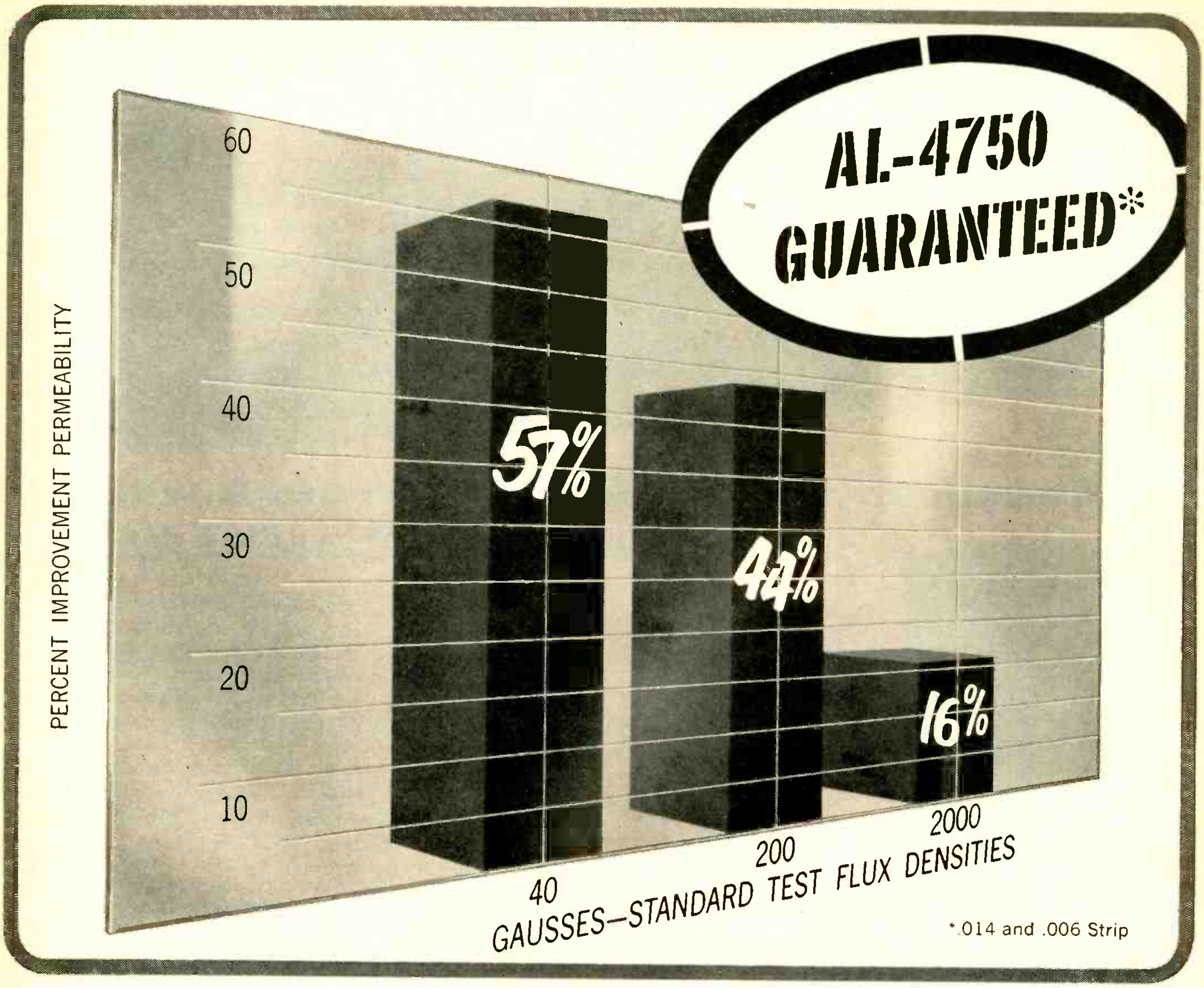

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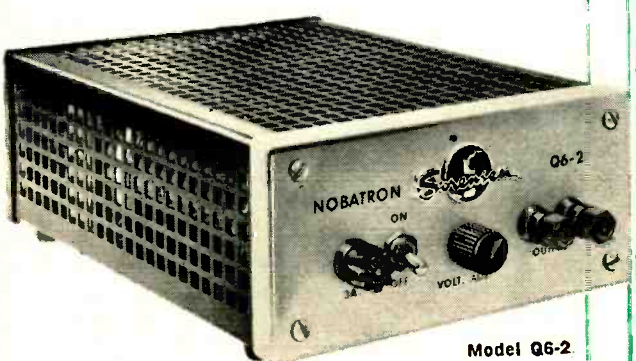
Full information on this important advance in low voltage, high current technology is now in print. Ask your Sorensen representative for full data, or let us mail it to you directly.



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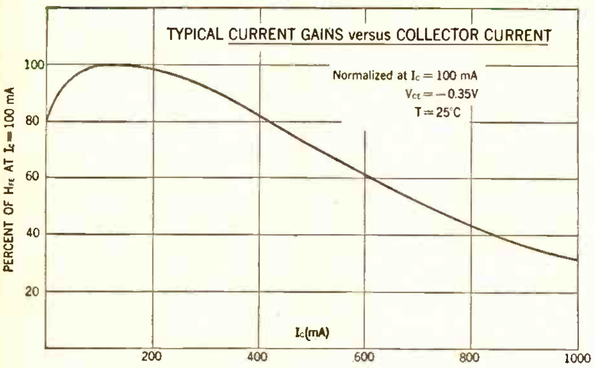

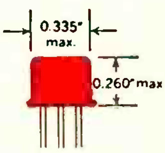

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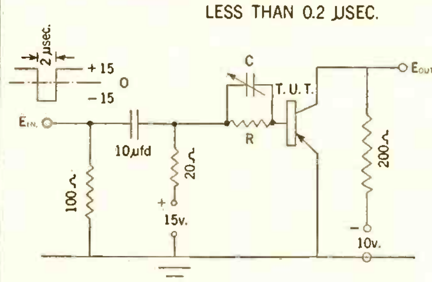
TYPICAL COMPENSATING CAPACITY VALUES FOR STORAGE TIMES LESS THAN 0.2 μSEC.



Type	R kil-ohms	C μμf
2N658	3.9	120
2N659	6.0	100
2N660	9.1	80
2N661	12.5	40
2N662	4.5	110

Type	Punch through Voltage max.	$f_{\alpha b}$ ave. Mc	H_{FE_1} ave. I_B = 1 mA V_{CE} = −0.25v	H_{FE_2} ave. I_B = 10 mA V_{CE} = −0.35v	I_{CO} at −12v μA	r_b' I_C = −1mA ohms	C_{ob} V_{CB} = −6v μμf
2N658	−24	5	50	40	2.5	60	12
2N659	−20	10	70	55	2.5	65	12
2N660	−16	15	90	65	2.5	70	12
2N661	−12	20	120	75	2.5	75	12
2N662	−16	8	30 min.	50	2.5	65	12

Typical values at 25°C unless otherwise indicated

Dissipation Coefficients: In air 0.35°C/mW; Infinite Sink 0.18°C/mW

These new PNP Germanium Computer Transistors made by Raytheon's reliable *fusion-alloy* process add to the already comprehensive line of Raytheon Reliable Computer Transistors which include several in the *Submin* (0.160" high, 0.130" dia.) package. Write for Data Sheets.

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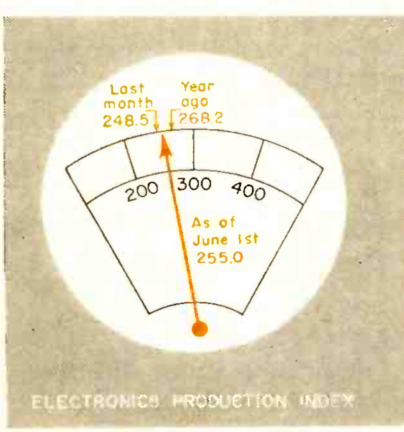
ELECTRONICS NEWSLETTER

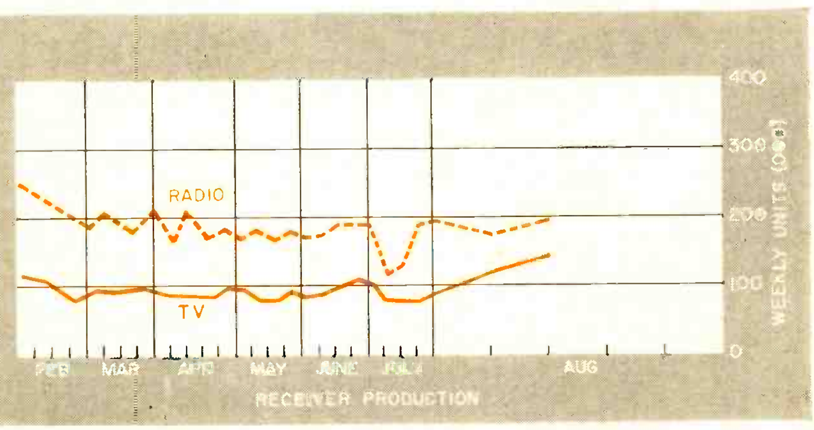
INSTRUMENT-CRAMMED FOURTH-STAGE ROCKET next month may get the chance that it didn't get to prove itself when the Air Force's first lunar shoot failed. Instrument payload of about 40 pounds includes a small infrared scanner, magnetometer, micrometeorite recorder, batteries, and telemetry system. Air Force says subcontractors for the fourth-stage include Hallamore Electronics, Atlantic Research Corp., Pacific Automation Products, Rantec Corp., Reeves Instrument Corp., Summit Industries, Western Electric and RCA.

EXPLORER IV's instrument package, designed to measure intense cosmic radiation that swamped earlier Explorers, has supplied data that permits some preliminary conclusions. State University of Iowa scientists now (1) eliminate theory that the intense rays are X radiation created within the satellite when electrons from the sun bombard the metal skin; (2) report the instrument package is speeding through an invisible shower of electronically charged particles, and that these are probably solar electrons striking the instruments directly, possibly including hydrogen protons or other atomic fragments; (3) disclose that at least 60 percent of these charged particles readily penetrate the $\frac{1}{16}$-inch thickness of lead that shields one Geiger tube; (4) conclude that starting at about 250 miles up, the radiation intensity seems to double with about every 60 miles of altitude. At 1,200 miles above South America, Explorer IV finds an exposure level of about 10 roentgens per hour, or more than 100 times the saturation level of Explorer III's Geiger tube.

SOVIET FIRING OF A LUNAR PROBE seems to be imminent, judging by recent statements of Russian scientists. An article in the official organ of the Soviet Academy of Sciences states: "Just as the launching of the satellites is conducted in accordance with a broad program, so we should similarly expect a series of launchings of lunar rockets." Soviet statements never refer to the timing of such firings, permitting the Russians to keep their failures secret. But, with an eye on the impact of such an achievement, the Academy of Sciences journal declares: "Flights of lunar rockets will testify to the maturity of rocket engineering, its readiness for flights to the nearest planets, Venus and Mars." The article says a moon flight requires rocket velocity of 11.2 km per second, while Venus and Mars would require rocket speeds of 11.5 and 11.6 km per second, respectively.

NEW INFRARED MISSILE DETECTION SYSTEM with a range of more than 1,000 miles is disclosed by Aubrey Jones, Britain's Minister of Supply, during a visit to Australia.





FIGURES OF THE WEEK

RECEIVER PRODUCTION

(Source: EIA)	Aug. 8, '58	Aug. 1, '58	Aug. 9, '57
Television sets, total	114,556	99,929	169,148
Radio sets, total	168,196	153,552	192,877
Auto sets	42,693	38,994	61,299

STOCK PRICE AVERAGES

(Source: Standard & Poor's)	Aug. 13, '58	Aug. 6, '58	Aug. 14, '57
Radio-tv & electronics	52.29	51.03	46.89
Radio broadcasters	65.70	64.17	61.08

FIGURES OF THE YEAR

Totals for first six months

	1958	1957	Percent Change
Receiving tube sales	190,406,000	221,175,000	—13.9
Transistor production	18,452,324	11,199,000	+64.5
Cathode-ray tube sales	3,689,587	4,814,659	—23.4
Television set production	2,167,930	2,722,139	—20.4
Radio set production	4,961,293	7,187,294	—31.0
TV set sales	2,177,652	2,810,403	—22.5
Radio set sales (excl. auto)	2,964,338	3,638,969	—18.5

MORE FIGURES NEXT PAGE

Both *Skate* and *Nautilus* employed celestial altitude recorder (right) in transpolar voyages as . . .

Subs Use Navaho's Guidance

Inertial guidance of extinct subsonic missile navigates *Nautilus* and *Skate* under polar ice

SUBMARINE navigation systems were given a severe test by the recent under-the-ice-pack transpolar cruises made by the nuclear-powered *U.S.S. Nautilus* and the *U.S.S. Skate*. Performance of the equipment, according to *Nautilus* skipper, Cdr. W. R. Anderson, exceeded all expectations.

General Dynamics is prime contractor for both subs.

Inertial guidance system in both *Nautilus* and *Skate* is a modified version of the Autonetics-developed inertial guidance used in the Navaho—North American's now-extinct subsonic guided missile.

Checking the drift in the inertial systems of both *Nautilus* and *Skate* is Sperry's Celestial Altitude Recorder (SCAR), an optical sextant that sights stars through a periscope, feeds the readings to an analog computer which corrects errors caused by ship motion, and then displays both the corrected altitude and time the reading was taken on tape.

Both *Nautilus* and *Skate* are equipped with Sperry's automatic course-keeping (CKC) and depth-keeping controls as well as electromagnetic logs. The CKC enables operator to make ultra-fine adjustments in steering. Magnetic amplifiers used in the CKC will be replaced in the future by transistors, Navy says. Also used were the C-11 Gyrosyn compass system, designed for use in polar regions, and the Mark 19 and Mark 23 gyrocompasses. *Skate* carried Sperry's depth detector.

Special high-definition sonar for close-in forward soundings kept the way clear for safe passage under the ice. Advanced hydrophone arrays provided sonarmen with the directional discrimination they required (ELECTRONICS, p 15, June 27).

Several devices were not ready for the transpolar voyages:

- Precision depth recorder (Naval Ordnance Lab) will go on the next cruise.
- Photoelectric astro tracker (Kollsman) will soon be installed. Evaluation, however, is probably a year away due to the long waiting list of equipment to be tested.

Here is the status of nuclear-submarine equipment (ELECTRONICS, p 28, March 7) still under development, as reported by BuShips:

- Sonar for measuring ground speed (GE and BuShips) has not yet been sufficiently miniaturized for subs.
- Optical tracker and horizon follower—a fine-line tv telescope for looking at the horizon in several directions at once (Farrand Optical) is not yet completed.
- Telescope with improved infrared detectors (Electronics Corp. of America) is not ready.
- Collins radiometric sextant (AN/SRN-4), which will line up radio transmissions coming from the sun or moon, is still too big for subs. A surface craft version is ready for the *U.S.S. Compass Island*.

Magnetics Papers Reveal Trends

LOS ANGELES—PAPERS on nonlinear magnetics and magnetic amplifiers drew the attention of computermen and amplifier spe-

(Continued on p 12)

TRANSISTOR AND TUBE SALES, MONTHLY

(Source: EIA)	June, '58	May, '58	June, '57
Transistors, units	3,558,094	2,999,198	2,245,000
Transistors, value	$8,232,343	$7,250,824	$6,121,000
Receiving tubes, units	36,270,000	36,540,000	35,328,000
Receiving tubes, value	$31,445,000	$31,406,000	$31,314,000
Picture tubes, units	725,846	560,559	1,104,013
Picture tubes, value	$14,203,381	$11,237,147	$19,981,319

EMPLOYMENT AND EARNINGS

(Source: Bur. Labor Statistics)	June, '58	May, '58	June, '57
Prod. workers, comm. equip.	339,300	336,100	394,200
Av. wkly. earnings, comm.	$82.78	$80.96	$79.59
Av. wkly. earnings, radio	$82.21	$79.98	$76.97
Av. wkly. hours, comm.	39.8	39.3	40.4
Av. wkly. hours, radio	40.1	39.4	40.3

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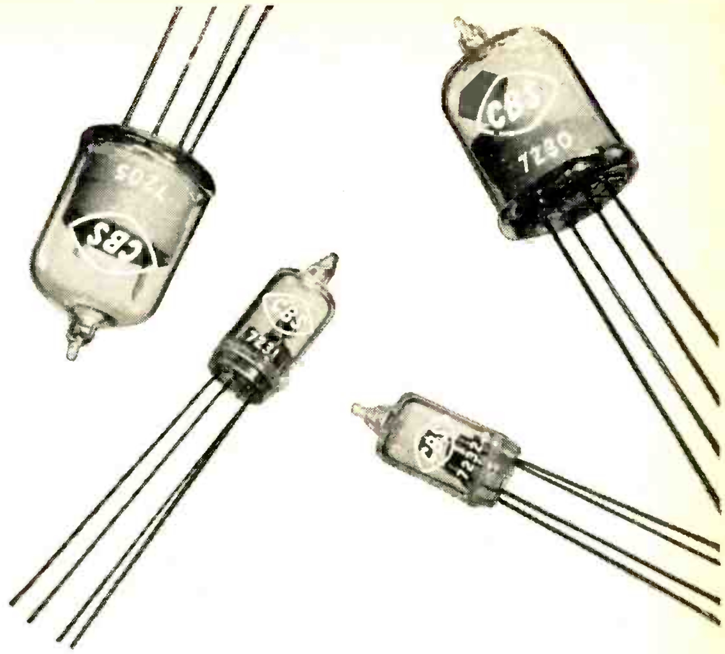
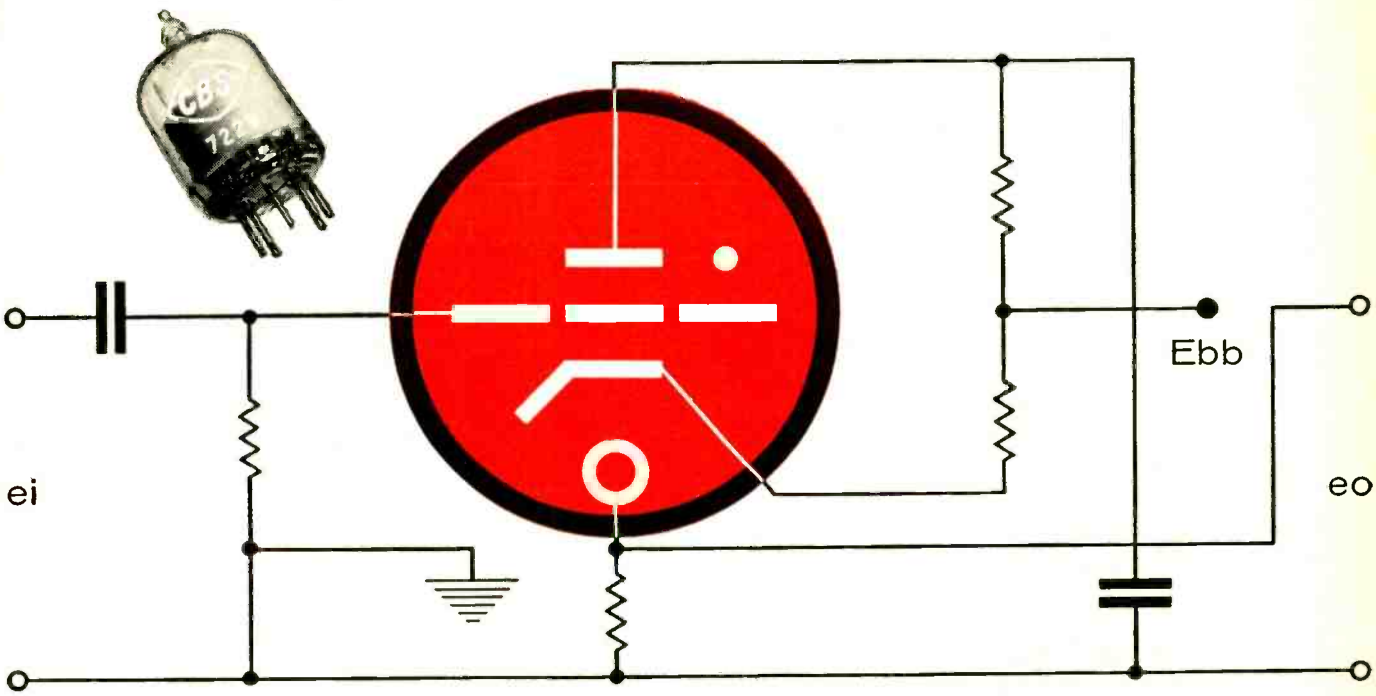
The miniature 7205, 7229 and 7230 and subminiature 7231 and 7232 . . . CBS-Hytron originals . . . introduce a new and growing family of fast-switching krytrons. These cold-cathode trigger tubes are efficient and accurate. They replace relays and thyratrons in simpler circuits for reliable military and industrial equipment. They control up to 500 amperes with input signals of fewer than 20 microamperes. And they are designed to operate under extreme conditions of heat, shock and vibration. You will find these new krytrons useful as electronic relays . . . timers . . . oscillators . . . sensers . . . and pulsers. Check their features and characteristics. Write for CBS-Hytron Bulletin E-287.



KRYTRON... NEW ELECTRONIC SWITCH



FEATURES

1. Rugged and reliable
2. Compact and light
3. Silent and cool
4. Stable inert gas fill
5. Instant-firing keep-alive
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MAJOR CHARACTERISTICS

- High hold-off voltages . . . . 1000, 2000, 3000 volts
- High instantaneous pulse current . . . . 500 amperes
- Low trigger voltage (tp=2μs) . . . . 205 min. volts
- Low driving current . . . . 20 microamperes
- Short anode delay time . . . . 4 microseconds
- Minimum anode delay variation . . . . 0.4 microsecond
- Wide ambient temperature range . . . . −55 to +85°C

Reliable products through Advanced-Engineering

CBS tubes®

CBS-HYTRON, Danvers, Massachusetts
A Division of Columbia Broadcasting System, Inc.

cialists at a special conference here this month.

Registration, which approached 800, was about double the attendance at a similar meeting last year, and the number of exhibitors jumped from 8 to 31.

At least two important technical trends were apparent:

- Magnetic amplifiers are being used successfully under extreme conditions of shock, vibration and temperature. Three technical papers cited dependable operation at temperatures as high as 500 C.
- Use of magnetics in combination with solid state devices looks promising.

Two papers were singled out by the conference for special recognition. The first dealt with a high-speed logic system and reported on recent work with magnetic memories and transfluxers. Second paper told of advances in high efficiency conversion of d-c to a-c in transistor-core combinations. One inverter described supplies 3-phase square-wave power to gyro motors used in missile guidance systems.

Among the items displayed were new automatic magnetic core testing devices, high quality regulated power supplies, airborne magnetic amplifiers, and compact, production model magnetic core memories with extremely fast access and readout.

One display featured cube-oriented steel for magnetic amplification. Core losses, said the exhibitor, are greatly reduced and performance improved. This may make possible the use of laminations for magnetic amplifiers, and also smaller, more efficient transformers.

Reactor Control Is Transistorized

Fully transistored instrumentation system will be used with the nuclear power reactor for the Army's cold weather training station at Fort Greeley, Alaska. It will be Alaska's first A-power plant.

The reactor will be in operation in 1960. The $100,000 power level

WASHINGTON OUTLOOK

Electronics manufacturers should take a close look at the new Reciprocal Trade Agreements Act. Congress extended it for another four years, giving the President authority to cut tariffs by as much as another 20 percent.

But loopholes through which domestic producers may win new trade protection were widened significantly. And an almost overlooked procedural timetable of the infant European Common Market means that the U.S. won't be signing any new tariff-cutting trade pacts before the new law nears expiration again in mid-1962. Thus the tariff-boosting features in the new law will be tested long before its rate-cutting power is used.

Most significant avenue to protection for domestic electronics producers is the so-called national security provision, through which any single individual may now request new imports curbs on any item on grounds of its defense essentiality. The Office of Defense and Civilian Mobilization, which handles these petitions, must now take broad economic impact of specific imports on the domestic economy into account in ruling on an industry's defense essentiality.

Also, Tariff Commission escape clause petitions will be easier to file, and if the Commission approves rate increases, the President may boost duties as much as 50 percent over the old 1934 Smoot-Hawley rates, instead of over the lower 1945 schedules. And Congress now may, by a two-thirds vote, overrule the President if he turns down Commission recommendations for tariff or quota boosts.

Entirely separate from the new trade law, Congress at the same time tightened curbs on low-priced foreign imports in amendments to the 1921 Antidumping Act. The Treasury now has broader leeway in comparing foreign and domestic classes of goods that compete, and is required to set higher punitive duties when an import is found to be selling here at less than "fair value". The Tariff Commission, which must rule that such imports threaten to injure a domestic competitor, may now rule injury is threatened even if its members vote 3 to 3.

The reason no new trade agreements will be signed before 1962 is that it will take the European Common Market that long to set its own external common tariff rates on which such new pacts must be based. This means export-import patterns will remain fairly constant over the next four years, with a slow rise in both predicted.

- **Western nations** have revised their control on exports to Communist countries for the first time in three years. An Allied Coordinating Committee (COCOM) made up of NATO nations plus Japan, minus Iceland, has eased the minimum bans and curbs on strategic exports.

  But U.S. controls will continue stricter than COCOM's. Some new electronic equipment will be added to the embargo list. However, the Commerce Dept. will ease restrictions on many items—particularly those which Russia and her European satellites may now buy more easily from other Western manufacturers—some electrical equipment, metals, machine tools, ships, aircraft, motor vehicles. The U.S. will continue to ban all shipments to Red China, North Korea and North Vietnam.

ONLY KIN TEL DIGITAL VOLTMETERS GIVE YOU ALL THESE ADVANTAGES...

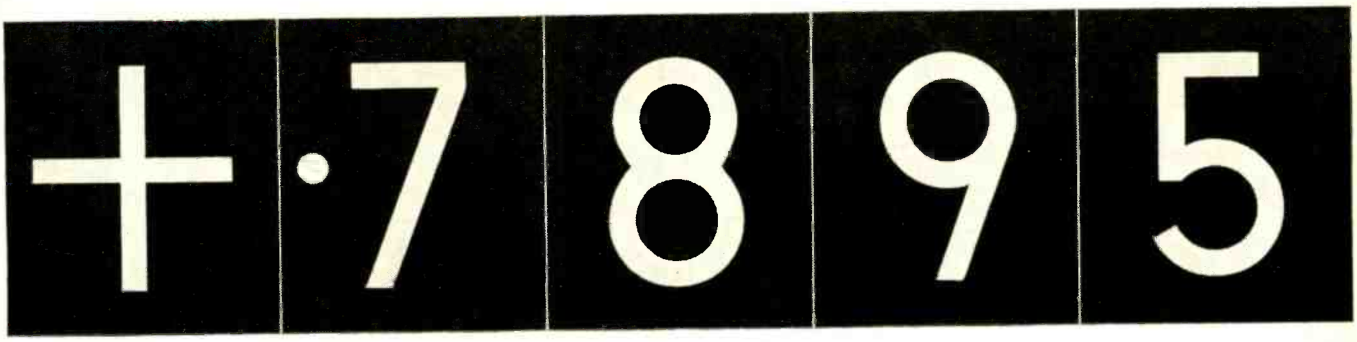
1. SINGLE-PLANE READOUT: KIN TEL digital voltmeters employ a simple projection system to present numbers on a readable single plane...no superimposed outlines of "off" digits...reduced possibility of error. Standard lamps give 7000 to 8000 hours of life, compared with 100 to 200 hours for ordinary readouts.

2. COMPLETE LINE OF ACCESSORIES—SPECIAL SYSTEMS: Versatile "digital building blocks" permit measurement of AC, ohms, ratios of AC and DC, automatic scanning of multiple inputs. Preamplifiers increase digital voltmeter sensitivity to 1 microvolt DC, 10 microvolts AC. Buffers permit driving typewriters, tape punches and printers. KIN TEL's Special Products Department can design and manufacture digital instruments to meet your special requirements . . . complete digital systems for data logging, missile checkout and automatic production line testing.

3. ADVANCED CIRCUIT DESIGN: Transistors employed where they contribute to performance and reliability...relay drive coils energized with DC as in telephone type service to provide long, trouble-free operation...automatic, continuous standard cell calibration. No electronic circuitry in readout allows easy remote mounting. Sensitivity control permits stable reading of noisy signals.

4. MANUFACTURING EXPERIENCE: KIN TEL has manufactured over 10,000 "standard cell accuracy" DC instruments on a true production line basis. Only by this method, by years of repeated manufacturing experience, by an over-all awareness of the accuracies and tolerances involved, is it possible to guarantee consistent accuracy and reliability...to assure real value for every dollar you invest.

5. NATIONWIDE APPLICATION ENGINEERING FACILITIES: KIN TEL has engineering representatives in every major city. An experienced staff of over 200 field engineers is always immediately available to help solve your application problems, provide technical data, or prepare a detailed proposal. Factory level service is available in all areas.



6. DESIDERATE SPECIFICATIONS (MODEL 401 DC DIGITAL VOLTMETER):

Display...Four (4) digit with automatic polarity indication and decimal placement. Total display area 2" high x 7½" long, internally illuminated. Individual digits 1⅛" high.

Automatic Ranges . . . 0.0001 to 999.9 volts covered in four ranges. Sensitivity control provides least digit sensitivities of .1, 1, and 10 mv.

Accuracy...0.01% ±1 digit.

Counting Rate...30 counts per second, providing average balance (reading) time of 1 second, maximum balance time of 3 seconds.

Reference Voltage...Chopper-stabilized supply, referenced to an unsaturated mercury-cadmium standard cell.

Input Impedance...10 megohms, all ranges.

Output . . . Visual display, plus print control. Automatic print impulse when the meter assumes balance. No accessories required to drive parallel input printers.

Input . . . 115 volt, 60 cycle, single phase, approximately 75VA.

Dimensions...Control unit, 5¼" high x 19" wide x 16" deep. Readout display, 3½" high x 19" wide x 9" deep.

Weight...Approximately 40 lb.

Price...$2,100

Write today for descriptive literature or demonstration. 5725 Kearney Villa Road San Diego 11, California

KIN TEL

A Division of Cohu Electronics Inc.

measuring system, being built by GE, will be completed in mid-1959. It will have transistorized amplifiers and readout devices and ion chambers to measure all neutron levels in the reactor.

The primary nuclear system is being built by ALCO Products, which also built the Army's first package power reactor at Fort Belvoir, Va.

Attitude Display For Helicopter

HELICOPTER pilot can now "see" his midair position in relation to the earth's surface by glancing at a display that appears to be on a cloud before the airplane.

The display, mounted on the instrument panel, consists of luminous east-west and north-south grid lines that simulate the earth's surface. If the helicopter pitches up, the entire grid-pattern appears to move down. Same compensating action applies to roll or yaw.

The device works this way: a contact analog generator, supplied by Du Mont, interprets information received from gyroscopes and other flight control instruments, and presents the data as a pattern on the face of a cathode-ray tube (see photo above).

From the tube, these images are directed toward the specially coated, combining reflector in front of the pilot.

Devised for the Army-Navy Helicopter Instrumentation Program, the device was designed and developed by Autonetics division of North American Aviation under subcontract to Bell Helicopter. Firm says the system can be modified for fixed-wing aircraft.

MILITARY ELECTRONICS

• **USAF** is currently firming up a big production contract for the Fairchild Goose (SM-73), diversionary, intercontinental missile. R&D contracts now pass $32 million.

Guidance for Goose is by Fairchild's Guided Missiles Division. Ground support is by American Machine & Foundry.

Objective of Goose is to send out spurious signals that will appear on enemy radar screens as a squadron of heavy bombers. Actual enemy radar signals will be absorbed to a great extent by Goose's plastic frame. Electronic countermeasures system is responsibility of Ramo-Wooldridge.

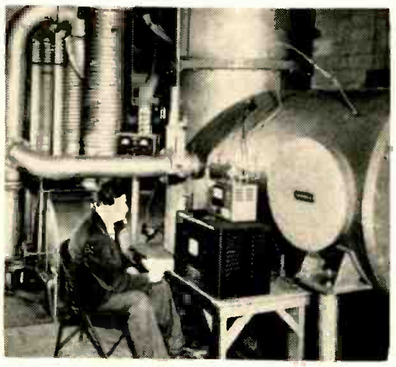
• **Appropriations to CAA** for air navigation facilities amount to $175 million for fiscal year 1959. Program provides for installation of long range radar units for five CAA air route traffic control centers. Radar information from 11 existing or programmed military radar units will be microwaved into CAA air route traffic control centers.

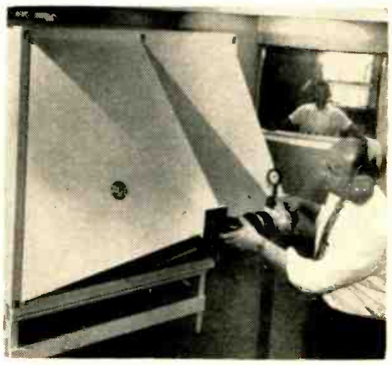
Nineteen airport surveillance radars (ASR) will be installed at CAA airport traffic control towers. Ten control towers will be equipped with airport surface detection equipment (ASDE). Forty-two radar beacons for long range radar units and six for use with surveillance radar will be installed.

Fiscal 1959 program also calls for establishment of instrument landing systems (ILS) at 19 new locations, including a second installation at four locations. Other improvements call for 23 new airport traffic control towers; the relocation of 16 air route traffic control centers; installation of 62 VORTAC short range navigation systems, and the integration of 150 existing VOR (very high frequency omnidirectional radio ranges) with TACAN (tactical air navigation), to make up VORTAC stations. A total of 13 airports will be equipped with terminal type VOR systems.

Seventy-three airports will be equipped with high intensity approach light systems, including six locations which will get a second such system. Seven airports will install sequence flashing lights on their approach light systems.

A simulator for air traffic control analysis costing $3,235,000 will be installed at CAA Technical Development Center, Indianapolis.





New noisemaker (left) and wind tunnel test instruments under flight conditions as . . .

Instruments Get Space Tests

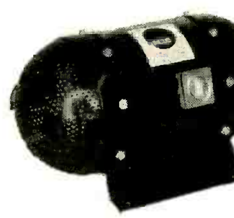
BEHAVIOR of instruments at hypersonic speeds and at altitudes up to 75 miles are being investigated in a specially built wind tunnel at the Lewis Flight Propulsion Laboratory of the National Advisory Committee for Aeronautics.

Experimental designs of air-speed probes, and devices for pressure, temperature, velocity and altitude

Hughes microwave tubes

TOUGH ENOUGH FOR AIRBORNE RADAR

Rugged, compact, light in weight... all Hughes Microwave Tubes have withstood the most severe requirements of airborne radar systems and therefore can be applied in the most taxing of environmental problems.

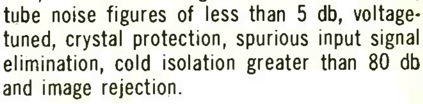


KU BAND BACKWARD WAVE OSCILLATOR

The Hughes Type LOU-2 is a precision built oscillator which tunes over the frequency range of 12.4 to 18.0 kmc. Typical power output over band is 10 to 60 milliwatts. The tube is housed in a self-contained permanent magnetic focusing package so that a separate power supply for a focusing electromagnet is not required.

S-BAND TRAVELING WAVE AMPLIFIER

Periodically focused, the type MAS-1A has a peak power output of one kilowatt over a band of 2-4 kmc at duties up to 0.005. The tube has a gain of 30 to 33 db, giving an excess of one kilowatt over most of the band. When two tubes are operated in cascade, the one kilowatt output can be obtained with a drive on only one milliwatt.



S-BAND BACKWARD WAVE AMPLIFIER

The Hughes type PAS-2 is a narrow-band, voltage-tuned amplifier that is designed for use as an r-f preamplifier stage in contemporary radar communications and other microwave receivers. Features: frequency range 2.4-3.5 kmc, insertion noise figures on order of 4½ db, tube noise figures of less than 5 db, voltage-tuned, crystal protection, spurious input signal elimination, cold isolation greater than 80 db and image rejection.

For additional information please write: Hughes Products, Microwave Tubes, International Airport Station, Los Angeles 45, California. Or contact our local offices in Newark, Chicago and Los Angeles.

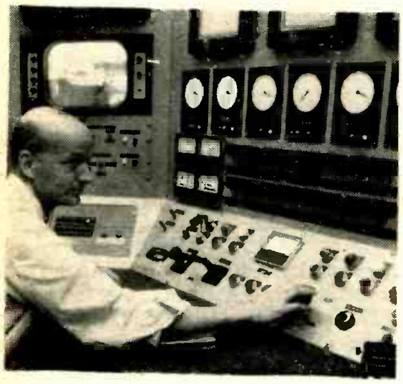
Creating a new world with ELECTRONICS

HUGHES PRODUCTS

determination are placed in the tunnel. Data obtained helps determine instrumentation requirements for hypersonic aircraft, missiles and space vehicles.

Another type of tester for aircraft, missile and rocket ship electronic gear was announced this month by RCA. It is a compressed air loudspeaker capable of generating a 160-decibel noise—equivalent to the total volume of 20,000 tv receivers. Still in development, its job will be to reproduce the buffeting given electronic equipment by high intensity noise.

MIT Reactor Aids Components R&D



Theos J. Thompson, director of MIT Reactor, at control board in basement of building. Two closed-circuit cameras feed pictures from reactor exterior

MORE than $100,000 worth of electronic instrumentation monitored the MIT heavy water research reactor which went critical for the first time recently.

Privately owned and commercially built, it is described as the first heavy water research reactor in the U. S. Electronic instrumentation was installed by Leeds & Northrup.

MIT plans to attach five neutron spectrometers to five reactor ports. They will be used to train students in the new Department of Nuclear Engineering, for materials and magnetism research, and to aid a Lincoln Laboratory project for improvement of electronic computer components.

A group under Clifford G. Shull hopes to obtain valuable data on magnetism, with a view to improving electronic devices.

FINANCIAL ROUNDUP

• **Temco Aircraft**, Dallas, Tex., expects its percentage of electronic equipment and missile sales to increase from its current 17 percent of total sales to 50 percent by 1961. Last year Temco bought an 80 percent interest in **Fenske, Fedrick & Miller** of Los Angeles to diversify its products and to strengthen its position in the competition for missile business. FF&M recently announced it has developed a new visual presentation system that projects radar inputs in 3-D color.

• **Western Union** buys a one-sixth stock interest in **Gray Manufacturing Company** of Hartford, Conn. Some 20,000 shares of WU common, recently traded on NYSE at $23 to $24, will be exchanged for 60,000 shares of Gray. The Hartford firm makes airborne radar equipment, television optical projectors, office dictating machines and telephone switchboards. It reported a loss of $168,357 in 1957 on sales of $8.7 million, and also had a deficit in 1956. WU had previously acquired a 33¼ percent interest in **Microwave Associates**, 25 percent in **Technical Operations**, 25 percent in **Wind Tunnel Instrument** and 14 percent in **Teleprompter Corp.** It also holds an option to buy part of the stock of **Teleprinter Corp.**

• **Electronic Industries**, Phoenix, Ariz., manufacturer of cathode-ray oscilloscopes, plans to issue 100,000 shares of common. Stock will be sold at $2 per share and without underwriting. New money will be used to exercise option to acquire assets of **Photo Chemical Products of California**, and for raw materials and working capital.

• **Small Business Administration** becomes a permanent agency of the government following passage of the Small Business Act by Congress and approval by the President. The dollar limitation on business loans to any one concern has been increased from $250,000 to $350,000. (Limitation applies only to government funds; larger loans can be made when bank is participating). Maximum interest rate on SBA's share of loans has been reduced from 6 to 5½ percent.

MEETINGS AHEAD

Sept. 10-12: Tube Technique, Fourth National Conf., Advisory Group on Electron Tubes, OSD, Western Union Auditorium, N. Y. C.

Sept. 12-13: Communications Conf., IRE, Sheraton Montrose Hotel, Cedar Rapids, Iowa.

Sept. 18-19: National Assoc. of Broadcasters, Fall Conf., Buena Vista Hotel, Biloxi, Miss.

Sept. 22-24: National Symposium on Telemetering, Americana Hotel, Miami Beach, and Patrick Air Force Base (Sept. 25).

Sept. 24-25: Industrial Electronics, 7th Annual Conf., IRE, AIEE, Rackham Memorial, Detroit, Mich.

Sept. 29-Oct. 3: Audio Engineering Society, Tenth Annual Conv., Hotel New Yorker, N. Y. C.

Oct. 1-2: Radio-Interference Reduction, U. S. Army Signal Research & Devel. Labs, IRE, Armour Research Foundation, Chicago, Ill.

Oct. 6-8: Symposium on Extended Range and Space Communications, IRE and George Washington Univ., Lisner Auditorium, Wash., D. C.

Oct. 8-10: IRE Canadian Convention and Exposition, Electronics and Nucleonics, Exhibition Park, Toronto, Canada.

Oct. 13-15: National Electronics Conf., 14th Annual, Hotel Sherman, Chicago.

Oct. 20-21: Aero Communications Symposium, Fourth National, PGCS, Hotel Utica, Utica, New York.

Oct. 20-21: USA National Committee, URSI Fall Meeting, Penn State Univ., University Park, Pa.

Oct. 30-31; Nov. 1: Electron Devices Meeting PGED, IRE, Shoreman Hotel, Wash., D. C.

Nov. 6-7: Prof. Group on Nuclear Science, IRE, Fifth Annual Meeting, Villa Hotel, San Mateo, Calif.

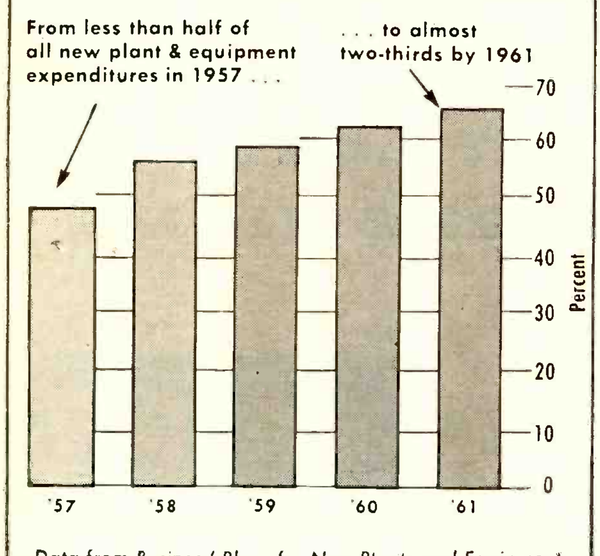
PLAN '59

A MESSAGE TO AMERICAN INDUSTRY

Modernize Now – For Growth and Profits

The biggest challenge facing American industry today is that of thoroughly modernizing its plant and equipment. This is the test period for companies to prepare for success — or failure — in the '60s. Success depends decisively on one key policy — modernization, for growth and profits.

INDUSTRY'S BIG PLANS FOR MODERNIZATION



Data from *Business' Plans for New Plants and Equipment, 1958-1961*, a survey by McGraw-Hill Dept. of Economics

The problem of business recession is fading. Sales and industrial production are moving up again, slowly. Business is swinging back into its normal course. This is growth, not retreat and recession. If the recovery takes us back to the normal growth trend, industrial production will be up 15% to 20% by 1960.

But how can we get this growth in production without the plague of price inflation that has blighted our economy in recent years? And, of fateful consequence for the individual business firm, how can it keep its costs down enough to make a decent profit — something a very large share of American companies are not doing today?

This is the new challenge that confronts business as the recession is left behind.

Nature of the Challenge

The recent record on costs and productivity is not reassuring. Since 1947 wages in manufacturing have risen 68%, while output per manhour has gone up 32%. This is a dismal record for a nation that has prided itself on gains in industrial efficiency. Clearly, if we are to avoid continuing inflation, labor must key its wage demands more closely to productivity increases. But clearly, also, we must do far better in raising output per manhour. Otherwise, industry cannot hope to offer stable prices, and still make a profit.

What, then, is the answer? It is modernization of plant and equipment, the replacement of obsolete producing facilities with new and more efficient machinery and buildings. Only in this way can industry hope to increase production, hold down costs and make a good profit showing in the years of growth that lie ahead.

Industry's Answer

The chart on the preceding page shows how American industry is buckling down to the task of modernizing its facilities over the next four years. It is planning to replace old equipment with new machines that will raise output per worker not just 2% or 3% a year, but more like the 5% annual gain in productivity that this nation achieved in the years following World War I.

Since World War II we have had to contend with shortages of capacity and materials that have held back the job of raising productivity. But today the machines and techniques are available. And industry is getting set.

A broad sample of manufacturing companies surveyed by the McGraw-Hill Department of Economics earlier this year reported these plans: **In 1958, expenditures for modernization will rise to 56% of total investment in new facilities — compared to 48% in 1957. And this emphasis will increase until by 1961, expenditures for replacement and modernization account for two-thirds of all capital spending by manufacturing companies.** In dollar terms, manufacturers will spend more on modernization in each of the four years 1958-61 than in any previous year except 1957.

Can It Be Done?

These are big plans. Can they be carried out? Is it too visionary to hope that after a decade of expansion, industry can now find the outlets for huge amounts of capital investment in the area of modernization? The answers are important to business and the nation, because on this new wave of modernization depends our hope of holding down costs and prices, and also the prosperity of the vital capital goods industries — generators of boom and bust in our economy.

To ensure that industry gets the answers, McGraw-Hill's 34 business publications are now starting a coordinated effort — the largest editorial effort in the history of our company — to find, report and publish the opportunities for modernization at a profit, in the fields we serve. These special reports will begin in late September and will run through November, with appropriate coverage for the specific needs of each field. We are proud to share with industry the responsibility for making sure that no opportunity is overlooked in the drive to modernize now for growth and profits.

This message was prepared by the McGraw-Hill Department of Economics as the first step in our company-wide effort to report on opportunities for modernization in industry. The Department is also preparing a longer report, on modernization as a national problem, for publication in October.

Permission is freely extended to newspapers, groups or individuals to quote or reprint all parts of the present text.

Donald C McGraw
PRESIDENT

McGRAW-HILL PUBLISHING COMPANY, INC.

Eimac Ceramic Tetrodes are the Best Approach to the Advantages of SSB

The growing demand on available spectrum space makes single sideband operation increasingly attractive in aeronautical communications. SSB operation allows the same amount of intelligence to be transmitted in one-half the bandwidth required for conventional AM transmission. Longer range is possible with greater signal-to-noise ratio and reduction of interference from other signals. Reliable communication with lower average power in the final rf stage results in substantial reduction in total weight and cost of SSB transmitting equipment.

A modern Class AB_1 linear amplifier is the ideal way to raise an SSB signal to the desired power level with stability and no distortion. Zero grid drive requirement minimizes driver stage design problems and eliminates distortion from this source. The 4CX250B, 4CX300A, and 4CX1000A shown above are especially well-suited for airborne use in Class AB_1 operation. The 4CX5000A is ideal for high power ground station use. These tubes offer the high power gain, low distortion, and stability needed for Class AB_1 operation. And, each has performance-proved reserve ability to handle the high peak powers encountered.

Eimac ceramic design gives these tubes the compactness, ruggedness, and high reliability demanded in exacting aeronautical applications.

Write our Application Engineering Department for a copy of the technical bulletin "Single Sideband".

EITEL-McCULLOUGH, INC.
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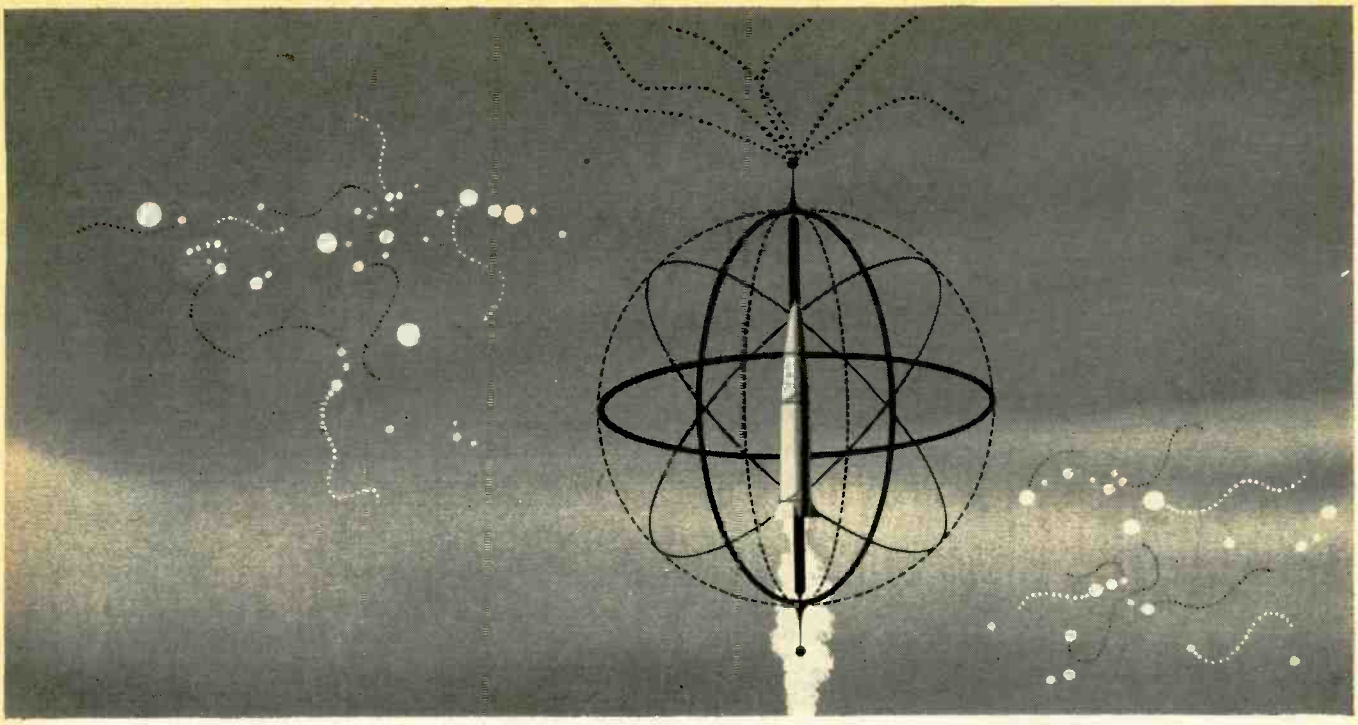
Eimac First with ceramic tubes that can take it

Eimac®

CLASS AB_1 SSB OPERATION

	4CX250B	4CX300A	4CX1000A	4CX5000A
Plate voltage	2000 v	2500 v	3000 v	7500 v
Driving Power	0 w	0 w	0 w	0 w
Peak Envelope Power	325 w	400 w	1680 w	11,000 w



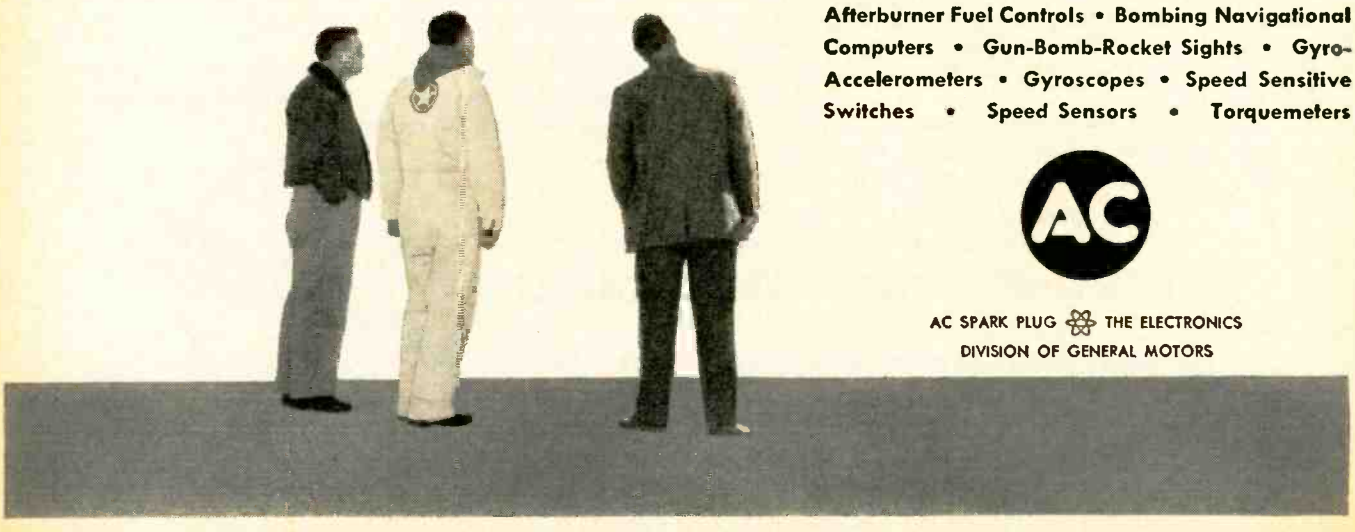
AIMING FOR THE STARS!

You'll be able to aim missiles at the stars . . . and hit your target . . . with AC's incredibly accurate Inertial Guidance Systems. And we're aiming for top-flight engineers to do the job . . . men who want to see their stars rise in the exciting electronics firmament.

This is opportunity. For at AC you can exploit your full talents on guidance systems . . . or any one of a dozen other fascinating and complex electro-mechanical, optical or infra-red devices that are now in the research and development stage or in production.

There's a bright and secure future for you with AC . . . and General Motors. You can grow with one of the most rapidly expanding industries, within an organization long known for its sound policies and enlightened interest in potential leaders.

If you are a graduate engineer or physicist with three to ten years technical experience in micro-wave techniques, electronics, the electrical or mechanical fields, or in gyroscope design, you should talk with the people at AC. Just write the Supervisor of Technical Employment: Mr. C. E. Sundeen, Dept. A, 1925 E. Kenilworth, Milwaukee 1, Wisconsin; or Mr. M. Levett, Dept. A, 1300 N. Dort Highway, Flint, Michigan.



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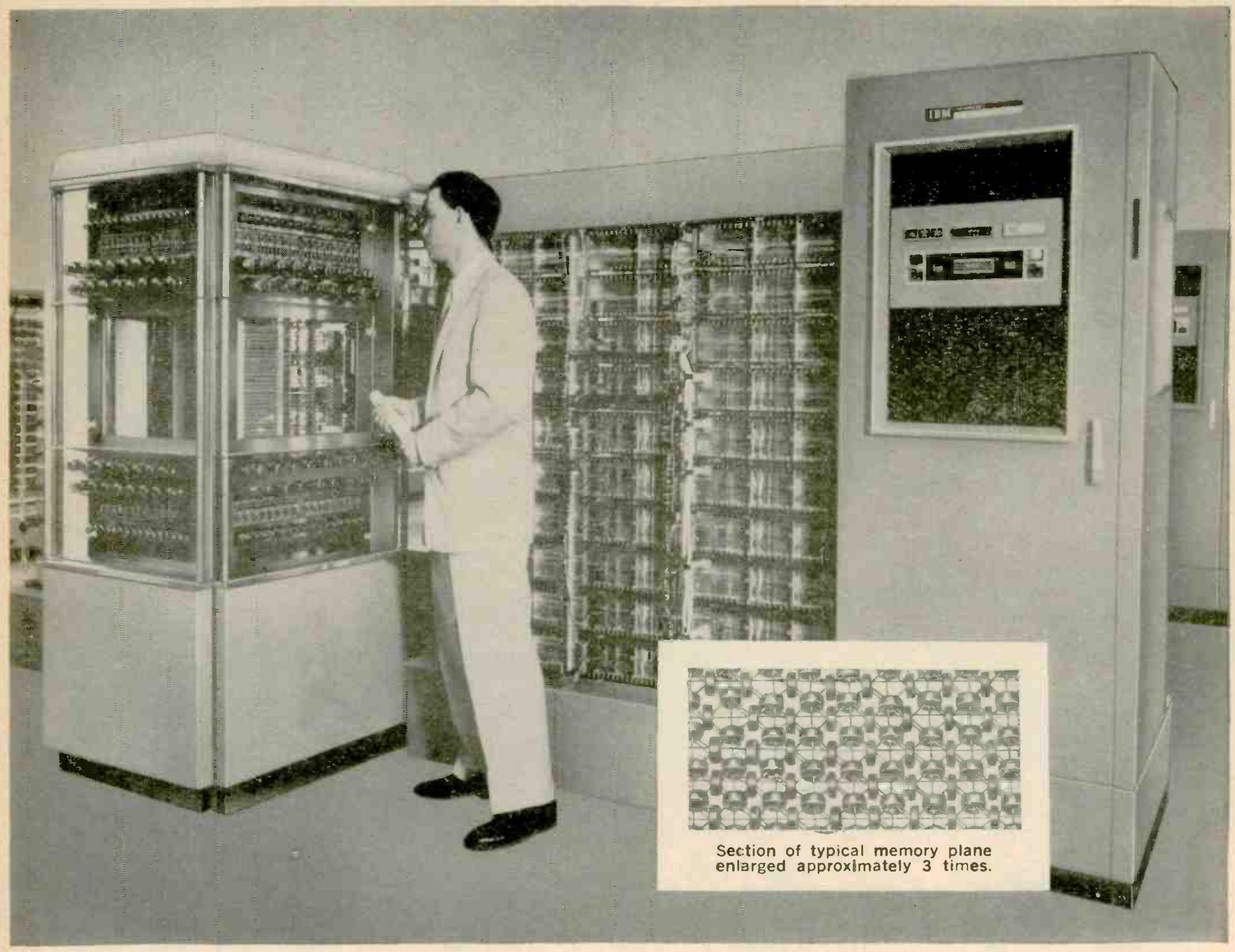
AC SPARK PLUG THE ELECTRONICS DIVISION OF GENERAL MOTORS

CIRCLE 16 READERS SERVICE CARD→

Another Application for FERRAMICS®



Section of typical memory plane enlarged approximately 3 times.

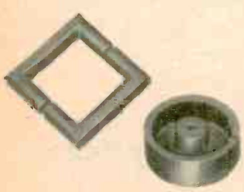
Ferramic® Cores help IBM Sage Computer Perform Amazing Feats of Memory

General Ceramics Magnetic Memory Cores play an important role in the reliable functioning of the Sage Computer. G-C engineers developed rectangular hysteresis loop ferrites and worked closely with Lincoln Laboratories at MIT and IBM to perfect toroids with the required magnetic properties for this vital defense system.

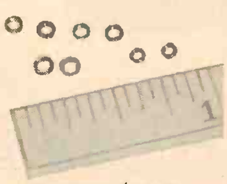
These dependable components provide increased speed and accuracy for computers and automatic controls. General Ceramics cores and completely assembled memory planes are available for automation systems. For complete information write today to General Ceramics Corporation, Keasbey, New Jersey—Dept. E.

GENERAL CERAMICS

Industrial Ceramics for Industrial Progress... Since 1906

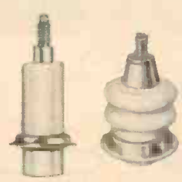


FERRAMIC CORES



MAGNETIC MEMORY CORES AND PLANES

PRECISION STEATITES



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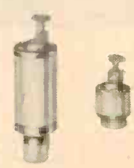

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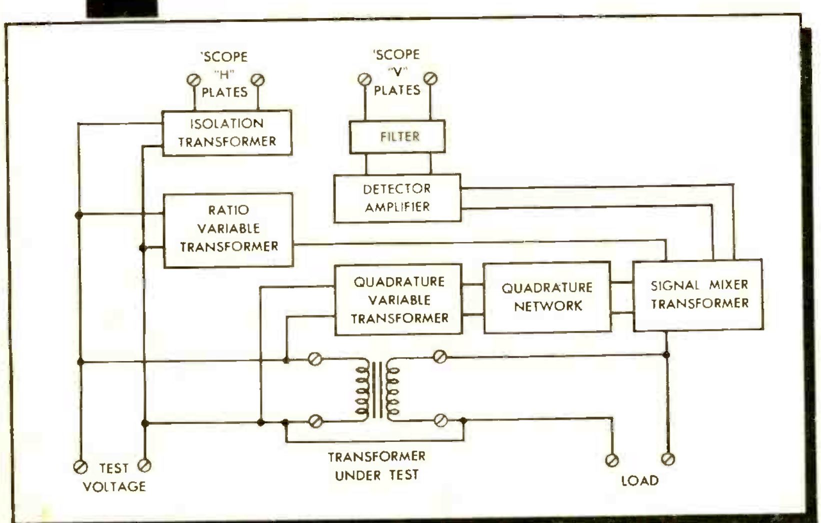

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electronics
engineering issue
AUGUST 29, 1958

Electronic photoflash units for amateurs and professionals use transistorized power converters to increase efficiency and decrease size and weight for portability

Transistor Photoflash Power Converters

More and more electronic photoflash units are using d-c/d-c transistor power converters. Transistor supplies are small, light, draw little idling current between charging cycles and contain no moving parts. New circuit designs described can also be used for other applications where d-c/d-c or d-c/a-c power or voltage conversion is required

By HAIG A. MANOOGIAN, Associate Editor

USE OF TRANSISTORS as switching elements in high-voltage power supplies permits higher operating frequencies. The resultant smaller transformers allow a considerable reduction in the supplies' size and weight. Within the last few months, many electronic photoflash unit manufacturers have incorporated transistorized d-c power converters in their equipment to make use of these advantages.

This article presents typical design approaches used for photoflash equipment. The new techniques, however, are just as useful for d-c/d-c converters for other applications.

All the circuits covered operate on the same basic principle of converting the battery or other low d-c source voltage into an alternating current and then using standard techniques for voltage step-up, rectification and power storage.

Figures 1 and 2 illustrate two symmetrical multivibrator oscillator circuits. The two power transistors alternately switch from cut-off to a saturated state of conduction, in turn alternately switching the battery voltage across windings N_1 and N_2. The number of turns on feedback windings N_3 and N_4 determines the magnitude of the positive feedback signals and cutoff potentials applied to the transistor bases.

In both circuits, bias networks are used for initial starting of

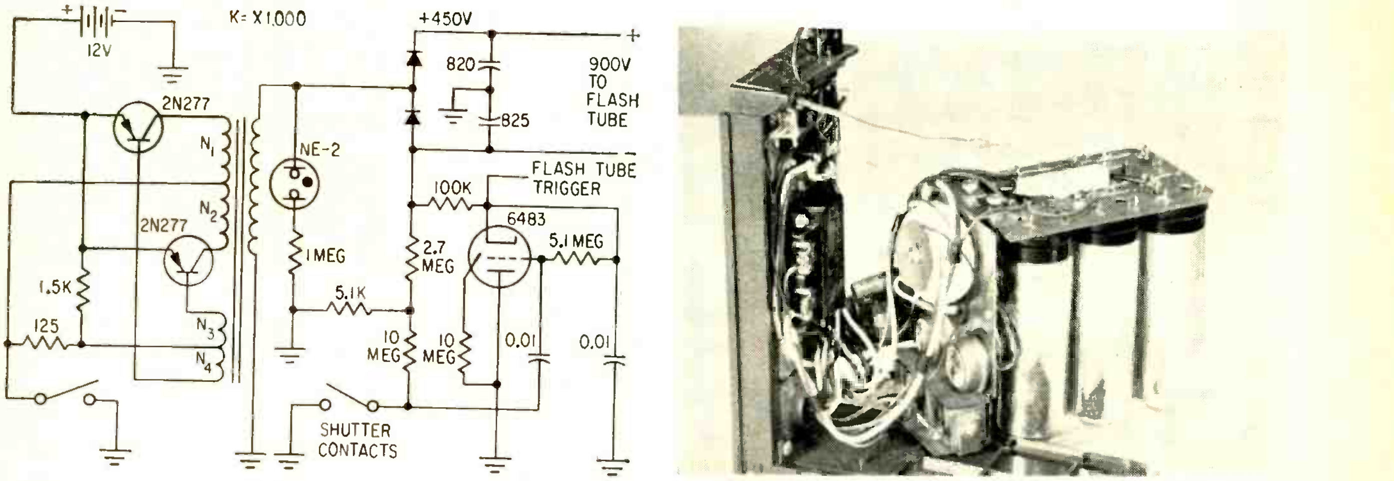


FIG. 1—Power unit by American Speedlight Ascorlight uses symmetrical inverter circuit. Thyratron trigger tube limits shutter contact current to less than 100 μa. Heat sink (photo) for two power transistors is provided by mounting them on aluminum chassis

oscillation under normal variations of battery voltage, load and temperature; the transistor bases are made sufficiently negative with respect to their emitters so that at the instant of switching on, the collector current of one transistor will be large enough for the loop gain to be greater than unity.

200 Watt-Sec Unit

The circuit of Fig. 1 is used in a photoflash unit designed for professional use. The converter charges the 200 watt-second storage capacitors to 90 percent of full charge in 7 or 8 seconds; peak current drain from the nickel-cadmium battery during charging is only 5 amp, while the idling current is only 350 ma.

Operating at approximately 1,500 cps, the oscillator uses a toroidal saturable-core transformer. The square-loop core material provides ideal square-wave switching for high circuit and transistor efficiency; in addition, transistor failure due to spikes is minimized. The collector-to-collector and base-to-base voltage waveforms are shown in Fig. 2.

To minimize high-voltage to ground insulation problems, the 900-v full-wave voltage-doubling circuit has its center grounded, making the maximum voltage above or below ground only 450 v.

The circuit of Fig. 3 charges the 30 watt-second capacitor to 300 v

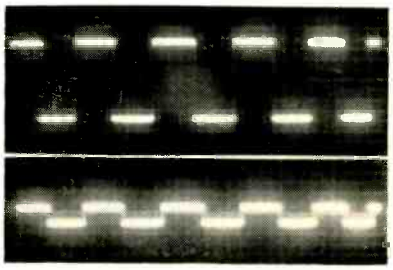


FIG. 2—Collector-to-collector (top) and base-to-base (bottom) voltage waveforms for circuit of Fig. 1

in 8 to 12 seconds through a series-line voltage doubler. Battery current drain is approximately 750 ma peak and 150 ma during idling. Since the transistors are rated at 2 or 3 amp collector current, these low values of operating current permit the transistors to be mounted off the chassis with insulating washers.

The circuit comprising R_1, R_2 and C_1 has a broadly tuned time constant that approximates the converter's period. This circuit reduces the idling current substantially over that which would be obtained without C_1, yet it permits the converter to draw the heavier current required to charge the energy storage capacitor in the minimum length of time (patent pending).

Transistor Rectifiers

Another unusual feature of the circuit of Fig. 3 is the use of the transistor collector-base junctions in a full-wave rectifier circuit to charge the nickel-cadmium battery from the stepped-down a-c voltage across N_1 and N_2 (patent pending). The charging current is limited to an approximately constant value of 35 to 40 ma by the 27-ohm resistor connected in series with the battery.

The converter operates as a 120-

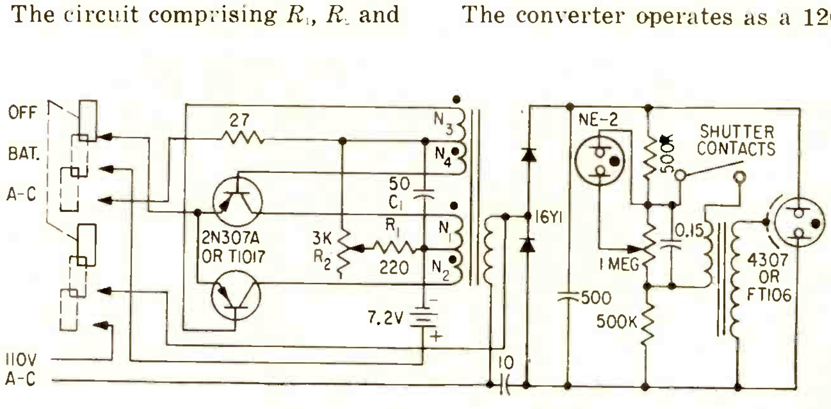


FIG. 3—Inverter transistors are used as rectifiers when charging integral nickel-cadmium cells in Romal Electric's Vanguard supply

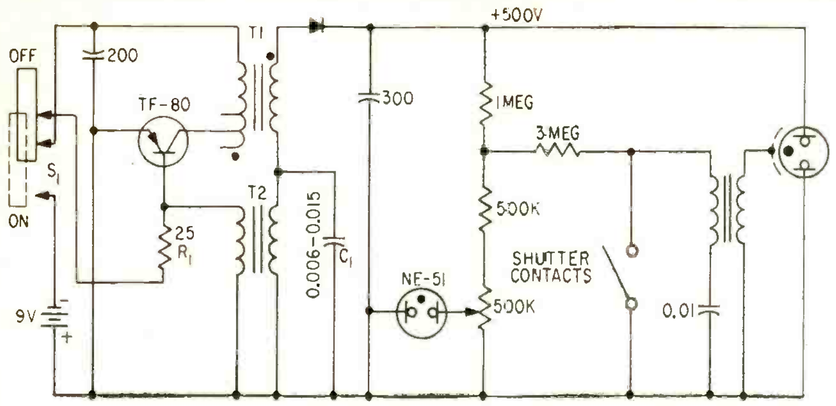


FIG. 4—Single power transistor is used in Burleigh Brooks Mecablitz 100 modified blocking-oscillator circuit. Half-wave rectifier requires higher voltage step-up by T_1

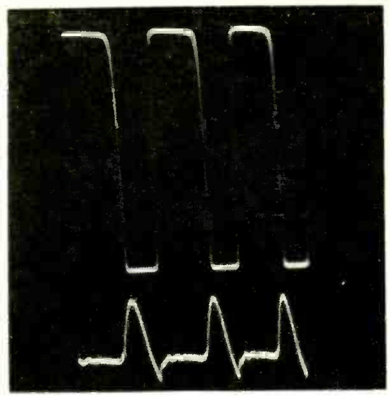


FIG. 5—Collector (top) and emitter (bottom) voltages for circuit of Fig. 4

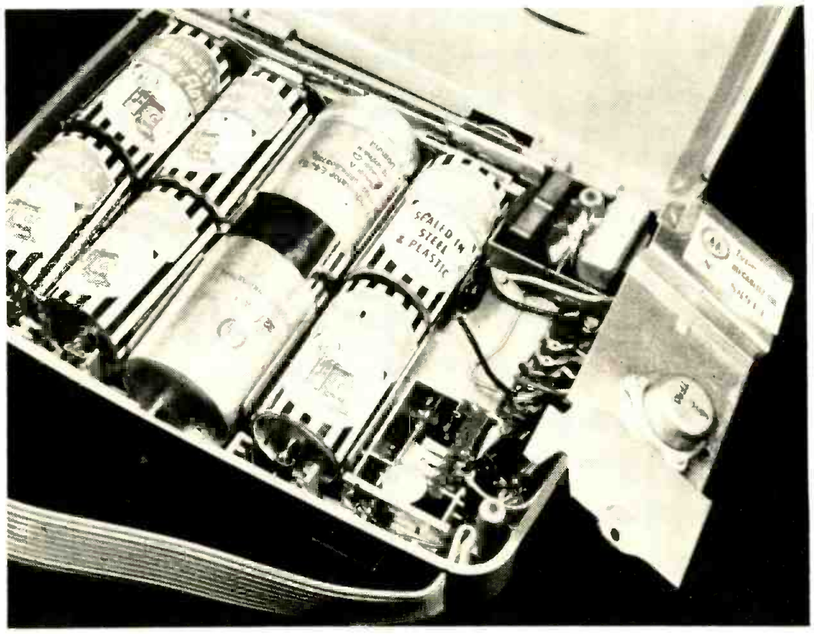
cps square-wave switch so the same transformer may be used for the 60-cps charging voltage. The fully charged battery provides 200 to 300 flashes.

Blocking Oscillator

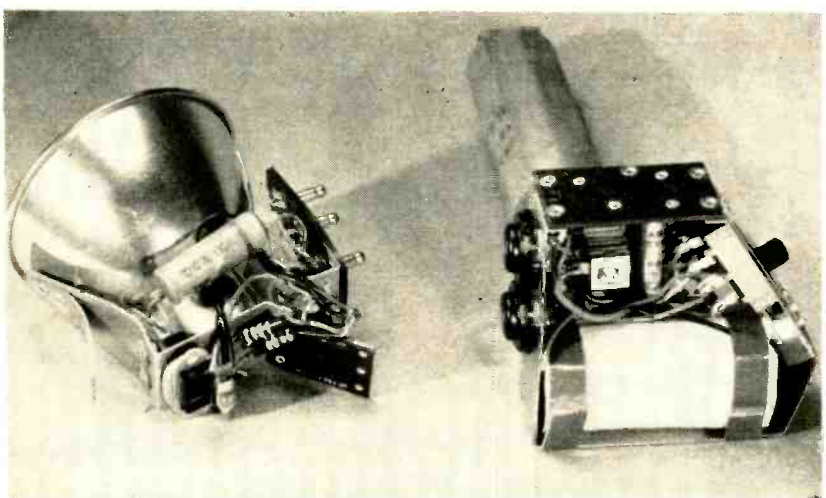
Unlike the previously described converters, the circuit shown in Fig. 4 uses a modified blocking oscillator to obtain square-wave switching at approximately 4,200 cps.

Using only one transistor and a half-wave rectifier, it charges a 300-μf capacitor to 500 v in 5 to 10 seconds from a 9-v dry-cell supply that can deliver as many as 700 flashes.

The circuit is unconventional in that it uses two transformers; T_1 provides power transfer and T_2 provides blocking oscillator operation.



Aluminum plate provides heat sink for Mecablitz's power transistor; 4,200-cps operating frequency permits decreasing transformer sizes to those shown



Flashtube and power supply illustrate off-chassis mounting of Vanguard's two power transistors, heat sink is not necessary because of relatively low current operation

As can be seen from the waveforms of Fig. 5, C_1 acts as a timing capacitor in the ringing circuit formed by C_1 and the secondary of T_2.

To start the oscillator, make-before-break switch S_1 momentarily connects one side of bias resistor R_1 to the negative side of the battery, causing the transistor's base to become sufficiently negative biased with respect to the emitter so that conduction and oscillation will occur.

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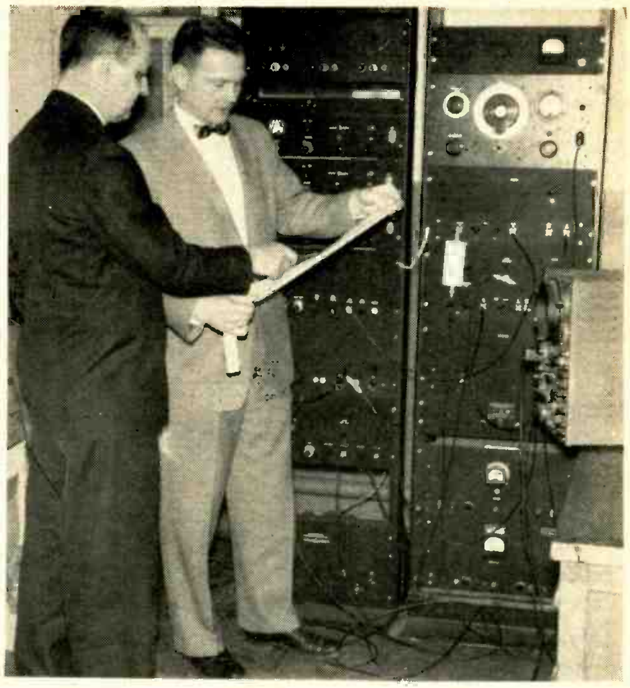

After adjustments are made on transmitting hydrophone, it is allowed to slide down track into the water to the desired depth (left photo). Receiving hydrophones are serviced by skin divers. Rack-mounted equipment (right photo) is the ultrasonic tester

By **WILLIS C. GORE**, Assistant Professor of Electrical Engineering,
The Johns Hopkins University, Baltimore, Md.

Ultrasonics Tests

Changes in propagation time of less than 20 μsec over a direct path up to 300-feet in length are measured by ultrasonic equipment providing a 50-watt test signal. Reflected-path signals are separated from direct-path ones

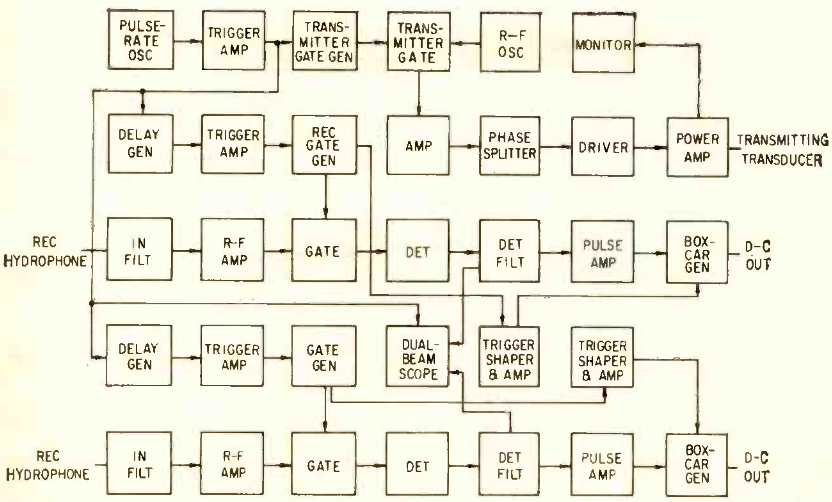

FIG. 1—Block diagram of the complete ultrasonic instrumentation system

ULTRASONIC EQUIPMENT to be described was designed for attenuation and propagation studies in sea water. For its intended use, the equipment had to meet several major requirements. First, a 50-watt test signal had to be furnished to an underwater transmitting transducer. Second, a means for amplifying the output of the receiving transducers for presentation on a recording meter was necessary. Third, the equipment had to be usable over a frequency range from 25 to 150 kc. Finally, the direct-path received signal had to be separated from the reflected-path signal.

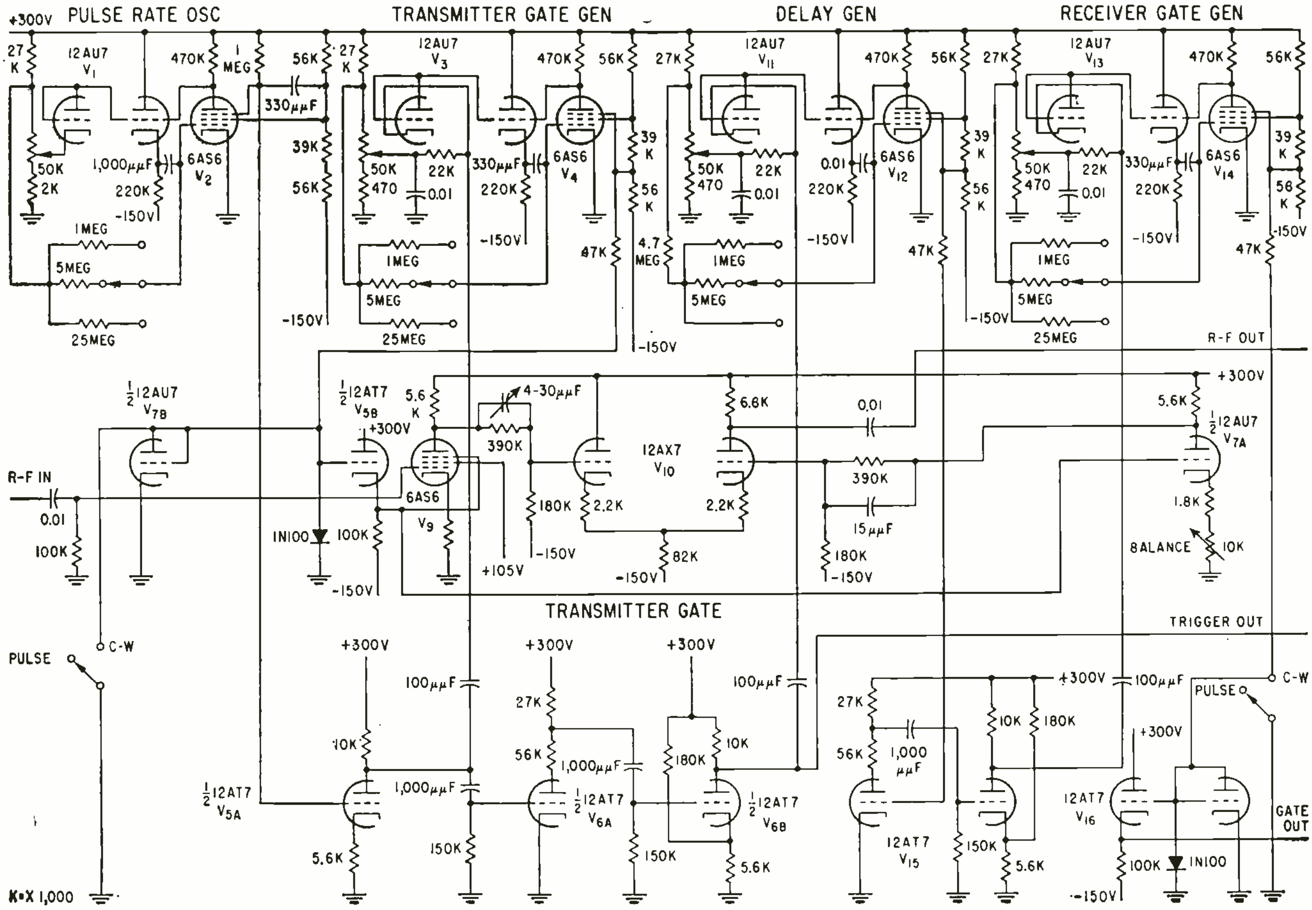

FIG. 2—Trigger and gate generator circuits used in equipment measuring propagation under the sea

Undersea Propagation

To solve the direct-vs-reflected-path problem, the receiver was made sensitive for intervals of time smaller than the time difference between the two paths. This time is variable from 10 to 500 μsec. Delay between transmission of the ultrasonic energy and the time at which the receiver is made sensitive varies from 0.3 to 170 millisec.

Signals as small as 20 μv in amplitude can be detected by the receiver. The operator can record two quantities. The first is received signal amplitude from either one or both receiving transducers. The second is variations in underwater transmission time. For the latter reading, full scale is 200 μsec or approximately a one-foot path-length difference.

Basic timing of the system is established by a trigger and gate generator. Triggering rate is fixed by the pulse-rate oscillator, Fig. 1, which generates pulses with a time interval variable from 0.3 to 170 millisec. Normal operation is at a spacing of 80 millisec, corresponding to 12.5 cps. Trigger pulses are amplified and delivered to circuits which trigger the transmitter, trigger the delay generators for both receivers and synchronize the sweep on a crt for visual presentation of the received pulses.

Gate Generator

First output of the trigger amplifier initiates the transmitter gate generator[1]—V_3, V_4, V_{5B} and V_{7B} of Fig. 2. Function of the transmitter gate generator is to generate a pulse of voltage of variable width, 10 to 5,000 μsec. This pulse is used to turn on the transmitter for a corresponding length of time. Output of the gate generator goes to the transmitter gate—V_9, V_{10} and V_{7A}—which connects the output of the r-f oscillator to the input of the transmitter for the duration of the gate voltage pulse. Input to the gate is one volt of r-f signal and output is also one volt of r-f signal. The gate can be left on continuously.

Output of the transmitter gate goes to V_{1A}, Fig. 3, where it is amplified and to V_{1B}, Fig. 3, where the phase is split to drive a push-pull amplifier, V_2. Output of V_2 drives a push-pull final power amplifier consisting of three tubes (V_3, V_4 and V_5) connected in parallel.

The transmitter can develop a 100-v peak signal across a 100-ohm resistive load for a mean power output of 50 w. The crystal transmitting transducer is resonated and matched at the transducer itself to represent 100 ohms of resistance. A meter enables the operator to monitor transmitter output.

In the transmitter, Fig. 3, P_1 and

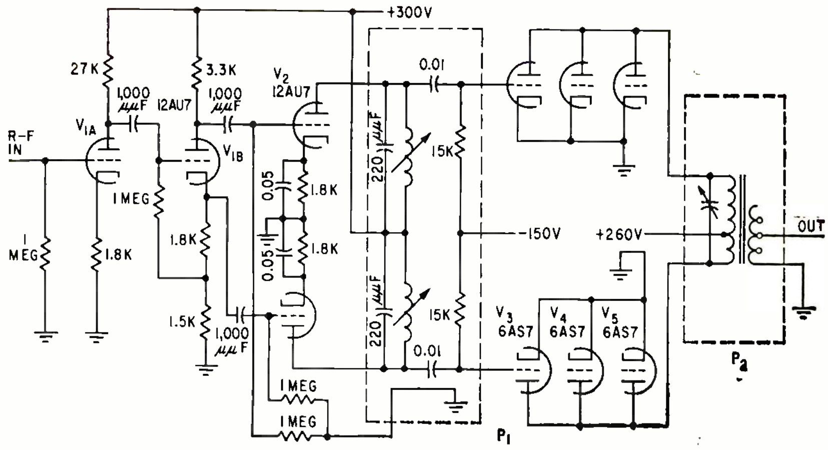

FIG. 3—Schematic diagram of the transmitter

P_2 are plug-in circuits which must be changed as the operating frequency is changed. The 100-kc output transformer was formed by winding an appropriate number of turns on a tv horizontal output transformer core. It matches the 100-ohm transmitting transducer to the output stage.

Receiving Circuits

Output from the receiving transducer is fed through input filters to the input of two receivers. The schematic of the filter is shown in Fig. 4A. The filter is approximately 20-kc wide, allowing a pulse rise time of about five μsec. Rejection at 86 kc was necessary to eliminate interference from a strong, locally generated carrier at that frequency. The filter and the plug-in components in the transmitter are the only components that must be changed in operation over the usable frequency range. Output of the filter is fed to the receiver for amplification and detection.

There are two receivers in the overall system. Both have similar modes of operation so only one will be described. For the first receiver, Fig. 5, the input signal is amplified by V_1, V_2, V_3 and V_4. Amplified output is fed to the receiver gate—V_5, V_6 and V_{7A}. The gate acts like a switch in that an output appears only when a pulse is applied. By this means the receiver is made sensitive only for short intervals of time in the vicinity of the time in which a return is expected. This gate enabling pulse is obtained from the receiver gate generator (V_{13}, V_{14} and V_{16} in Fig. 2). The pulse is adjustable in width from 10 to 5,000 μsec.

The gate generator is triggered by output of the delay generator, V_{11} and V_{12} in Fig. 2, through the trigger amplifier, V_{15}. The delay generator is triggered by the same pulse which starts the transmitter. Delays variable from 0.3 to 170 millisec are obtained from the generator. These delays correspond to separations of about 1.5 to 80 feet between the transmitting and receiving transducers. Output of the gate in the receiver is detected by V_8, Fig. 5, and filtered so that the envelope of the received pulse is available for presentation on an oscilloscope. Filter schematic is shown in Fig. 4B.

Amplitude of the received pulse is recorded in this manner. It is amplified by V_9, Fig. 5, and used to charge a capacitor in the box-car generator, V_{10} and V_{11}, so that the amplitude of the pulse is remembered in the interval between pulses. To record rapid variations in the received signal amplitude, the box-car generator must forget the old amplitude when another pulse is received. This action is accomplished by taking the receiver gate and shaping it into a narrow pulse. The pulse is then amplified by V_{7B} and V_{12} and used to discharge the capacitors in the box-car generator through V_{11} just prior to arrival of the next pulse.

Key Waveforms

Output of the box-car generator is as shown in Fig. 6A. The drop in voltage corresponds to the discharge of the capacitor. It occurs at the time the receiver gate is opened. The rise in voltage corresponds to the reception of a pulse. Note that the width of the most negative-going portions of the waveform is the time between opening of the receiver gate and arrival of the pulse. At the output of the box-car generator, there is a continuous voltage representing the amplitude of each received pulse.

Current available from the output is not enough to drive the pen recorders. Further amplification is accomplished with recorder amplifiers, making the output sufficient

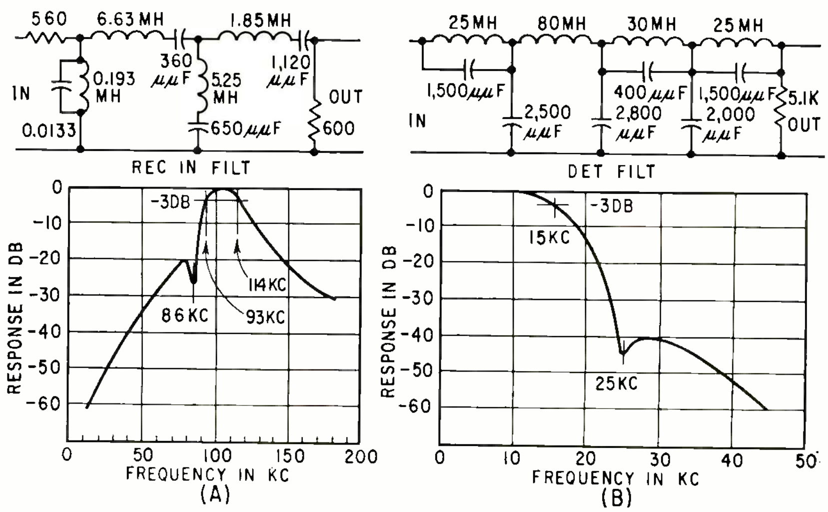

FIG. 4—Receiver input filter design and response (A) and detector filter design and response (B)

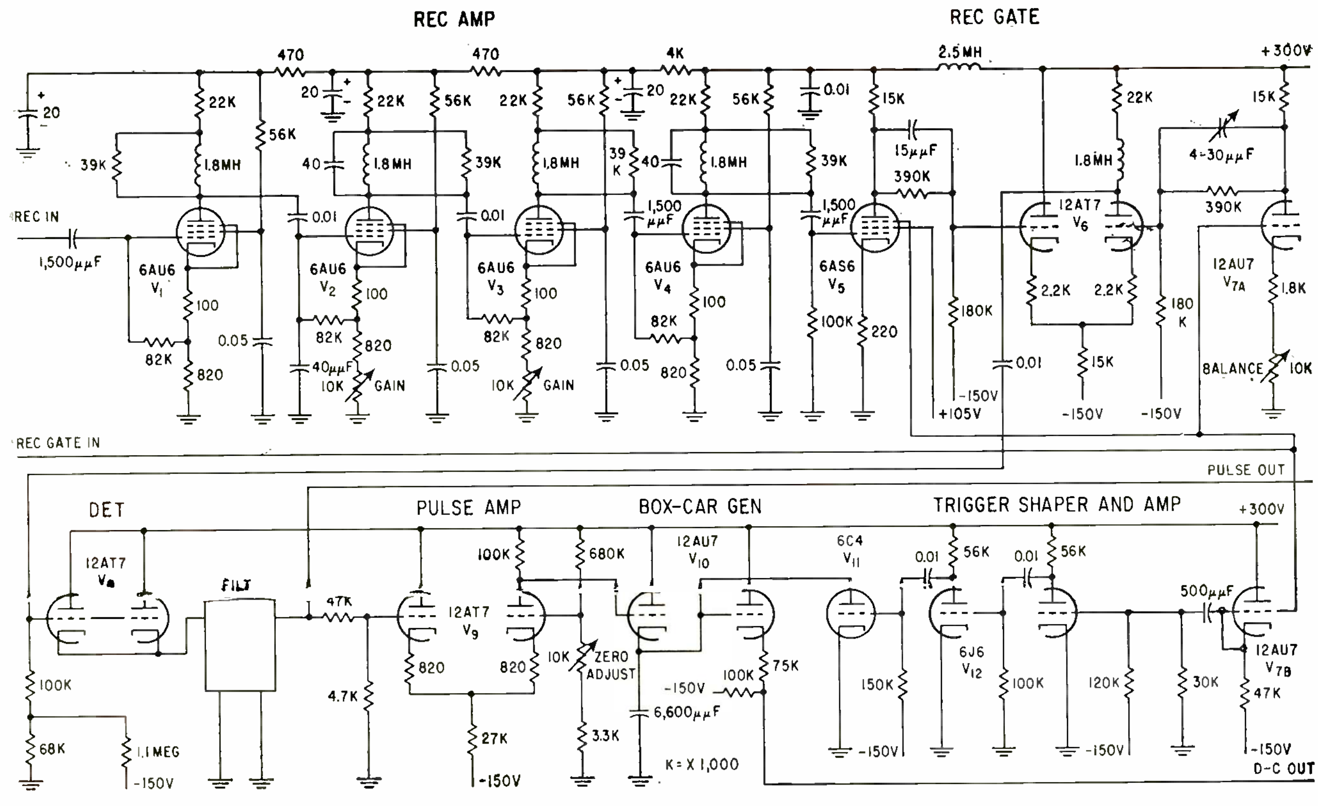

FIG. 5—Complete circuits for one of the receivers. The second receiver is similar in design

to cause full-scale deflection of the recorders.

To measure variations in the time of arrival of the received pulses, output of the box-car generator is shaped, amplified, and limited. Resultant waveform is shown in Fig. 6B. Amplitude of all pulses are the same and their width is the same as the width of the negative pulses in Fig. 6A. They represent the time between the opening of the receiver gate and the arrival of the received signal. The received signal is integrated and amplified into the waveform shown in Fig. 6C. Peak amplitude of the triangular waves is proportional to the width of the pulses in Fig. 6B. This output is sent to another box-car generator, to produce an output as shown in Fig. 6D. This waveform shows the variations in time of arrival of the received pulses. It is suitable for presentation on the recorder.

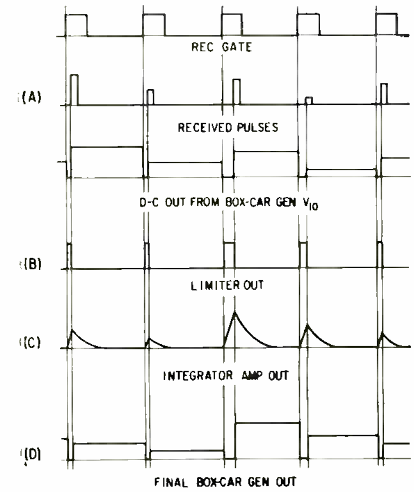

FIG. 6—Key waveforms for the ultrasonic equipment

Waveforms in Fig. 6 have exaggerated time scales. Normally, the times for the gates and pulses are measured in tenths of millisec while time between pulses is measured in tens of millisec.

Direct operating potentials for the equipment were supplied by regulated supplies furnishing +300 v at 250 ma, −150 v at 100 ma and +260 v at 300 ma.

In use, the equipment has yielded significant and consistent results in evaluation of underwater sound propagation.[2] To see if the results obtained were actually caused by variations in propagation time rather than equipment instability, the following experiment was conducted. A signal generator was connected to the input of the first receiver and the receiving hydrophone was disconnected. The receiver was gated and the gated signal appearing at the output of V_6, Fig. 5, was attenuated and used as an artificial signal for the input to the second receiver. Delays of the two receivers were made about equal with the first receiver's delay only slightly longer than that for the second.

With the fixed-signal input, delay stability is better than one part in a thousand or 0.1 percent. Since measured time variations were well in excess of 15 μsec, significance can be attached to these results.

This equipment was developed under contract to Geophysics Branch of the Office of Naval Research.

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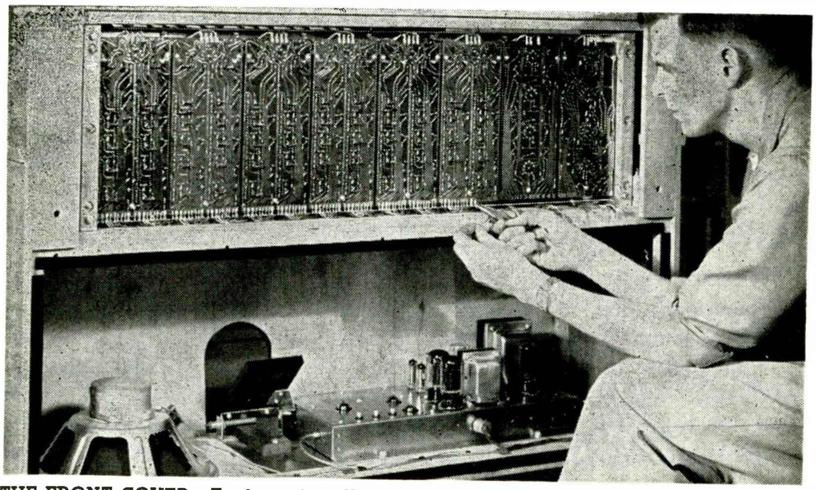
(2) E. R. Pinkston, J. J. Pollak and J. R. Smithson, Sound Fluctuations and Related Oceanographic Parameters in an Estuary, Chesapeake Bay Institute, The Johns Hopkins University, Ref. 57-6, Sept. 1957.

Electronic Organ Uses

Twelve neon tone generators mounted on six printed circuits supply 12 notes of the chromatic scale. Each tone generator has four pairs of neon tubes in series, each pair shunted by two series capacitors. With the signal taken from common point between capacitors, sufficient isolation exists to prevent feedback and spurious tones in output. Formant voicing system is provided in analog form. Switching circuits permit duplexing of voices on either manual

By RICHARD H. DORF Consultant, Kinsman Manufacturing Co., Inc., Laconia, N. H.



THE FRONT COVER—Engineer installs removable printed-circut modules in electronic organ. Modules include tone generators, voicing panel and amplifier

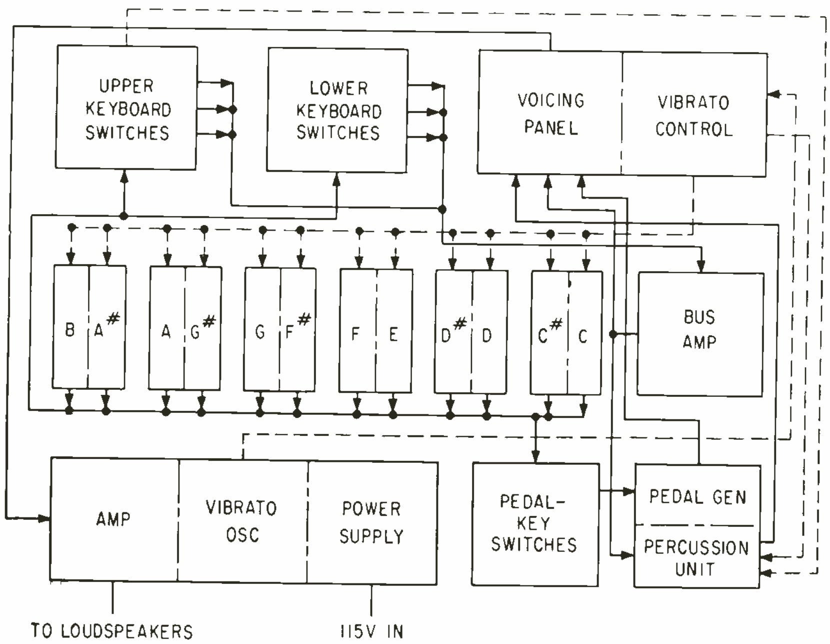


FIG. 1—Each main block in organ block diagram is a removable module with two tone generators on each of six tone modules

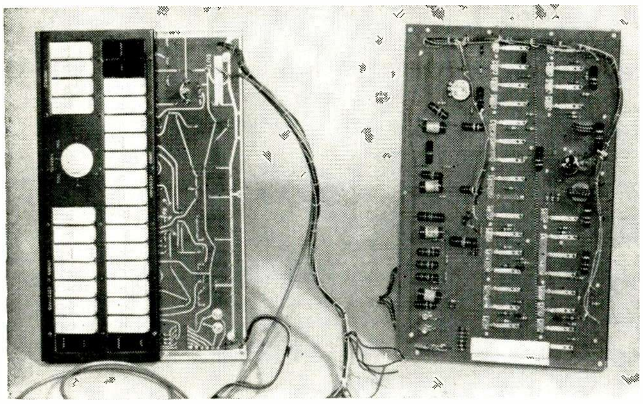
FOR MANY YEARS designers of electronic organs have tried to design instruments with neon-lamp relaxation oscillators as tone sources.[1] Neon lamps are economical and they yield a saw-tooth waveform ideal for a formant tone-coloring system, the type which makes possible many of the most realistic imitations of pipe-organ and orchestral sounds. Neon lamps generate little heat, require little power and are easily adapted to printed circuitry.

Since relaxation oscillators are basically unstable, they must be synchronized. Efforts to develop a suitable neon-lamp tone generator have, therefore, been directed toward devising frequency-divider chains in which a master oscillator synchronizes the highest-frequency neon oscillator and each subsequent neon oscillator synchronizes the next at half its frequency, an octave lower in pitch.

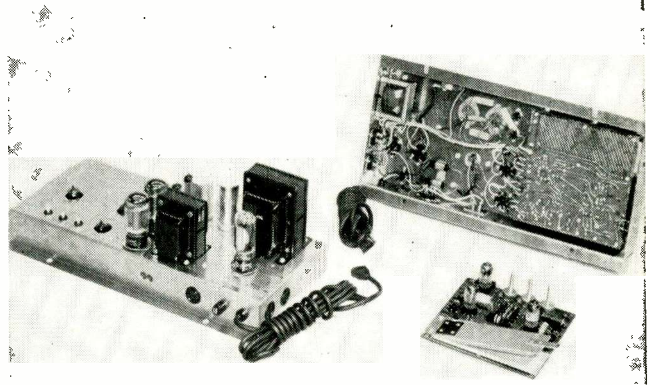
Generators of this type have been commercially impractical because synchronizing methods could not prevent a tone an octave lower fed back from the next divider being heard as part of each output, and could not prevent the inherent instability and large tolerances of the gaseous tubes from overcoming the sync within a short time. Recently, though, a neon-lamp frequency divider has been developed that overcomes these shortcomings and makes possible commercial manufacture of a reliable organ.

The new organ, a spinet-type

Neon Tone Generators



Voicing panel contains all filter components plus stop switches operated by plastic stop tablets shown at left



Printed-circuit section of amplifier (left and right background) contains capacitor plate operated by swell shoe (right foreground)

instrument, is designed to meet all the normal standards of the modern spinet organ. It has two manuals of 44 keys each, 25 stop tablets selecting tone colors and pitch registers for the manuals and a 13-key pedal clavier, with additional controls for vibrato selection, percussive effects and limited individual volume control of the manuals for balancing purposes. A three-unit, two-way speaker system with dividing network is enclosed in the lower half of the console, which is designed as a bass-reflex enclosure.

A block diagram of the organ circuit is shown in Fig. 1. The tone-generator system has six printed-circuit panels, each containing circuits for two of the 12 generator-divider chains necessary for the 12 notes of the chromatic scale. Each chain generates six octavely related notes ranging down in frequency from 3,951 to 65.4 cps, from the high 4-ft B to the low 8-ft C.

Pitch registers in organ terminology are based on the lengths of the longest pipes for each register. In effect, an 8-ft note is produced when the pitch obtained from a given playing key is the same as that obtained from the physically corresponding key on a piano. A 4-ft tone produced by the same key is an octave higher; and a 16-ft tone produced by that key is an octave lower. The range mentioned covers, therefore, the 16th through 87th keys on a piano, or approximately from two octaves below to four octaves above middle C.

General Operation

A wiring harness conducts all the generated tones to the key-switching system that is a part of the playing manuals. Pressing a key causes three contacts to touch three separate buses so that each bus carries all tones of the selection being played, but in three different octave relationships corresponding to the 4-, 8- and 16-ft registers. The buses are connected to a bus amplifier panel containing three dual triodes, one triode section for each bus, plus another dual triode for outphasing even harmonics to produce the symmetrical waveforms required for realistic imitation of certain instrumental tone colors.

From the bus amplifiers all tones go to the voicing panel which is located under the stop or tone-color-control tablets on the left cheek block of the upper manual. Here the tones of selected pitch registers can be switched through filters having spectrum responses similar to the acoustic spectrum responses of the orchestral instruments and pipes to be imitated. After filtering, tones are passed to the main amplifier located on the floor of the console and the speaker system.

The 16-ft pedal tones ranging down to 32.7 cps for low C are provided by a pedal generator consisting of an aperiodic flip-flop circuit. The pedal key switches select one of 12 tones from the lowest-frequency stage of a main generator; this tone is fed to the flip-flop, which divides its input frequency in half and thereby furnishes an extra octave of tone without an extra divider stage on each main

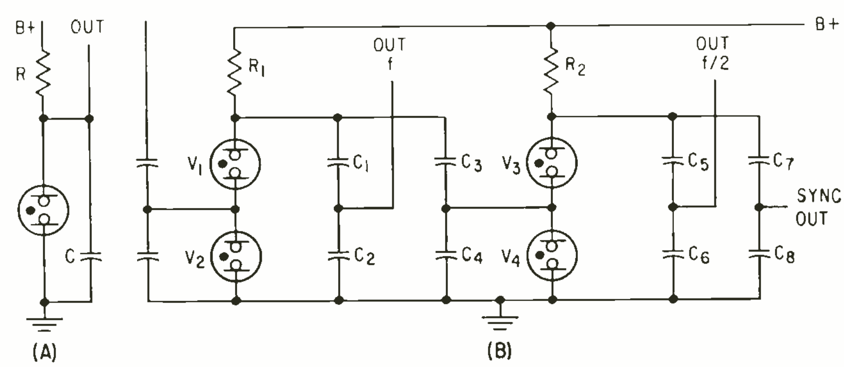


FIG. 2—Standard neon relaxation oscillator (A) is modified (B) so that series lamps have high-impedance point between lamps for sync injection

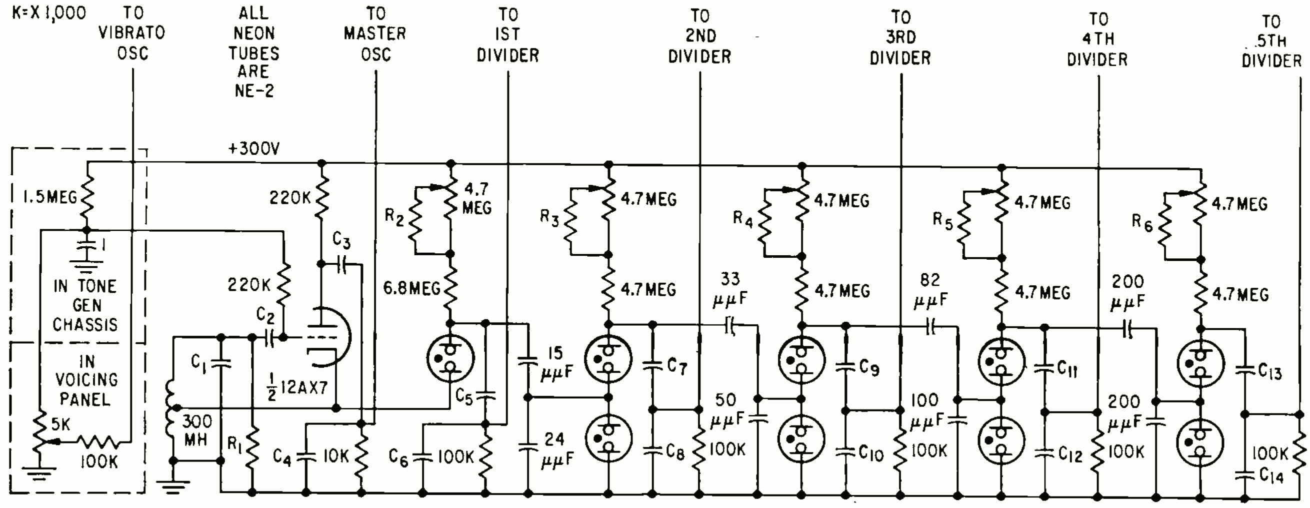


FIG. 3—Complete tone generator for one series of octavely related tones has master oscillator that provides initial sync for neon-lamp divider chain. Resistor R_1 varies from unit to unit and maintains oscillator Q within common range

generator. This one-note-at-a-time system is desirable because in most organ playing only one note at a time is desired, and a lockout system, which is part of the pedal key-switch design, makes it impossible to play two notes simultaneously.

Pedal tones feed filters in the voicing panel and join the manual tones to be amplified and reproduced. Triggering and gating circuits in the percussion unit on the pedal-generator panel simulate the fast attack and slow decay characteristic of percussive instruments. The main amplifier chassis also contains the power supply for the entire organ and a 5- to 8-cps oscillator, selected amounts of whose output are fed to the generator master oscillators to cause the rhythmic variation in frequency which produces the necessary vibrato effect. A knob on the voicing panel provides continuous control of vibrato intensity from zero to maximum.

Tone Generators

While the classic, neon relaxation oscillator shown in Fig. 2A can be synchronized to an externally generated signal, it cannot be done reliably. No single-lamp method rigidly synchronizes through two to three semitones either side of center without distorting the output waveform.

Two frequency-divider stages appear in Fig. 2B. The first neon oscillator syncs the second stage at frequency f. The second stage, like the first, is a modified neon oscillator with series lamps V_3 and V_4 replacing a single lamp, and series timing capacitors C_5 and C_6 replacing a single capacitor. Added components do not alter circuit operation because C_5 and C_6 are a voltage divider with the smaller C_5 acting as the main timing unit. The capacitive divider isolates the output from the oscillator so that loading does not disturb the timing constants.

Firing Voltage

Although the oscillators of Fig. 2A and Fig. 2B operate similarly, the modified circuit needs a higher B+ because the firing voltage of the two series lamps is higher than that of a single lamp. The two lamps provide a point in the circuit whose impedance both to ground and to the timing components is extremely high before firing or during the capacitor charge time.

Capacitors C_3 and C_4 in another voltage divider are 1/100 of the value of timing capacitors C_1 and C_2 and do not load the first stage. Because their junction connects to a high-impedance point between V_3 and V_4, the portion of the output of the first stage at the second-stage junction is approximately proportional to the values of the two capacitors.

The negative flyback pulse of the first stage appears before the charge on C_5 and C_6 is high enough to ionize V_3 and V_4 and is applied to the junction of V_3 and V_4. Hence, the lower electrode of V_3 is suddenly made sufficiently negative to ignite it. Once ignited, a higher

Table I—Capacitor Values for Each Musical Note

Note \ C in μf	C	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}	C_{13}	C_{14}
C, C♯, D, D♯	0.002	0.025	0.1	0.0008	0.008	0.0016	0.016	0.0032	0.032	0.0064	0.064	0.0125	0.125
E, F, F♯, G	0.0016	0.02	0.08	0.00064	0.0064	0.00125	0.0125	0.0025	0.025	0.005	0.05	0.01	0.1
G♯, A; A♯, B	0.00125	0.016	0.064	0.0005	0.0005	0.001	0.01	0.002	0.02	0.004	0.04	0.008	0.08

C in μf \ Note	C	C♯	D	D♯	E	F	F♯	G	G♯	A	A♯	B
C_1	0.02	0.02	0.016	0.016	0.0125	0.0125	0.01	0.01	0.008	0.008	0.0064	0.0064

positive potential appears on the upper electrode of V_4 and that tube ignites. Capacitors C_5 and C_6 quickly discharge and extinguish V_3 and V_4. Capacitors C_5 and C_6 begin recharging to create the rising portion of the second-stage output wave.

Frequency Dividing

The first stage thus triggers the second. Second-stage output frequency can be adjusted to $f/2$ by triggering the oscillator on every other sync pulse. No appreciable amount of $f/2$ generated by the second stage feeds back to the output of the first stage. Despite the small values of C_3 and C_4, a large-amplitude sync signal can be transmitted by them to the high-impedance junction of V_3 and V_4. But any second-stage tone transmitted back to the output of stage one must pass through high-impedance, series voltage divider C_3 and C_1 and low-impedance shunt divider C_2. Actual attenuation of the back-coupled signal is about 60 db.

Capacitor Values

The complete tone generator is shown in Fig. 3 and Table I gives the capacitor values for generators of different notes. With the exception of the tabulated capacitor values and padding resistors R_2 through R_6 and R_1, component values for all 12 generators are the same. Because of wide tolerances in neon-lamp characteristics, the padding resistors must be factory selected for proper timing period. In some generators resistor R_1, is placed across the master-oscillator coil to lower its Q. The Q of all master oscillators must be within a common range so that the injected vibrato signal causes approximately equal frequency changes from unit to unit.

Although the plate of the grounded-plate Hartley master oscillator in the first-stage generator is not really at a-c ground potential, the oscillation theory operates as if it were. The plate-load resistor allows the output to be taken from the plate for the highest-frequency octave of tones in the organ. The plate voltage, which tends to be pulsed, is integrated when passed to ground through selected capacitance and has roughly a saw-tooth shape with a relatively long flyback time.

Only a single neon lamp comprises the first divider, because it is synchronized from the cathode of the master oscillator and feedback of lower tones to the highest output is not possible. The second, third, fourth and fifth divider stages are identical with those in Fig. 2B.

Commercial neon lamps, like other gas tubes do not compare in stability of characteristics with hard tubes. Their firing and extinction voltages may vary with temperature, use and age.

Artificial aging brings the tubes past the initial period of unpredictability and stabilizes firing and extinction voltages within the requirements of the circuit. Expected life, thereafter, may exceed 10,000 hours, during which time the characteristics change slowly but predictably.

Pedal Generator

Generated tones are switched to three output buses for each manual, each bus reproducing the selection played in a different pitch register. The outputs of the lowest generator stages are also connected to transfer-type pedal key switches, which permit only a single tone to pass to the pedal generator.

The pedal generator shown in Fig. 4, to which the selected tone goes, is located on the same printed circuit as the percussion unit. All eight of the main printed-circuit modules are of the same size and shape.

The pedal-generator input from the pedal switches goes through amplifier and shaper V_2 which yields a saw-tooth wave with a steeper flyback than that obtained from a neon oscillator. Because only one tone at a time is handled, no intermodulation results. The output passes at the original frequency to the voicing filters for the 8-ft pedal tones.

The output wave from V_2 feeds bistable multivibrator V_1 which changes state with each input trigger. The bistable output at V_{1A} is half the frequency of the input. Hence, the 16-ft pedal tones are produced without a low-frequency divider stage for each tone generator. The bistable frequency divider is not subject to mistuning; it is merely an economical extension of the main generators and is fully synchronized to them.

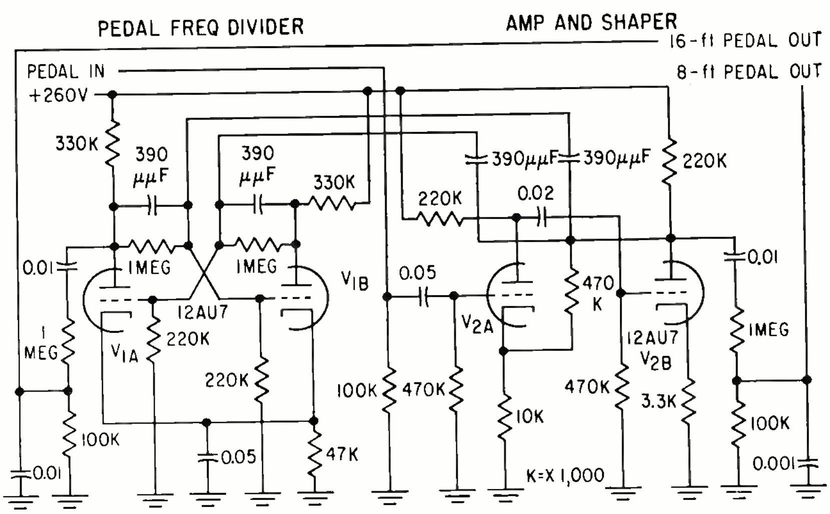


FIG. 4—Pedal generator produces notes an octave lower than main generator with the use of bistable multivibrator V_1

Bus Amplifiers

The tones keyed by the manuals emerge from the six keying buses at low amplitude, because a resistor is in series with each key switch and each bus is terminated in a much lower resistance. Thus, all tones are isolated to prevent robbing, an effect which causes a tone to sound at lower volume than normal if used twice or more—say as an 8-ft tone on both manuals or as an 8-ft tone for one key and a 4-ft tone for the key an octave below, and so on. Isolation also prevents paralleling generator-stage outputs of different frequencies, which might cause errors in synchronization.

The bus terminating resistors appear in the schematic of the bus amplifier panel in Fig. 5. Each of the six bus outputs is amplified by a triode stage to improve signal-to-noise ratio. The negative feedback from plate to grid of each stage yields a fairly low dynamic output impedance and reduces noise and distortion.

Outphasing

Production of outphased tones is an important function of the amplifier panel. Certain instruments and tone colors, characterized by almost total absence of even harmonics, have a distinctive hollow, woody tone. Stopped flute, clarinet and tibia are typical. To produce a wave composed almost entirely of odd harmonics from an original saw-tooth, the saw-tooth of one frequency must be combined with a phase-inverted and amplitude-halved saw-tooth an octave above.[3] The resulting square-shaped signal has a frequency equal to that of the lower of the two combined frequencies.

For an 8-ft outphased tone for the upper manual, the 8-ft upper-manual signal, which is fed to the grid of V_{2A} for amplification as a straight 8-ft tone, is fed to the grid of V_{1B}. Through resistive network R_1 and R_2, the 4-ft upper-manual tone is also fed to the same grid from the plate of V_{1A}, which produces straight 4-ft tones. The resistive network causes the 4-ft phase-inverted tone to reach the grid of V_{1B} at half the amplitude of the 8-ft tone. The plate of V_{1B} then produces an upper-manual 8-ft symmetrical tone. Triode V_{2B} and the upper-manual 16-ft and 8-ft tones similarly produce an outphased 16-ft tone.

Voicing

Organ voicing—production of the variety of tone colors which can be called upon at will—is the most important feature of the instrument. All that has gone before is in preparation for the voicing. Any organ may be expected to produce a certain number of the correct pitches, plus keys and pedals for selecting them; but it is the character and variety of the tone colors that distinguishes a quality organ. In every organ, the generated waveform and the keying system are selected to conform to the voicing method; in this organ, the formant system of voicing is used, and the saw-tooth waveform and the provision of keying to produce different pitch registers is ideal.

The formant system of tone coloration is used in virtually all standard musical instruments and is an outgrowth of perfectly natural factors.

A formant is a point of emphasis of a peak on an instrument's response curve; but as a practical matter it is customary to refer to the entire curve as the formant characteristic of the instrument.

The widely held belief that harmonic structure of a tone determines its timbre is only partly true, and imitation of a natural instrumental or pipe tone cannot be obtained by employing the same harmonic structure for notes of all fundamental frequencies. On the contrary, formant theory shows that in any normal instrument the harmonic structure must change with variation of fundamental input frequency.

Musical Tone Limitation

In the organ described here the same formant system is employed, but in analog form with electrical rather than acoustical signals. The generated waveform is a saw-tooth, as in most instruments, especially reeds and brasses. For imitation of stringed or bowed instruments, the saw-tooth is differentiated to produce the sharp pulses caused by the rough bow hair energizing the strings. For flute-type tones, the saw-tooth is integrated to substantially eliminate most of the harmonics; the purer, or more hooty, woody flute tones are produced by integrating the symmetrical waves obtained by outphasing.

All tones are passed through selector switches into the filters contained on the voicing panel, which is diagrammed in Fig. 6. Nineteen different tone colors or timbers are available ranging from sharp strings and reeds to bland flutes and pipelike diapasons. The filters are partially interlocked; some produce several stops of the same tone color but in a different pitch register, and parts of some filters in conjunction with parts of

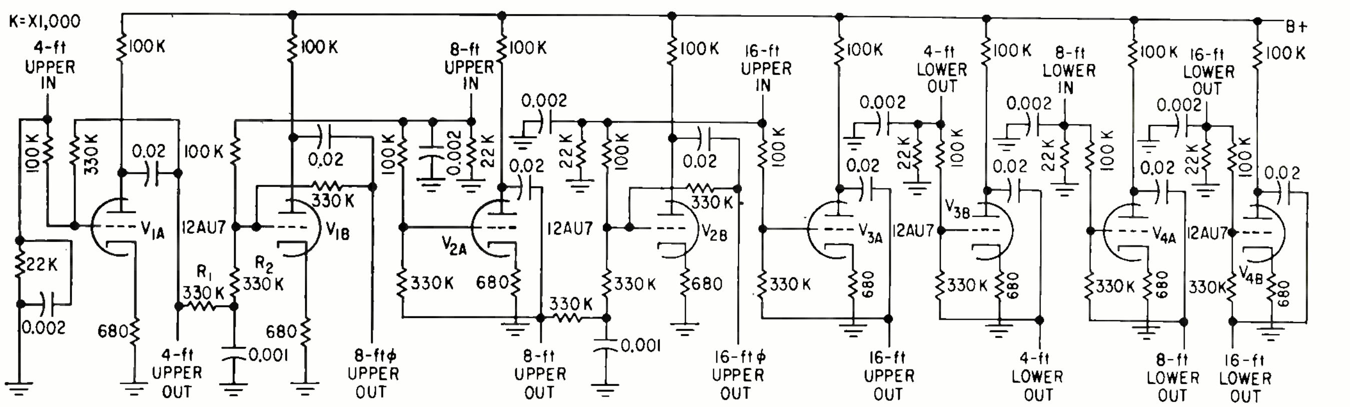


FIG. 5—Bus amplifiers located between keying-system outputs and formant filters provide outphased signals ϕ that lack even-harmonic content. Combinations of these produce the tone colors called for by the voicing panel

others, produce composite effects. Filter interlocking reduces cost and saves space without any sacrifice in voicing.

To trace a typical tone-color effect in Fig. 6, select the lower-manual 8-ft trumpet. Begin with the input carrying the lower-manual 8-ft saw-tooth from the bus amplifier, and assume that the trumpet 8-ft switch has been closed by depression of the appropriate plastic tablet. The signal passes through R_1 and C_1 to a series resonant circuit of L_1 and C_2. Output of this filter is at the junction of L_1 and C_2 at which a resonant rise of voltage at a frequency corresponding to the principal formant of the original instrument exists.

In passing through R_1 and C_1 the signal loses a portion of fundamental and lower harmonic components depending on fundamental input frequency. In addition to the resonant rise of voltage because of L_1 and C_2 the incorrectly loaded constant-K filter causes a rather sharp falloff beyond the nominal cutoff frequency which is twice that of resonance. The filter sections and the component values closely duplicate the acoustic filter characteristics of the orchestral trumpet, so that this stop produces a surprisingly realistic trumpet sound.

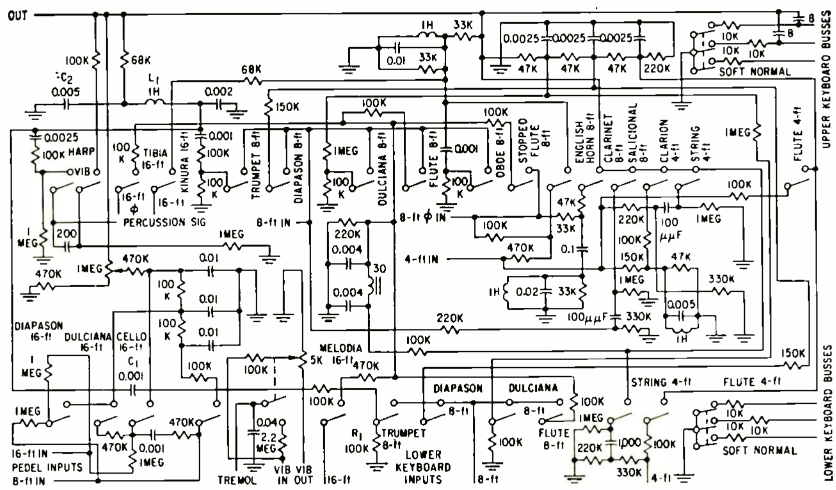


FIG. 6—Voicing panel contains formant filters which transform sawtooth-generator signals into waveforms of various instruments

Organ Stops

The stop arrangement in the organ duplicates in type the duplexing which was characteristic of theater organs. Theater instruments were designed for maximum flexibility of tonal effects, and the duplexing allowed several ranks of pipes, each with different tone color, to be played from either manual rather than from only one manual as in classical organs.

Duplexing is provided by switching tones at the inputs of the filters, so that tones of either manual and of any pitch register can be put through any filter. Duplexing is limited, of course, by the number of control tablets and associated switches. Fourteen stops are provided on the upper manual, six of which are duplexed on the lower manual, in addition to four unduplexed pedal stops.

A soft-normal tablet is provided for each manual. In the soft position, the associated triple switch shunts the normal terminations of the keying buses with additional resistors so that volume of all three registers of the manual is reduced. The filters and their terminations determine volume and timbre of the various stops, and the soft-normal tabs add flexibility by allowing the player an additional adjustment for balancing relative levels of the two manuals.

Vibrato

The amplifier chassis also contains in addition to the power supply the vibrato oscillator, operating at an adjustable frequency between about 5 and 8 cps. Output is fed through the circuits in Fig. 3 to all generator master oscillators, where it varies the frequency about its mean value. The amount of frequency variation and thus the intensity of vibrato effect may be varied manually with the 5,000-ohm potentiometer, which is located on the voicing panel.

The amplifier, itself essentially straightforward, ends in a pair of 6L6's and employs a good deal of negative feedback to maintain linearity. Its unusual feature is the volume-control arrangement operated by the swell shoe and diagrammed in Fig. 7. Its design is entirely capacitive to eliminate an expensive industrial-type potentiometer as well as possible noise problems.

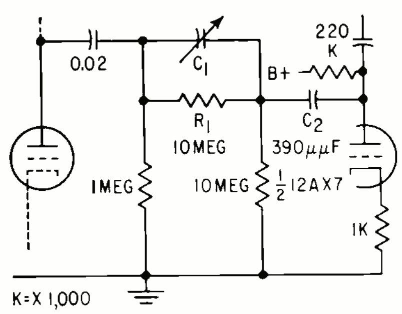


FIG. 7—Swell shoe operates capacitive volume control C_1 that replaces expensive industrial-type potentiometer

Operating the swell shoe varies the value of capacitor C_2 which consists of a metal rectangle about 2 by 6 in., hinged at one end and moving in relation to a similar rectangle which acts as the other plate and is fixed. Capacitor C_1 is the series leg of a capacitive voltage divider, the shunt leg of which is a dynamic capacitance of about 0.02μf across the grid of the tube due to capacitive feedback from the plate through C_2. The range of attenuation is great, and because of the low dynamic impedances, noise and hum are negligible.

Resistor R_1 adds a loudness control effect to the system. As C_1 is decreased R_1 becomes more prominent and the circuit begins to resemble a low-pass filter with R_1 as the series element and the dynamic tube capacitance as the shunt element. The filtering effect maintains the apparent bass-treble balance at reduced volume levels.

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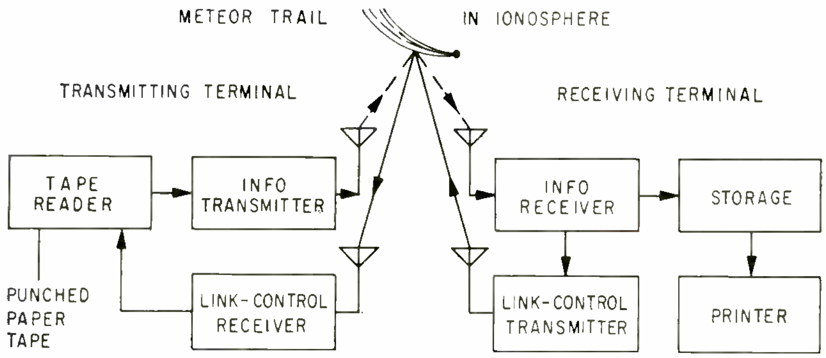


FIG. 1—Overall block diagram of meteor-burst communications system shows signal path for the detection and control of transmission, as radio waves bounce from ionized meteor trail. Information is transmitted only during meteor-burst

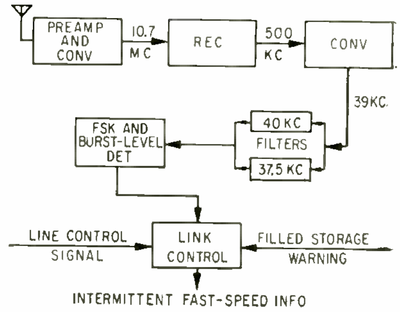


FIG. 2—Information receiver detects the presence of a usable signal during a meteor burst and demodulates the fsk signal information

By B. M. SIFFORD and W. R. VINCENT Stanford Research Institute, Menlo Park, California

Meteor Bursts Provide

Meteoric-scatter propagation system synchronizes transmission of radio waves with ionized trails of meteor particles. Meteor bursts reflect transmitted signals and convey intelligence in vhf band for transmitter-receiver distances up to 1,500 miles. High-speed, intermittent transmission may use recorded voice, stored pulse or facsimile information. Advantages: wide bandwidth, low power, information security and compact antennas

PROPAGATION of radio signals by reflection from ionized meteor trails, as shown by experimental meteor-burst systems, such as the Janet system pioneered by the Canadians, and the circuits discussed in this article show that a reliable, low-capacity communications channel can be established for distances up to 1,500 miles.

Meteor-burst communications permit the use of low-power transmitters and low-gain antennas. Usable frequencies up to 100 mc are far higher than can be normally propagated by the ionosphere. The vhf band is not affected as severely by ionospheric disturbances as are h-f circuits.

Falling-Star Link

An experimental meteoric-scatter propagation link, established between Montana State College in Bozeman, Montana, and Stanford Research Institute in Palo Alto, California (830 miles apart), has been in almost daily use since October, 1956. Excellent teleprinter performance is now obtained, and no propagation failures have been encountered for over 18 months.

A block diagram of the meteor-burst link is shown in Fig. 1.

Teleprinter information is transmitted from Bozeman on 40 mc, while link-control information is transmitted back from Palo Alto simultaneously on 32.8 mc. The intermittent meteor-burst channel is utilized effectively only when an acceptable signal is picked up at the receiver.

Detection and control of transmitted information takes place in three steps. First, the information transmitter at Bozeman radiates its 40-mc c-w recognition signal. A sensitive receiver at Palo Alto monitors this frequency. During a meteor burst, the receiver detects the presence of a usable signal and modulates the link-control transmitter on 32.8 mc.

Finally, the Bozeman receiver demodulates the link-control signal from Palo Alto, and uses it to start and stop the teleprinter modulation of the Bozeman transmitter.

Conventional teleprinter is used. Each character is represented by a start pulse, five information pulses, and a stop pulse transmitted sequentially. Conventional fsk modulation with a frequency deviation of 2.5 kc is used for both information transmitter and link-control transmitter. Laboratory constructed 2-kw transmitters are

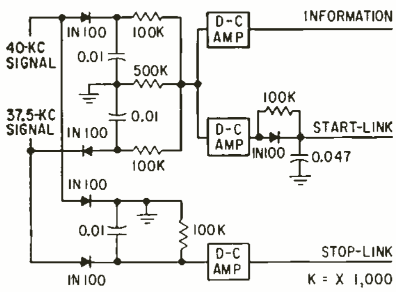
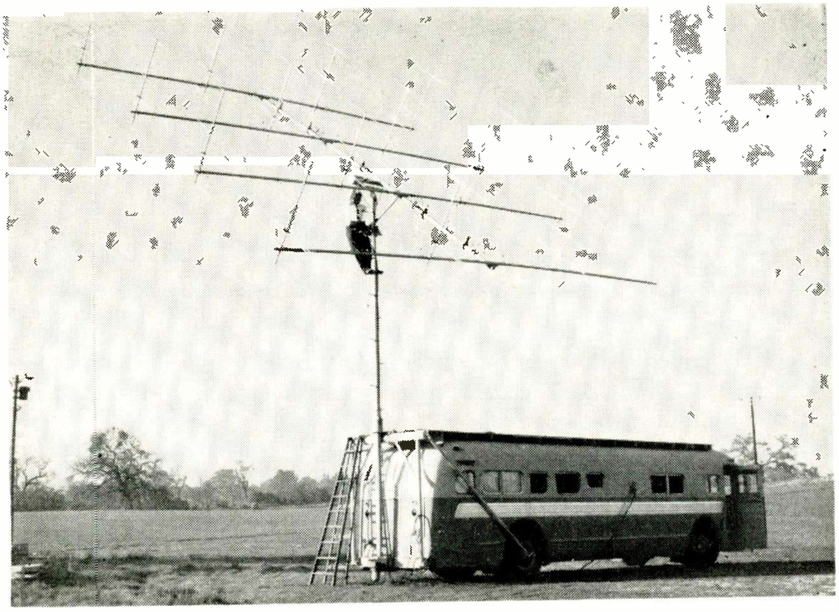


FIG. 3—Simplified schematic of burst detector. The start-link channel indicates when the incoming signal exceeds a usable threshold



Equipment to study meteor auroral reflections was constructed by Stanford Research Institute for Rome Development Center, Griffiss Air Force Base, Rome, New York

Communications Path

used at each terminal installation.

The power amplifier is a conventional class-C push-pull amplifier that uses a pair of 4-400A tetrodes.

During bursts, information is transmitted from Bozeman at ten times the normal 60 wpm rate.

Antennas

Simple three-element Yagi antenna arrays are used at both terminals. Transmitting and receiving antennas are spaced about 200 feet apart, in a line perpendicular to their line of directivity. This spacing reduces transmitter coupling into the receiver so that simultaneous transmission and reception takes place without the need of filters in the antenna feed line.

Receivers at both terminals are similar, with the exception that the information receiver at Palo Alto also detects the received signal strength in addition to demodulating the fsk information.

A block diagram of the information receiver is shown in Fig. 2. A cascade preamplifier with a 2-db noise figure is followed by frequency conversion to 10.7 mc. A Collins 51J receiver, used as an i-f stage, is followed by another conversion to 40 kc. Filters separate mark and space frequencies, and detectors and control circuits follow.

Two separate and independent types of teletypewriter storage and speed converters are used at the receiving terminal. One type uses a continuous loop of magnetic tape as the recording medium, while the other uses magnetic cores. Storage components are interchangeable and the only input required for each is the detected intermittent teletypewriter signal from the receiver. Storage outputs drive conventional 60-ma line current communications teleprinters.

Burst Detectors

The dual-purpose detector of the information receiver first decides when a usable signal is received from the transmitting station. This rapid decision uses minimum meteor-burst time. The receiver is quick to detect the end of a burst to halt information before the signal fades below a usable level. Transmitted information is detected with minimum signal-to-noise ratio, making full use of all available transmission time.

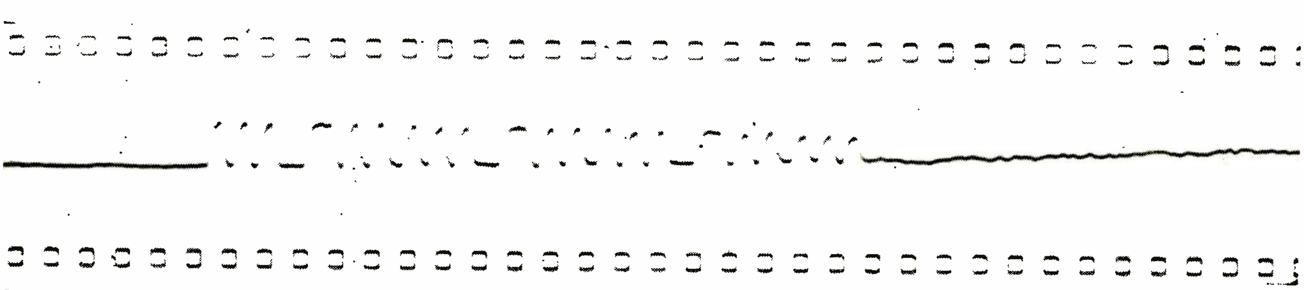
A simplified schematic of the detector is shown in Fig. 3. Outputs of the two mark space filters are rectified and d-c outputs are added both destructively (+ to −), and constructively (+ to +). The de-

ABOUT METEOR-BURST COMMUNICATIONS

Our earth, traveling in its orbit around the sun, sweeps up millions of meteors each day, ranging from dust-sized particles to large bodies weighing many tons. Although few large meteors are intercepted by the earths upper atmosphere, showers of meteor particles enter the E-region of the ionosphere. Meteoric collisions with the sparse upper-atmosphere atoms, 30 to 50 miles above the earth, cause the meteors to become white hot and leave trails of ionized meteoric and upper atmospheric particles. Ionization density of these particles is sufficient to reflect incident vhf radio waves.

Received signals from meteor bursts vary in duration from a few milliseconds up to many seconds. Spacing between signal bursts vary from a fraction of a second to minutes. The number of signals received vary with the time of day. The maximum number of signals occur in the early morning, and the minimum in the evening. Although the signals are erratic in duration, spacing and amplitude, a dependable communications path is statistically available.

Recent propagation studies, together with the general advancement in communication knowledge, show that an intermittent system that transmits information only during the brief intervals in which a usable reflected system is received, has many advantages



Oscilloscope photo of filtered and detected signal from an actual meteor burst

structively added d-c output is connected to two channels. The start-link channel indicates when the incoming signal exceeds a usable threshold. The other channel supplies received fsk information.

Transmission is continuous between bursts on one of the two signal frequencies. When the signal reaches the receiving terminal at Palo Alto with sufficient strength so that the output of one filter exceeds the output of the other filter by a preset level, a signal in the link-control circuits shifts the frequency of the link-control transmitter.

This method of starting the link discriminates against coherent interference in both filters. The start-link signal is also filtered with a special diode circuit after detection. Thus the probability of starting the link on large impulse noise signals is decreased. The additional filtering causes a loss of about 10 millisec of transmission time.

Once information transmission starts, the destructively added d-c output follows the fsk signal by reversing polarity. Detected pulses are regenerated by a Schmitt trigger in the link-controls and sent to the storage system. This information is the desired intelligence.

The constructively added detector output measures the signal level during fsk. As the received signal is always in one filter or the other, detector output is independent of the received information and is a function only of the received signal strength. This signal indicates when the meteor-burst signal fades below the stop-link threshold. Little post-detector filtering is done on the stop-link signal to permit rapid response to fast-fading meteor signals.

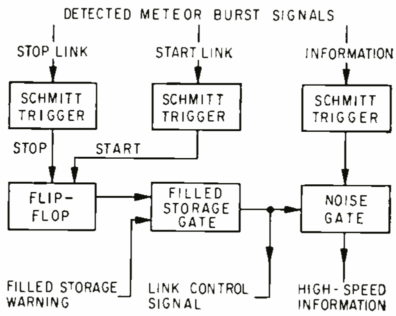


FIG. 5—Link-control block diagram. Start and stop links are regenerated by Schmitt trigger circuits

A circuit diagram of the detector circuits is shown in Fig. 4.

Control Circuits

Signals from the link-control circuits modulate the link-control transmitter and supply regenerate information signals used by the storage devices.

A block diagram of the link-control circuits is shown in Fig. 5. Start-link and stop-link signals are regenerated by Schmitt triggers with separately adjusted thresholds. The start-link threshold is about 6 v. As an increasing start-link signal goes through 6 v, a pulse sets a flip-flop. The flip-flop output switches the link-control transmitter to the start-link frequency. Additional start-link signals caused by the frequency shift keying have no effect on the flip-flop.

The stop-link trigger threshold is adjusted to about 5 v. As the signal fades below this level, a pulse, generated by the Schmitt trigger, sends the flip-flop back to the stop-link frequency. When the storage capacity is approached, a filled-storage warning signal overrides the flip-flop output through the filled storage gate, and the link-control transmitter is immediately

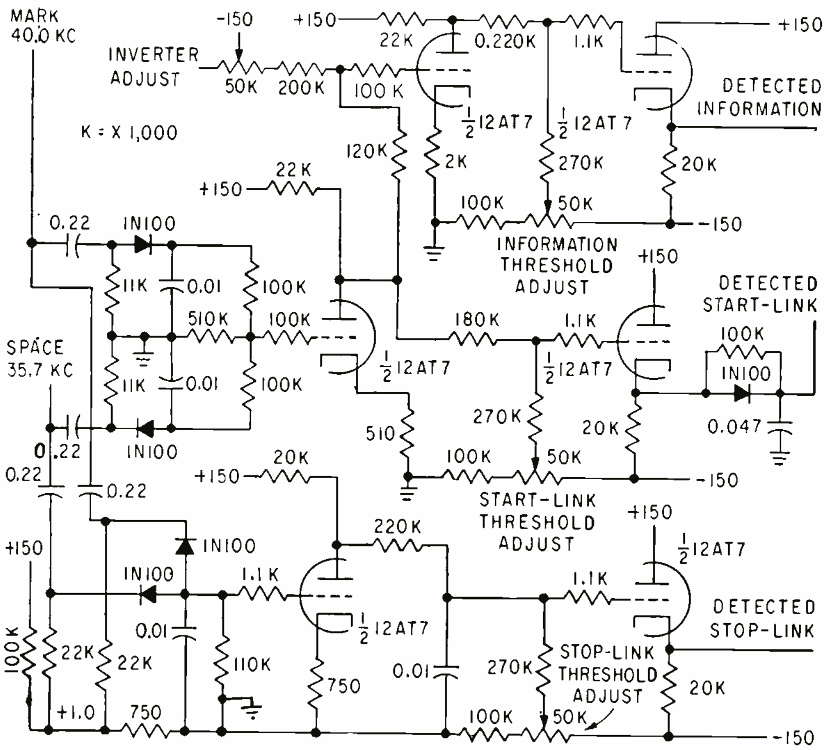


FIG. 4—Detector circuitry. Rapid response start-stop signals use minimum burst time

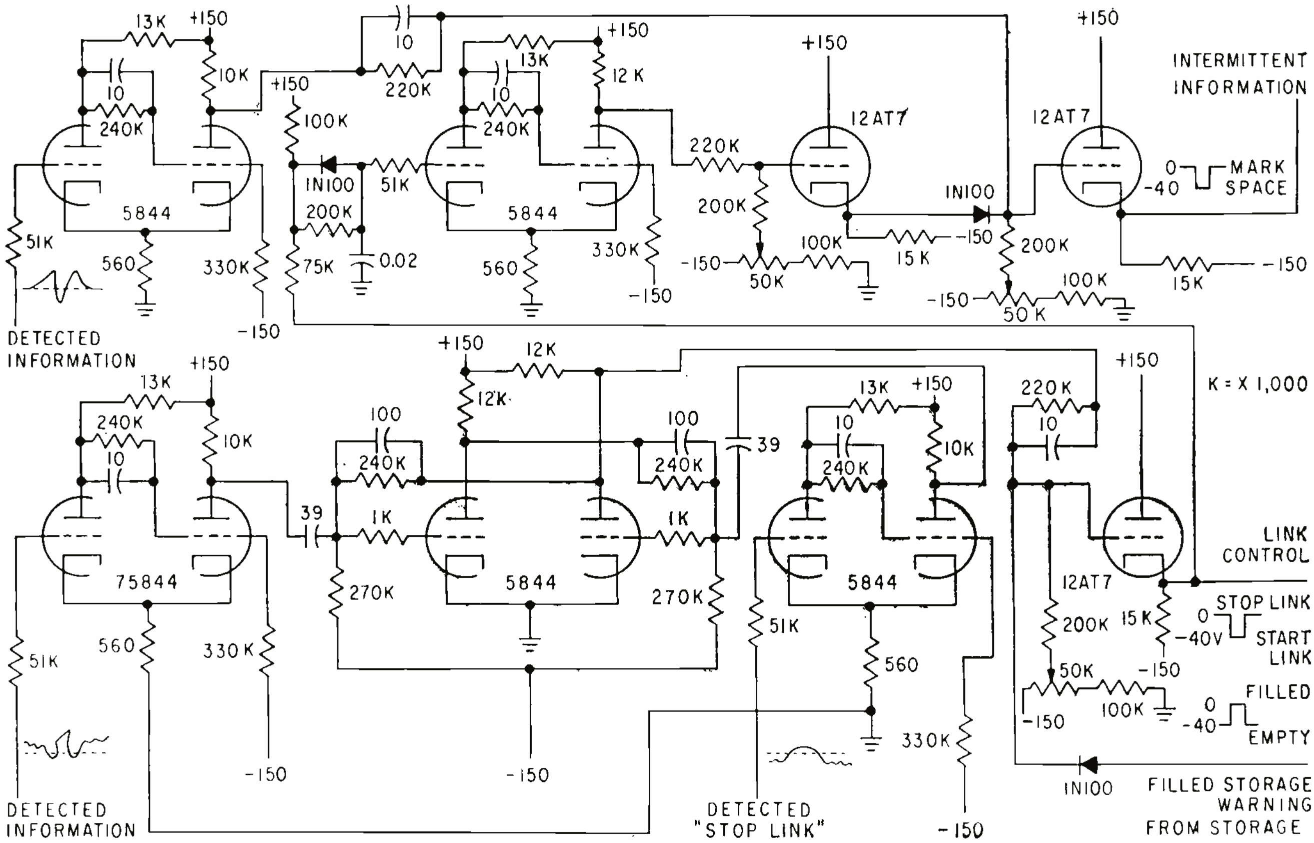


FIG. 6—Link-control schematic. Triggers are set well above ambient noise to preclude false triggering by noise spikes

switched to the stop-link frequency.

The threshold of the fsk information signal Schmitt trigger is adjusted to 0 v so that pulses are regenerated on the basis of polarity only and not amplitude. In the absence of a received signal, noise coming through the filters would trigger the circuit in a random manner. To prevent this noise from producing an output, the regenerated signal passes through the noise gate, which is opened and closed by the link-control signal. This insures that there will be no information output until the received signal exceeds the start-link threshold, at which point the received signal is large enough to control triggering of its regenerator.

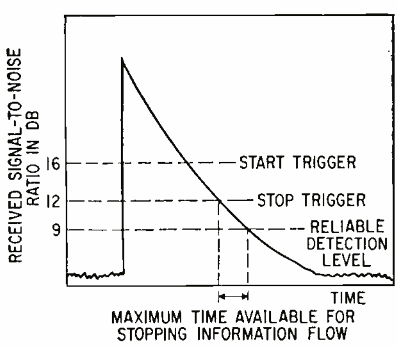


FIG. 7—Threshold levels of stop-link trigger are based on known maximum fade rate of meteor burst

The noise gate is closed by the stop-link signal, but only after a time longer than the inherent delay between the stop-link signal and the arrival of the last information pulse at the receiver. This delay is a combination of the two path-transient times, the response time of the link-control receiver, and the time for the transmitter to finish sending the last character. This total delay was found to be about 30 millisec maximum.

The link-control circuit is shown in Fig. 6. At the transmitting terminal only the differential detector and one Schmitt trigger control the tape recorder. Otherwise the two link-control circuits are identical. The threshold level of the Schmitt trigger, set well above ambient noise, precludes false triggering of the transmitter modultion by noise spikes. This circuit is also filtered with a diode circuit, as in the start-link of the information receiver.

A constant signal-to-noise ratio of about 9 db gives a character-error rate of less than one percent, using this detection system. Information stops before the signal-to-noise ratio deteriorates much below this level. The 30-millisec time required to stop arrival of information is time anticipated by the burst detector when the signal-to-noise ratio will fall to 9 db. The method of anticipation is based on the assumption that meteor signals have a finite maximum fade rate. This known maximum fade rate establishes a minimum signal-to-noise ratio at the end of all bursts. Extrapolating back to 30 millisec can determine the threshold level of the stop-link trigger, see Fig. 7.

The stop-link threshold is set, generally, at about 12 db and the start-link threshold at about a 16 db signal-to-noise ratio.

The average information transfer rate is approximately 15 wpm with parameters used in the present system. Character error rates were less than 1 percent but, of these, over 60 percent occurred at the end of bursts.

This meteor-burst communications program is conducted under contract with Air Force Cambridge Research Center, AF 19(604)-1517.

How to Measure

Unit uses a double-mixing process and linearly transposes phase shifts accumulated at 30 mc down to 2 mc where they are accurately compared against a calibrated 2-mc reference signal. Principles can be extended to measure phase shifts at any frequency in high-frequency range

By **ALLAN NIRENBURG**

Project Engineer, Department of Radar and Navigation, Airborne Instruments Laboratory, Inc., Mineola, New York

WITH THE ADVENT of mti radars, phase-sensitive hyperbolic navigation systems, Doppler navigators, and other modern phase-sensitive electronic systems, accurate measurements of phase at all frequencies is vital.

Below 50 mc the trombone coaxial lines become too large to be physically realizable, just as the lumped parameter lines become too small to be physically realizable above 5 mc. A unique method of measuring phase shifts is therefore required for the frequency range of 5 to 50 mc.

Phase-Shift Measurements

Such a system has been developed and can be explained with the pentagrid mixer shown in Fig. 1. The total output signal current flowing at any time is a nonlinear function of the product of input signals $p\ (t)$ and $q\ (t)$. The difference-frequency term $(p - q)\ t$ can be isolated and extracted with a bandpass filter. If input signal $q(t)$ is made equal to $(p + k)t + \theta$, where k is some arbitrary frequency and θ is a phase-shift term, the output difference-frequency term $(p - q)t$ is equal to frequency kt plus the original phase-shift term θ.

Thus, a phase shift θ at one frequency $(p + k)t + \theta$ may be linearly transposed to another frequency $(kt + \theta)$ with phase term θ unaltered. Using this principle, a recently designed system measures phase shifts in i-f amplifiers as a function of input signal amplitude at frequencies in the region of 30

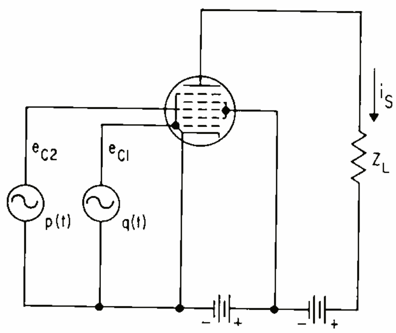


FIG. 1—Output of pentagrid mixer is a nonlinear function of its two inputs

mc. It can be adapted to any frequency in the 5 to 50-mc range.

The phase-measuring system shown in the block diagram of Fig. 2 uses a double mixing process that linearly transposes any phase shifts that are accumulated at 30 mc down to 2 mc. These phase shifts can then be accurately compared against a calibrated 2-mc reference signal.

A 30-mc signal feeds through a piston attenuator into the unit being tested. The attenuator is essentially a waveguide operated far below its cutoff frequency, so that attenuation is a linear function of length and the phase shift through it is a constant 90 deg for all lengths. The attenuator, therefore, exhibits no internal phase shift as it is varied over an 80-db range.

Heterodyning the 30-mc signal with a 2-mc reference signal yields a signal at 32 mc. The test-unit signal which is (30 mc + θ), where θ is the phase shift of the unit, is now heterodyned with the 32-mc signal. A resulting difference frequency (2 mc + θ) can now be compared with the 2-mc reference signal, and the value of θ can be determined.

Phase shift θ is measured by superimposing the 2-mc reference and the (2 mc + θ) signals on an oscilloscope with an electronic switch. The scope is synchronized to the reference signal and the patterns are shown in Fig. 3. As the (2 mc + θ) signal shifts in phase while passing through the unit under test, it moves across the scope a distance proportional to θ with respect to the reference signal.

The reference signal remains superimposed on the (2 mc + θ) signal when it is shifted an amount of calibrated variable delay line proportional to the phase shift in the unit under test. With a 0.75-μsec variable delay line whose complete dial-face range represents 540 electrical deg at 2 mc, phase shifts of less than 1.5 deg can be resolved.

Reference Frequency

Choice of 2 mc as the reference frequency is a compromise between a number of opposing design considerations. The reference frequency must be low enough to permit accurate phase-shifting by a lumped-parameter delay line and also low enough to permit it to be viewed on and to synchronize a conventional cro. It must be high enough so that the (30 mc + 2 mc) sum-frequency of interest can be easily filtered and isolated from the 30-mc base-frequency and 28-mc

Midfrequency Phase Shift

difference-frequency terms.

Tube V_{1A} of the instrument, shown schematically in Fig. 4, is an oscillator tuned to the 30-mc frequency at which tests are to be conducted. The oscillator signal is fed through cathode follower V_{1B} to the attenuator and to the unit actually under test. The 2-mc reference signal generated in tube V_{2A} is fed, through cathode follower V_{2B}, to the variable delay line and to the external synchronization input of the scope indicator. A sample of both the 30 and 2-mc signals are mixed in mixer tube V_5, and the 32 mc sum-frequency term is extracted when the signal passes through two

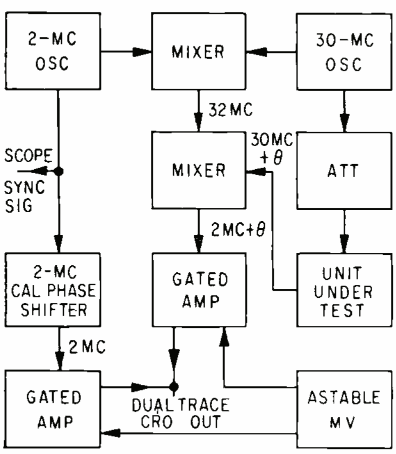


FIG. 2—Phase-measuring system has two mixers that brings 30-mc input down to 2 mc

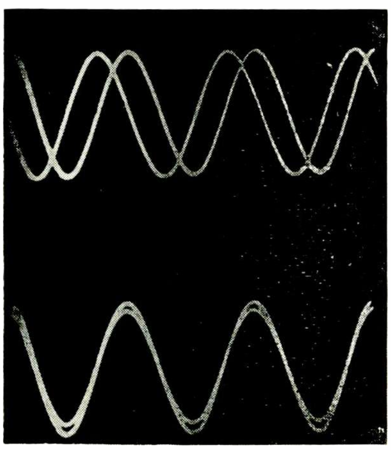


FIG. 3—Error signal shifted in phase with respect to reference signal (top) and reference signal shifted into phase with error signal by calibrated phase shifter (bottom)

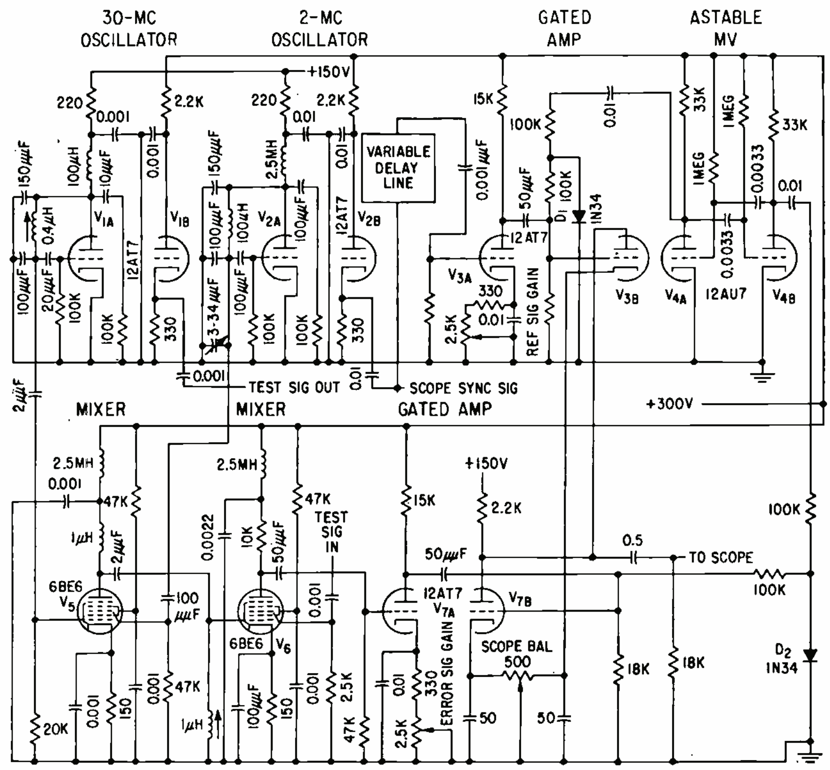


FIG. 4—Free-running multivibrator output is R-C coupled to grids of gated amplifiers V_{3B} and V_{7B}. Output of V_{7B} is a composite signal

sharply-tuned band-pass filters. The 32-mc signal is mixed with the phase shifted, 30-mc signal from the unit under test. Mixer tube V_6 mixes the signal and the resulting difference-frequency term (2 mc + θ) is amplified in V_{7A}. The signal is then fed through gate V_{7B}.

The 2-mc reference signal that is passed through the variable delay line is now amplified V_{3A} and fed to gated amplifier V_{3B}. Both gated amplifiers V_{3B} and V_{7B} have a common 2,200-ohm plate load resistor. A square wave, generated in a stable multivibrator V_4 alternately gates the amplifiers ON. The multivibrator runs free at an arbitrary frequency many times lower than the reference frequency of 2 mc and couples to the gated-amplifier grids by R-C-diode networks.

Positive portions of the square-wave, are shunted to ground by diodes D_1 and D_2 and the amplifier operates in a conventional manner. During the negative portion of a square wave, the diode does not conduct and the negative waveform cuts off the amplifier. With alternate square waves applied from the plates of the multivibrator to both gated amplifiers, the 2-mc reference signal and the 2 mc + θ phase-shifted signal appear alternately on the plate of V_{7B}.

Composite Signal

With an oscilloscope synchronized to the reference signal, and the composite signal at the plate of V_{7B} fed to the vertical deflection amplifiers of the cro, the reference and phase shifted signals appear superimposed; the phase-shifted signal can be seen to shift phase with respect to the stationary reference signal. Gain controls in both signal amplifier channels facilitate accurate superimposition of the signals on the scope and a trace separation control in the common cathode circuit of the gated amplifiers positions and superimposes the dual traces.

This device was developed under AF contract with the Cambridge Research Center.

Designing Noisefree Enclosure Openings

Technique reduces interference introduced by meter and ventilation openings in electronic equipment enclosures. When apertures are designed as waveguide attenuators operating below cutoff for lowest propagating frequencies, shielding efficiencies up to 100 db are obtained

By **ARNOLD L. ALBIN,** Senior Engineer, Filtron Co., Inc., Culver City, California

OPENINGS for control shafts, meters and ventilation may permit radiation of electromagnetic energy from transmitters, or introduction of spurious signals into a receiver. Interference is reduced by designing the aperture through which leakage occurs as a waveguide-type attenuator.

A cutoff frequency for each waveguide is the lowest frequency at which propagation occurs without attenuation. Below cutoff, attenuation is a function of guide length and frequency. When an aperture is designed in a shielding enclosure as a waveguide operating below cutoff for the dominant mode or lowest propagating frequency, theoretical shielding efficiencies of 80 to 100 db are readily achieved.

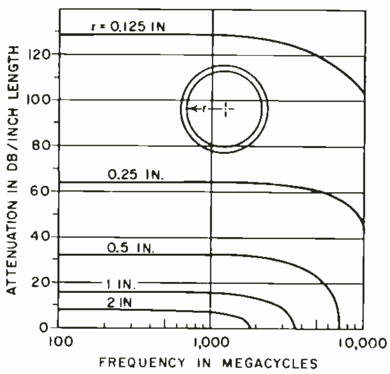


FIG. 1—Attenuation of a circular waveguide for TE_{11} mode. Curves continue horizontally down to 10 mc

Circular Openings

The attenuation down a waveguide may be found from

$$\alpha_{TE_{11}} = 16/r\sqrt{1-(fr/3{,}460)^2} \text{ db/in.} \quad (1)$$

where r is the radius of the guide and f is frequency, if the TE_{11}, the dominant mode in a circular guide, is considered.

Inductance coupling causes propagation in the TE_{11} mode, while capacitive coupling favors the TM_{01} mode.

Because the attenuation for the TM_{01} mode is greater than that of the TE_{11} mode, at frequencies well below cutoff, the design is based on the TE_{11} mode. Figure 1 is a set of design curves based on Eq. 1 for circular waveguides with r from 0.125 to 2 in.

Figure 2 is a design chart for rectangular waveguides ranging from 0.25 to 4 in. in width. When the diameter of hole or other opening is known, select maximum frequency at which interference suppression is desired. From either chart select appropriate curve. At intersection of desired frequency and attenuation curve, read attenuation in db/in. of length. Compute required length from desired value of attenuation where 80 to 100 db

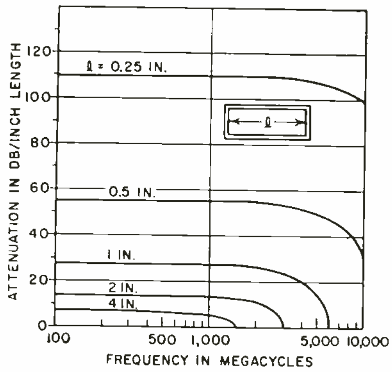
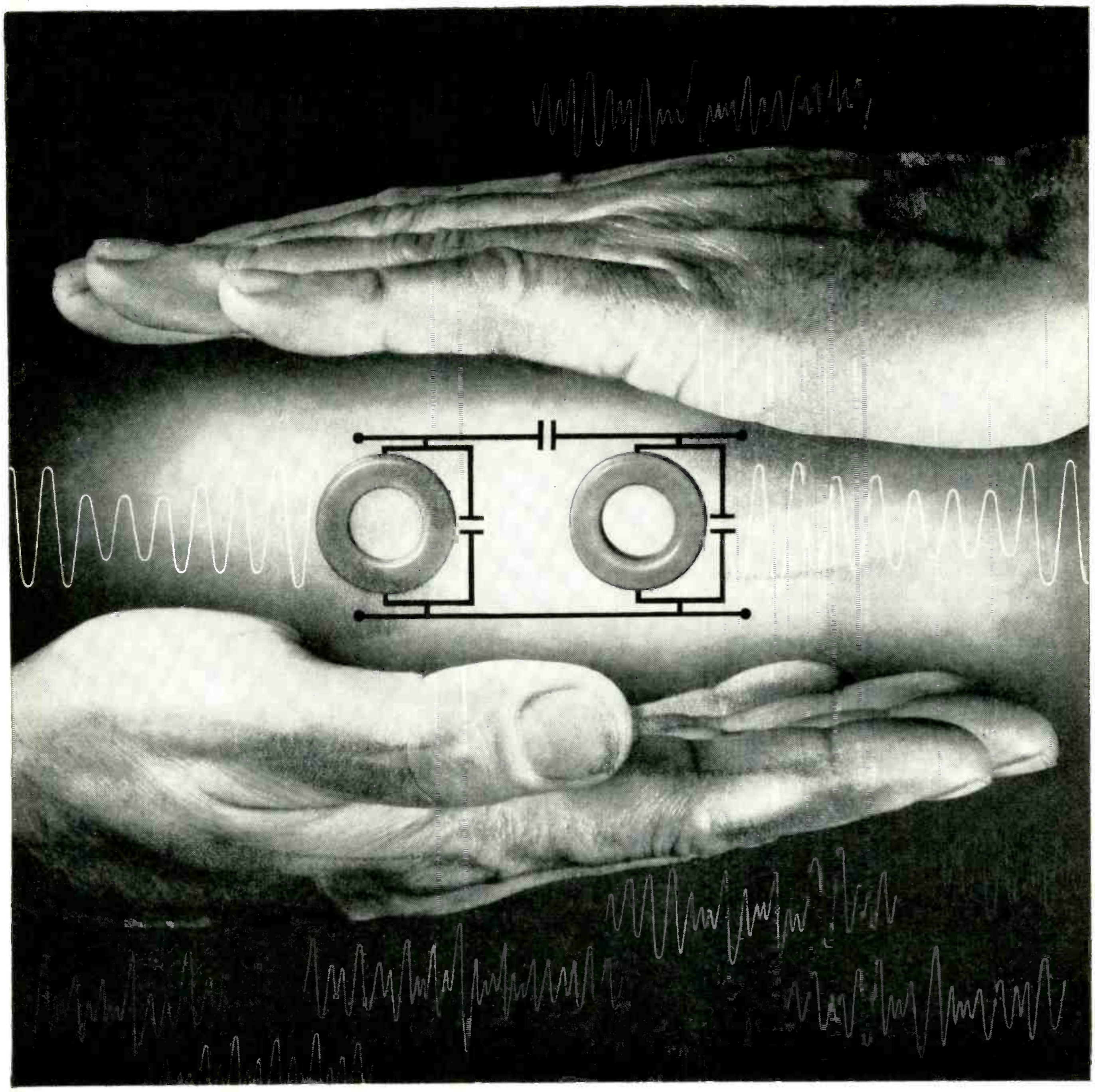


FIG. 2—Attenuation of a rectangular waveguide for TE_{10} mode. Curves continue horizontally down to 10 mc

is suggested as an average figure.

Making the length of waveguide three times the diameter for 100 db of attenuation with circular guides and 80 db with rectangular guides is a useful shortcut for frequencies well below cutoff.

As an example, a 1-in. meter opening is required in a transmitter control panel. It is necessary to find the required length of the meter housing for 100 db of attenuation. Transmitter frequency is 100 mc. From Fig. 1 α = 32 db/in. at the intersection of the 100-mc ordinate and the curve for ½-in. radius. The required length = 100 db/32 db/in. = 3.13 in., but from the shortcut it equals 3 × 1 = 3 in.



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High-Frequency Phase Detector

OPERATION at higher frequencies where stray capacitances become significant was an important requirement for a phase-sensitive detector. The circuit and an adjustment procedure are described that provide optimum balance and linearity with minimum complications.

One advantage of the circuit, shown in Fig. 1, is that one terminal of the three pairs for signal, reference and output is grounded, for both r-f and d-c. Hence, there are no bypass capacitors to upset symmetry and no floating coils that require electrostatically shielded inductive coupling.

Amplitude of the in-phase component of the signal is primarily a function of reference voltage. If one-percent accuracy is required, the reference should be the order of ten times the maximum input signal. For 10-percent accuracy, a two-to-one ratio should be adequate. As long as the crystal diodes are reasonably symmetrical, some difference in their characteristics will have only a minor effect on performance. However, it can do no harm to select matched diodes.

To achieve good balance, it is necessary that the signal voltages applied to the diodes be exactly equal in amplitude and opposite in phase. This requirement can be satisfied most easily by making the signal input transformer a bifilar winding. In this type coil, inductive coupling between the two ends is extremely tight, and the distributed capacitance, although large, is symmetrical. Because of the poor dielectric properties of wire insulation, the Q of such a coil will be lower than that of a simple winding of the same net inductance with the same form diameter and wire size. The lower Q is minor compared to the advantage of symmetry.

In a bifilar winding for 10 mc or above, the number of turns in the two halves of the coil must be the same within a small fraction of a turn. Also, the lead lengths from the coil to the crystals must be equal.

The signal may be capacitively coupled from the plate of a pentode to one end of the bifilar coil. The balance is not likely to be disturbed if capacitance added by the input circuit is small compared to the tuning capacitance in shunt with the coil.

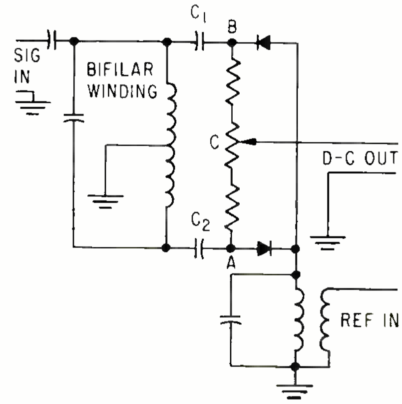

FIG. 1—Bifilar winding ensures that signal voltages applied to diodes are equal in amplitude

Two pentodes in push-pull, each one capacitively coupled to one end of the bifilar coil, also preserve symmetry. The coil should be well shielded to prevent inductive pickup from the reference circuit.

When reference voltage is present, capacitors, C_1 and C_2 charge at opposite polarities on alternate half cycles. If the circuit is balanced, the d-c voltage at *A* will be equal and opposite to that at *B*. The potentiometer is adjusted for zero voltage at *C*. With reference voltage reduced, d-c output should stay nulled. If it does not, asymmetry of the diodes is indicated.

When the diodes conduct, a voltage at reference phase will be developed at each end of the signal input transformer. However, this voltage, measured with respect to ground, has the same phase at each end of the input transformer and therefore is zero from end to end.

If there is an input signal but no reference, capacitors C_1 and C_2 again charge to equal and opposite voltages. In this case, failure to balance indicates asymmetry of the input.

In normal operation with a large reference voltage and a small signal input, conduction of each diode is proportional to the vector sum of the two voltages present, phased so that conduction of one diode is increased when that of the other is decreased. The voltage at point *C* is proportional to the unbalance. This voltage will be zero when the input and the reference are in quadrature.

This circuit has been used successfully by the author at a frequency of 16 mc in an application where precise quantitative results were required. No serious difficulties were encountered, and it seems reasonable to expect that the circuit could be made to work at higher frequencies.

This material was abstracted from "Design and Construction of High-Frequency Phase-Sensitive Detectors" by the University of California Radiation Laboratory.

Override Circuits Are Simplified

By RONALD L. IVES Palo Alto, Calif.

INDUSTRIAL and military systems often require that electronic control stations be arranged so that one station can take over system control from another. Later control must be restored to the original station. The equipment must constantly give clear indications of which station is in control.

This operating requirement makes necessary a system of override circuits, which all too often consist of an array of relays and vacuum tubes of considerable complexity and maddening proneness to trouble.

To reduce both complexity and fallibility of override circuits and their indicators, a group of relayless overrides has been developed. The fundamental circuit, illustrat-

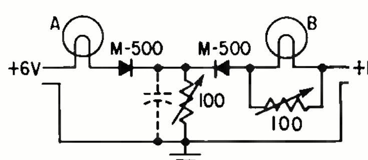

FIG. 1—Basic override circuit will operate with d-c, like-phased a-c, mixed a-c and d-c and, with a capacitor, unlike-phased a-c

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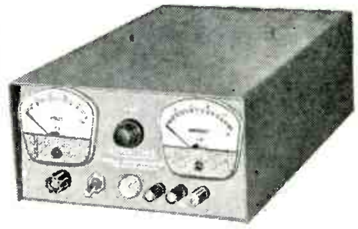
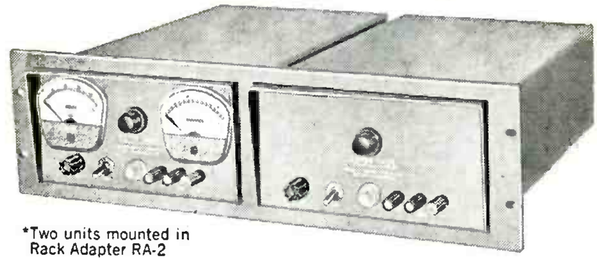


Model SC-18-2-M



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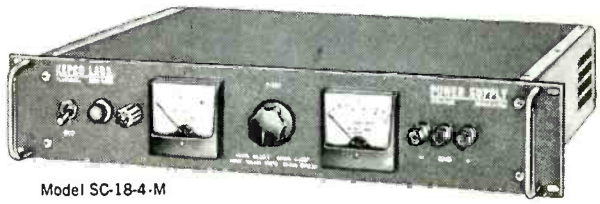

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SC-18-1	0-18	0-1	.02	.2	8¼"	4 5/32"	13⅝"
SC-18-2	0-18	0-2	.01	.1	8¼"	4 5/32"	13⅝"
SC-18-4	0-18	0-4	.005	.05	19"	3½"	13"
SC-36-0.5	0-36	0-0.5	.08	.8	8¼"	4 5/32"	13⅝"
SC-36-1	0-36	0-1	.04	.4	8¼"	4 5/32"	13⅝"
SC-36-2	0-36	0-2	.02	.2	19"	3½"	13"
SC-3672-0.5	36-72	0-0.5	.15	1.0	8¼"	4 5/32"	13⅝"
SC-3672-1	36-72	0-1	.08	.8	19"	3½"	13"

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  0.1% or 0.003 volt for load changes 0 to maximum (whichever is greater) at any output voltage in the range minimum to maximum.
- **RIPPLE:** 1 mv. RMS.
- **RECOVERY TIME:** 50 microseconds.
- **STABILITY:** (for 8 hours) 0.1% or 0.003 volt (whichever is greater).
- **AMBIENT OPERATING TEMPERATURE:** 50°C maximum. Over-temperature protection provided. Unit turns off when over-temperature occurs. Power-on-off switch on front panel resets unit.
- **TEMPERATURE COEFFICIENT:** Output voltage changes less than 0.05% per °C.
- **SHORT CIRCUIT PROTECTION:** No fuses, circuit breakers or relays! Designed to operate continuously into a short circuit. Returns instantly to operating voltage when overload is removed. Ideal for lighting lamps and charging capacitive loads.
- **OVER-CURRENT CONTROL:** Can be set from 0 to 120% of full load. Current is limited to preset value for any load including short circuit.

- **REMOTE PROGRAMMING** at 1000 ohms per volt is provided. Remote programming allows mounting a voltage control at a remote point.
- **REMOTE ERROR SIGNAL SENSING** is provided to maintain stated regulation directly at load.
- **CONSTANT CURRENT OPERATION:** These units can be set up for constant current operation without internal modification.
- **POWER REQUIREMENTS:** 105-125 volts, 50-65 cycles. 400 cycle units available.
- **OUTPUT TERMINATIONS:** DC terminals are clearly marked on the front panel. All terminals are isolated from the chassis. Either positive or negative terminal of each DC output may be grounded. A terminal is provided for connecting to the chassis. The DC terminals, the remote programming terminals and the remote error signal sensing terminals are brought out at the rear of the unit.
- **CONTROLS:** Power-on-off switch, one turn voltage control, on front panel. Over-current control on rear of unit. Ten turn voltage control available on special order.

- Continuously Variable Output Voltage. No voltage switching.
- Suitable for square wave pulsed loading.
- Either positive or negative can be grounded.
- Units can be series connected.
- High efficiency
- Low heat dissipation.
- Compact, light weight
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*Rack adapter for mounting any two 8¼" x 4 5/32" units is available. Model No. RA2 is 5¼" high 19" wide.

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ing the principles, is shown in Fig. 1. This arrangement will work effectively with a d-c supply, with like-phased a-c and with mixed a-c and d-c. If a large capacitor is shunted across the ground return (shown dotted in Fig. 1), it will also work with unlike-phased a-c.

When the main station has control, the indicator lamp labeled *A* glows, and lamp *B*, having no current supply, does not. The silicon diodes function as sneak-circuit preventers when the supply is d-c. When the supply is a-c, they act as both rectifiers and sneak-circuit preventers.

When the second station takes control, it produces 10 volts. This voltage, minus the drop across lamp *B* and its shunt resistor and across the silicon rectifier, raises the potential from *Y* to ground to more than 6 volts. Therefore, lamp *A* is extinguished since there is no longer a potential across it.

Adjustment is simple and straightforward. Station *A* is energized, and the resistor between *Y* and ground is adjusted until lamp *A* has the desired brilliance. Reducing the voltage to 0.8 of rating apparently multiplies lamp life by a factor of about ten without impairing its usefulness as an indicator.

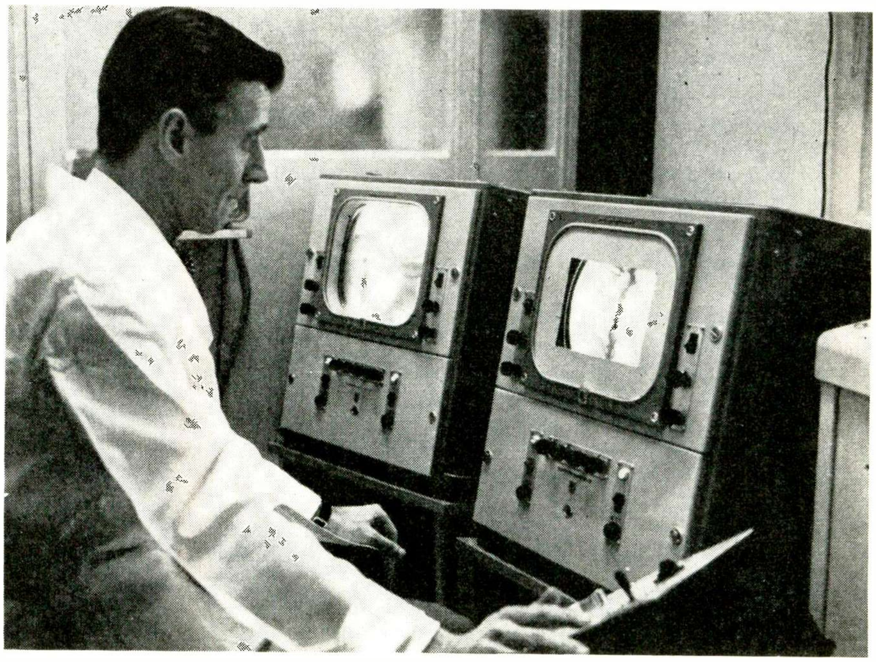
Next, station *B* is energized, and the resistor across lamp *B* is adjusted until the brilliance of the lamp is satisfactory. The resistor controls are locked, and no further adjustment is needed.

Successive overrides can be cascaded by adding sections identical to the right half of Fig. 1 to point *B*. Each added section needs about four more supply volts than the succeeding one.

Two methods of locking out overridden units have been found satisfactory by test. The first, suitable for systems consisting only of a main station and one remote station, is illustrated in Fig. 2. The remote station control-line output, which is five volts, is fed to one half of a 10-volt winding on a small filament transformer. Output across the whole winding is fed to lamp *B*. Output from the 115-volt winding of this transformer is rectified and filtered, producing approximately 150 volts of negative hold-off bias for the main station.

When the remote station is on, the main station pilot is out, and the remote station pilot lamp is lit. The operating circuits of the

Long-Range X-Rays



Peristaltic movement of a patient's intestine is viewed by doctors eight miles away in a Montreal hospital. Closed-circuit or transmitted tv pictures of x-ray images used with a Philips intensifier permit consultants to diagnose human ills without being on the spot

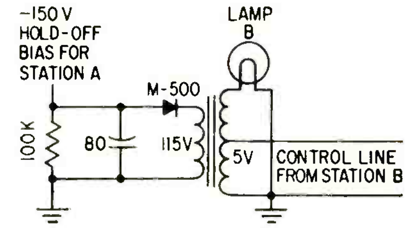


FIG. 2—Hold-off bias of —150 volts is developed to override unused station

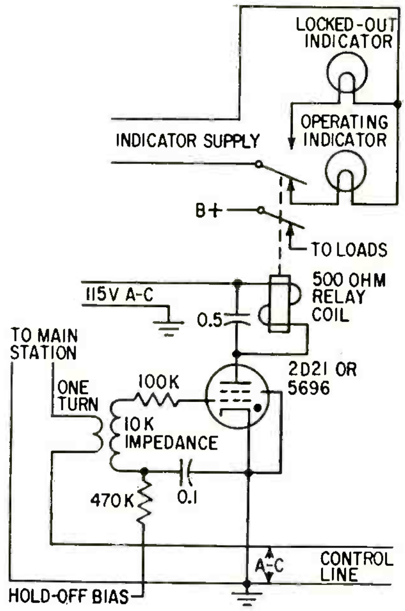


FIG. 3—Current transformer in control line locks out overridden station in system with any number of stations

main station are effectively biased off.

The second method, suitable for any number of interlocked stations, uses a current transformer in the control line. The control line from a given station draws no current when that station is locked out. Therefore, the current transformer will have output only when the station under consideration is actually in control. A number of alternatives to this circuit, shown in Fig. 3, will function as well.

As with all indicating circuits, the problem of indicator lamp failures kept recurring. Using slightly lower voltage for the lamps and systematically changing lamps after about 60 percent of their probable service life were found effective.

Two special circuits also were found useful in permitting service to continue despite lamp burnouts and in indicating plainly when a lamp did need replacement. In Fig. 4A, each of two lamps in series is individually shunted by a resistor. In the event of a lamp failure, the lamp goes out but current still flows.

In Fig. 4B, the indicator forms one leg of a balanced bridge. The other three legs are resistors equal in value to the hot resistance of the lamp. A lower current lamp, normally not lit, is connected across the bridge. If the main lamp burns out, current flows through the system. The auxiliary lamp lights preserving the indicating function and pinpointing the trouble.

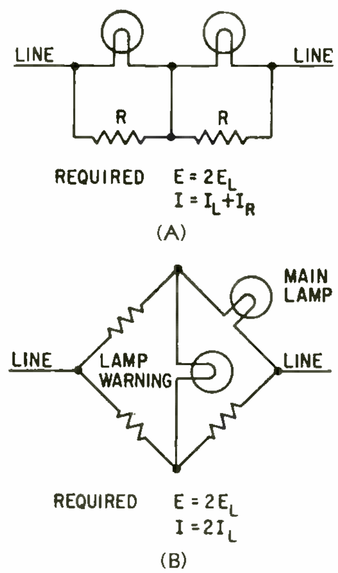


FIG. 4—Lamp failure in circuits at A and B does not stop current flow, and circuit at B also indicates lamp failure

Using this general type of over-ride circuit greatly simplifies construction and greatly reduces maintenance time and frequency. It also eliminates many relays, with their attendant contact, flyback and sneak-circuit troubles.

100 Disks Store 10 Million Units

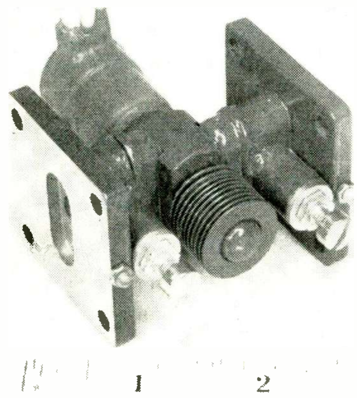
ONE HUNDRED metal disks—spinning at 1,200 rpm and capable of storing 10 million units of information—now operate in United Airlines' reservation dept.

Information on 365,000 flight departures annually is electronically transferred from IBM cards and magnetically recorded on disks, which make up memory units of IBM's first two production models of RAMAC—Random Access Method for Accounting and Control.

Installation is at Stapleton Airfield in Denver.

Klystron Amplifier Uses Capacitive Tuning

By ROBERT G. ROCKWELL, Varian Associates, Palo Alto, Calif.



Type VA-824 klystron amplifier

NEW DESIGN of a klystron amplifier features capacitive tuning with a screw inserted through a broad wall of the waveguide forming the external cavity. The design results in a rugged, easily tuned tube with good thermal stability.

Tuning range is six percent in X-band. At midband, power gains as high as 12.5 db have been obtained. Mean gain is 10 db. Saturated power outputs of two to five watts may be obtained with low voltage and current. Primarily, the tube is aimed at service in airborne equipment—either c-w, pulse-modulated, synchrodyned or serrodyned.

Mechanical Design

Since the tube is designed for airborne applications, the cathode and heater connections are potted in silicone rubber compound to prevent voltage breakdown and corona at high altitudes. Figure 1 is a schematic sectional view of the new VA-824. The internal cavity is rigid-walled. It does not have a thin-walled flexible diaphragm as does a gap-tuned tube.

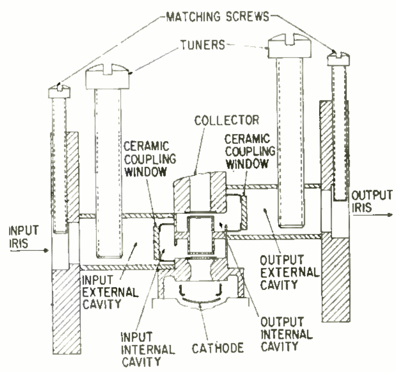


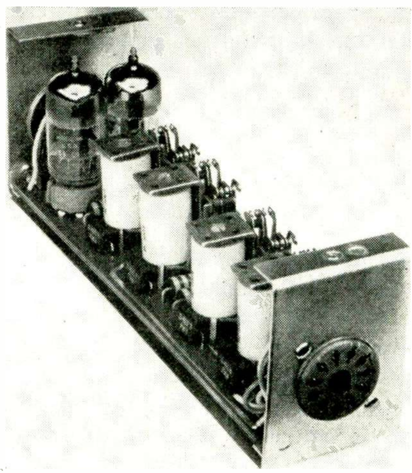
FIG. 1—Sectional view of klystron

Figure 2 is a mechanical drawing of the electron gun. A pancake heater is held snugly against the back of the cathode button. This type of construction is rugged and thermally efficient. Ceramic, rather than glass, was chosen to enhance further the ruggedness of the mount. A single ceramic ring is used for both the cathode support and the vacuum seal. The gun has a perveance of 2.4 micropervs. Convergence is less than two because of ion focusing.

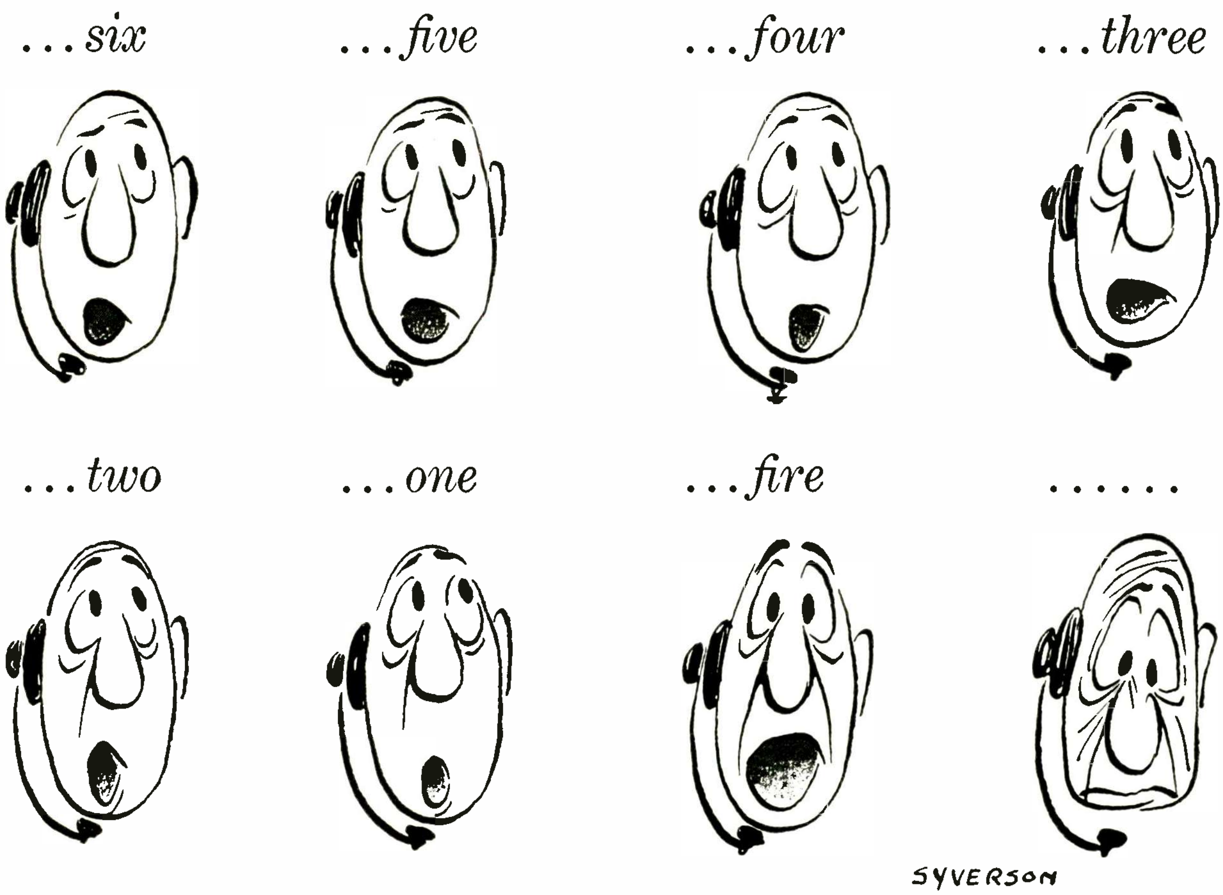
A transmission efficiency of 65 percent is obtained through four copper hexagonal-honeycomb grids and the 0.185-in. diam drift tube which is 0.330-in. long. At the designed operating potential of 750 v, these conditions correspond to a power density in the beam of about 240 w/cm^2 which is safely below the power density which will melt the copper grids.

Ceramic windows were used

Planes of Neon Lamps Display Numerals

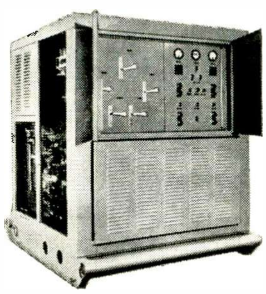


Planes of bright neon lamps form and hold easily-read 2½-inch numerals. In-line readout was designed by Computer Measurements Corp, North Hollywood, Calif., for use with electronic counters. Controller receives read-command pulses from frequency counter and operates code converters at proper moment to receive 4-line 1-2-2-4 binary decimal code from counter. Six code converters (right) translate input into 10-bit code in form of relay contact closures. Converters use unique folded relay tree which requires fewer contacts than usual relay tree. Digit modules use 10-bit code to fire neon lamps in proper order for numeral display. At end of counting cycle, memory circuit in controller unlatches relays so they may be reset when counting instrument has completed its next cycle. Displayed numerals will not cycle except as a test procedure. Digit modules contain 40 long-life neon bulbs and matrix of 201 resistors on 6 component boards



When the target is space and a million dollars' worth of missile rests idly on the ground—not even a long countdown helps. In a showdown situation, the successful shoot depends on the "go, no-go" type of test that pinpoints the trouble.

NEXT TIME...LOOK TO INET FOR PRECISE GROUND POWER



This INET 400-cycle ground power unit was tailor-made for the Atlas. In meeting all of Convair's specifications for pre-flight calibration of electrical systems, the unit operates in parallel with the missile's power system and provides remote control regulation. Frequency regulation is ±0.2%. With shock load equal to a third of rated output, frequency recovers to ±0.2% in 0.15 seconds. Voltage regulation is ±0.5% with recovery time at 0.30 seconds.

Missile men desiring a special reprint of the above cartoon should write to "Count-down", c/o Inet Division of Leach.

INET DIVISION LEACH CORPORATION

18435 SUSANA ROAD, COMPTON, CALIFORNIA

DISTRICT OFFICES AND REPRESENTATIVES IN PRINCIPAL CITIES OF U. S. AND CANADA mounted in platinum cups. Platinum was chosen since it has nearly the same coefficient of expansion as the ceramic.

Electrical Design

Starting point for development of the tube was the general principle of coupled-cavity tuning as originally applied to reflex klystrons.[1] This principle was combined with the necessity of at least

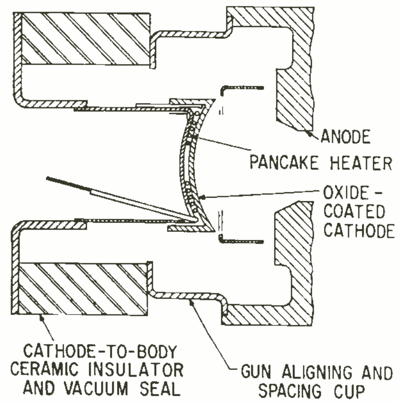


FIG. 2—Electron-gun assembly

two cavities when building an amplifier. Figure 3 shows the tuning curves of a tightly coupled double-tuned cavity such as used in the VA-824. Frequency of the internal cavity is fixed and independent of the tuning which affects only the external cavity.

Because the two cavities are heavily coupled together, the actual tuning curves are as shown by the solid lines. They exhibit the two resonant frequencies that are characteristic of over-coupled, double-tuned circuits.

A third resonance at a higher frequency involves the coupling network between the internal and external cavities. Normal operating range of a VA-824 is in the full-wave cavity mode, where the greatest gain is normally attained. Useful tuning range is intimately connected with the coupling network which imposes an upper limit on the frequency attainable. Lower limit on the tuning range is imposed by the half-wave cavity mode.

A cavity mode which has one null of the electric field at the waveguide-coupling iris and another null on the other side of the drift tube on the internal cavity is defined as a half-wave cavity mode. If there is an intervening null, the resultant mode is termed a full-wave cavity mode. For each additional null, the higher-order cavity modes are referred to as three-halves, two-full-wave, five-halves, etc.

Since the VA-824 operates on the full-wave mode, a null occurs somewhere in the vicinity of the ceramic coupling window. The half-wave mode has an upper frequency limit of about 9.3 kmc. The three-halves mode has a lower limit of about 11 kmc. Because the tube is driven by an external frequency source, it is not necessary to provide mode suppression means for the two spurious modes. It is possible, however, to achieve some gain in the spurious modes if the drive frequency is adjusted to the frequency of a spurious mode.

Figure 4 is a drawing of a coupled-cavity resonator showing the magnetic and electric field configurations. From the electric field sketch, it can be seen why the tuning may be likened to capacitive tuning. The tuning screw is near a peak of the electric field of the full-wavelength cavity mode.

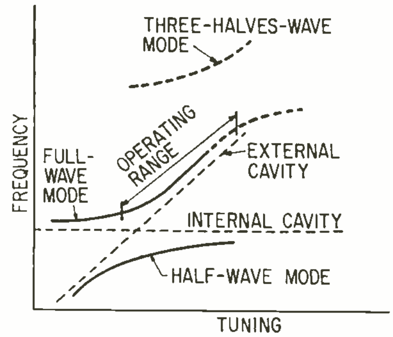
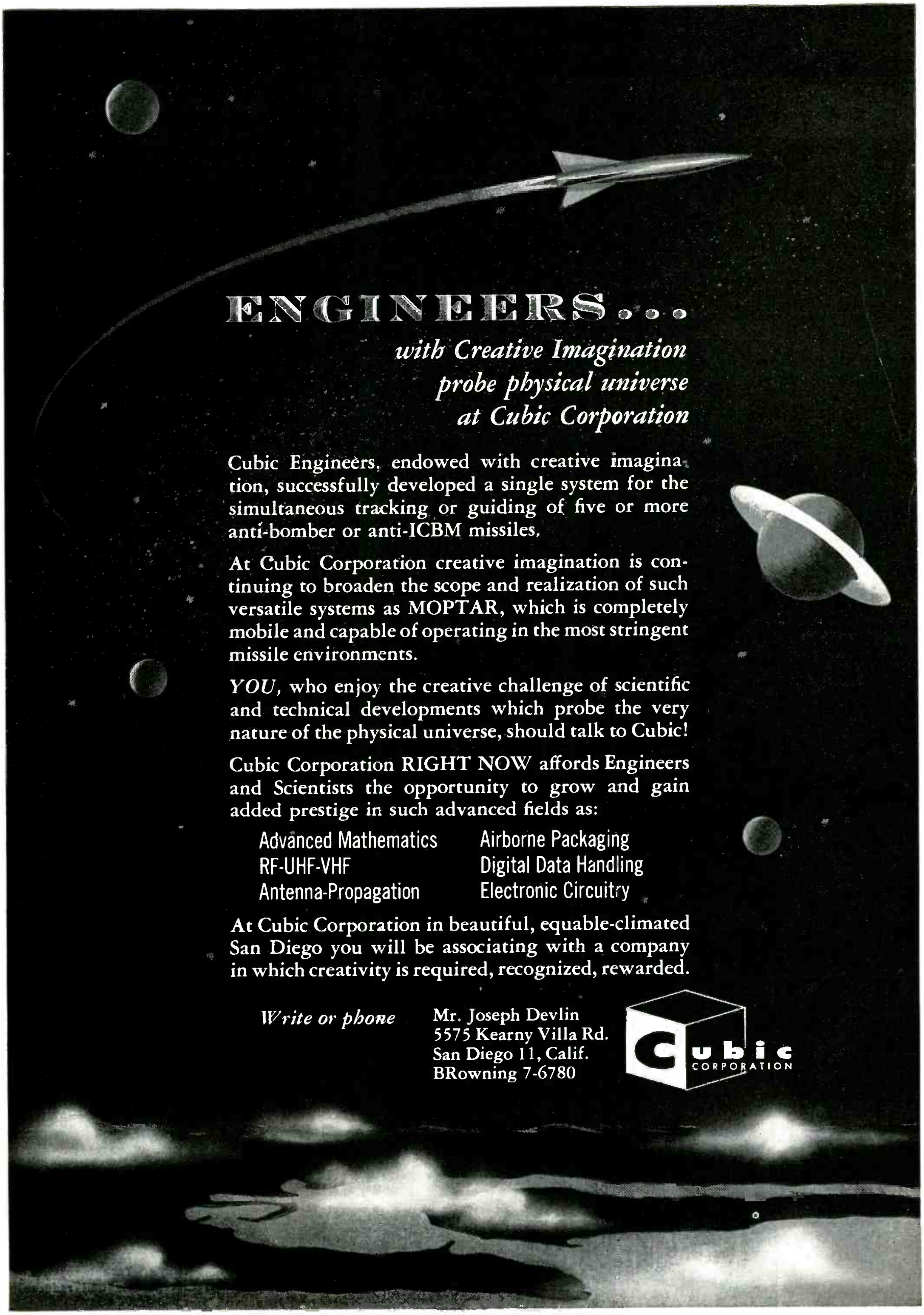


FIG. 3—Tuning curves for tightly coupled double-tuned cavity

Dimensions of the ceramic window and frame were initially chosen based on results of tests which measured the r-f transmission through the combination in waveguide with a maximum of transmission adjusted to occur at midband.

Internal cavities are of the singly re-entrant type. Both input and output cavities consist of an internal and external cavity coupled tightly by a large iris at the vacuum seal. The internal cavity is



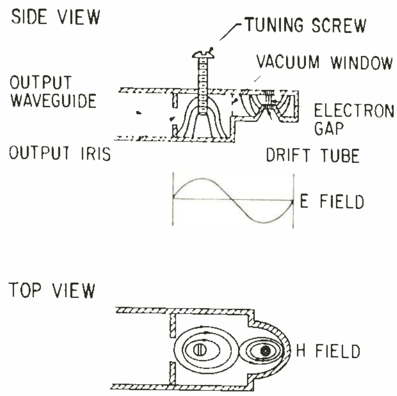


FIG. 4—Electromagnetic fields for tube

evacuated and contains the electron interaction gap. Since the portion of the resonator inside the vacuum is not tuned, it has been made rugged.

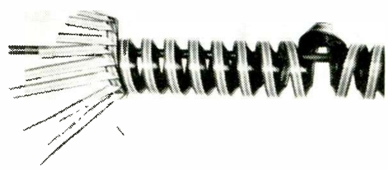
The external cavity is outside the vacuum envelope. Since it is not evacuated, a simple rugged protrusion through one wall forms a convenient tuner. The ceramic windows in the coupling irises serve as rugged vacuum seals.

As a consequence of the external-cavity construction, it was possible to design the tube with good thermal conductivity. It reaches thermal equilibrium rapidly and thermal compensation is achieved easily. In terms of the change in gain at the desired operating frequency, it has been possible to achieve temperature compensation of less than 0.025 db/C.

Conclusion

Design of an all-ceramic klystron to meet objectives of a medium power amplifier has resulted in tubes with more than specified 7.8-db gain over a 6.2-percent range in X-band. This was achieved by using a satis-

Reverse-Twist Cable



Multiconductor, multicolored retractible cable manufactured by Organic Development Corp., Garden Grove, Calif., has its winding direction reversed in the middle of its length. Technique eliminates strain at terminals and reduces inductive effect factory bandpass network between the internal and external cavities. For the particular distance of the ceramic from the gap and the thickness of the ceramic, there is a unique shape and size of the iris to result in a successful klystron amplifier of this type.

No magnetic focusing is necessary for the tube. Weight is about 8½ oz and overall dimensions are about 1½ by 2 by 3 in.

REFERENCE

(1) T. Moreno, Characteristics of Modern External Tuning Cavity Reflex Klystrons, WESCON, Los Angeles, Calif., Aug. 1956.

Dials and Scales Are Self-Illuminating

ELECTRICAL LUMINESCENT scale and dial material capable of providing its own illumination has been developed by Deutsche Philips GmbH of Hamburg, Germany.

The sheet material is built up as shown in Fig. 1. A layer of fluorescent material is located between a layer of transparent conductive material at the front and a layer of nontransparent conductive material at the back. These three layers are sandwiched between two sheets of glass.

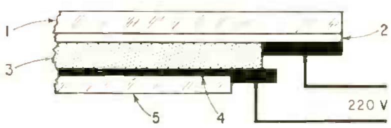
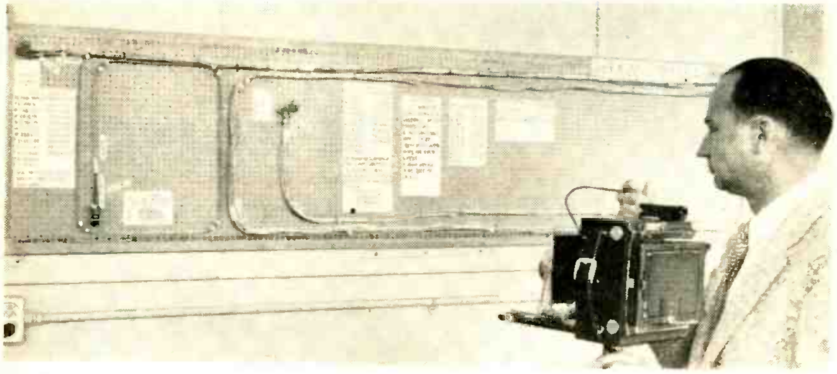


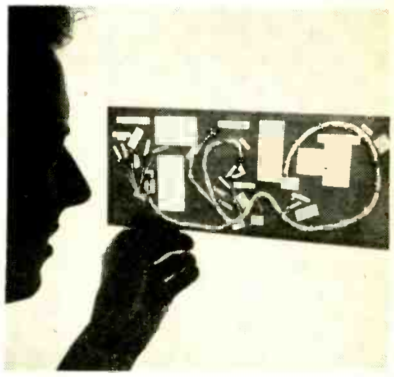
FIG. 1—Laminated scale and dial material has following layers: (1) glass front plate, (2) transparent conductive layer, (3) fluorescent layer, (4) nontransparent layer of conductive material and (5) backing plate

When the two layers of conductive material are coupled to an a-c source, electrical fields with high local field intensities are formed. The fields cause high electron acceleration. At each half-cycle point, the field polarity is reversed and the electrons give up their surplus energy in the form of light. Using a 220-volt, 50-cps source, the laminated material is said to have an indoor life of several thousand hours.

Peg Board Photos Give Permanent Harness Guide



Mockup of wiring harness and assembly directions are photographed for files and production use



5 by 20 inch blowup of master photo is easily read

ADJUSTABLE harness boards avoid storage of permanent wiring boards when harnesses must be produced in small lots over a long period of time. Permanent records and production wiring guides are provided by photos of the setups.

Convair division, General Dynamics Corp., San Diego, Calif., devised the boards shown. The firm had been using 1,600 feet of storage space for the hundreds of boards used with one airliner and would have required more space for 865 wiring setups for a new plane.

The new boards look like a giant cribbage board, painted gray. They measure 2 by 8 feet. A grid of $\frac{1}{8}$ inch peg holes is drilled in the board, with holes $\frac{5}{8}$ inch apart. Hole positions are indexed by numerals across the top and bottom of the board and letters along the sides.

The harness is first made on the board in the mockup department. Serial number and assembling directions such as peg positions, splicing instructions, wire identifications, location of identifying tapes and so on are printed on small wooden slips and fixed in place on the board.

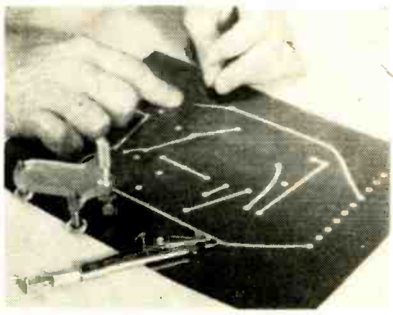
The setup is photographed and the harness, pegs and directions are stripped from the board so that it is ready for the next mockup. Three copies of the photograph are made. Two go into the planning folder for each harness and the third is sent to tooling for later transfer to assembly records.

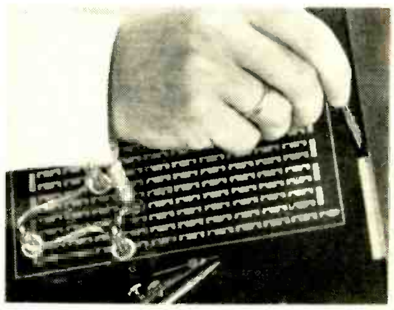
Photo copies are 5 by 20 inches, large enough for easy reading of the information on the boards. Copies are made on DuPont Chronoflex. It has a thin plastic base and can be folded and unfolded often without losing legibility.

Wiring Board Pattern Cut to Size on Film

NEGATIVES for photo-etched single and double-sided printed wiring boards may be prepared in the actual board size on coated Stabilene sheets made by Keufel and Esser Co., Hoboken, N. J.

The transparent base film is covered with a strippable translucent red coating which inhibits passage of ultraviolet rays during board exposure. Burroughs Corp. research lab in Paoli, Pa., uses the following method to prepare experimental wiring boards:





Coating is stripped from plastic film to produce photo-etch negative

A layout of the conductor side of the board is made on the reverse side of Cut 'N Strip with pencil or ink. A grid pattern slipped under the sheet facilitates spacing. After the surface is laid out, the sheet is turned red side up.

Full width conductor lines are cut with the 3-legged tool shown, using a straight-edge or French curve as a guide. The tool has twin knife points held in a metal block. Adjusting knives in 3 block sizes allows conductor lines to vary from $\frac{1}{32}$ inch to $\frac{3}{32}$ inch. Plastic buttons on the tool legs slide over the film.

The red film between the parallel line cuts is stripped away, leaving clear plastic in the conductor pattern. If a cutting mistake is made, the red coating can be renewed with a touch-up dope.

Arcs and pads are cut with a modified drop bow compass with a center dot attachment and a tungsten carbide blade. The center dot

WHAT THE "SYSTEMS CONCEPT" MEANS AT HUGHES

Activity at the Hughes Research & Development Laboratories is spread over a wide range of sciences. However diverse this activity—whether interest centers on components, sub-systems, or systems themselves —the final systems use is always a common denominator. As a result of this view, Hughes has evolved as the West's leader in advanced electronics.

COMMUNICATIONS SYSTEMS

Projects underway include the development of systems capable of deflecting their signals from meteors, artificial satellites, and even the moon. Still another area is the development of systems which transmit intelligence through media impervious to radio frequencies.

AIRBORNE SYSTEMS

Made up of advanced radars, computers, automatic flight control, communication and navigation equipment, these Hughes systems are designed to meet the ever-increasing operational and flight demands of supersonic flight.

GUIDED MISSILE SYSTEMS

A combination of most of the advanced technologies in a number of fields, the Hughes guided missile development and study programs include Ballistic Missiles, Air-to-Air Missiles, AICBM, and Surface-to-Air Missiles.

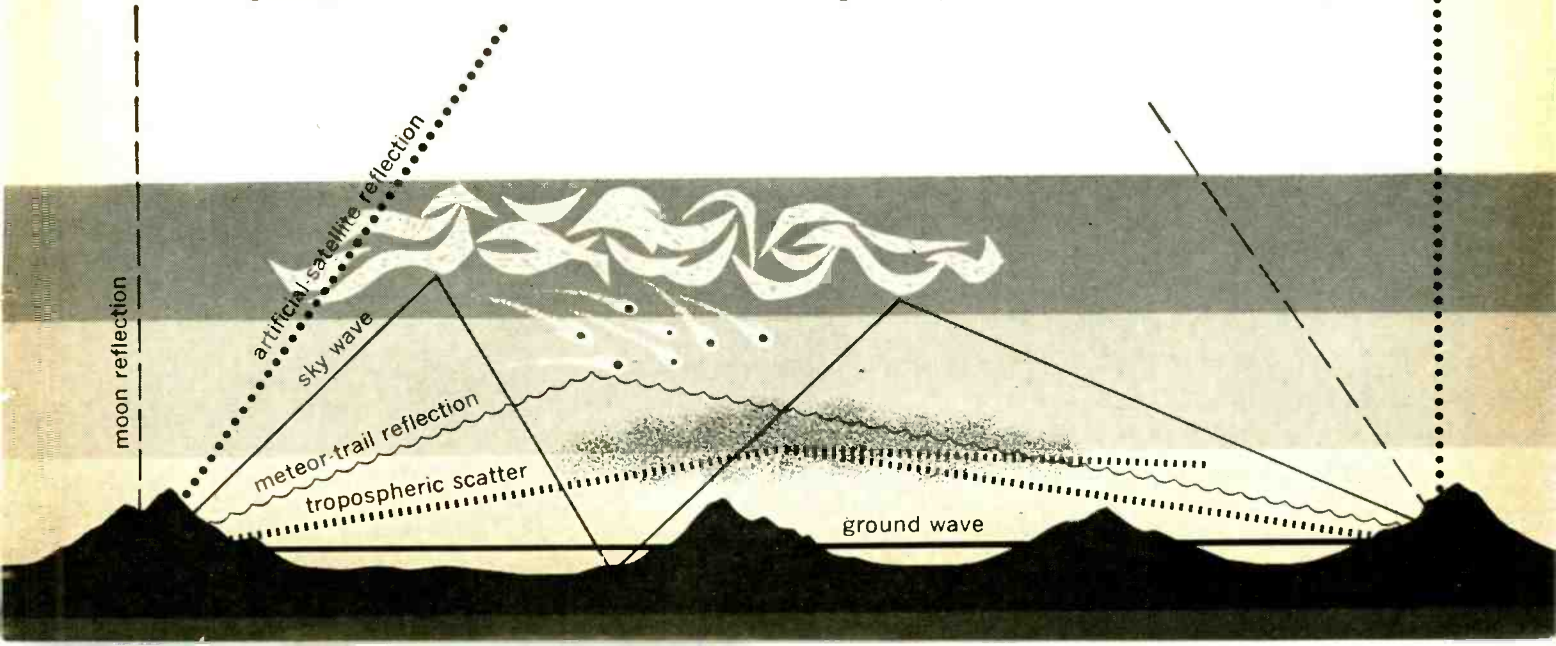
Diversification and expansion by the Hughes Research & Development Laboratories into unexplored new areas have created more engineering openings than ever before existed! Engineers or Physicists, with degrees from accredited universities may investigate by writing directly to:

Dr. Allen Puckett, Associate Director,
Systems Development Laboratories

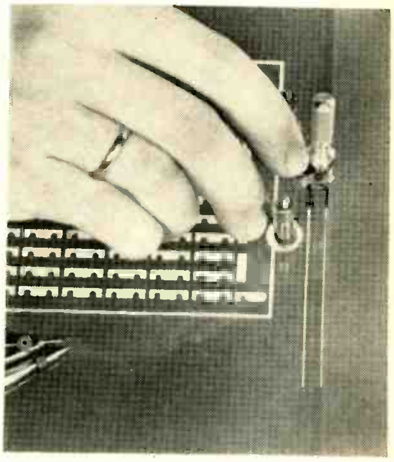
the West's leader in advanced electronics

HUGHES

Hughes Aircraft Co., Culver City 22, Calif.



is a guide for drilling holes. The dot is made by a sleeve cutter on the compass center post. Where a hole, but not a pad, is desired, the sleeve cutter is used and the dot stripped off so the hole location will appear as a small island of copper on the finished board.



Cutting tool scribes parallel lines

Double-sided boards can be made from a layout on one sheet of film. The pattern of one side is drawn with solid lines and the other side with dotted lines. Hole locations for both sides have common center points.

The front side of the board is then cut on the red surface of the sheet on which the layout is made. The under side is cut on a second sheet placed with its layout side against the layout side of the first sheet, so the red is up.

The conductor lines may be cut with an ordinary knife, but the edge definition and the uniformity of the conductors will probably suffer.

Fixture Design Makes Wire Assembly Easier

WIRING ASSEMBLY fixture with sheet metal slots and stalls enables assemblers to organize their work better, saves bench space and is easier to work with, reports United Controls Corp., Seattle, Wash.

The firm uses the fixture shown in production of a missile change-over switch assembly. The assembly consists of 111 wires which are soldered to 3 connectors, bundled

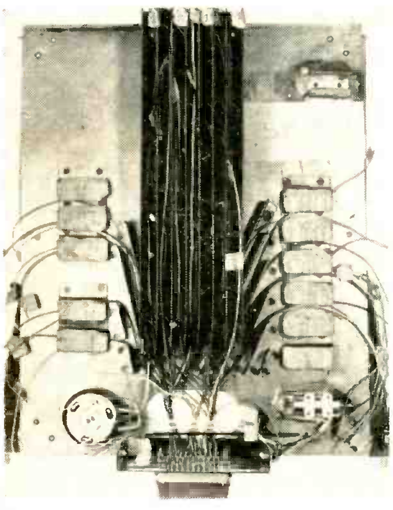
Slots keep wires sorted out after soldering to connectors

and lugged to 32 switches.

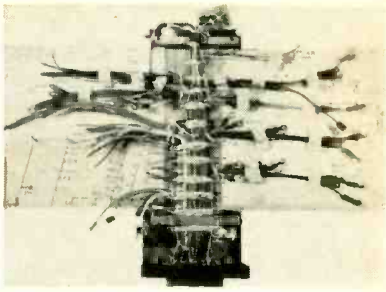
Base of the fixture is a plate resting on triangular supports at right and left edges. The back leg of the triangle is 2 pieces connected by a wing nut so that the slope can be adjusted. The connectors, in an end plate which becomes part of the final assembly, rest in a holder at the bottom of the plate.

Three groups of wire channels are provided. One group, above the connectors, holds the wires for the top switches. This group is mounted on pegs to provide clearance for the 2 other groups of channels, which are riveted to the main plate. The latter run diagonally from the connectors and hold the wires for the lower switches. Holding stalls are placed alongside the lower wire channels.

Routing directions are taped on the fixture. Wires are color coded and tagged with identifying tape. Channeling and tagging eliminates checking back on wires



Top view of wiring fixture



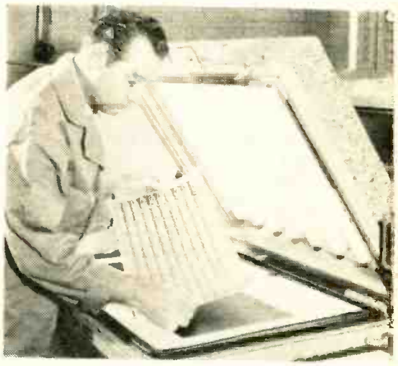
Second fixture directs terminal attachment

during assembly. Faults found in functional testing can be localized in a single bundle of wire.

Previously, assemblers snaked wires between pegs on a flat fixture. The new fixture, designed by Mrs. Bette Koons, wire assembler, is credited with a 30 per cent saving in wiring time.

After assembly, the harness is laid out on a second fixture, which rests on top of the final assembly chassis. Wires going to particular switches or other components are kept loosely bundled with tape and terminals are attached. The fixture is marked with terminal locations.

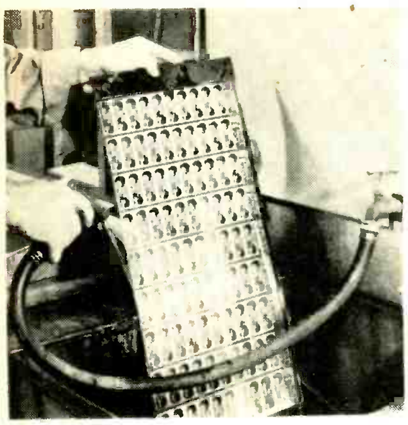
Sensitized Metal Is Base for Name Plates



Negative of multiple artwork is placed on metal sheet in printing frame

NAME PLATES, instructions and dials may be produced with sensitized metal sheet and photographic techniques. The technique is reported as suitable for short run needs, or for quantity production when name plate changes are frequent.

The process illustrated was adopted by Hughes Aircraft Co., El Segundo, Calif. It uses an anodized metal sheet coated with a



Sheet of name plates is rinsed after unexposed areas are etched off

Sheet is sheared into finished name plates

light-sensitive, acid-resistant ink. The material and processing chemicals were supplied by Miller Dial and Name Plate Co., El Monte, Calif.

After preparation of multiple artwork, a composite negative or positive is made. The negative is placed in a printing frame in contact with the Fotofoil and exposed for one minute. The exposed sheet is bathed in ink hardener for 45 seconds. The solution hardens exposed areas of the coating and softens unexposed areas.

A hard stream of cold water washes the coating from unexposed areas. The colored anodized coating revealed is then etched away so that printing appears as clear metal on a colored background. After another rinse, the sheet of name plates is ready for shearing and punching.

When runs of several thousand duplicate plates are made, Hughes reports, two men (with assistance of art and photographic departments) can produce 7,000 plates daily in a working area of 48 square feet.

NEW PRODUCTS

Events Counter
two versions

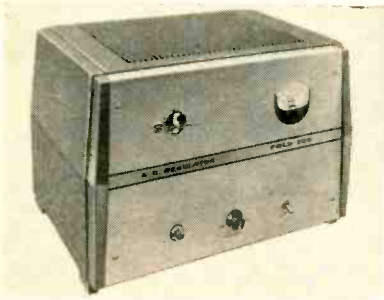
The Hunter Mfg. Co., 108 N. Linn St., Iowa City, Iowa, is producing two versions of its electrical events counter. Model 122A will count at rates up to 1,000 events per sec, while the 122B handles up to 2,000 events per sec. Six digits in the model 122 permit counting up to 999,999. A pushbutton reset control will instantly clear all figures at any time. The unit counts electrical pulses of at least 12 v magnitude, with the recommended range from 12 to 50 v. Terminals for accepting the pulses are located on the rear panel. The last two figures in the count appear on glow decade tubes. The other four digits appear in a mechanical counter lo-

cated on the left side of the front panel. **Circle 300 on Reader Service Card.**

Teflon Terminals
tiny feed-through type

Sealectro Corp., 610 Fayette Ave., Mamaroneck, N. Y., has developed a subminiature feed-through Teflon terminal which provides an excellent mechanical as well as soldering bond especially with finer wires. Instead of just being wrapped around each end

lug, in this type the connecting wire first passes through a hole and then wraps around the lug for greatest security. Each end lug is flatted on both sides, rather than just plain round, for tighter wrapping of the wire. This type FT-SM-93 ML measures only 0.093 in. for bushing diameter by 0.100 in. long, or 0.380 in. overall including both end lugs. The holed and flatted lugs provide extra holding power where vibration and shock are vital operational factors. **Circle 301 on Reader Service Card.**

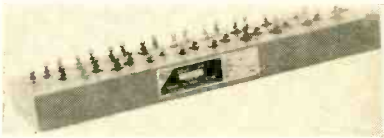


Voltage Regulator
fast response

Sorensen & Co., Inc., Richards Ave., South Norwalk, Conn. Model FRLD 750 a-c voltage regulator features fast response and the ability to reduce line distortion below 0.35 percent. Transients caused by line or load changes are suppressed within less than one cycle, and regulation accuracy is within ±0.25 percent for line and load changes combined. Even when input distortion is above that of the normal utility supply, its effect on the output is reduced by a factor of at least 8:1, and transient magnitude is also reduced by the same factor. **Circle 302 on Reader Service Card.**

H-V Delay Line
multitap unit

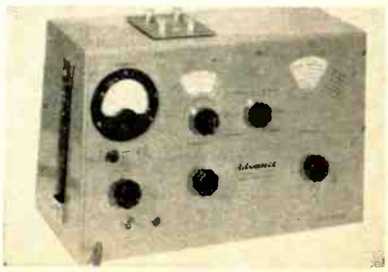
Control Electronics Co., Inc., 1925 New York Ave., Huntington Station, N. Y. The F384 h-v, lumped constant, multitap delay

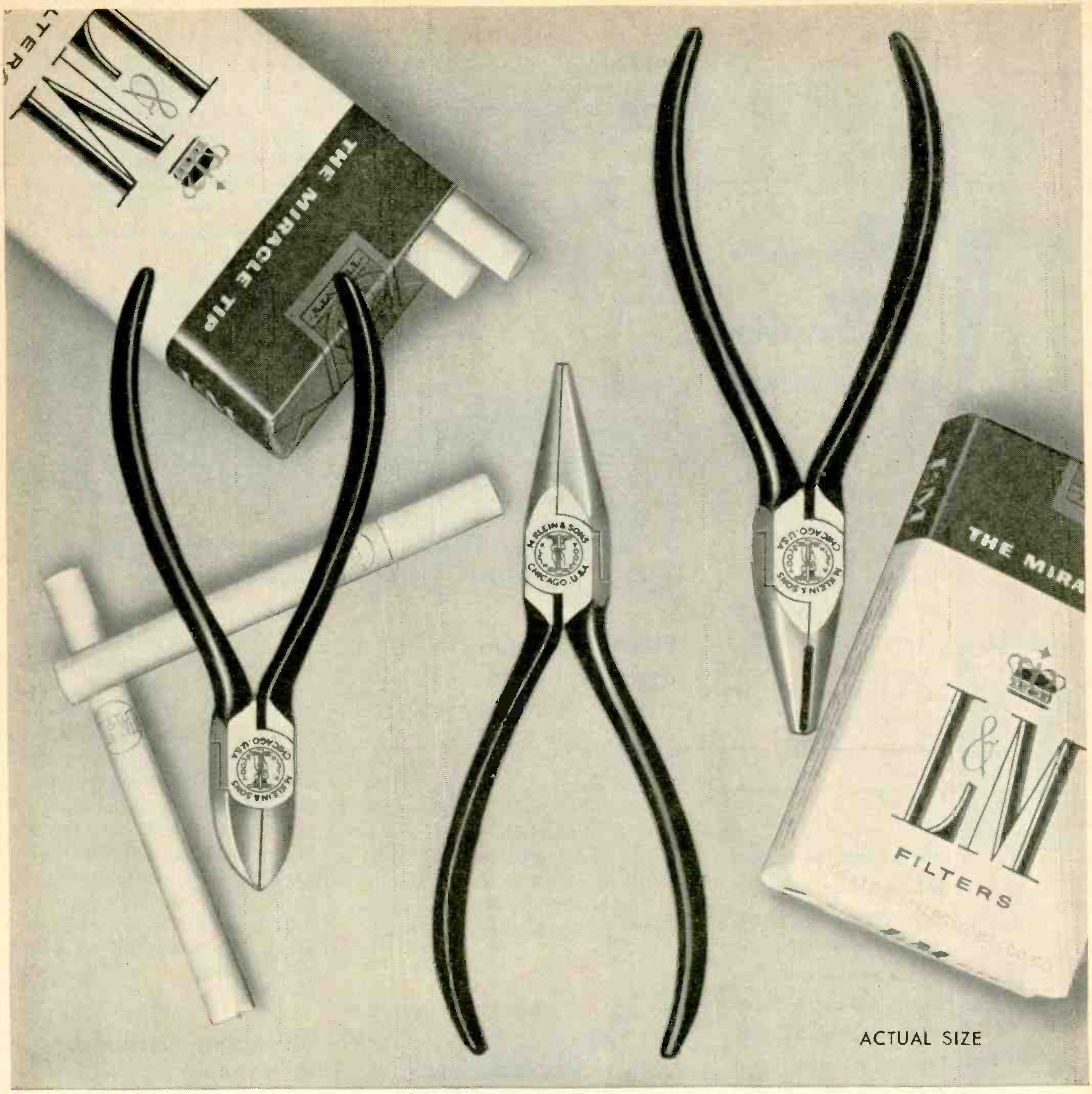


line features a 2.5 kv d-c rating and high accuracy in its multitap positions. It has a 66 μsec total delay with taps every 2.0 μsec. Rise time is approximately 10 percent of the delay selected at any one of its 33 tap points. Impedance is 9,100 ohms. **Circle 303 on Reader Service Card.**

Q Meter
a-c operated

North Hills Electric Co., Inc., 402 Sagamore Ave., Mineola, N. Y. This new Q meter provides a convenient method for making r-f measurements of circuit magnification, inductance, capacitance and power factor at frequencies between 100 kc and 100 mc. A signal from the internal oscillator is injected into an inductive loop across which the voltage is metered and adjusted to a set level. A fraction of the loop provides a signal with low input impedance to the test circuit. The coil under test is in series





3 New Midget Pliers by KLEIN

Here is a new line of genuine Klein Pliers in oblique and long nosed patterns specially designed for wiring modern electronic assemblies or doing any close work in confined space.

These midgets are hardly longer than your favorite package of cigarettes and their extremely small size will simplify many small close-tolerance jobs.

Available in oblique cutting, long nose with and without knurl, and end cutting pliers.

See your distributor.

No. 257-4	Oblique Cutting Plier. Size	4 in.
321-4½	Long Nose Plier	4½ in.
322-4½	(Without Knurl)	4½ in.
224-4½	End Cutting Plier	4½ in.

Available with coil spring

No. 257-4C Oblique Cutting Plier
321-4½C Long Nose Plier
322-4½C (Without Knurl)
224-4½C End Cutting Plier

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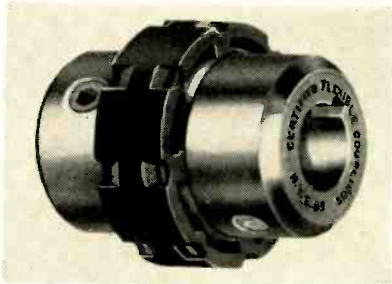
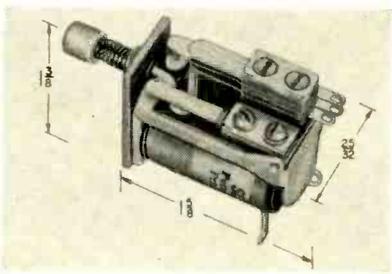
Bulletin 758 on Klein Pliers sent you on request.

resonance with an internal low loss, variable capacitor. The voltage across the capacitor indicates the Q, and is detected by a voltmeter calibrated directly in terms of circuit magnification. The oscillator is modulated at 60 cps 50 percent, so that d-c amplifiers need not be used in the voltmeter, thus eliminating zero setting. **Circle 304 on Reader Service Card.**



Flexible Coupling new size added

CERTIFIED FLEXIBLE COUPLINGS, INC., 37 North Bond St., Mt. Vernon, N. Y., has added a new size flexible coupling to its line. The 5R flexible coupling is for shaft sizes $\frac{3}{4}$ in. to $1\frac{5}{8}$ in. with every $\frac{1}{16}$ in., millimeter size, and their combinations inclusive. It is rated for 15 hp maximum at 1,750 rpm. **Circle 305 on Reader Service Card.**



Relay telephone type

POTTER & BRUMFIELD, INC., Princeton, Ind. A miniature telephone type relay features a push-to-release reset lever. Designated the MA, it operates on 2.4 w, 25 millisec pulses and features contact arrangements up to 4 pdt. It can be furnished to operate on d-c voltage or current values up to 110 v or 11 amperes. When the relay operates, a latch lever locks the armature in position so that the contacts remain transferred when power is removed from the coil. The contacts return to their original position when the reset lever is pushed to release the latch lever. **Circle 306 on Reader Service Card.**

Beam Power Tube high-perveance

RADIO CORP. OF AMERICA, Harrison, N. J. The 7027 is a high-perveance beam power tube for use in push-pull power-amplifier circuits of high-fidelity audio equipment. Featuring high power sensitivity and high stability, it is capable of delivering high power output with low distortion. For example, two 7027's in class AB_1 push-pull service with 450 v on the plate can deliver a maximum-signal power output of 50 w with total harmonic distortion of only 1.5 percent. **Circle 307 on Reader Service Card.**

Sweeping Oscillator dual output

KAY ELECTRIC CO., Maple Ave., Pine Brook, N. J., announces a sweeping oscillator with marks which provides two simultaneous sweeps—high to low and low to high—for suppressed carrier frequency alignment. Called the Dual Radar-Sweep, the all-electronic instrument features two individual outputs centered at 37.5 mc. The low-to-high sweep is from 30 mc to 45 mc; the high-to-low sweep, from 45 mc to 30 mc. Unit has a built-in agc circuit that equalizes the amplitudes of both sweeping outputs. A coherent frequency excursion is maintained in both directions to establish a crossover point directly at the center of the bandwidth. The instrument also presents simultaneously on the oscilloscope both the wide and narrow sweeps around a common center. Circle 308 on Reader Service Card.

Frequency Test Set audio and carrier

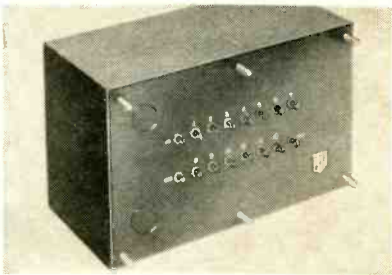
Stewart Brothers, Div. of Instrument Laboratories, 315 W. Walton Place, Chicago 10, Ill., announces model JK audio and carrier frequency test set. Transistor oscillator supplies stable 1,000 cps constant voltage. Output is 0, −13, −16 db into 600 ohm line. Output impedance is 600 ohms. The db meter is accurate from 60 cps to 600 kc; readable from −20 to +53 dbm. Self contained loads of 150 and 600 ohms can be selected by switch if desired. Circle 309 on Reader Service Card.

Audio Oscillator panel mount

Waveforms, Inc., 331 Sixth Ave., New York 14, N. Y. A new method of instrument mounting is embodied in the 510B-P oscillator. Assembled on an oversize panel which serves as both mounting plate and escutcheon. the total panel area of the instrument is only 7 in. by 4$\frac{3}{4}$ in. The unit can be bolted to any panel with a cutout of 6$\frac{1}{16}$ in. by 4$\frac{5}{16}$ in. The oscillator covers the range 18 cps to 1.1 mc and delivers 10 v output. Frequency accuracy is 2 percent. Response is $\pm\frac{1}{2}$ db. Price is $160. **Circle 310 on Reader Service Card.**

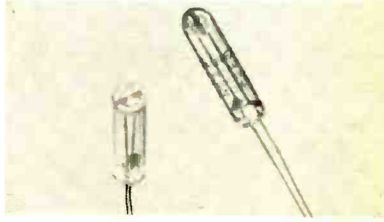
C-R Tubes
three types

SYLVANIA ELECTRIC PRODUCTS INC., 1740 Broadway, New York 19, N. Y., has announced a series of three 5-in. crt's featuring high deflection sensitivity and resolution. Type 5UP1 is characterized by green fluorescence and medium persistence. The 5UP7 has a blue-white fluorescence, yellow phosphorescence, and long persistence phosphor. The 5UP11 employs blue phosphor and has a short persistence. **Circle 311 on Reader Service Card.**



Delay Line
145 to 1 ratio

ESC CORP., 534 Bergen Blvd., Palisades Park, N. J. A new lumped-constant delay line has an extended bandwidth. Delay-to-rise-time ratio of 145 to 1 enables computer engineers to design delay line memories with 72 bit storage capacity rather than 25. The new unit measures 3 in. by 4$\frac{1}{2}$ in. by 8$\frac{1}{2}$ in. Temperature coefficient of delay is less than 65 ppm per deg C and can be improved considerably. **Circle 312 on Reader Service Card.**



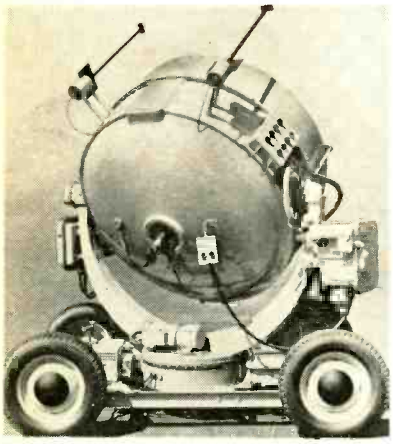
Photocells
polycrystalline

CLAIREX CORP., 50 W. 26th St., New York 10, N. Y., announces a series of polycrystalline photoconductive cells. The elements consist of photoconductive material on one side of a ceramic wafer which is $\frac{3}{16}$ in. in diameter and $\frac{1}{16}$ in. thick. Indium electrodes symmetrically cover part of the surface, leaving a sensitive area which is a rectangle $\frac{3}{16}$ in. long by approximately $\frac{3}{64}$ in. wide, with the electrodes along the length of the sensitive area. **Circle 313 on Reader Service Card.**

Centrifugal Pump
miniaturized

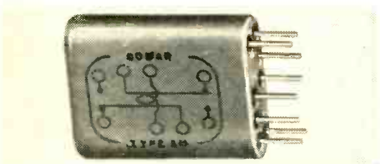
NORTHERN RESEARCH AND ENGINEERING CORP., 100 Memorial Drive, Cambridge 42, Mass., has developed a miniature, high specific speed, centrifugal pump for aircraft and missile heat transfer and cooling systems. Life expectations exceed 15,000 hr. Flow rates in excess of two gallons per minute and pressure exceeding 100 in. (of the fluid being pumped) can be obtained at speeds up to

10,000 rpm. Less than 6 w input to the pump are required through this entire range of operation. Maximum pump efficiency is from 35 to 40 percent at pressures of 40 to 60 in. and at wheel speeds from 8,500 to over 9,500 rpm. Circle 314 on Reader Service Card.



Solar Furnace fully automatic

THERMAL DYNAMIC PRODUCTS, INC., 38 W. 53rd St., New York 19, N. Y. A new and fully automatic solar furnace is now available to research laboratories, and scientific and industrial testing companies. Important features incorporated in its design include a fully automatic electronic solar tracking system to maintain precise alignment of the parabolic lens with the sun, as well as motor driven remote controls for sample positioning and temperature adjustment. The solar furnace is ideally suited for testing materials such as those used in a missile nose cone. It may also be used for simulating temperature conditions present in a nuclear reactor. Circle 315 on Reader Service Card.



Subminiature Relay high precision

COMAR ELECTRIC CO., 3349 W. Addison St., Chicago 18, Ill. Type

S-M relay, less than 1 in. long and weighing less than ½ oz, is designed for control systems, computers, aircraft, missiles and applications requiring miniature size and dependable performance. It is designed for continuous use in the −65 C to +125 C temperature range. Life expectancy is 100,000 operations minimum, at rated load. Nominal coil voltage is 26.5 v d-c; contact arrangement, 2 pdt; contact rating, 2 amperes at 28 v d-c resistive (maximum). Circle 316 on Reader Service Card.

Positioning Towers all-dielectric

SCIENTIFIC-ATLANTA, INC., 2162 Piedmont Road N.E., Atlanta, Ga., announces the series 401 model range towers for supporting and positioning antennas, reflectors and scale model airframes. Constructed entirely of low dielectric constant materials above the base unit, allows reflectivity or radiation pattern measurements to be made under simulated free space conditions. Other features include variable speed drive and dual synchro position information for both axes, optional height of 8 and 16 ft by use of an 8 ft extension section and a load capacity of 200 lb. Circle 317 on Reader Service Card.

Trigonometric Pot 3 in., 15 turn

ANALOGUE CONTROLS, INC., 39 Roselle St., Mineola, N. Y., announces the model PT315 trigonometric potentiometer. Developed initially for extreme accuracy conversion of slant range to ground range and altitude in d-c analog computation, these pots enable accurate triangle solution over a range of angles commonly encountered in navigational problems. They are usable at conventional carrier frequencies as well as d-c. The units are internally compensated for a specified load so that no isolation amplifier is required. Circle 318 on Reader Service Card.

Low Noise Amplifier 150 mc to 300 mc

HALLER, RAYMOND, AND BROWN, INC., Circleville Rd., State College, Pa., has developed a new, low noise distributed bandpass amplifier to cover the frequency range 150 to 300 mc. It has a gain of 24 db and a noise figure of 6 db over frequency range. Design incorporates an input network consisting of a pair of low noise triode amplifiers which allows for greatly improved sensitivity and flutter response characteristics. Subminiature components and printed circuit techniques have been employed to reduce weight and space required. Circle 319 on Reader Service Card.

TWT Solenoid light weight

NEW YORK TRANSFORMER CO., INC., Alpha, N. J. The No. 39803 solenoid was designed to produce a flux of 600 gauss for focusing traveling wave tubes. The solenoid proper is 7½ in. long and has a circular opening of 1½ in. to accept the tube and wave guide assembly. Weighing only 13 lb, it produces a full flux field with a low input power of 100 to 125 w. A small built-in blower keeps the temperature rise to 65 C. Circle 320 on Reader Service Card.

Literature of

MATERIALS

Insulation Tubing. The William Brand & Co., Inc., Willimantic, Conn. A four-page publication includes samples, applicable specifications, operating temperatures, available sizes, standard colors stocked and a general description of Turbo plastic and coated insulation tubings. **Circle 321 on Reader Service Card.**

Epoxy Resins. Marblette Corp., 37-31 Thirtieth St., Long Island City 1, N. Y., has published a guide to resin selection for plastic tooling, potting and impregnating, coating and adhesion. **Circle 322 on Reader Service Card.**

COMPONENTS

Decade Counter Tubes. Sylvania Electric Products Inc., 1100 Main St., Buffalo, N. Y. An 8-page brochure lists minimum and maximum ratings on a variety of bidirectional counter tubes. It includes data on two new tube types, 7155 and 6476A. **Circle 323 on Reader Service Card.**

High-Voltage Switch. G. H. Leland, Inc., 123 Webster St., Dayton 2, Ohio. Bulletin 158-HV gives performance data and environmental conditions of the C-80335-001 hermetically sealed high voltage rotary selector switch. **Circle 324 on Reader Service Card.**

Precision Pots. Electromath Corp., 42-14 Greenpoint Ave., Long Island City 4, N. Y., has available a brochure containing data sheets on its latest designs of single and multiturn precision potentiometers. **Circle 325 on Reader Service Card.**

Transistorized Chopper. Solid State Electronics Co., 8158 Orion Ave., Van Nuys, Calif., has available literature explaining the operation and application of the model 50 transistorized chopper, a solidly encapsulated unit designed to alternately connect and disconnect a

the Week

load from a signal source. **Circle 326 on Reader Service Card.**

Waveguide Filters. Microphase Corp., Box 1166, Greenwich, Conn. Supplement 1 to Catalog C2 illustrates typical waveguide r-f filters with very sharp cutoff and low insertion loss in the passband. **Circle 327 on Reader Service Card.**

EQUIPMENT

Airborne Power Supply. General Electric Co., Schenectady 5, N. Y. Bulletin GEC-1497 deals with a 28-v, one-ampere unregulated transformer-rectifier airborne power supply. **Circle 328 on Reader Service Card.**

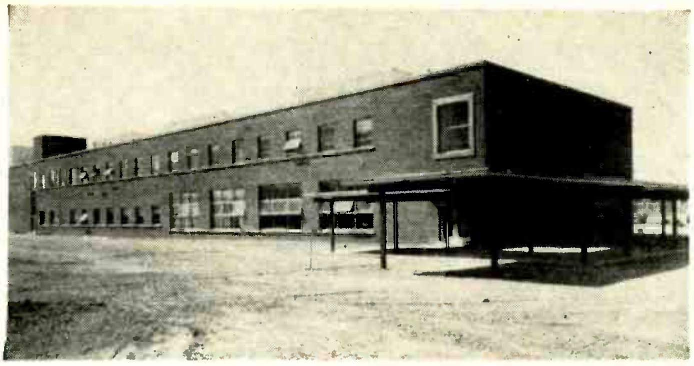
Nuclear Instruments. Hamner Electronics Co., Inc., P. O. Box 531, Princeton, N. J. A condensed catalog shows the company's complete line of nuclear instruments for research and industrial control. **Circle 329 on Reader Service Card.**

Sweep Signal Generator. Electronics Division, Van Norman Industries Inc., 186 Granite St., Manchester, N. H. A four-page folder illustrates and completely describes model SG-132 15-400 mc vhf-uhf sweep signal generator. **Circle 330 on Reader Service Card.**

FACILITIES

Precision Gears. U.S. Gear Corp., 81 Bay State Rd., Wakefield, Mass. A recent folder shows the company's facilities for inspection and assembly, cutting, quality control and machining of precision gears. **Circle 331 on Reader Service Card.**

Transistor Circuitry. Transistor Applications, Inc., 50 Broad St., Boston, Mass. A recent booklet discusses the company's personnel and facilities for work in the transistor circuitry field. A list of the company's complete equipment is also included. **Circle 332 on Reader Service Card.**



GE Opens New Silicone Lab

PART of the latest multimillion dollar expansion of the General Electric silicone operation is a new laboratory (picture) now being occupied in Waterford, N. Y. Expansion of silicone facilities, begun in 1956, will be continued through 1958 and '59 in conjunction with the Operation Upturn program being conducted by GE throughout the country.

The new laboratory, a two-story brick structure, houses complete equipment and services required for study of new silicone gums and rubber compounds, silicone fluids, resins and emulsions. Also located there are advance development laboratories, complete library facilities, management offices and conference rooms.

A considerable portion of the department's analytical services will also be performed in the new lab as soon as supplementary equipment now on order is delivered and installed.

Major items in the Operation Upturn program for GE silicones are the completion and equipping of a new process development laboratory and conversion of the original product lab into a marketing technical center.

Charles E. Reed, department general manager, points to this work as excellent examples of the major goals of the program. "New and improved silicones and the added values they will contribute to products in which they are used will lead directly to increased sales and employment by us and our customers," he says.

Total costs for the current expansion of silicone facilities will exceed $5 million, reports Reed. This figure includes the purchase of an additional 69 acres of land acquired at Waterford two years ago. Most of this land has been earmarked for growth expected in the 1960's.

ERI Gets New Name, Functions

CHANGES in the name and functions of the Engineering Research Institute at the University of Michigan were made recently. The new name is "University of Michigan Research Institute." Its functions are broadened to include all areas of University contract research programs. ERI research has been concentrated largely in engineering and physical sciences.

The director of the institute now will report to the vice president and dean of faculties rather than to the dean of the college of engineering. In another change approved by the University's Board of Regents, the Willow Run Laboratories have been recognized as a separate research unit with a director and an executive committee. These laboratories are to confine research activities to the fields of engineering and physical sciences.

In separate actions, the board of regents approved appointment of Robert E. Burroughs, acting director of ERI since March 1, 1958, as director of the University of Michigan Research Institute, and of Joseph A. Boyd as director of the Willow Run Laboratories. Both appointments were effective July 1, 1958. Executive committees for both units also were approved.

Society Admits Sperry Division

THE American Astronautical Society announces that Sperry Gyroscope Co., division of Sperry Rand Corp., has become a corporate member of the society.

A certificate of corporate membership will be given to the Long Island aviation electronic company at the society's annual meeting in December in Washington, D. C.

Advance Moody At Beckman

APPOINTMENT of Robert E. Moody as a chief project engineer for Beckman/Scientific Instruments Div., Fullerton, Calif., is announced. He will direct research and design work on ultraviolet spectrophotometers and accessories.

Moody moves to the new post from that of project engineer. Prior to joining Beckman in 1953, he was an electronics supervisor with Boeing Airplane Co., Wichita, Kansas.

'Copter Launches New Plant

HELICOPTER delivery (picture) of building plans by pioneer 'round-the-world' flier Jimmie Mattern to J. F. (Jack) Ray, vice president, recently started construction in Burbank, Calif., of a new General Controls Co. Aircraft and Electron-

ics Divisions facility. Ultimate cost will be $5,600,000.

Ray and Mattern formally broke ground for the first $2 million unit of 70,000 sq ft. Mattern made the plans delivery while hovering over a bulldozer.

General Controls is a pioneer in controls for aircraft and missiles automation, with products ranging from thermocouples to air data computers.

Mattern said precision hovering over the bulldozer was made possible by a new helicopter altitude controller developed by General Controls engineers.

It is an electronic device that feeds signals to the cockpit that enable the 'copter pilot to automatically hold and correct the craft's altitude within two feet. The controller will be one of the first products made in the new plant.

Microtech Gets More Space

ACQUISITION of an additional plant in North Haven, Conn., is announced by Microtech, Inc., Hamden, Conn. Total manufacturing space is now increased to 11,000 sq ft. Much of the new space will be devoted to various double ridged waveguide programs for electronic counter measures.

Servomechanisms Division Moves

MECHATROL division of Servomechanisms, Inc., has moved its entire sales, engineering and manufacturing operations into its recently completed 55,000 sq ft building (picture) in Westbury, L.I., N.Y. The new building will provide the necessary room and ideal conditions for the manufacture of Mechatrol's expanding line of servo and control motors, tach generators and packaged rotating components for missile and air frame equipment manufacturers.

Kaufman Takes Key Post at Del

DEL ELECTRONICS CORP., Mt. Vernon, N. Y., appoints Raymond Kaufman (picture) to the position of vice president and director of research. He was formerly senior physicist and project engineer with the Farrand Optical Co. Inc.

Name Ogilvie Chief Engineer

ELECTRICAL Communications, Inc., San Francisco, Calif., has appointed Allan R. Ogilvie (picture) chief engineer.

Since relocating on the west

coast over a decade ago, Ogilvie has served as v-p of the Remler Co., v-p of Hancock Electronics Corp., and product manager for Sierra Electronic Corp., a subsidiary of Philco Corp.

In the east he was associated with RCA and was v-p and general manager of the electronics division of Maguire Industries.

Ogilvie's new post entails responsibility for the firm's research and engineering in the fields of communications signaling and industrial control systems.

RCP Hires Fellendorf

George W. Fellendorf (picture) has joined the staff of Radio City Products Co., Inc., Easton, Pa., as sales and contracts manager. He will coordinate the firm's military products program and its growing R&D lab. He will also be responsible for selecting additional engineering personnel to augment the present technical staff.

Prior to joining RCP, Fellendorf was v-p of Instruments for Industry, Inc., Mineola, N. Y.

Organize New Company

Formation of Measurements Research Co., Philadelphia, Pa., is announced by O. J. R. Troup, president of Prudential Industries Inc. The new firm was formerly known as the Electronics Division of Atlas Precision Products which is also part of Prudential Industries.

Scope of operations of the new

company includes research, design, development and fabrication of electronic test and measuring equipment, instrumentation and control devices.

Executive Moves

James L. Anast has left the top technical post with the Airways Modernization Board, to accept the position of assistant for technical planning to the president of Lear Inc., Los Angeles, Calif.

Three execs move up at Varo Mfg. Co., Inc., Garland, Texas. **Austin N. Stanton,** former president, becomes chairman of the board. **Robert L. Jordan** is promoted from executive vice president to president. **George F. Lewis** advances from assistant secretary to vice president.

Kendall Clough has been named director of engineering for the Paraplegics Mfg. Co., Inc., designers and fabricators of electronic assemblies at Franklin Park, Ill. Formerly a consultant, he will have charge of the project engineering, design, research and development staff.

News of Reps

Product sales for Offner Electronics Inc., Chicago, Ill., will be handled in upper New York State by the **Snelling-Bogossian Co.**

F-R Machine Works, Inc., Woodside, N. Y., appoints **J. R. Dannemiller Associates** as exclusive sales reps for precision microwave equipment in Ohio, Michigan and western Pennsylvania.

Electro-Pulse, Inc.. Culver City, Calif., will be represented in western Wisconsin, western Iowa, and Minnesota by **Engineering Products Associates;** in Texas, Oklahoma, Louisiana, and Arkansas, by **Paul Wallace Co.**

Daystrom Transicoil appoints **Zak & Cowen** as its sales rep in the states of Missouri, Kansas and eastern Nebraska.

NEW BOOKS

Feedback Control Systems

By OTTO J. M. SMITH. *McGraw Hill Book Co., Inc., New York, 1958, 694 p, $13.50.*

This textbook is of singular significance in the contemporary literature on feedback control systems. Its quality is the unified result of contents, approach and a high level of sophistication. The material contained is advanced, dealing mainly with the optimization of feedback system performance based upon statistical synthesis.

Major Divisions—The book is subdivided into four major parts, the first of which is entitled Linear Analysis. Here is included the normal material on transient response, complex plane mapping and stability criteria. A good chapter introduces the concept of power spectra and its relationship to correlation functions and system design.

Part II is devoted to linear synthesis; it is here that this text shows a rapid departure from the conventional approaches. A minimum error power criterion coupled with the restrictions of physical realizability and stability in system design are examined and applied. Spectra of servo inputs are developed, including those where random step ramp, acceleration and thermal noise are the reference variable.

The design problem is given as the prediction and generation of the best signal to enter the unalterable portions of the control system. Emphasis is also applied to the adaptive type of system which alters its internal parameters as a function of changes in signal and noise power. After specification of closed-loop responses, the author shows the use of the root-locus technique for synthesizing the open-loop transfer function based upon closed loop criteria.

The final chapter in this part is devoted to systems with distributed parameters and to linear predictor control as applied to systems of this type.

Steady-State Nonlinear Analysis—Part III is devoted mainly to the application of describing function techniques to various classes of nonlinear systems. The method is applied to relay servos, systems with multilevel decision devices, systems with saturation, dead-zones, hysteresis and other unilateral nonlinearities. Bilateral nonlinearities, including backlash, velocity hysteresis and coulomb friction are also treated.

Predictor Control of Nonlinearities—In Part IV the advantages of operating output transducers at their maximum or saturated output level is demonstrated and the design of nonlinear computers to determine optimum switching and control intervals is examined. The method of phase plane analysis is applied to these problems; the action of nonlinear compensation is also studied. Examples of predictor control of elementary saturating servos and of complex nonlinear systems are given. The last chapter in this section is devoted to carrier systems, its inclusion is apparently more for the sake of completeness than continuity.

As is clearly demonstrated from the text's coverage outlined above, this book should be as important a source of information for the research and development engineer in the field as for the graduate level student in advanced feedback control. Its material is a well organized compilation of the latest techniques being developed and used in the field today. As such, it represents a worthwhile addition to the library of the serious student of the literature of feedback control systems.—A. E. Nashman, *Executive Engineer, Federal Telecommunication Labs., Nutley, N. J.*

THUMBNAIL REVIEWS

Dictionary of Electronics and Waveguides. By W. E. Clason, D. Van Nostrand Co., Inc., Princeton, N. J., 1957, 628 p, $17.50. Terms and definitions in English, with equivalent French, Spanish, Italian, Dutch and German terms in parallel columns, are arranged across two pages. Each English term is numbered. Five alphabetically arranged cross-indexes, one in each other language, give number of equivalent English terms.

COMMENT

A Dropped Resistor

A reader in Palo Alto, Calif., forwards us this exchange of correspondence:

G. B. Miller esq.
Rugby, England

Your recent paper "Transistor Q-Multiplier for Audio Frequencies" (Electronics p 79, May 9) was most interesting. One item in it, however, a seeming inconsistency, excites my interest. I am unable to determine whether it is a drafting error or whether some new principle is involved.

In Fig. 4 (p 81) you show a 100K resistor from transistor base to ground. This is a fairly standard voltage-divider base connection which keeps base bias from running wild as the temperature changes. In Fig. 5, however, on the same page, bases of the three transistors are biased through a series resistor to the −12-volt supply, and there is no external voltage divider.

Is the omission of the 100K resistor from base to ground a drafting error, or is the GT-3 transistor so thermally stable that a divider is unnecessary?

Ronald L. Ives
Palo Alto, Calif.

Author Miller replied:

You were quite correct of course in assuming that a drafting error had occurred. The error was mine and not that of Electronics. . . . I did not spot it until the paper was printed.

In actual fact the error is not vital and most readers of Electronics, like yourself, would have seen that an omission had occurred. If the circuit is built up as shown in the figure, it will still work perfectly satisfactorily assuming the full calculation is made to determine the value of the feedback resistor, and trouble would only be experienced if coils having the exact values quoted by me were used with the value of the resistor given in the paper. This is a highly unlikely contingency!

G. B. Miller
Bilton, Rugby
England

LEAD INSTRUMENTATION ENGINEER

To guide a Research and Development group in the design and application of electronic gathering and reduction systems. Required: B.S. or M.S. in E.E., plus 5 years electronics experience in telemeter applications of flight test instrumentation data.

GUIDANCE DESIGN ENGINEER

To design various active and self-contained missile guidance systems, and to design and develop radar beacons. Required: E.E., or Physics Degree, plus 2 or more years experience.

Current Vought hardware includes the F8U jet fighter series and the Regulus guided missiles. Among projects under way are Dyna Soar, ASW studies, spacecraft, other advanced weapons programs. To investigate the key openings described above, qualified engineers are invited to write to C. A. Besio, Supervisor, Engineering Personnel, Dept. R-9.

CHANCE VOUGHT AIRCRAFT
INCORPORATED · DALLAS, TEXAS

SALES ENGINEER
WANTED

Location will be either New York City or Philadelphia, Pa. to sell to missile and aircraft companies high speed relays, choppers, pressure switches and transducers. Should have electrical engineering degree although will consider mechanical engineers who have good background in electrical field. Excellent opportunity.

Write Harry E. Beane, Vice President,

THE BRISTOL COMPANY
Waterbury, Connecticut.

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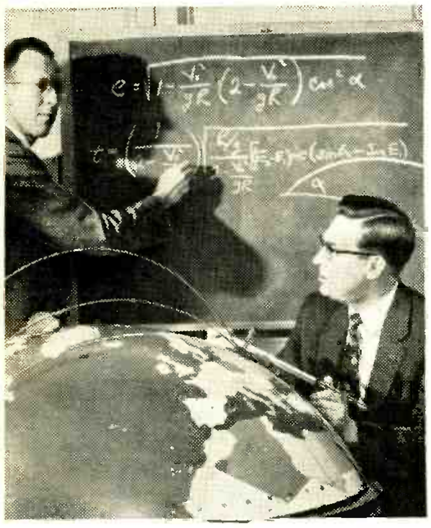

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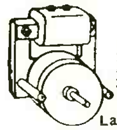

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INDEX TO ADVERTISERS

AC-Electronics Division 22
Aeronautical Communications Equipment Inc. 10
Airpax Products Co. 61
Allegheny Ludlum Steel Corp. 4
American Radio Co. 75
Ampex Corporation 27

Bendix-Pacific Division of Bendix Aviation Corp. 70
Bruel & Kjaer 20

C B S Hytron, A. Div. of Columbia Broadcasting System, Inc. 11
Celco-Constantine Engineering Laboratories Co. 76
Constantine Engineering Laboratories Co. 76
Continental Wire Co. 67
Cross Co., H. 80
Cubic Corp. 59

du Pont de Nemours & Co. (Inc.) E. I. "Freon" Products Division 55
Dynacor, Inc. 82

Eitel-McCullough, Inc. 21
Epsco Inc. 71
Esterline-Angus Company, Inc. 66

Fenwal Electronics, Inc. 84

General Ceramics Corp. 24
General Electric Apparatus 73
General Radio Co. 3

Haydon Co., Inc., A. W. 80
Haydon Division of General Time Corp. 64
Hewlett-Packard Company 2nd Cover
Hughes Products, a Div. of Hughes Aircraft Co. 15, 63

ITT Laboratories a Division of ITT 85
International Tel. & Tel. Corp. 85

Kepco Laboratories 51
Kintel, a Div. of Cohu Electronics Inc. 13
Klein & Sons, Mathias 69

Lafayette Radio 92
Lambda Electronics Corp. 9
Lapp Insulator Co., Inc. 60
Leach Corporation 57

Magnetics, Inc. 49
Mallory and Co., Inc., P. R. 28
Marconi Instruments, Ltd. 65
McGraw-Hill Book Co. 83
McGraw-Hill Publishing Co. 18, 19
Microwave Chemicals Laboratory, Inc. 66

Nems-Clarke, Inc. 23
North American Aviation, Inc. 92
Northeastern Engineering, Inc. 77

Radio Corporation of America 4th Cover
Radiation Inc. 74
Raytheon Mfg. Company 6
Rohn Mfg. Co. 72
Ryan Aeronautical Corp. 79

Sorensen & Co. 5
Sprague Electric Co. 17
Stromberg-Carlson Company 58

Telrex Laboratories 82
Temco Aircraft Corp. 26
Terminal Radio Corp. 52
Texas Instruments Incorporated 3rd Cover
Thermal American Fused Quartz Co. 85
Transformers Inc. 25

Weinschel Engieering 52
White Dental Mfg. Co., S. S. 54

Zippertubing 91

PROFESSIONAL SERVICES 86

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EMPLOYMENT OPPORTUNITIES...86-89

EQUIPMENT
(Used or Surplus New)
For Sale 90

WANTED
Equipment 90

ADVERTISERS INDEX

Alleximma 90

Barry Electronics Co.................... 90
Blan 90
Bristol Company 86

Chance Vought Aircraft, Inc............. 86
Chrysler Corporation, Missile Division... 88

General Electric Co..................86, 89

Martin Company 87

Norden-Laboratory—Norden Div. United Aircraft Corp. 87

Philco Tech Rep. Division.............. 88

Radio Research Instrument Co........... 90

Technical Systems Corp................. 90
Telephone Engineering Co............... 90

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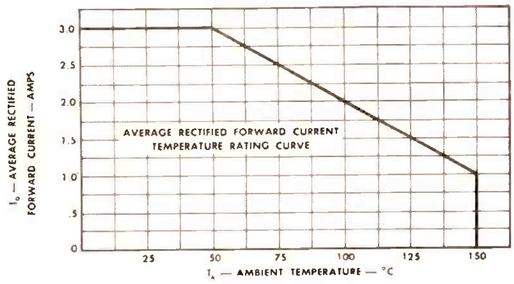

Anode-to-stud units denoted by "R" suffix to type number.

maximum ratings	1N1124 1N1124R	1N1125 1N1125R	1N1126 1N1126R	1N1127 1N1127R	1N1128 1N1128R	unit
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*Average Rectified Forward Current at +50°C	3	3	3	3	3	Amp
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*Recurrent Peak Forward Current at +50°C	10	10	10	10	10	Amp
Surge Current, 1 Cycle at 60 Cycles at +50°C	25	25	25	25	25	Amp
Operating Temperature, Ambient			−65 to +150			°C
specifications						
Max. Full Cycle Avg. Reverse Current at +150°C	0.3	0.3	0.3	0.3	0.3	mA
Max. Reverse Current at PIV at +25°C	10	10	10	10	10	μA
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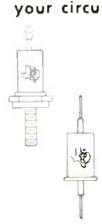

	Peak Inv Voltage V	Ave Rect Fwd Current mA	Recurrent Peak Current
1N1130*	1500	300	1A
1N1131†	1500	300	1A
1N588	1500	25	150 mA
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* cathode-to-stud † anode-to-stud

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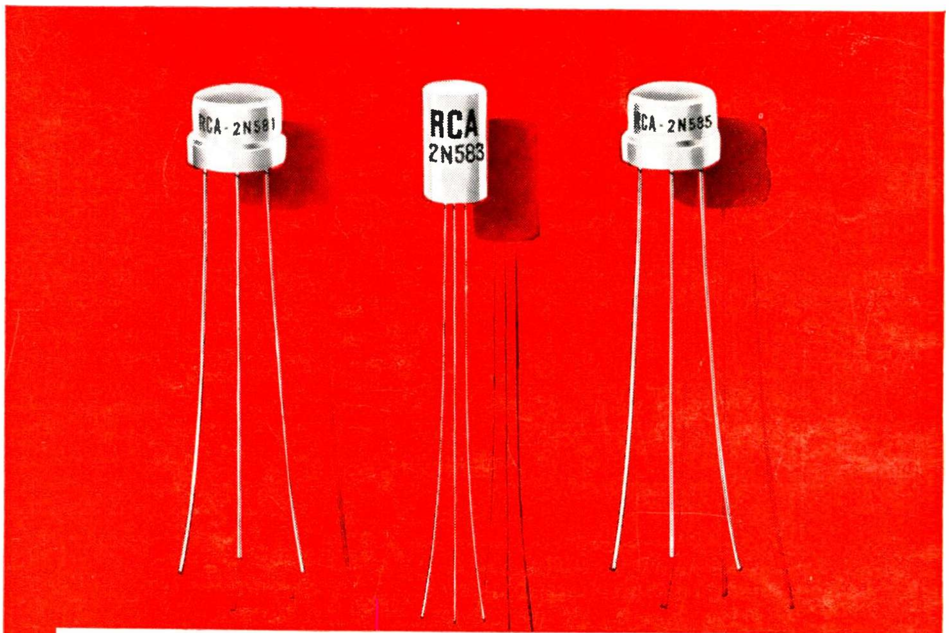

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*Jetec TO-9 Outline (formerly referred to as Jetec Size-Group 30 Case)
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