Electronics World

MAY, 1967
60 CENTS

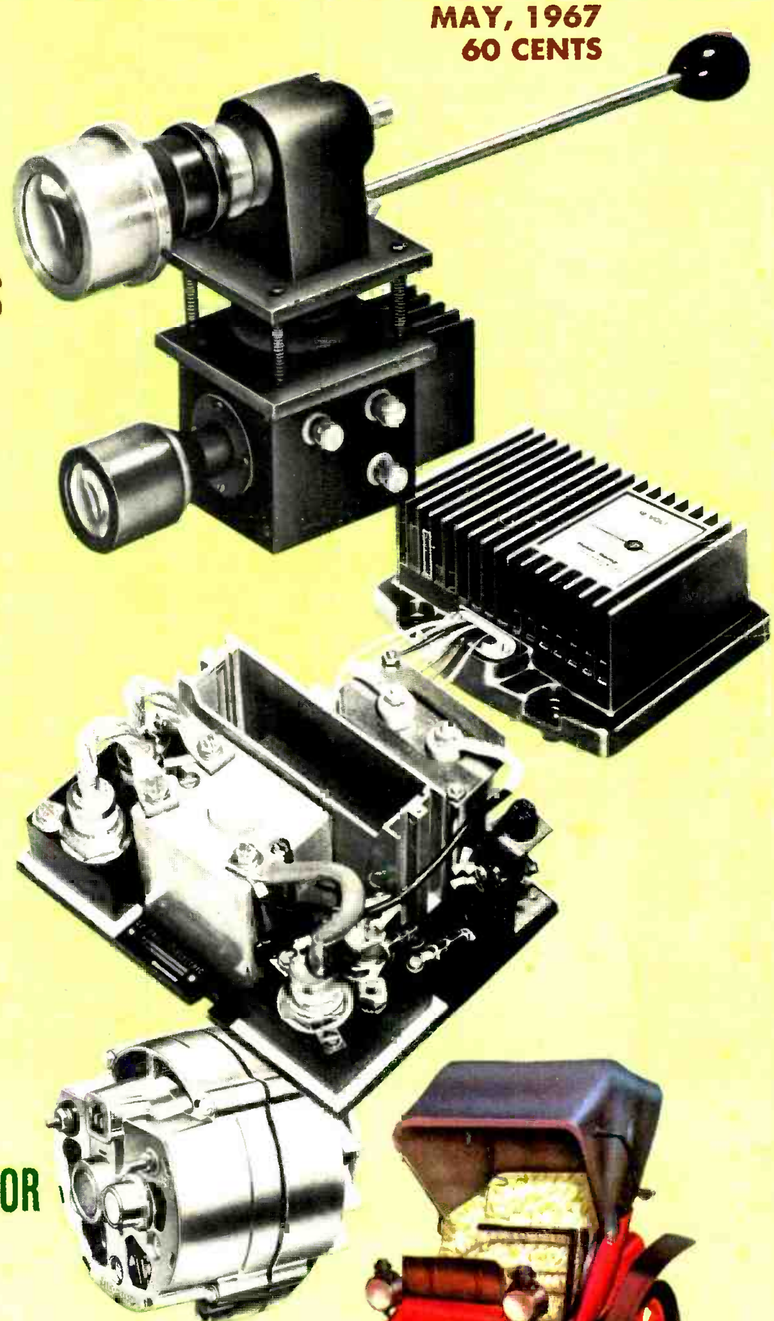
RADIO MEASUREMENTS IN SPACE

MICROWAVE EDUCATIONAL TV

SELECTING FREQUENCY AND TIME STANDARDS

FIELD-EFFECT TRANSISTOR CIRCUITS

SELECTING AND USING PULSE GENERATORS



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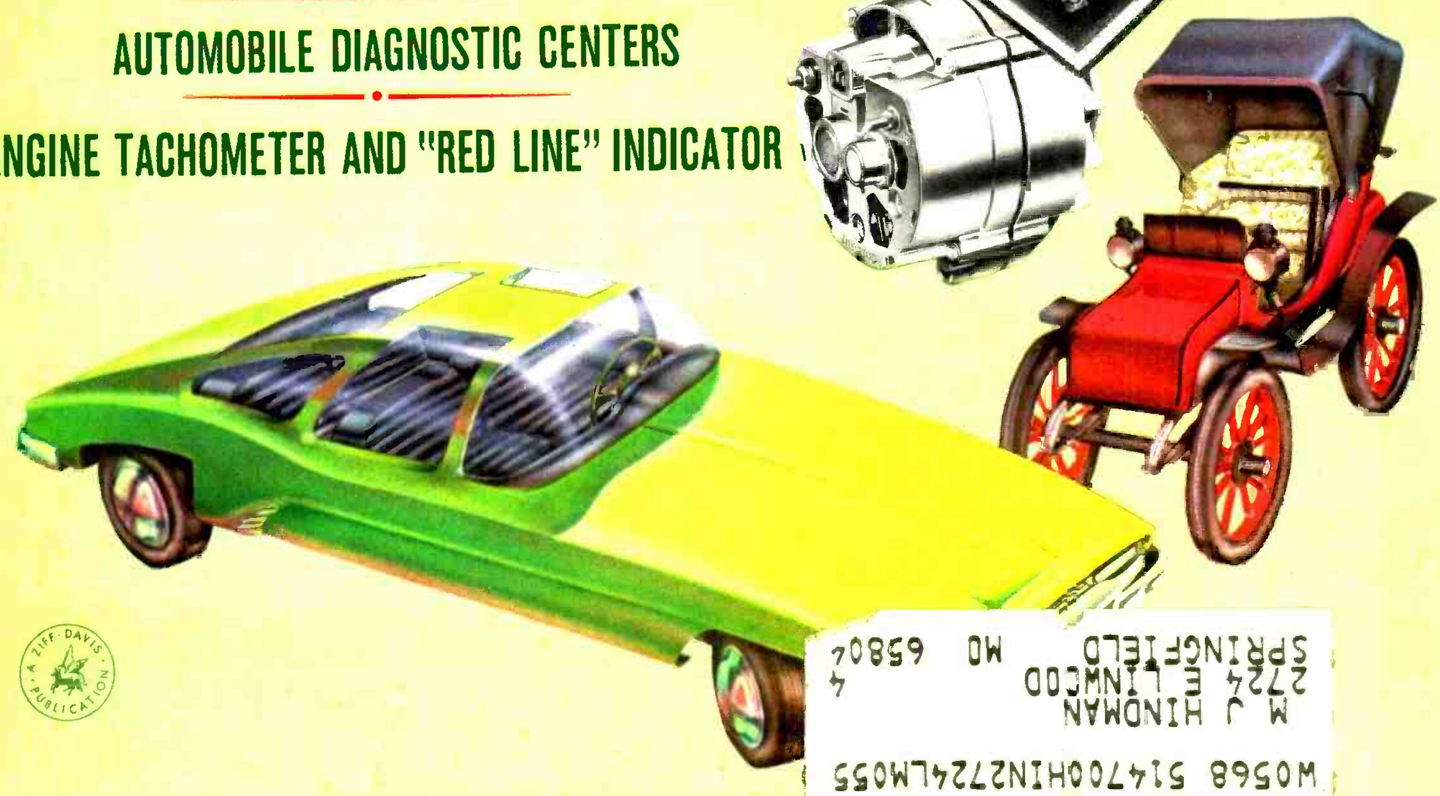

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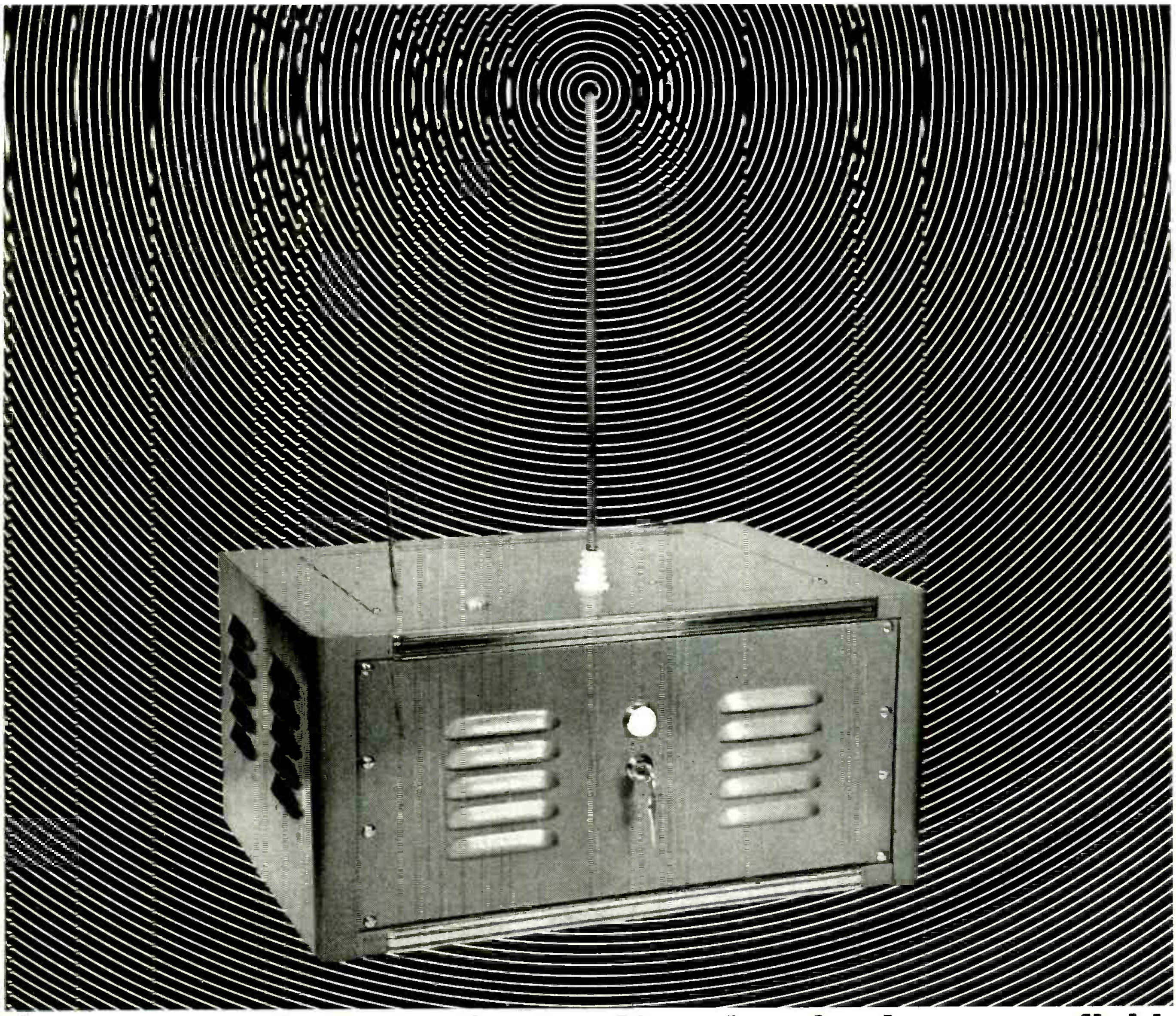

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Just this: Radar Sentry is no ordinary alarm. It is the most modern and effective security system available. And it's also electronic.

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Men like *you*.

How about it?

Do you want to start a business of your own . . . or expand your present business with a product that in 8 years has become the world-wide leader in its field?

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Fill out the coupon and get complete Dealer/Distributor information . . . free.

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EW-4

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CIRCLE NO. 100 ON READER SERVICE CARD

THIS MONTH'S COVER illustrates some of the electronic devices discussed in the automotive electronics articles in this issue. At the top is an experimental laser range measuring device proposed by G-E. Below that is a capacitive discharge ignition system as made by Delco-Remy. The next large unit is a portion of a d.c. motor controller made by G-E and used in d.c.-powered work vehicles. Below the controller is an alternator also made by Delco-Remy. The two cars represent the extremes of the electric car spectrum. The red one from the not-so-demanding past, and the racy green model an artist's version of the electric car of the future.

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MAY 1967 VOL. 77, No. 5

CONTENTS

MONTHLY FEATURES

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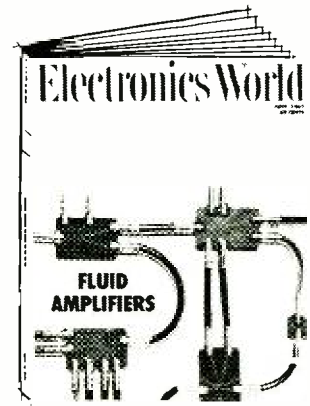
COMING NEXT MONTH



MEASURING TRACKING ABILITY OF PHONO CARTRIDGES
James H. Kogen, Chief Engineer at Shure, describes a number of present and proposed methods of measuring this important cartridge parameter including the new variable-speed turntable method, CCIF technique, and use of tone burst, scope observations, and special test records.

OCCUPATIONAL OUTLOOK FOR ELECTRONICS TECHNICIANS
Engineering and science technicians are the fastest growing occupational groups in the U.S., with the demand exceeding the supply for the next decade. Here is up-to-the-minute information on training, where the jobs are, the current salary ranges, and how to prepare for such well-paying careers.

SEMICONDUCTOR SWITCHING OF LOW-POWER CIRCUITS
Semiconductors can be used in place of relays to control d.c. loads up to 35 amps and a.c. loads up to 10 amps. Advantages, as outlined by Aubrey Harris of Ampex, include no contact bounce, wear, or maintenance, along with increased reliability, and reduced noise generation.

FLUID AMPLIFIERS
Small by nature, these new mechanical devices are beginning to find increasing application in the computer industry, replacing electronic circuits. This article explains their operation, special features, and circuit advantages.

SEARCH FOR A HIGHWAY EMERGENCY RADIO PROGRAM
Although up to now much has been said and little done about establishing a means of communications between drivers and local authorities for the purposes of routing, information, and road service, now the race is on to be the first to establish the approved highway emergency radio system which will be adopted nationwide. At stake for the winner are auto-maker contracts, prestige, and federal-aid grants.

*All these and many more interesting and informative articles will be yours in the **June** issue of ELECTRONICS WORLD . . . **on sale May 18th.***

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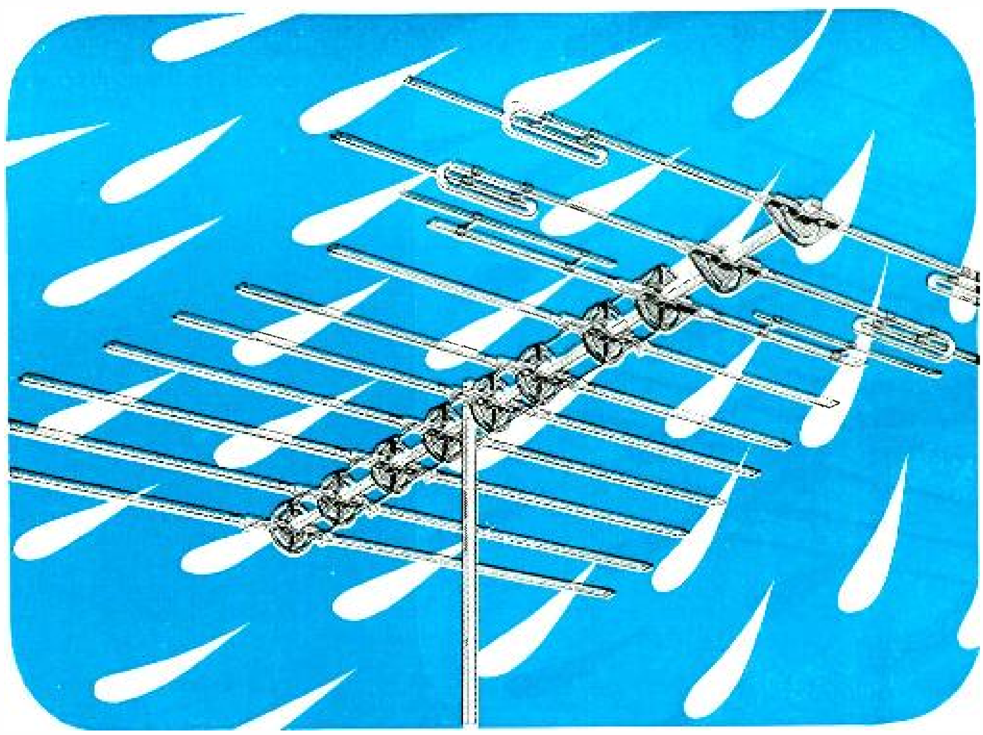
New Jerrold Colorpeak™ VHF Antenna weathers any reception problem



Here's one outdoor antenna that stays put—even in a howling storm. The new Jerrold Colorpeak 300-ohm VHF-FM Antenna.

Colorpeak is a high gain antenna with unusual flatness across the entire VHF-FM band. It picks up strong, clear signals—even in difficult reception areas—because of its excellent front-to-back ratio. And it's built as rugged as a tank. Vibration-proof point-contact element locks, corrosion-resistant Golden Armor Coating and tough Cycolac insulators make each insulating mount a strong point. No shorting out because of icing. No wavering image as wind whips through the antenna. No flimsy criss-cross conductors for transfer of the signal. Jerrold Colorpeak quality construction sees to all that.

Jerrold Colorpeak antennas, like Jerrold VUfinder, Paralog Plus and Pathfinder antennas, assemble faster than any other antenna made today. All parts snap into place—anywhere—on the ground or on the roof. For hook-up ease, Colorpeak lead connections are made close to the mast.

For more details on the Jerrold Colorpeak antenna, see your Jerrold distributor.

JERROLD®

Focusing on one thing—better reception.

CIRCLE NO. 111 ON READER SERVICE CARD

For the record

WM. A. STOCKLIN, EDITOR

FCC BEARS DOWN ON CB

IN a move which could effect sweeping long-range changes on 27 MHz, the FCC has announced its proposal to require "type acceptance" of all class-D CB equipment at point of manufacture.

Although the Commission has stated that this action "does not impose any new or significantly tighter standards other than a requirement for a modulation limiter," close inspection reveals that in reality the move may well be the first step towards a major overhaul of the service, aimed at ridding it of the hobbyist element.

The type-accepted CB set would not be much different from those now being used, although a few interesting limitations will be imposed. For one, the ICAS rating on the final tube will not be allowed to exceed 10 watts. Further, all crystals must be supplied by the manufacturer. If r.f. output is more than 2.4 watts, a "device which automatically prevents modulation in excess of that specified" must be included in the circuit. Finally, panel connectors and controls would be restricted to the following: a.c. plug, mike connector, r.f. output connector, "on-off-volume" control, sideband selector (if SSB set), p.a. switch, channel selector, and transmit-receive switch. What makes these changes significant, however, are not the design limitations so much as the new restrictions on the set owner.

With a type-accepted CB transceiver, the operator will not in any way be permitted to "tube" the output for best matching to the transmission line nor can he substitute crystals. If channel-switching is desired, he will have to either buy a multi-channel set or employ the services of a 1st or 2nd Class Commercial ticket holder. Should component replacement be required, he can use only those parts (including tubes and crystals) listed in the instruction manual by the manufacturer.

Far more important, however, are the regulations concerning even minor circuit changes. Type-accepted CB sets, according to the FCC, "shall be *in no way* modified by the user." Obviously, this will apply to the countless books and magazines presenting do-it-yourself material for souping up receivers, add-on noise limiters, etc.

Dealing a crushing blow to the CB accessory business is another stipulation that strictly prohibits "external connection or addition of any accessory not originally included" with the transceiver. Clearly, this would render illegal all outboard "S" meters, s.w.r. bridges, modulation boosters, etc.

Behind this move is the feeling in many circles that the CB industry may be contributing to the increasing number of rule violations by including such questionable equipment features as "25-watt construction," "30-channel operation," and occasionally slip-shod spurious radiation suppression techniques. By regulating the manufacturing community, the Commission hopes to somewhat improve the caliber of the signal (if not the operator) to be found on 27 MHz.

It is interesting to note that just prior to this type-acceptance disclosure word was out that the FCC was planning to remove unlicensed 100-milliwatt walkie-talkies from 27 MHz and place them on a newly created 49.9-50.0 MHz band. According to the story, millions of dollars worth of transceivers (largely Japanese) would have to be scrapped in favor of redesigned walkie-talkies which would meet tight Commission *type-acceptance* requirements. The idea, apparently, was to rid the CB band of millions of these "toys"—many of which are poorly designed from a technical standpoint—and substitute a new breed of crystal-controlled transceiver (running no more than 60 mW measured "at the battery") on 49 MHz.

Shortly after *The New York Times* stated, in an item "FCC Weighs Ban on Walkie-Talkies" (Feb. 3, 1967), that it had confirmed this report, the FCC all but denied it had ever proposed such a drastic measure. More recently, Commission spokesmen have stated that the 49-MHz plan is just "one of many concepts under consideration" by the agency and that no matter what emerges, "it will take some time yet."

In September of last year Chairman Rosel H. Hyde warned the CB industry that unless something were done to curb the rising tide of rule violations on 27 MHz, the FCC might have to consider "the cessation of issuance of any new Citizens Radio licenses pending a reexamination of the justification for and proper operation of the Service."

Whether the type-acceptance proposal and whatever walkie-talkie solution eventually emerges will materially help upgrade the 27-MHz band, remains to be seen. Although industry cooperation is now at hand, the question is will individual CB-ers respond? Many users seem to think in terms of enforcement and this is one area in which the Commission is hamstrung.

Whether or not Hyde's threat to CB materializes, it is now apparent that the FCC clearly intends to grasp control of the mess on 11 meters. ▲

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The day you enroll with NRI this new starter kit is on its way to you. Everything you need to make a significant start in the Electronics field of your choice is delivered to your door. It's an outstanding way of introducing you to NRI training methods . . . an unparalleled "first dimension" that opens the way to new discoveries, new knowledge, new opportunity. The Achievement Kit is worth many times the small payment required to start your training. No other school has anything like it. Find out more about the NRI Achievement Kit. Mail the postage-free card today.

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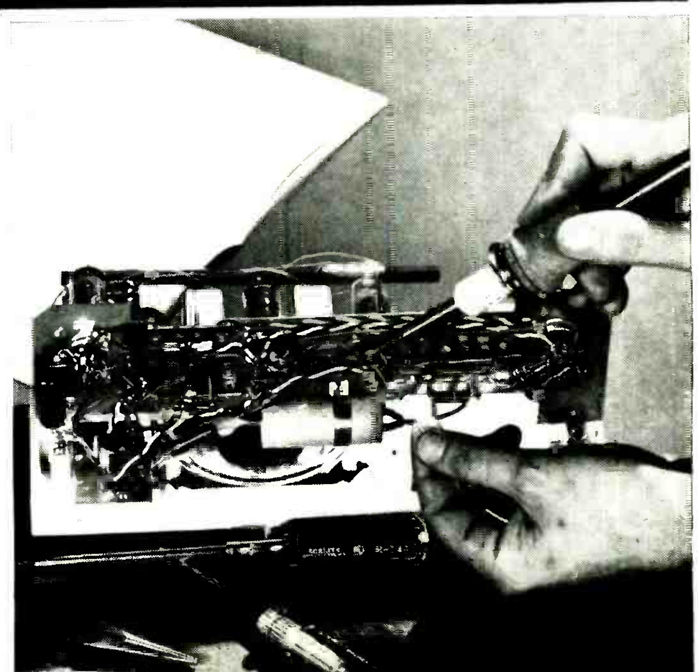
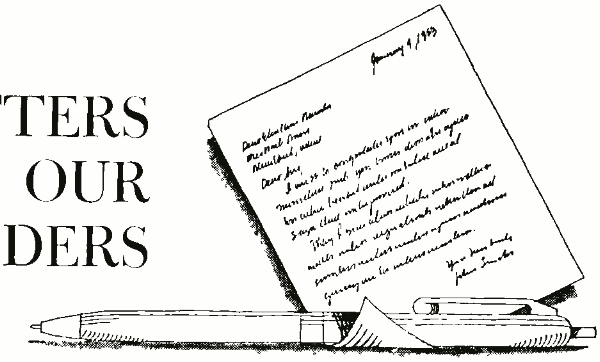
AVAILABLE UNDER NEW GI BILL — If you served since January 31, 1955, or are in service, check GI line in postage-free card.



LETTERS FROM OUR READERS



ELECTRONIC EAVESDROPPING

To the Editors:

The article *(on "Electronic Eavesdropping" in the April issue)* is first-rate and will, hopefully, diminish my naiveté on the subject. It would be most helpful if we could have your permission to reprint the article in our upcoming hearings on the subject.

SEN. EDWARD V. LONG (Dem., Mo.)
Washington, D.C.

We are, of course, pleased to grant permission to reprint our story. Senator Long, as most of our readers know, is Chairman of the Senate Subcommittee on Administrative Practice and Procedure, which has been conducting hearings on the subjects of wiretapping and electronic eavesdropping. On February 8, the Senator introduced a proposed Right of Privacy Act of 1967, as recommended by President Johnson. The bill (identified as S. 928) is designed to protect the right of privacy of individuals by prohibiting wire interception and eavesdropping. For further details on the bill, see "Radio & TV News" on page 78 of this issue.—Editors

* * *

SONALERT PREDECESSOR

To the Editors:

I was surprised to find an old friend in John Frye's column in your January, 1967 issue. The Sonalert® description very closely resembles what I called a "P-n-p/n-p-n CPO" in the February, 1962 issue of 73 magazine.

The basis of the circuit was a pillow speaker using a piezoelectric crystal as the frequency-determining element as well as the tone reproducer. The actual circuit was published rather than epoxied.

ROY A. MCCARTHY
Fullerton, Calif.

* * *

SLIDE-RULE SHORT CUTS

To the Editors:

I have found the parallel-resistance formula in the article "Calculating Parallel Resistor Values" by Shu H. Loui (October, 1966, p. 60) very useful in making slide-rule calculations.

Another formula that always gives me problems when I try to use it while making calculations on my slide rule is the Pythagorean equation $a^2 + b^2 = c^2$. Employing the same principles used to derive the parallel-resistance equation, I have transformed the Pythagorean equation to the following: $c = b\sqrt{(a/b)^2 + 1}, a > b$.

Using this formula, it takes two settings of the slide and one of the cursor to perform a calculation that previously required three settings of the cursor and a good deal of paperwork.

The formula for finding b when a and c are known is as follows: $b = a\sqrt{(c/a)^2 - 1}$.

The use of the cursor is not even necessary, but it is convenient, especially if one has a tendency to forget numbers, which the cursor will remember.

JOSHUA LEVIN
Flushing, N.Y.

An even simpler technique for solving this equation is by use of sine and tangent scales on the slide rule. In order to solve a right triangle for which two legs are given, it is only necessary to set the proper index of the slide to the larger leg on scale D and then push the hairline to the smaller leg on scale D. At the hairline, the smaller acute angle of the triangle is read on tangent scale T. This angle is then drawn on scale S under the hairline. Finally, at the index of the slide, the hypotenuse may be read on scale D. This technique is excellent for use with impedance problems involving a resistance and reactance.—Editors

* * *

PREDICTING ACADEMIC SUCCESS

To the Editors:

Recent letters by Cliff Erickson and John Frye in your "Letters" column indicate some disagreement as to what kind of man is successful in studying engineering. Has anyone checked a number of successful engineering students to find out just what makes them tick and why others quit the study of engineering?

RICHARD L. PRENDERGAST
Kansas City, Mo.

A recent issue of Engineer *published by the Engineers Joint Council, Inc. contained an article on this very sub-*

Let's talk sense about color TV lead-in!

The common sense of the situation calls for *two* 82-channel lead-ins for color and UHF TV... one to give a stronger signal in uncongested fringe areas where interference usually is not a serious problem. The other to give a much cleaner signal in congested or close-in areas where serious interference problems are likely to exist. This is why Belden gives you a choice—the *Color Guard Twins.*

8285

*Color Guard Twin—Belden Permohm**

Use to get stronger signals in uncongested fringe areas, like this . . .

8290

*Color Guard Twin—Belden Shielded Permohm**

Use to get cleaner signals in congested or close-in areas, like this . . .

You get an excellent color image . . . because in a 100-foot run, Permohm delivers 38% to 200% more signal voltage than RG-59/U with matching transformers and 23% to 80% more signal voltage than "Low Loss Coax" with transformers.

Permohm obtains the highest efficiency of any available unshielded 300 ohm line when exposed to weathering and industrial atmospheres. Low loss cellular polyethylene insulation around the conductors provides the necessary protection.

You don't need expensive transformers and connectors.

Belden Shielded Permohm (8290) combines strong signal strength with the clean signal protection of shielded cable.

Shielded Permohm eliminates transmission line pickup of noise and ghost signals. You can install it easily anywhere . . . no need for standoffs, twisting, or inconvenient routing of lead-in. Tape it to a mast, route it through metal pipe, or bury it underground.

Beldfoil† shielding is used to shield against outside signal interference. The jacket is weatherproof polyethylene. The critical signal area is protected from rain, snow, salt, smog, fog and industrial contamination. No expensive transformers or connectors are needed.

Belden Trademarks Reg. U.S. Patent Office
**Patent No. 2,782,251 and Pat. Pending*
†Patent No. 3,032,604.

Choose the Color Guard Twin that gives your customer the best 82-channel color TV reception. Get complete information on the Belden Color Guard Twins.

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CIRCLE NO. 125 ON READER SERVICE CARD

ject by Dr. Roger D. Augustine. While Dr. Augustine was Assistant to the Dean of Engineering at Michigan State University, he conducted a study of engineering students at three Midwestern universities. Among other things, he found that students who persevered in engineering had the following characteristics. They tended to come from working-class and upper-middle-class socio-economic backgrounds as opposed to lower-middle-class origins. They tended to come from suburban high schools as opposed to city and rural high schools. They generally enjoyed repairing things and thinking about how things work; they had an inclination to "tinker around the house." Often, a close relative or father was an engineer. Their commitment to engineering was made at an earlier age than those who left engineering. They met their first exposure to sophomore technical courses with enthusiasm.

Students who quit engineering seemed to have a strong need for upward social mobility; they attached more importance to working with people than with things; and they had tended to choose engineering studies for materialistic and prestige purposes or to acquire a "good" background for careers in other fields. Many left because the technical courses were too difficult; they felt unable or unprepared to succeed in their engineering programs.—Editors.

* * *

LIFE OF CRYSTAL MICROPHONES

To the Editors:

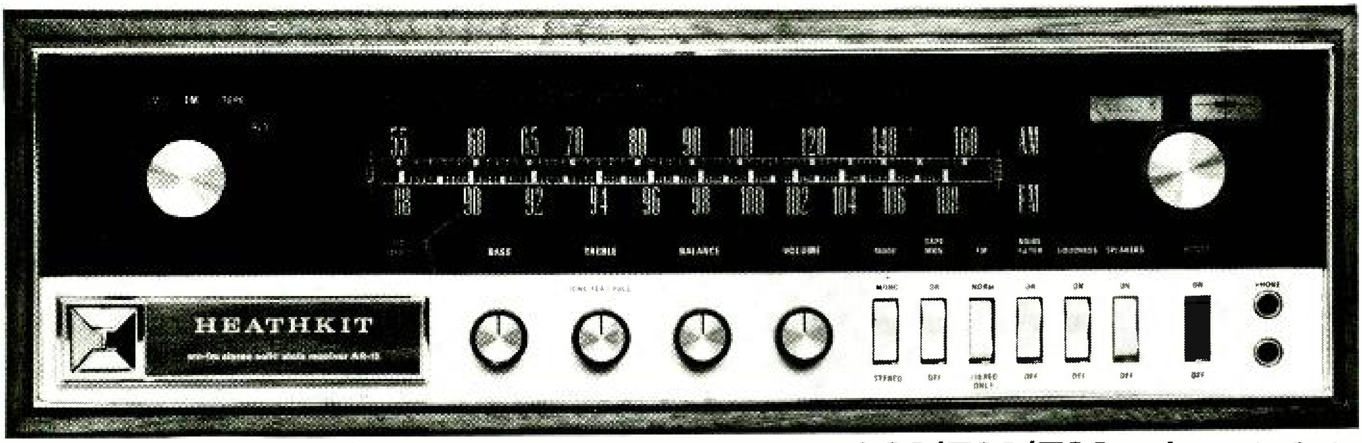
I have noticed that when crystal microphones are left on a shelf for a few years they go bad. Can you tell me what goes wrong and if it can be fixed? There must be a definite pattern because four of my crystal mikes have gone bad in about three years with no usage at all.

DAVE RUNNION
Prospect Park, Pa.

Here are some comments on Reader Runnion's letter from The Astatic Corp.*, one of the largest manufacturers of crystal microphones and phono cartridges:*

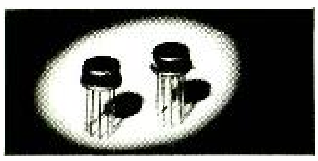
"Although Rochelle salts make the most efficient piezoelectric crystal generators, the efficiency of this material is decreased by extremes of heat and humidity. Temperatures above 120° F will result in permanent damage to crystal microphones and cartridges, as will long-term exposure to high humidity. In general, crystal microphones will perform reliably for many years if they are used and stored under conditions of temperature and humidity where the user would be comfortable. Where climatic conditions of high temperature and humidity prevail, ceramic units are recommended."—Editors ▲

World's Most Advanced Stereo Receiver...

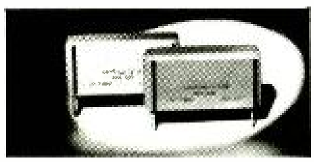


New Heathkit® AR-15...150 Watts...AM/FM/FM...$329.95†

"Black Magic" Panel Lighting
A touch of the power switch and presto! . . . The black magic panel lights up with a slide-rule dial for easy tuning, and instant identification of all controls.



Integrated Circuits . . . two are used in the IF amplifier for hard limiting excellent temperature stability, increased reliability. Capture ratio is 1.8 db. Each IC is the size of a tiny transistor, yet each contains 10 transistors, 7 diodes, and 11 resistors.



Crystal Filters . . . two are used in the IF amplifier to replace the usual transformers . . . Heath hi-fi exclusive. Provide near-perfect bandpass characteristics, (70 db selectivity) yet no adjustment is ever needed!

AR-15 SPECIFICATIONS — AMPLIFIER SECTION: Dynamic Power Output Per Channel (Music Power Rating): 8 ohm load; 75 watts. **Continuous Power Output, Per Channel*:** 8 ohm load; 50 watts. **Power Bandwidth For Constant 0.5%, Total Harmonic Distortion*:** 6 Hz to 25 kHz. **Frequency Response (1 watt level):** ±1 db, 6 to 50,000 Hz. +3 db, 4 to 70,000 Hz. **Harmonic Distortion:** Less than 0.5% from 20 to 20,000 Hz at 50 watts output. Less than 0.2% at 1,000 Hz with 50 watts output. Less than 0.2% at 1,000 Hz with 1 watt output. **Intermodulation Distortion (60 Hz: 6,000 Hz—4:1)** Less than 0.5% with 50 watts output. Less than 0.2% with 1 watt output. **Damping Factor:** 45. **Input sensitivity:** PHONO; 2.2 millivolts (overload 155 mv) TAPE; 200 millivolts (overload 4.5v). AUX; 200 millivolts (overload 4.5v) **Hum & Noise:** Volume control at minimum position; —80 db. PHONO; (10 millivolt reference); —60 db. TAPE & AUX. (100 millivolt reference); —65 db. **Channel Separation:** PHONO; 45 db. TAPE & AUX.; 55 db. **Output impedance (each channel):** 4, 8 & 16 ohms. **Tape Output Impedance:** 100 ohms. **Input Impedance:** PHONO; 51 K ohm (**RIAA equalized). AUX., TAPE & TAPE MON ; 100 K ohm. **Tape Output:** 0.17 volt. **FM SECTION (Mono): Sensitivity:** 1.8 uv*. **Frequency Response:** ±1 db, 20 to 15,000 Hz. **Volume Sensitivity:** Below measurable level. **Selectivity:** 70 db*. **Image Rejection:** 90 db. **IF Rejection:** 90 db minimum*. **Capture Ratio:** 1.5 db*. **AM Suppression:** 50 db*. **Harmonic Distortion:** 0.5% or less*. **Intermodulation Distortion:** 0.5% or less*. **Hum & Noise:** 65 db*. **Spurious Rejection:** 100 db*. **FM SECTION (Stereophonic): Channel Separation:** 40 db or greater. **Frequency Response:** ±1 db, 20 to 15,000 Hz. **Harmonic Distortion:** Less than 1% at 1,000 Hz with 100% modulation. **19 & 38 kHz Suppression:** 55 db or greater. **SCA Suppression:** 50 db. **AM SECTION: Sensitivity:** 12 microvolts at 1,000 kHz. **Image Rejection:** 60 db at 600 kHz. 40 db at 1400 kHz. **IF Rejection:** 70 db at 1,000 kHz. **Harmonic Distortion:** Less than 1.5% at 400 Hz, 90% modulation. **Hum & Noise:** 45 db. **Power Requirements:** 105-125 or 210-250 volt 50/60 Hz AC. **Dimensions:** Overall, 16 7/8" wide x 4 3/4" high x 14 1/2" deep.

*Rated IHF (Institute of High Fidelity) Standards.

The New Heathkit AR-15 . . . Crowning Achievement Of The World's Most Experienced Solid-State Audio Engineers! There's nothing like it anywhere in the transistor stereo market place. Besides the use of space-age integrated circuits and exclusive crystal filters in the IF section, it boasts other "state-of-the-art" features like these:

150 Watts Dynamic Music Power . . . 75 IHF watts or 50 RMS watts per channel . . . the highest power output of any stereo receiver. Delivers the coolest, most natural sound you've ever heard.

All-Silicon Transistor Circuitry . . . a total of 69 transistors, 43 diodes and 2 IC's for maximum reliability & stability.

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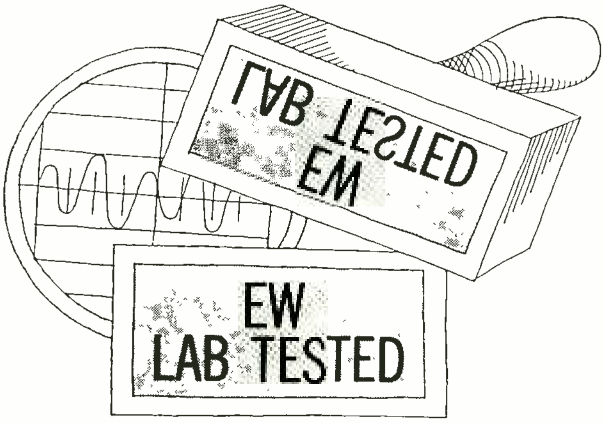


HI-FI PRODUCT REPORT

TESTED BY HIRSCH-HOUCK LABS

Heath AR-15 Stereo Receiver
Shure Model 565 "Unisphere I" Microphone

Heath AR-15 Stereo Receiver

For copy of manufacturer's brochure, circle No. 26 on Reader Service Card.

THE "Heathkit" line of hi-fi equipment has grown in sophistication compared to the rather basic kits of a few years ago. The new AR-15 stereo receiver is one of the most advanced receivers on the market today, with a number of features not found in factory-wired units.

Heath implies strongly that the AR-15 represents a new high in advanced performance and circuit concepts. After testing and living with the AR-15 for a while, we must concur. The unit is among the best receivers we have tested and its FM tuner is especially outstanding.

The receiver is an all-solid-state unit with silicon transistors throughout and with integrated circuits in its FM i.f. amplifier. The AR-15 is large and heavy with much of its weight concentrated in the power transformer. This affirms its great audio power capability, which is rated at 50 watts per channel continuous, or 150 watts total music-power output.

The AR-15 tuning dial, which covers most of the frontal area, is an opaque jet black when the receiver is turned off. Turning the receiver on illuminates the dial numerals, the input-selector switch markings, function lights, and the two tuning meters. One meter indicates signal strength and the other is a center-tuning indicator for FM reception. The *only* features possessed by any other receiver but not found on the AR-15 are center-channel output, speaker switching provisions, rumble and scratch filters, and tape-head inputs.

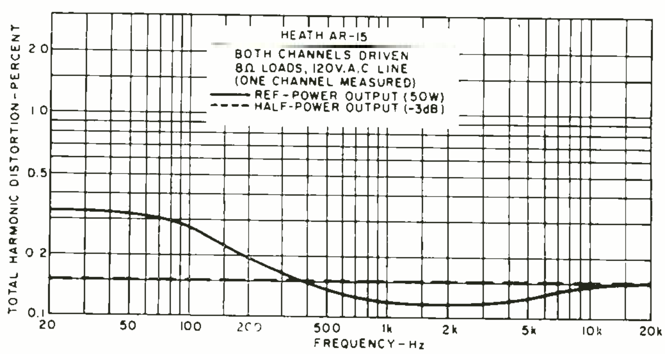
Worthy of special mention is the exceptional dynamic range of the magnetic phono-cartridge preamplifier stages, which can handle up to 180 mV without distortion. Even the highest output cartridges can be used with it without danger of over-driving when playing a disc with high recorded levels. This is achieved by operating the preamplifier stages with a 50-volt supply, higher than any other stages in the receiver except the output stages.

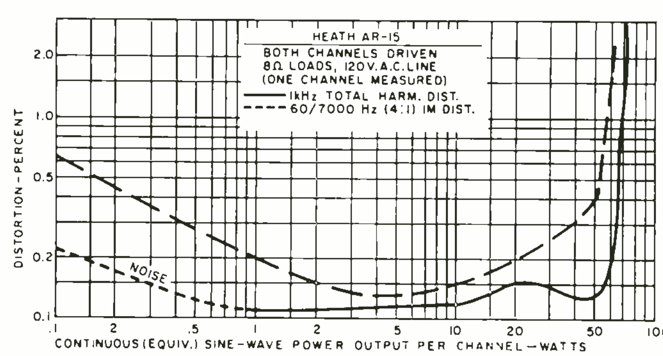
The tone controls can be bypassed completely by pulling out the treble tone-control knob. The output transistors are protected against damage from short circuits or over-driving. If the overload persists, thermal cut-outs remove the voltage from them until they cool down to a safe temperature. A red light on the panel indicates operation of the protective circuit breakers.

The FM tuner front-end uses field-effect transistors (FET's) for high sensitivity and freedom from cross-modulation. The FM i.f. amplifier is completely unique. This marks the first use of integrated circuits in a kit receiver. Each IC, about the size of a transistor, contains 10 transistors, 7 diodes, and 11 resistors. Instead of the usual i.f. transformers, which require alignment periodically and have less-than-ideal response characteristics, the receiver uses two crystal lattice filters. Although costly, these have a virtually ideal "flat-topped" response characteristic, with extremely steep skirts which offer a degree of adjacent-channel selectivity unobtainable with conventional i.f. transformers. (*For further details, refer to "Integrated Circuits Used in New Hi-Fi AM FM Receiver" in our January, 1967 issue.—Editor*)

The IC's have exceptionally fine limiting characteristics, which obviates the need for separate limiter stages. In order to provide automatic gain con-

(*Continued on page 82*)





NEW Heathkit®/Thomas "Paramount" Transistor Theatre Organ

Kit TO-67
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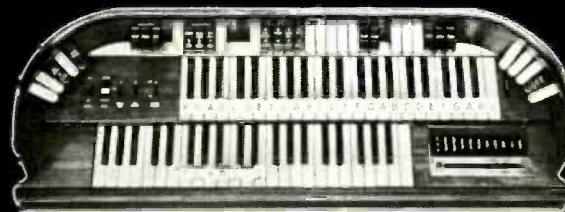

Professional Horseshoe Console Plus Color-Glo Keys . . . a beautiful array of multi-colored stop tablets at your fingertips for convenient selection of all 19 organ voices. Plus famous Thomas Color-Glo lighted keys so you can play complete songs the first time you try it . . . even if you've never played an organ before!

19 Voices, 200 Watts Peak Power, Chimes, 2 Speaker Systems, "Stereo" Sound And Full Professional Features At Over $500 Savings!

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15 Manual Voices; 4 Pedal Voices . . . all at the flip of a tab. For solo work . . . diapason 16′, bass clarinet 16′, trumpet 16′, English horn 8′, oboe 8′, violin 8′ and tibia 16′, 8′, 5⅓′, 4′. For accompaniment . . . diapason 8′, saxophone 8′, French horn 8′, oboe horn 8′ and cello 8′. And now, *four* pedal voices . . . diapason 16′, major flute 8′, bass clarinet 8′ and string bass 8′. And you'll soon learn voice combinations to produce the sounds of a Spanish guitar, zither, bagpipes, calliope. Plus other rhythm and voice variations for every musical mood. Rock & roll. Classical. Show tunes. Even religious music.

Two Separate Speaker Systems . . . a built-in 2-speed rotating Leslie plus a main system with two 12″ speakers that can handle the 200 watts peak power delivered by two separate amplifiers. You can even create "stereo" sound, since the Leslie also acts as a second standard channel.

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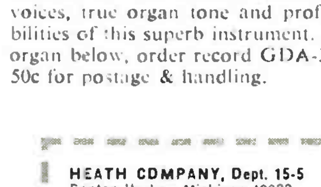

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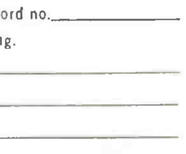

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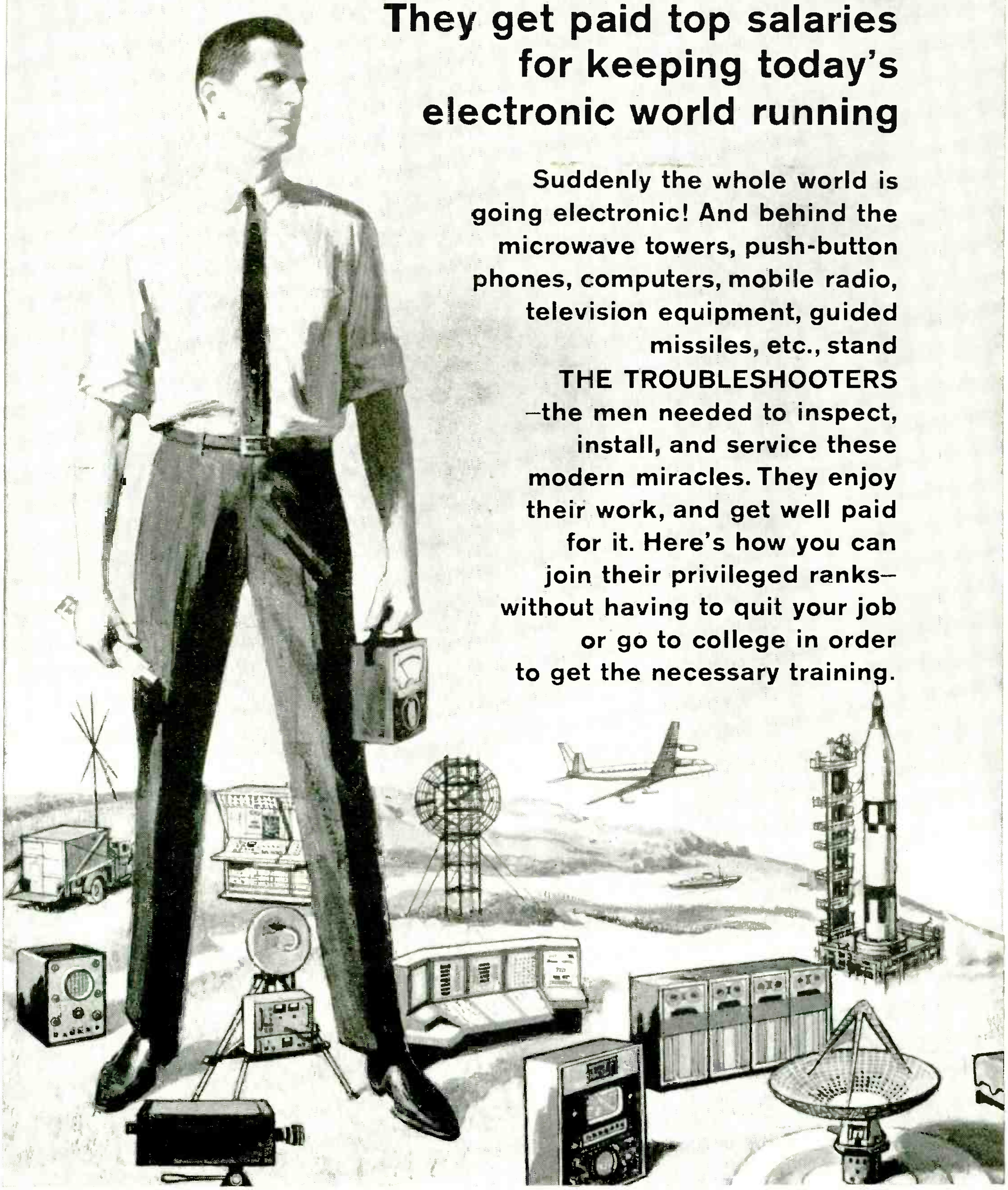

JUST THINK HOW MUCH in demand you would be if you could prevent a TV station from going off the air by repairing a transmitter...keep a whole assembly line moving by fixing automated production controls...prevent a bank, an airline, or your government from making serious mistakes by repairing a computer.

Today, whole industries depend on electronics. When breakdowns or emergencies occur, someone has got to move in, take over, and keep things running. That calls for one of a new breed of technicians—The Troubleshooters.

Because they prevent expensive mistakes or delays, they get top pay—and a title to match. At Xerox and Philco, they're called Technical Representatives. At IBM they're Customer Engineers. In radio or TV, they're the Broadcast Engineers.

What do you need to break into the ranks of The Troubleshooters? You might think you need a college diploma, but you don't. What you need is know-how—the kind a good TV service technician has—only lots more.

Think With Your Head, Not Your Hands

The service technician, you see, "thinks with his hands." He learns his trade by taking apart and putting together, and often can only fix things he's already familiar with.

But as one of The Troubleshooters, you may be called upon to service complicated equipment that you've never seen before or *can't* take apart. This means you have to be able to take things apart "in your head." You have to know enough electronics to understand the engineering specs, read the wiring diagrams, and calculate how a circuit should test at any given point.

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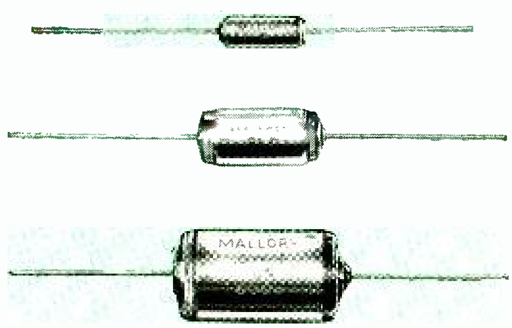
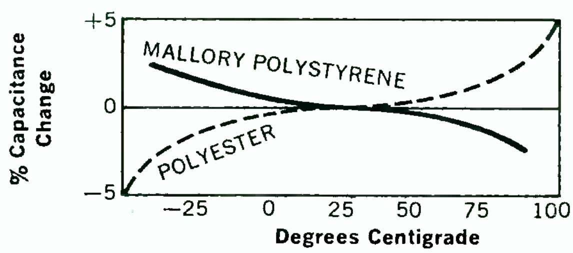
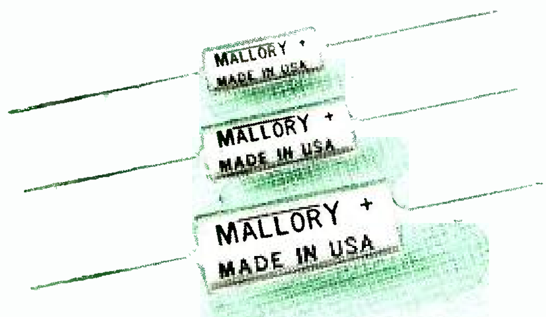
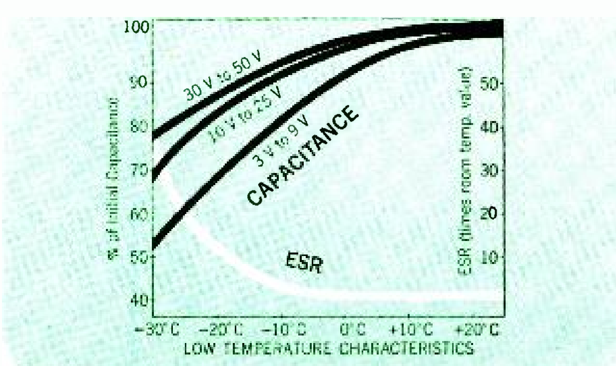
Capacitor stability at bargain prices





Capacitance vs. Temperature





Any capacitor changes its microfarad value when temperature varies. And some capacitors change more than others. In some circuits, capacitance drift with temperature can cause real problems.

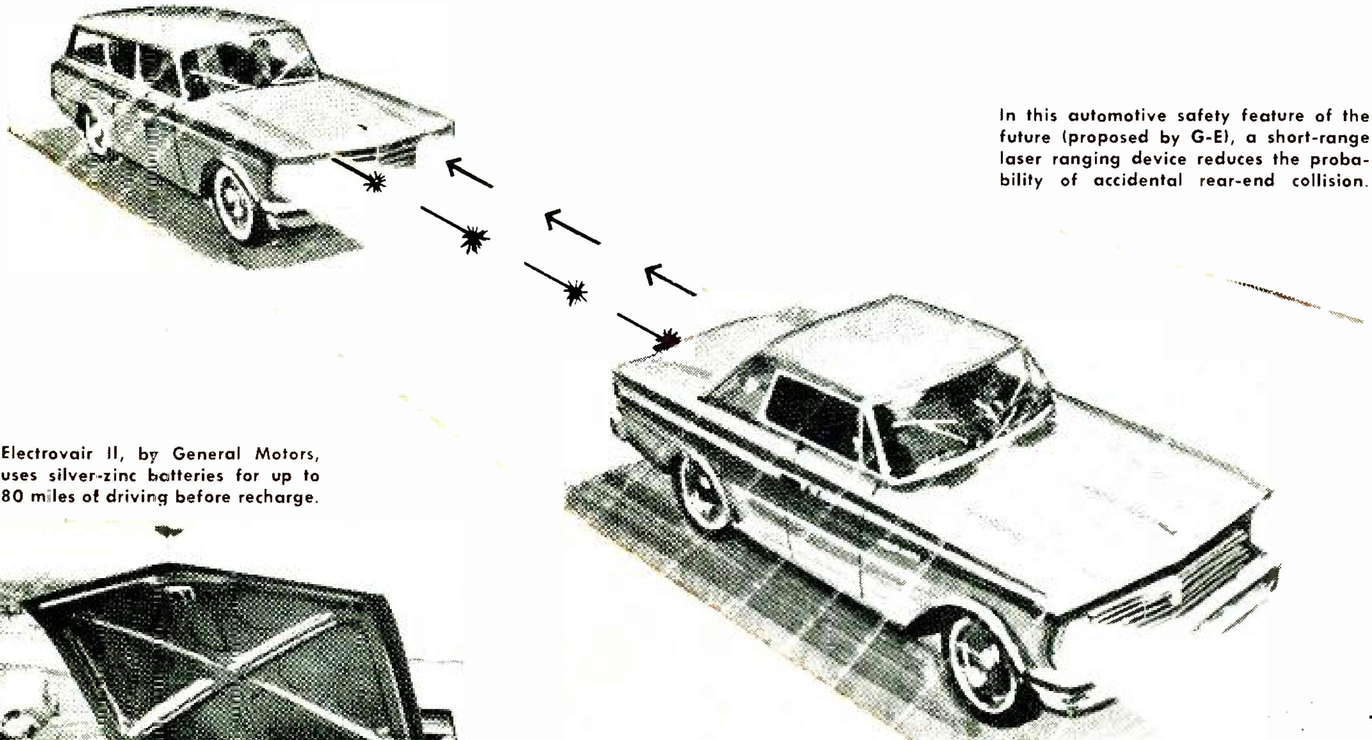
Look at circuits where you have fractional microfarad values of paper, film, ceramic or mica capacitors. During warm-up from room temperature to 65° C ambient, a capacitor with a temperature coefficient of, for example, 500 parts per million per degree C will increase capacitance value by 2%. This change is enough to cause troublesome drift in tuned circuits, where inductance *also* increases with temperature. It can knock the accuracy of a timing circuit off, or mess up the performance of a differentiator network. For these applications, we have a new kind of capacitor that beats anything we've seen in the stability race. It's the new Mallory Polystyrene Capacitor. They're made of stretched polystyrene film and high purity aluminum foil. The assembly is fused into one piece, with the polystyrene forming a solid case of clear plastic that you can look through and see the foil. Their temperature coefficient is less than 150 parts per million per degree C, which is about half that of polyester film capacitors. And the coefficient is *negative;* capacitance goes down when temperature goes up, compensating for the upward drift of inductance elements in tuned circuits.

Want more? Mallory Polystyrene Capacitors have the lowest dielectric loss . . . only a small fraction of that of other film capacitors. Their insulation resistance is way above that of mica, film or paper capacitors. And the best part of the whole deal is that they're really *low* in price!

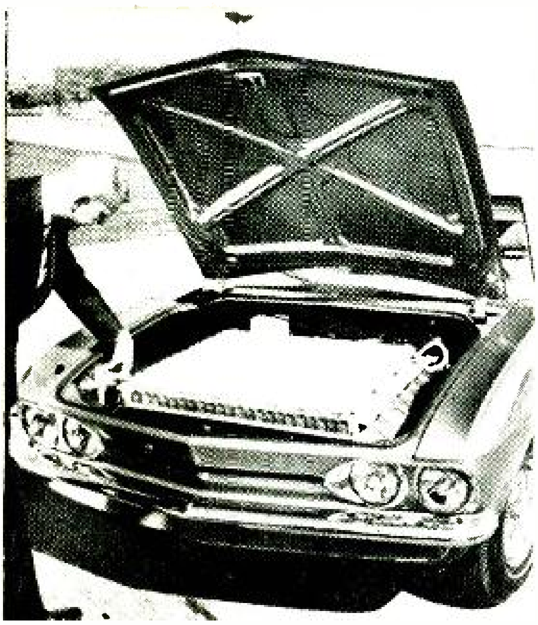
There's something new from Mallory, too, in stable electrolytic capacitors. It's the molded-case MTA, which has temperature stability that beats most metal case types. It has shown up so well on life test that manufacturers are using it in instruments and computers. And while it's priced down with cardboard-case tubulars, it beats them every way on quality.

You can get these stable Mallory capacitors, and everything else you need for service or experimenting, from your nearby Mallory Distributor. Ask him for a copy of our 1967 General Catalog, or write to Mallory Distributor Products Company, a division of P. R. Mallory & Co. Inc., Indianapolis, Indiana 46206.

DON'T FORGET TO ASK 'EM – *"What else needs fixing?"*



In this automotive safety feature of the future (proposed by G-E), a short-range laser ranging device reduces the probability of accidental rear-end collision.



Electrovair II, by General Motors, uses silver-zinc batteries for up to 80 miles of driving before recharge.

AUTOMOTIVE ELECTRONICS

By ROBERT M. BROWN

Tomorrow's cars will lean heavily on electronics. For example, voltage regulators, fuel warning systems, anti-skid control, and a radar-like laser system to prevent rear-end collisions are among items proposed.

UNTIL quite recently, major developments in the automotive field seemed to be limited to such areas as better styling, improved gasoline consumption rates, and, lately, the feasibility of turbine-powered vehicles. Within recent months, however, electric and electronic equipment has moved to the forefront. To talk about transistorized car radios, automobile safety, and electric autos all in the same article might seem a rather disjointed method of approaching the status of automotive electronics, but these developments are all related and point to the fact that sweeping changes are indeed beginning to be felt in Detroit.

At this writing, it is still not known exactly which safety improvements will actually show up with the 1968 models, but if Dr. William Haddon, Jr., chief of the National Traffic Safety Agency, has his way, twenty stringently imposed features will debut this coming September.

Although most of the controversy has revolved around certain mechanical changes (such as better seat anchorages) and the auto manufacturer's leadtime requirements, considerable fallout has hit both the automotive accessory makers and the original equipment manufacturers (OEM) who now find themselves scurrying about for electronic devices designed to plug the more obvious safety loopholes in the American car. And since considerable Detroit funds have suddenly been diverted to meet Washington's new demands, a severe cutback is being felt by many standard component R & D companies now faced with the problem of economical and rapid production. The solution appears to be electronics.

Some Electronic Developments

Although we are all familiar with perhaps the first application of solid-state components in the family car—the transistorized radio—the most significant step forward was the use of the silicon diode in the alternator. This move represented a real risk for the automobile manufacturer because his use of these diodes affected both the safety aspect of the car and his costs, both initially and under warrantee. The success story of the alternator rectifier was so remarkable that the industry began to take a long, hard look at the electronic technology it had for so long ignored.

The next step was to see what could be done about the voltage regulator. It seemed logical that a transistor could be used for this purpose because a circuit could be designed to respond to the difference between battery voltage and a stable reference source, with this signal controlling the output of the alternator. Fig. 1A illustrates a simplified transistor-type regulator, while Fig. 1B shows an approach using an SCR. Several manufacturers (including *Motorola*) now have transistorized voltage regulators on the market, while *Ford Motor Company* has announced that it will be using

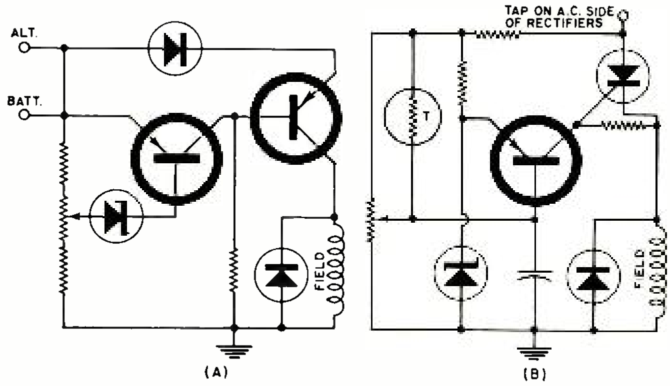


Fig. 1. (A) Simplified voltage regulator using a transistor. (B) Simplified SCR alternator voltage regulator.

some solid-state regulators in many of their 1968 models.

Although transistor ignition systems have been with us for some time, they are still undergoing further development. Of the several approaches commercially available, the capacitor-discharge system appears to be taking the lead, and some of the major auto manufacturers are already supplying such systems as an extra in some of their latest model cars.

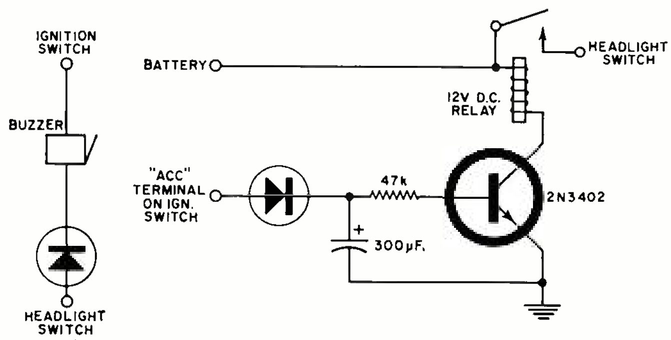
In some of the more advanced versions of the transistor ignition system, even the mechanical point contacts are being replaced by either a photoelectric or magnetic pick-up, which, in turn, activates the ignition system.

As this latter approach reaches the customer, it then removes the last mechanical component that stands in the way of an all-electronic transistor ignition and voltage regulator system.

With the safety-equipment drive in full swing, renewed interest in the automatic headlight dimmer has arisen. Currently available in the top cars of the big three auto makers, this unit, in addition to turning the lights off after a predetermined delay, turns the headlights on and off according to ambient light. At present, there is considerable talk of using the same principle in dual-intensity tail lights—one brightness for daytime and a lower one for nighttime. This application has evolved from the problem of temporary "blindness" resulting from the increase in total light given off when a car is braked at night with four, five, or six bulbs across the back of the vehicle.

The day/night rear-view mirrors offered by the leading auto makers on certain models also show the extent to which solid-state circuitry is beginning to be used in safety apparatus. During night driving, if a following auto's headlights are on high beam, a photocell in the mirror sends a signal to a transistor amplifier, which in turn activates a miniature solenoid that flips the mirror to a different angle. This automatic action deflects the bright headlamp reflection away from the driver's field of vision. When the high-

Fig. 2. (A) Headlight-on reminder buzzes when ignition is off and lights are on. (B) Headlight time delay automatically turns headlights off after a 60-90 second delay.



beam light disappears (or the following car switches to the low beam), the mirror flips back to its normal angle.

The acceptance of these devices is significant because it shows that both the automobile manufacturer and the owner are willing to trust certain control functions of the car to solid-state technology.

The Future

While it remains impossible to predict to just what extent the trend toward more and more electronics in the automobile will advance, startling work is currently being done on sophisticated safety device systems that may ultimately find their way into family vehicles. A number of firms (including *Bendix*) are presently conducting research into the possibility of an anti-skid control circuit, a design that will initially be tested on jet aircraft landing wheels. Since in many instances it is the sharp, prolonged application of pressure to the brakes that causes an automobile to veer into a skid and consequently go out of control, the suggested system would keep this from occurring by partially disengaging the pedal from the brakes while applying a moderate amount of braking by itself. The idea is simply to cause an automatic and *gradual* slowing down, regardless of how much frantic pumping the driver might exert.

This system will use four transistorized tachometers, one on each wheel, feeding an IC logic circuit which would compare each wheel revolution rate to the rest while at the same time using a fifth feed (consisting of any one of several proposed methods) for arriving at an actual vehicular motion reference (total car speed in relation to the roadway). The logic center would in turn be coupled to an electrical mechanism with override capability that would be attached to the conventional hydraulic brake system normally under driver control. When the IC control sensed a severe departure from the balanced rpm "norm" on any one or more of the wheels and also "felt" that over-all vehicle speed exceeded a safe level, it would apply moderate braking pressure to the wheels. This pressure would vary, depending upon the total motion factor and what was actually happening on that one wheel. Should the skid situation correct itself, full braking control would revert to the driver.

Although considerable research is now underway on just such a control circuit, it is felt in many circles that Detroit will never permit this much of a vehicle's mechanical system to be turned over to solid-state components. "Consider what would happen if the system failed!" is a frequently encountered remark. On the other hand, it is known that a similar system will soon be tested on aircraft grounding apparatus, and the ever-growing confidence in current automotive solid-state devices has far from reached a peak.

General Electric is presently offering interested automobile accessory suppliers its ideas for an anti-tailgating device using a laser beam. The arrangement calls for use of a low-cost laser that would put out low-power pulses of light, coupled with an extremely sensitive solid-state sensor to pick up the light reflections. The laser device would mount on the front of the vehicle and "look" directly ahead for a distance of perhaps 300 to 400 feet, depending upon what range the driver is calling for at the moment. With the sensor feeding a transistor amplifier which in turn might activate a buzzer, lamp, or meter readout, the driver would know approximately how far he is behind the vehicle ahead even though that car might not be visible. Any number of sophisticated laser alerting systems could be developed. However, G-E feels that this system will probably make its debut as an anti-tailgating gadget designed primarily for use in heavy snow, sleet, and fog conditions where even radar is undependable. A spokesman for the company claims that such equipment could be mass-produced at "a very reasonable cost, although it must be stressed that the laser for passenger cars is still far from a reality."

Long before such exotic designs become standard equipment, a host of less complex yet still impressive gadgets will appear. In fact, many such devices are here now.

The Boom in Accessories

A quick glance at the "available equipment" chart (Table 1) confirms that solid-state components are presently playing a major role in many new products for the car. For example, let us take a look at what the photoelectric headlight dimmer has stirred up. Fig. 2A shows a simple way to remind the driver that he left his headlights on after he turned the ignition off. In operation, when both ignition and headlights are on, both sides of the device are at the same potential. If the ignition switch is off and the headlights are on, current flows through the diode, activating the buzzer. Fig. 2B illustrates one method of achieving automatic headlight-off 60- to 90-second time delay. This unit is really two devices in one. *(Continued on page 26)*

D.C. MOTOR DRIVE FOR ELECTRIC CARS

By JOHN MUNGENAST
Electronic Components Div., General Electric Co.

That workhorse of the electric vehicle field, the fork lift truck, uses a d.c. motor control that has much to offer the electric car.

As we explore the electric drive for vehicles of the future, it is well to draw on the experience with solid-state drives presently being used on tens of thousands of vehicles throughout the world. The basic solid-state control system to be described is over six years old and has been in service in European delivery trucks, American golf carts, lift trucks, and personnel carriers as well as a complete German passenger train. The fundamental principle of a d.c. motor controlled by a solid-state "chopper" makes a natural starting point for discussions of future vehicle drive techniques. In addition, it should be noted that *Ford* research engineers claim they have in operation d.c. motors weighing only a quarter as much per unit power as the best now available and that these motors promise to be "low in cost and durable."

Essential vehicular drive requirements involve (1) the ability to reverse directions; (2) provision for dynamic braking; and (3) the ability to vary vehicle speed by lowering the voltage applied to the motor.

Categories (1) and (2) are generally provided by conventional methods of mechanical switching and the insertion of an appropriate armature resistance, which has been done conventionally for many years. The efficient reduction of battery voltage for speed control of the motor, however, poses a much more difficult problem.

While a variable resistor could do the job and indeed has been used in past electric vehicle controls, it has the disadvantages of lower efficiency, discernible control "steps," and poorer speed regulation (since the voltage drop changes with the motor current). Phase control, the answer to a.c. motor variation, is out of the question since the power source is a battery or other d.c. source. The power "chopper" mode of operation as shown in Fig. 1 seems like one answer. While this control method supplies the motor with power pulses, the motor responds to the *average* power level so that little sign of the pulsing is evident in operation.

A "chopper" is essentially a fast-acting switch, mechanical or solid-state, used to convert a d.c. level into a fluctuating waveshape for purposes of power control, subsequent amplification, etc. (Other "chopper" applications include vibrator power supplies, automotive ignition points, etc.)

The solid-state chopper can use either power transistors or an SCR, and each has certain advantages and disadvantages. But since the majority of high-current choppers use SCR's, this type will be discussed.

The advantage of latching-type operation, where a small momentary signal turns the device on, is offset to some extent by the difficulties in turning the SCR off when it operates from a d.c. source. To turn the SCR off it is necessary for the load current to be interrupted momentarily. The complete circuit for such an operation is shown in Fig. 2—actually an overgrown power flip-flop.

In operation, it functions as follows. *SCR1* is the main load-carrying SCR. When its gate is triggered on by unijunction transistor *Q1* circuit, current is allowed to flow through half the winding of *T3* and through the armature and field coil of the motor, which starts to run. The start of current flow induces a voltage into the other half of *T3* which charges up *C1*. This charge is held until the "off" SCR (*SCR2*) is triggered by unijunction transistor *Q2* circuit. The voltage across *SCR1* is then reversed and turned off. One of the advantages of this circuit is its ability to start reliably. Because of autotransformer *T3*, capacitor *C4* is always charged up whenever load (motor) current starts to flow; thus, commutation energy is always available. The main SCR is turned on again at an interval based on desired motor speed. Variation of motor speed is based on either varying pulse width or pulse frequency, or a combination of both.

A typical control, built by the Industry Control Department of *General Electric*, is now in use in thousands of electric fork trucks and is shown in the photo below. The SCR's, heatsinks, and commutating capacitor are mounted on the large board with the firing circuit board held in the hand.

The control potentiometer (not shown) is connected to the accelerator pedal. Bypass switch *S1* (Fig. 2) is usually energized at the end of accelerator travel, providing direct drive from battery to motor for maximum speed. ▲

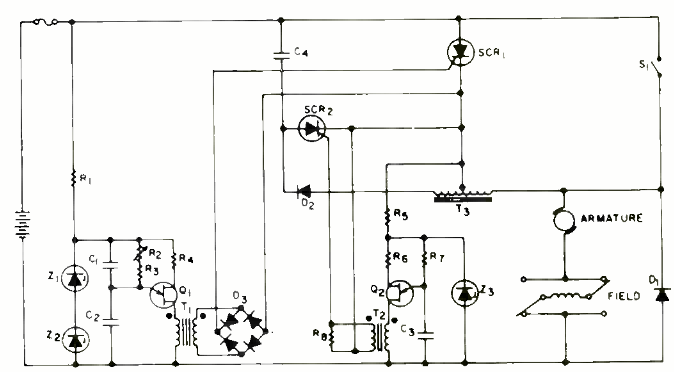


Fig. 2. SCR chopper circuit used for controlling a variety of battery-operated, d.c.-motor-driven electric vehicles.

Large SCR's and commutating capacitors on rear board, with firing circuit located on the smaller board. This system has been used for many years on electric fork lift trucks.

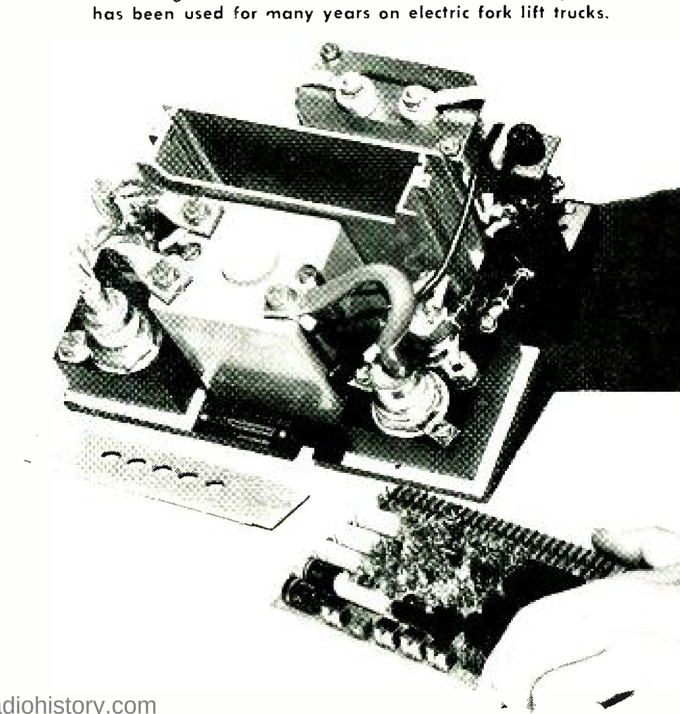
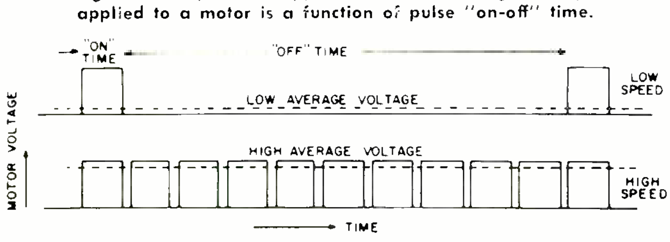


Fig. 1. In a power chopper circuit, the average voltage applied to a motor is a function of pulse "on-off" time.



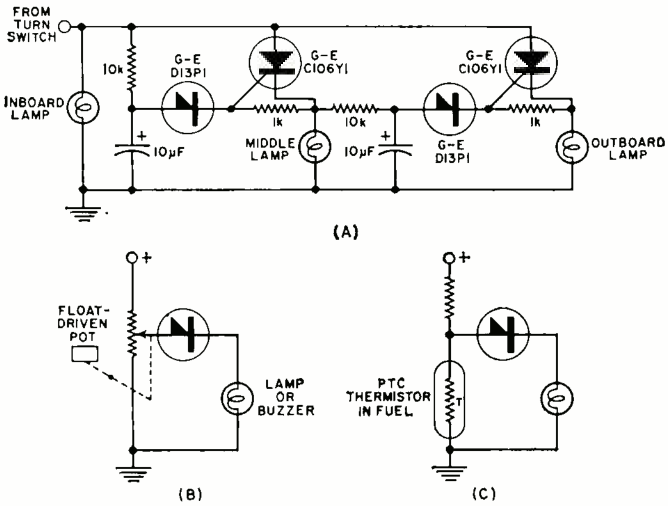


Fig. 3. (A) A system for creating sequential tail-light flashing. (B) Low fuel warning system using float. (C) Low fuel warning system using a self-heated thermistor.

It will delay the light-off signal to illuminate the way down the driveway or automatically turn headlights off should the driver forget.

Several manufacturers are introducing a solid-state module to produce the dazzling sequential tail-light effect now seen on certain cars. One way to do this is shown in Fig. 3A. These systems use SCR's to control the lamps and a conventional thermal flasher to open the circuit and reset the SCR's. A heavy-duty variable load flasher will not work with this system because it has a heater in parallel with the contacts and never really opens the circuit to shut off the SCR's. The breakdown diodes in the schematic are four-layer diodes which breakover (essentially short circuit) at a specific voltage (6 to 10 volts), thus triggering on the associated SCR. These diodes are well suited to such applications as level sensing. For example, one way that a manufacturer might indicate a low fuel supply is shown in Fig. 3B. In this circuit, as the float drops due to lowering of the fuel level in the tank, the potentiometer arm approaches the battery voltage until the diode fires, operating the buzzer or lamp. Fig 3C shows a method of employing a self-heated thermistor that uses the fuel liquid as a heat sink to achieve the same low-level sensing. When the fuel level goes below the thermistor level, the thermistor heats up, raising its resistance, until the diode voltage is sufficient to cause breakover.

Semiconductors have also been finding their way into products related to service and performance, although permanent auto equipment applications are still being watched very carefully because of the undetermined reliability factor. *Delco-Remy* has introduced a capacitive-discharge ignition system which uses a magnetic arrangement to eliminate the points. This system requires a switch signal amplifier, a transistorized inverter to produce a high voltage for charging a capacitor, and an SCR to switch the capacitor charge through the ignition coil in step with the switch signal.

Three English firms have been demonstrating a fuel-injection system that uses electronics to provide metering information and to control solenoid valves at each cylinder.

The Car of Tomorrow

Arthur E. Fury, a specialist in market development for *G-E's* Semiconductor Products Division, has some interesting thoughts on the dream car of the future. He visualizes an electronic speedometer used to drive an electroluminescent numeric readout as well as to provide information to the car's system. A laser range finder (an expansion of the proposed anti-tailgating system) supplies information about the distance and relative velocity of other vehicles. An accelerometer measures acceleration and deceleration, while a tachometer measures engine rpm.

Additional solid-state devices? "Thermistors, photocells, and silicon strain gages are placed about the car to measure ambient light, engine temperature, inside temperature, coolant level, gas level, oil level, oil pressure, tire pressure, and so on. Fuel flow is measured by two thermistors in the gas line, and exhaust emission is checked electrostatically. We add a two-way radio, and presto! we have a car that could be driven onto a superhighway and controlled either manually or by autopilot."

How would it work? A driver with such equipment would now have information about his speed condition, efficiency of the car, and road conditions. When it gets dark, his lights

Table 1. Three categories of automotive safety devices divided into electric, non-electric, and electronic divisions.

PERFORMANCE/EFFICIENCY	SAFETY/WARNING	LUXURY/EXTRAS
ELECTRIC	**NON-ELECTRIC**	**ELECTRIC**
Tandem fuel pumps that deliver 70 gallons per hour	Magnets that pick up stray bits of metal in engine blocks	Push-button door openers
Fuel flowmeters that read out engine consumption in gallons per hour	Fiber-optic tubes carrying light from outside lamps to warn of malfunctions	Motorized seats, antennas, windows, etc.
ELECTRONIC	**ELECTRIC**	**ELECTRONIC**
Alternator/generators, SCR	"Lights on," "Door not closed," etc., warning lights	Power inverters for powering electric shavers, etc.
Transistorized tachometers	Trunk and door locks	Transistorized AM/FM/short-wave receivers, often with reverb.
Solid-state voltage regulators	Transmission lock in "Park"	Transistorized in-car stereo playback systems
Exhaust gas analyzers that measure combustion efficiency and fuel-air ratio for correct carburetor settings	Windshield wipers	Converters for h.f. and v.h.f. reception on AM car radios
Electronic superchargers	Cornering lights, activated by turn signal	Two-way mobile communications equipment (CB, etc.)
Transistorized ignition systems	**ELECTRONIC**	Sequential tail-light systems for high-style rippling effect
Capacitive discharge ignition systems	Transistorized 4-way emergency flashers	Electronic throttle and speed controls
	Photoelectric headlight activators and dimmers	Automatic climate controls using thermistors and transistor amplifiers to activate outside air flow, heater, air conditioner, etc.
	Delay circuits to keep lights on 90 seconds after ignition is off	
	Siren/flashers for police vehicles	
	Transistorized burglar alarms	
	Overspeed warning devices	
	Flip-flop rear-view mirror using photocells, transistors, solenoids	

would go on automatically and the brake lights would be set to a dimmer degree. Should he go too fast, a buzzer would warn him and then some automatic counterpressure would be applied to the gas pedal. If he approaches the car in front too rapidly, the laser would control his brakes and accelerator. Should he panic, an anti-skid circuit would take over. Dashlights would tell if the gas is low, etc., and a major failure of something such as oil pressure would tell the computer to stop the car. (See "Integrated Circuits and the Automobile" in the February, 1967 issue of this magazine.)

Too way out? Probably, but the publicity over the HELP (Highway Emergency Locating Plan) program two years ago has already given way to *GM's* DAIR (Driver Aid, Information, and Routing) system now being tested in Detroit. It utilizes a basic CB set in an advanced-design configuration (Fig. 4) which affords the driver the following basic aids:

1. It provides reception of voice messages pertinent to traffic conditions and the road ahead.

2. It provides a display panel on the dashboard which reproduces roadside traffic signs by lights and readout tubes through its reactions to magnetic traps in the roadbed (see Fig. 5).

3. It provides illuminated instructions (turn left, make right, etc.) over a predetermined route, eliminating the necessity for map reference.

4. It provides a facility for tone-coded or voice communications between driver and a service center (on the CB band), permitting the motorist to summon aid or get road information when traveling on non-magnetic highways.

The Phenomenon of the Electric Car

Detroit's 1966 electric car revelation has perhaps more than any other factor been responsible for hastening the transition to solid state in the family vehicle. With the mass media supplying the public with daily reports of electric car R & D progress, potential customers are becoming increasingly aware that if anything truly revolutionary is ever to emerge from the automotive scene, a high degree of ultimate reliance on electronic components is essential. Mechanically inclined teenagers are poring over auto magazines bristling with facts about fuel cells and sodium-sulfur batteries while their parents skeptically await the first production-line electric car. Behind the open "can-it-be-done?" controversy, however, there lies a feverish undercurrent of activity felt not only by the auto makers but indeed by their suppliers and substantially influential segments of the electronics industry.

The reason for much of this is the inherent competitiveness associated with the American auto manufacturing business, well exemplified last fall when *Chrysler*, *Ford*, and *GM* made public for the first time their research into better storage cells. These announcements were made within a week or so of each other. In spite of the massive *GM* work which seemed to culminate in its "Electrovan" and "Electrovair" experimentals, one factor that has kept this entire business from simply becoming relegated to the status of a publicity stunt was *Ford's* public statement that perhaps "within five years we will have a production-line electric car" that would utilize the company's new sodium-sulfur batteries, "good for the life of the vehicle." While *Ford* talked about small two-passenger runabouts and the rest of the industry concentrated on competing with existing gasoline types, electronics engineers were developing improved drive systems utilizing sophisticated SCR control apparatus and IC logic units. Since October, 1966 the over-all size and prototype costs for one such high-voltage system (necessary for the a.c.-motored types *GM* and *Chrysler* envision) have been nearly halved.

Ford, on the other hand, is holding to its simple, low-voltage d.c. drive concept which appears to be gaining

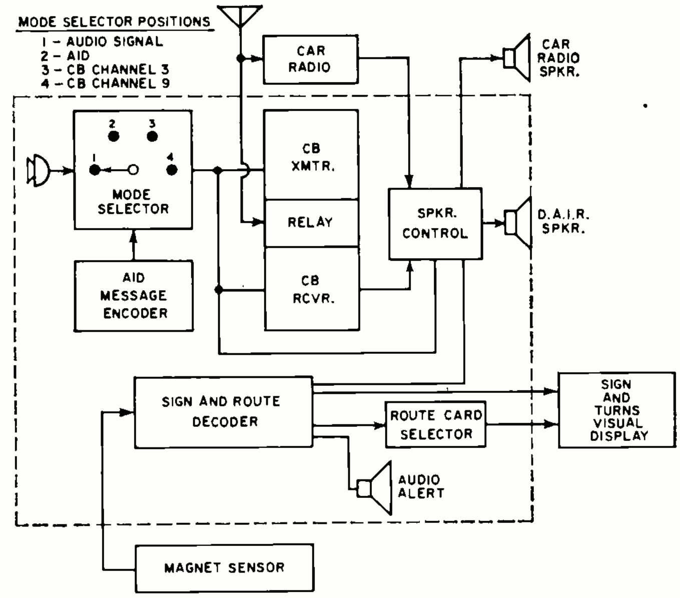


Fig. 4. Basic arrangement of General Motor's DAIR (Driver Aid, Information, and Routing) system now being tested.

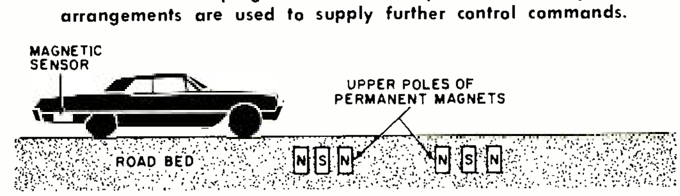
steadily in industrial acceptance. A recent Gallup poll confirmed that the public, too, would be interested in seeing *Ford's* scaled-down motorcar. Temporarily compromising for the sake of competition, *Ford* has promised to deliver from its British factory "the first prototype"—using conventional lead-acid storage batteries—"to be shipped to the United States in June." Walter Hayes, a British *Ford* official, admits that "this is going to be no Batmobile . . . but a bigger version could take a minimum of 10 years to get on the road in the U.S." *GM* and *Chrysler* seem to agree but on the surface appear to be sticking to their "average-sized car" battleguns. Rumblings from the OEM camp and certain segments of the solid-state industry, however, indicate quite the opposite. It remains to be seen just what will eventually emerge from Detroit, but it is quite clear that a considerable amount of auto maker R & D funds is being spent on exploration of various types of electronic car control systems.

However, not all this money is coming from Detroit. The Edison Electric Institute (a trade association of power companies) has earmarked over $1 million for 1967-68 work on "battery-fuel cell development." Obviously, associated solid-state systems research also falls into this category. U.S. Senator Magnuson's pending bill would grant huge sums of Federal aid to electric car development, and two quite similar bills are currently awaiting action in both houses of Congress. The U.S. Post Office is now test-driving four battery-powered trucks in various sections of the East. *Lear-Siegler* has developed a six-motor electric-driven test bed vehicle for the Army. Since 1964, teams of researchers from the General Atomic Division of *General Dynamics* have been exploring diverse facets of electric cars. And the list goes on and on.

The Role of Solid State

Recurrent off-the-cuff remarks by electronics firms largely dependent upon Detroit contracts would have one believe that all the talk about future scarcity of gasoline, traffic

Fig. 5. In the DAIR system, the magnetic poles are sensed and decoded as programmed vehicle speed. Other magnetic arrangements are used to supply further control commands.



noise, reduced electrical costs, and air pollution is just so much nonsense. This viewpoint has been given momentum by *American Motors'* announcement in February of its intention to market a small combustion-type passenger car which would openly compete with the Volkswagen.

Coupled with the near reality of *Ford's* electric car for city driving, this makes a pretty good argument for those with vested interests in d.c. drive configurations controlled by SCR choppers. Again, though, it is becoming apparent that regardless of the a.c.-d.c. controversy, solid-state components will be used as the "heart" of the vehicular drive system.

If fuel cells are employed in mass-production cars, thermistors, transistor amplifiers, and in some cases IC's will be required to maintain required temperature control. The widely publicized hydrogen-oxygen cells require a cooling level between −279°F and −423°F. Most of the experimental motors now in use must be constantly temperature-compensated, using circulating oil as a coolant.

A host of new solid-state safety devices is also imminent,

A.C. MOTOR DRIVE FOR ELECTRIC CARS

PUBLIC excitement over Detroit's sensational electric car disclosures last year was somewhat dampened by the apparent impracticality of available batteries. In the wave of disappointment which followed, one major point was all but overlooked—the fact that a lightweight, a.c. electric-drive system had proven itself in a passenger car, turning in a performance comparable to that of any current internal combustion engine. Not that a.c. electric motors are new by any stretch of the imagination, but the fact that their first trial with an electronic control system in an automobile achieved such satisfactory performance is nonetheless startling. Particularly as employed in cars where the maximum weight area must be allotted to batteries, the a.c. drive system holds much promise for the future.

Squirrel-cage a.c. induction motors have traditionally been used as single-speed machine power sources in applications demanding high rpm action. To supply the motor adequately, it is only necessary to feed it a constant voltage, at a constant frequency, consistent with the requirements of the motor. This consistency depends upon "slip" frequency—the difference between the actual mechanical rotor speed and the rotating stator field speed. (The rotor actually runs a bit behind the field.) Since the "slip" is plainly evident at a constant speed, a prescribed frequency requirement is met with the feed current. Hence, to attain variable speed operation, both the voltage and the frequency would have to be varied. To further complicate matters, the percentage of "slip" may be as little as 1% or as much as 10%, depending upon motor design and operating parameters.

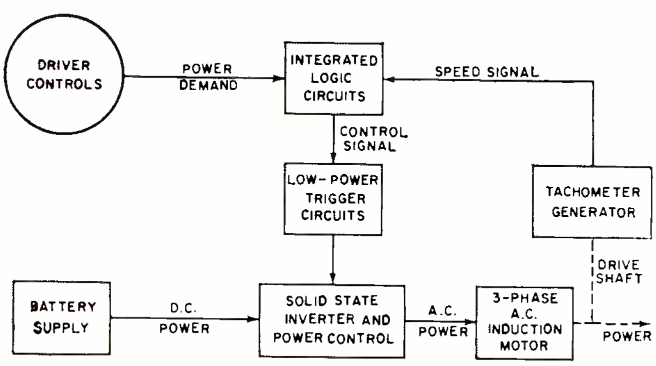
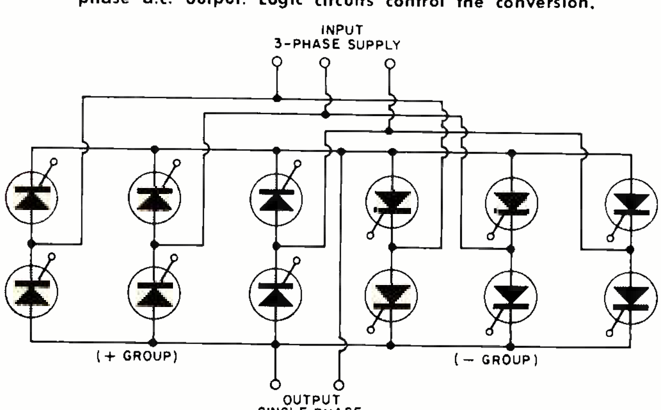


Fig. 1. Loop system of a.c. drive used by General Motors.

Fig. 2. Basic SCR unit of Lear-Siegler changes three-phase power from gas-engine-driven alternator to single-phase a.c. output. Logic circuits control the conversion.



These obstacles are somewhat diminished when it is considered that this apparatus can also take care of reverse action and braking, while the resultant high rpm will eliminate the necessity for bulky three- or four-speed transmissions. Existing 4:1 gears and differentials can be employed for the sake of expediency.

Several approaches can be taken. The *Henney* "Kilowatt" (a refitted *Renault* "Dauphine") employs electric relays for closing magnetic switches in sequence as the accelerator is pressed to provide six power levels. Yet accelerator technique is tricky and frequently results in blown fuses. Critics also call attention to "uneven acceleration". Electronic switching could be achieved using thyratrons or ignitrons. However, these outdated elements, in addition to being ungainly and heavy, do not solve the "slip" frequency problem.

The Loop A.C. Drive System—GM

Using integrated circuitry and SCR choppers, the "modulating inverter" has been devised to cope with a.c. induction motors. This, in effect, varies both the voltage and frequency in accordance with motor slip requirements and the driver's acceleration. Known as a "loop" control system (Fig. 1), *General Motors* is banking on it for all future electric car research and production, although engineers on the "Electrovair" and "Electrovan" estimate 1966 costs at about $5000. Part of this expenditure was due to the use of 400-ampere, 1200-volt SCR's which have to be series- and parallel-connected in the inverter. It is hoped that within a few years inexpensive 500-A, 2000-V versions will lower this cost appreciably.

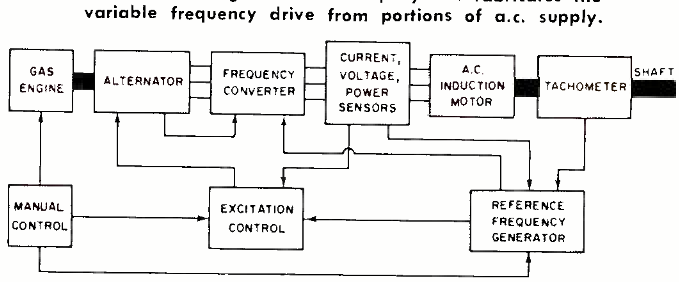
In the loop system, a voltage proportional to motor speed is obtained by a tachometer/generator on the drive motor shaft. This signal is passed to an IC logic circuit where it is compared with a preset voltage (derived from a potentiometer coupled to the accelerator) to produce the frequency for switching the solid-state inverter and power control (SCR's) on and off. Since the inverter *reduces* the average voltage to the motor by supplying it with power pulses, the ratio of on-to-off time of the pulse determines motor voltage. Varying the ratio of the on-to-off time of the pulse while keeping the pulse frequency constant, accomplished by varying the frequency of repetition of a constant-width pulse, renders a combination of pulse-width and pulse-frequency modulation. This combination has been found to produce excellent variable speed operation of an a.c. induction motor. To change motor speed, the driver alters the value of the preset voltage by depressing the accelerator (connected to a potentiometer). A switch turns the system off each time the accelerator is released.

The Loop Drive System—Lear Siegler

With many organizations attempting to develop high-performance a.c. motor-drive systems simultaneously, it is logical that different approaches would be tried.

Thinking more in terms of heavy-duty truck-type vehicles or applications for railroad transportation (and even drive systems

Fig. 3. Lear-Siegler's motor loop system fabricates the variable frequency drive from portions of a.c. supply.



since reliability will again become a major area of concern (power could lock on, motor could overspeed, control lever could slip from forward to reverse, etc.). New warning lights and failure-compensating circuitry will be required. If the *GM* concept is accepted, adequate safeguards against SCR overheat and over-all system shorting will have to be developed, as well as safeguards against possible danger to the driver as a result of 400-volt, 400-ampere currents, particularly in the event of severe physical vibration or collision with another automobile. Even the low-voltage *Ford* approach will ultimately necessitate a means of driver-monitored performance, optional automatic speed-reduction circuits to optimize battery life, and wherever feasible over-all substitution of solid-state components for present mechanical counterparts to achieve the absolute minimum drain on the already overworked storage cells.

Even if electric cars fail to materialize to the degree anticipated, at least the controversy will have left the automotive electronics industry many years ahead of where it might have been without it. ▲

How some companies plan to use an a.c. source as power for their cars. Unique among them is a drive motor mounted within the wheel.

By ROBERT M. BROWN

for large parabolic antennas), *Lear Siegler* (*LSI*) took a somewhat more complex approach to the problem. However, the fallout from this research represents still another possibility for a.c. electric passenger vehicles.

Lear Siegler's theory for varying squirrel-cage motor speed is basic. Using fast electronic-switching techniques, a variable-frequency, single-phase input to the motor is created from selected portions of a fixed-frequency, three-phase supply. Originally this was attempted in the post-World War I period with the "cycloconverter," a mercury-arc system that proved a bit too massive and expensive to be practical at the time. Today, however, the company has revived its interest in this dormant concept because of the availability of suitable SCR's.

The result is an all-a.c. system that can be powered from a commercial three-phase, 60-Hz power source; a battery-powered three-phase inverter source; or an engine-driven, three-phase alternator, probably the most practical of the group.

Lear Siegler's solid-state "cycloconverter" is a step-down frequency device comprising a number of "choppers" interposed between the power source and load. When actuated, the load is selectively coupled to the power source in such a manner that the current to the load is at a lower frequency than the source power frequency. The output is thus "fabricated" from small bits of the input.

The basic module in the frequency converter is a 12-SCR, three-phase-in/one-phase-out unit. Each single-phase module (Fig. 2) uses two groups of three-phase, full-wave rectifying bridges. This permits power from each of the input phases to supply power to the single-phase output.

Using seven integrated-circuit modules in the logic unit, the basic 3-to-1 converter module successively selects the appropriate portions of the supply-voltage waves which will closely approximate a desired waveform for the induction motor. At this point, suitable filtering is introduced to smooth out the waveform so that it is acceptable, although the inherent inductance of the squirrel-cage motor is sufficient, when the motor is used at varying speeds, to cause the current to be almost perfectly smooth to begin with.

Since more segments of the input power waveform are available for fabrication of the output waveform as the frequency ratio is accelerated, it is necessary to limit the minimum input-to-output ratio of the frequency converter to 2 (no limit on the maximum). For example, a conventional 60-Hz alternator produces a 30-Hz output frequency to the motor, which results in a drive motor speed of 1800 rpm, according to *LSI*. For a higher speed, it would be necessary to supply more than 60 Hz to the converter (which could be accomplished by driving a high-frequency alternator by a 60-Hz induction motor).

The balance of the system is much the same as that previously explored, employing the tachometer/generator at the motor shaft, etc. (See Fig. 3.)

But what about speed? Although *LSI's* experiments have not been primarily concerned with this factor, the company has developed an Army vehicle which employs an oil-cooled motor that rotates at 16,000 rpm at a vehicle speed of 50 mph. However, this approach uses the vehicle's conventional 6-cylinder gasoline engine to drive a rotary alternator which serves as the prime power source.

Motor Placement

Depending upon application, the a.c. squirrel-cage motors can be placed almost anywhere. *LSI's* Army test bed vehicle uses six powered wheels, each one capable of 16,000 rpm as indicated above. For the most part, the motor is inside the wheel with planetary reduction gearing just outside, less than two inches from the wheel itself. This arrangement is shown in Fig. 4. The gear mechanism is bolted to the outside of the vehicle frame, with the SCR frequency converter box located with others toward the rear center of the chassis. The result is a compact power wheel that at first glance looks much the same as conventional types. Fig. 5 shows the electrical arrangement.

An English firm, *Telearchics, Ltd.*, has a prototype of a small three-wheeled electric car that is driven by a single motor on the front wheel. With batteries in the rear, the "Winn City" car can maneuver a right-angle turn at 40 mph (its top speed).

General Motor's experimental "Electrovair" and "Electrovan" make optimum use of available equipment, placing a single a.c. induction motor where the conventional combustion engine would normally be situated and employing a standard differential to achieve rear two-wheel drive. The cooling system is a six-quart-capacity circulating-oil type that also serves to cool the SCR modulating inverter (total cooling system weight is 80 pounds).

It becomes apparent that location of the motor is not at all critical except where engineers must work with specific existing designs. Indeed, the electric car of the future may well be a combination of both approaches, perhaps using two rear *LSI*-type powered wheels with *GM's* simplified motor-loop concept. ▲

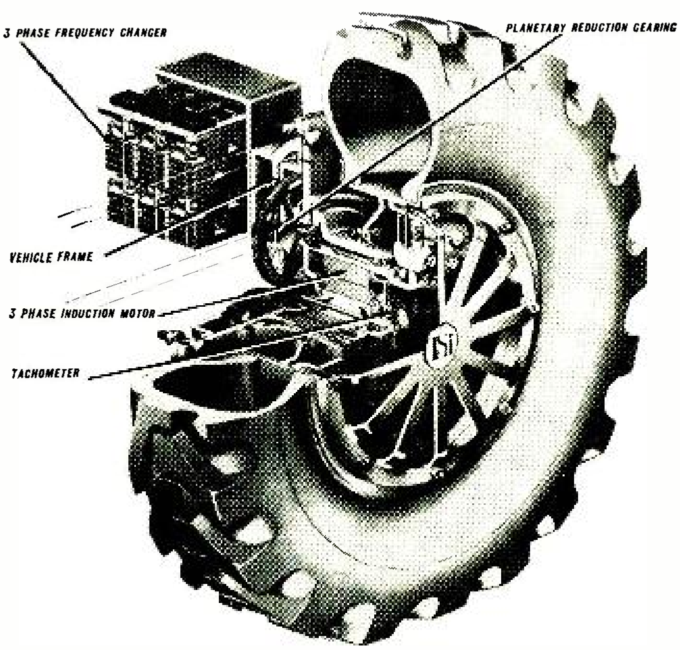
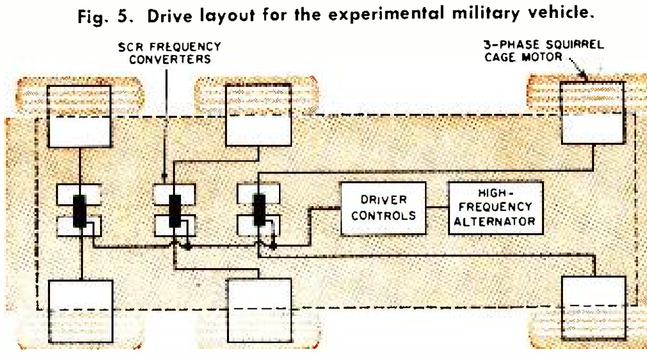


Fig. 4. In the powered wheel, the drive motor and its associated gearing is located within the drive wheel itself.

Fig. 5. Drive layout for the experimental military vehicle.



Field-Effect Transistor Circuits

By JOSEPH H. WUJEK, Jr. and MAX E. McGEE

A grouping of six simple, low-cost circuits that illustrate many of the principles of FET operation.

ONE of the most important new semiconductor devices is the *field-effect transistor (FET)*. This article describes six low-cost circuits which may be built to demonstrate the important properties of FET's. The U-110 and/or U-112 *p*-channel FET's are used in the circuits discussed and are relatively low priced. *Siliconix* has offered the U-110 and U-112 together as a package for $2.75. The U-110 may be had alone for $1.00 under this offer. The industrial-type FET's, U-146 and U-147, are slightly higher in price. The bipolar transistors used are *General Electric* epoxy devices which sell for $0.50 to $1.00 each.

General Properties of FET's

For convenience, the similarities among vacuum tubes, transistors, and FET's are given in Fig. 1. We must recognize the inherent differences which exist among vacuum tubes, transistors, and FET's and the table serves only as an aid in pointing out bias polarities.

The FET resembles the vacuum tube in that the impedance looking into the gate is very high and can be on the order of hundreds of megohms. Also, the FET is a low-noise device, better than bipolar transistors and competitive with vacuum tubes. On the other hand, FET's resemble transistors in the leakage currents which flow between their electrodes when the device is cut-off.

The Source Follower

The source-follower circuit is analogous to the vacuum-tube cathode-follower or transistor emitter-follower. We might expect similar behavior from these circuits and such is the case. We thus have high input impedance, relatively low output impedance, and a voltage gain that can be made very close to unity.

Fig. 2 shows a simple source-follower circuit and the bandpass characteristics obtained with two different FET

Fig. 1. Tabular comparison of tubes, transistors, and FET's.

		Vacuum Triode	Bipolar Transistor	Field-Effect Transistor (FET)
Elements		Anode (A) Cathode (C) Grid (G)	Collector (C) Emitter (E) Base (B)	Drain (D) Source (S) Gate (G)
Symbol		A, G, C	B, C, E n-p-n	G, D, S n-CHANNEL
BIAS	Normal linear operation	Anode positive, grid negative with respect to cathode	Collector and base positive with respect to emitter	Drain positive, gate negative with respect to source
BIAS	For cut-off operation	Grid more negative with respect to cathode than for linear operation	Base negative with respect to emitter	Gate more negative with respect to source than for linear operation
COMPLEMENT	Symbol	———	B, C, E p-n-p	G, D, S p-CHANNEL
COMPLEMENT	Normal & cut-off operation	———	Bias opposite of "n-p-n"	Bias opposite of "p" channel

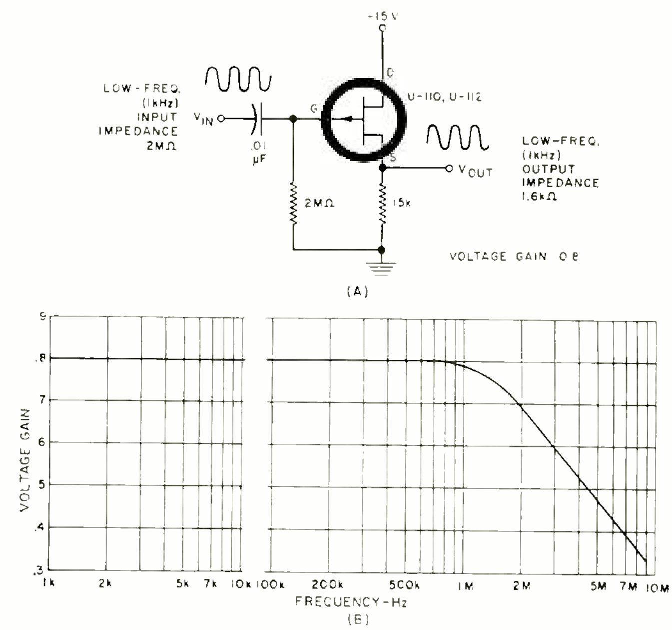
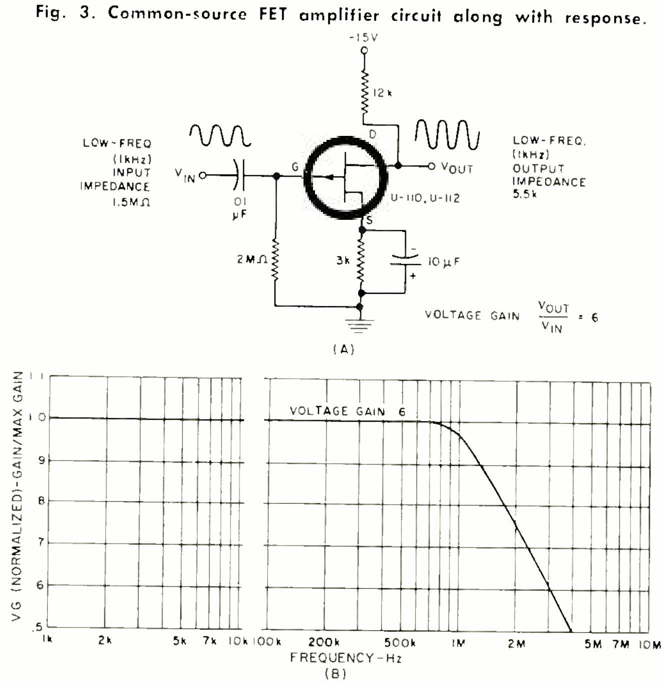


Fig. 2. A source-follower circuit along with frequency response.

Fig. 3. Common-source FET amplifier circuit along with response.



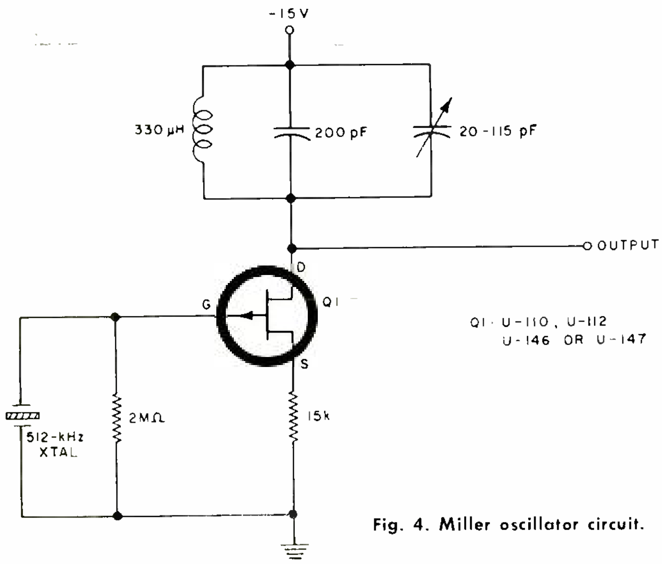


Fig. 4. Miller oscillator circuit.

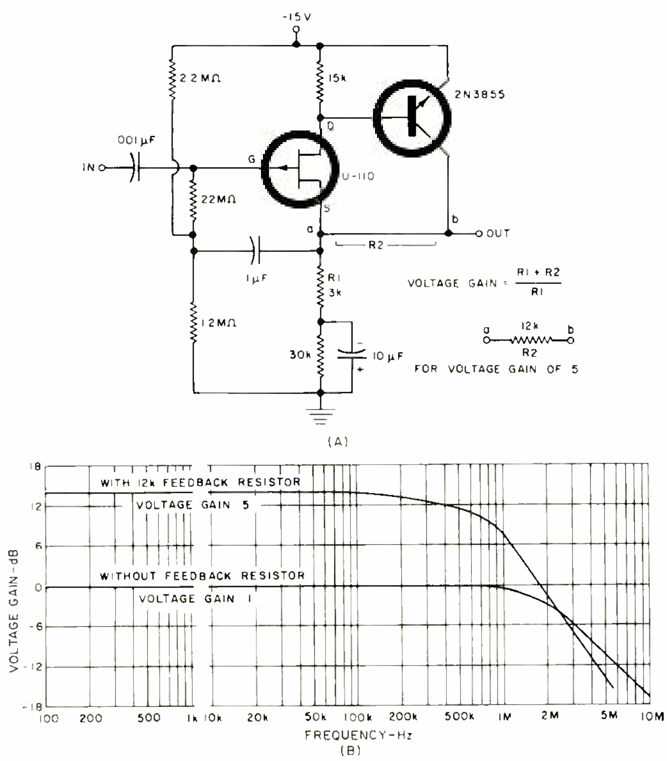


Fig. 5. FET/transistor pair has gain and high input impedance.

devices. The 2-megohm resistor establishes the gate bias and is similar to the grid-leak resistor used in tube work. However, this resistor must be made small enough so that increased leakage current between the gate and source will not drastically change the bias. For the U-110 and the U-112, leakage between gate and source at room temperature is on the order of 5 nanoamps (5×10^{-9} amp), so a 1- or 2-megohm resistor is adequate.

At elevated temperatures the increase in leakage current would dictate that a smaller resistor be used so as to reduce changes in bias with leakage current. It is possible to bias FET's so that very small temperature drift results.

Common-Source Amplifier

The common-source circuit is analogous to the common-emitter transistor and common-cathode vacuum-tube circuits. Again, properties of this circuit are similar to the transistor and tube counterparts. Input and output impedances are intermediate in value and a voltage gain greater than unity may be realized.

Fig. 3 shows a common-source circuit and the bandpass plot obtained by using either the U-110 or U-112 FET.

Miller Oscillator

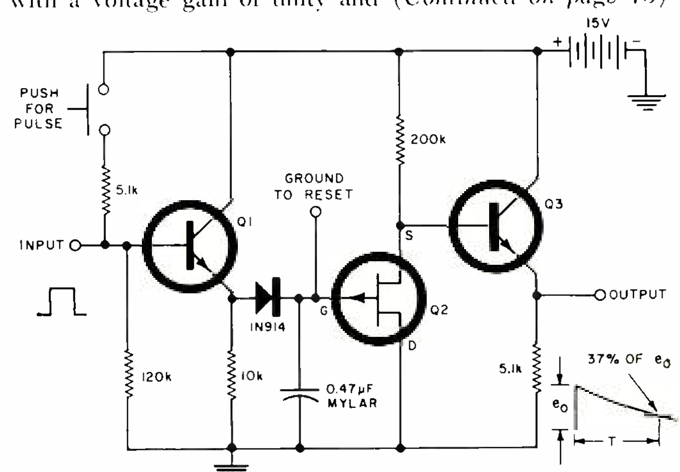
The very high input impedance of the FET enables us to build the simple Miller oscillator of Fig. 4. The high impedance of the gate circuit results in light loading of the crystal. The *LC* combination in the drain circuit is tuned to resonate slightly below the parallel resonance of the crystal. For the type of devices considered in this article, the upper limit of frequency operation is only a few megahertz. For crystals other than the 512-kHz unit shown, the *LC* combination must be changed accordingly.

The output of the oscillator will not tolerate much loading, but the source-follower circuit can be used as a driver to provide low output impedance without loading the oscillator stage excessively. With differences in FET types and layout details, some modification of the *LC* network may also be required. For the circuit we tested, "clean" oscillations were observed for the four FET types indicated on the figure without retuning the circuit, and with the supply voltage varying from 6 to 22 volts.

FET/Transistor Pair

A circuit which performs like an improved source-follower or emitter-follower is shown in Fig. 5. The FET again provides very high input impedance, while the transistor output provides low output impedance. Unlike the source-follower or emitter-follower, this circuit can be built to have a voltage gain greater than unity. This is accomplished by a resistor in the feedback path as shown in Fig. 5A (lower right).

Fig. 5B gives the bandpass characteristics when used with a voltage gain of unity and (*Continued on page 75*)

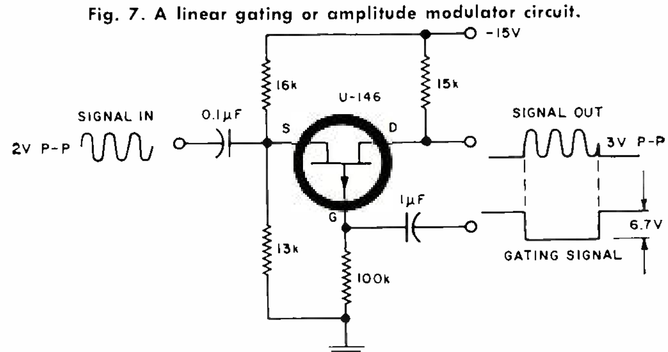


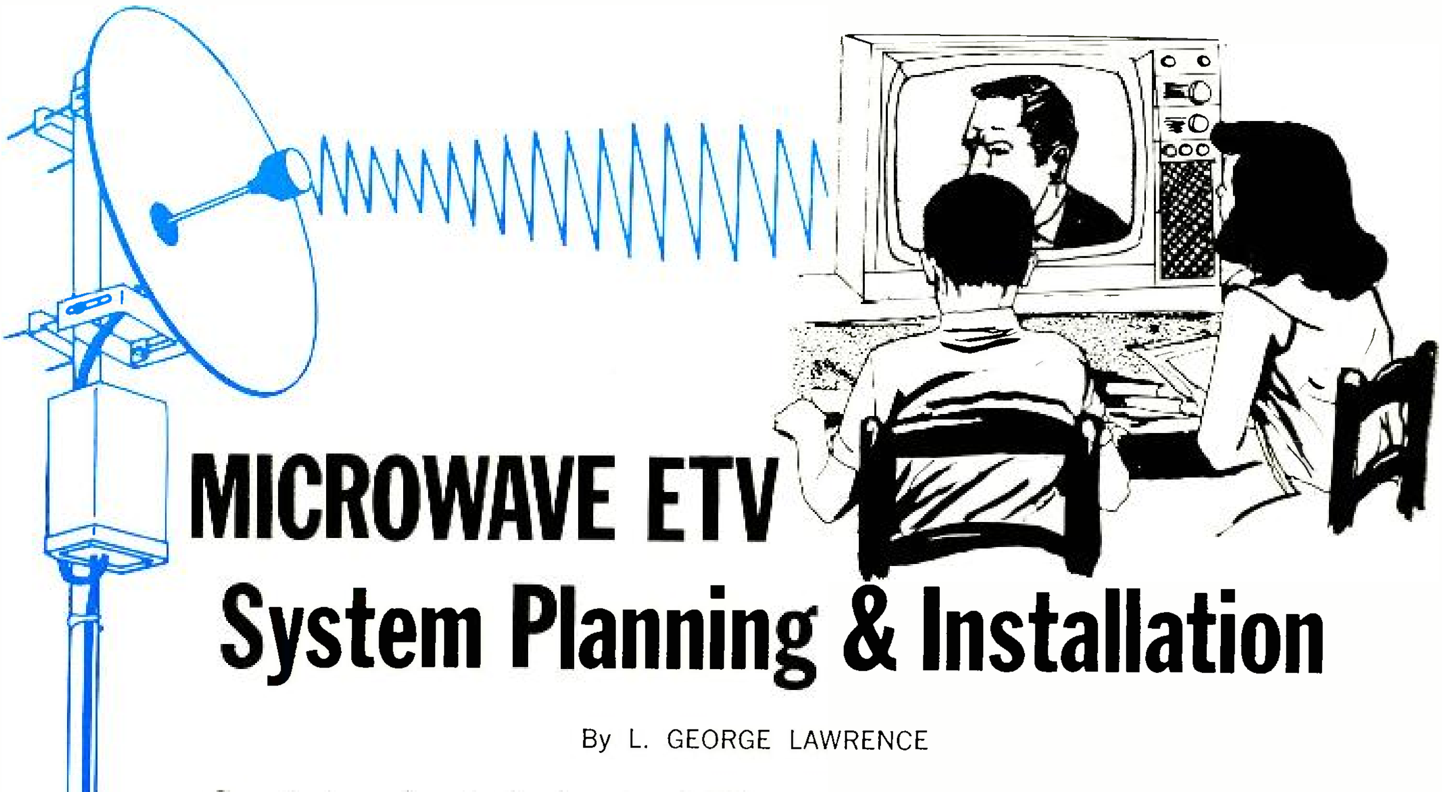
Q1 & Q3 ARE ANY OF THE FOLLOWING: 2N3855, 2N3391, 2N3394

Q2 FET TYPE	T (MINUTES)
U-110	4
U-112	2.5
U-146	6
U-147	5

Fig. 6. Pulse-stretcher circuit with FET and transistors.

Fig. 7. A linear gating or amplitude modulator circuit.





MICROWAVE ETV System Planning & Installation

By L. GEORGE LAWRENCE

Description of typical educational TV installations and methods of planning for school-originated transmissions in the 2500-MHz microwave frequency band.

EDUCATIONAL television, now well into its second decade, has established itself as an outstanding audio-visual tool in a good many teaching situations. Today, microwave transmission is emerging as an effective data carrier between widely separated school districts. The propagation techniques have been learned empirically, and system planning and installation follow but a few basic rules common to line-of-sight transmission paths.

On July 30, 1963 the Federal Communications Commission established the "Instructional Fixed Station Service" to meet the needs of educators for school-originated transmission of visual and aural material. The agency set up thirty 6-MHz channels in the microwave frequency band 2.5 to 2.686 GHz (see Table 1).

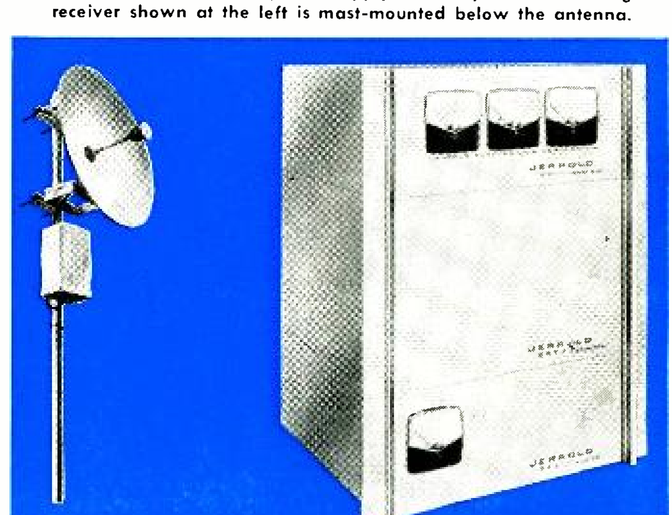
With nominal transmitter power set at 10 watts output, the transmission standards are the same as those for regular TV broadcasting, with some exceptions. Vestigial-sideband transmission, for example, is not required, but the lower sideband must not exceed the amplitude of the upper one. The microwave transmitter must maintain the 4.5-MHz sound-carrier separation and the visual carrier may not drift more than ±60 Hz. Stations are required to transmit call signs consisting of three letters and two digits. These identifications must be transmitted at sign-on, hourly during operation, and at sign-off.

From an electronics point of view, both transmitter and receiver are relatively simple affairs. Fig. 1 shows *Jerrold's* Model SRT-1 transmitter (right) and the same firm's Model SRR-1 school receiver. The transmitter is completely solid-state, including exciter-modulator and power supply, except for the traveling-wave tube in the final output stage. Monitoring is achieved by detecting the output after the final stage. The apparatus requires 300 watts of operating power for the transmitter and 30 watts for the exciter-modulator.

The receiver (Fig. 1, left), a solid-state design, uses a quadruple-tuned cavity preselector, a transistor and varactor oscillator-multiplier chain (crystal-controlled in the 130-MHz region), a two-stage broadband output amplifier, and *external* power-supply arrangements. The latter consists of a 20-volt a.c. indoor supply feeding the receiver through its coaxial output cable. Power requirement is 24 watts.

The received microwave-frequency signals are converted to v.h.f. signals and injected into the school's MATV system. Fig. 2 shows the common transmission and receiving

Fig. 1. Typical school transmitter at the right consists of an exciter-modulator unit (bottom), the rest of the transmitter (center), and the metered power-supply unit (top). The matching receiver shown at the left is mast-mounted below the antenna.



	CHANNEL NUMBER	BAND LIMITS (MHz)
Group A	A-1	2500-2506
	A-2	2512-2518
	A-3	2524-2530
	A-4	2536-2542
Group B	B-1	2506-2512
	B-2	2518-2524
	B-3	2530-2536
Group C	C-1	2548-2554
	C-2	2560-2566
	C-3	2572-2578
	C-4	2584-2590
Group D	D-1	2554-2560
	D-2	2566-2572
	D-3	2578-2584
	D-4	2590-2596
Group E	E-1	2596-2602
	E-2	2608-2614
	E-3	2620-2626
	E-4	2632-2638
Group F	F-1	2602-2608
	F-2	2614-2620
	F-3	2626-2632
	F-4	2638-2644
Group G	G-1	2644-2650
	G-2	2656-2662
	G-3	2668-2674
	G-4	2680-2686*
Group H	H-1	2650-2656
	H-2	2662-2668
	H-3	2674-2680

Upper limit.

Table 1. Frequency allocations for instructional fixed stations.

	1000 MHz	6000 MHz
Path length	25 miles	25 miles
Antennas	6′ parabolic	6′ parabolic
Free-space path loss	124.5 dB	140.0 dB
Antenna gain (2 antennas)	46.0 dB	77.0 dB
Normal transmitter power	37 dBm	30 dBm
Normal misc. losses (trans. lines, combining filters, circulators, etc.)	8 dB	5.2 dB
Net received signal power	−39.5 dBm	−38.2 dBm

Table 2. Typical path-length characteristics at 1 and 6 GHz.

method. The arrangement's main advantages are low cost, independence of fixed broadcasting schedules, and a more intimate approach to diversified teaching than possible before.

Field Surveys

Specifications for ETV systems can only be detailed after the propagation path has been determined. Bidding on an unsurveyed system can be a dangerous gamble, since a proposing firm may not be fully aware of obstacles and/or electromagnetic interference which can attenuate signals. To cover itself against severe losses, the company must either overbid—which can lose it the contract—or conduct a careful optical and electromagnetic field survey to safeguard against these possibilities.

There are five general types of field surveys, categorized as visual, map, photogrammetric, aerial, and electromagnetic (to detect effective field strength).

1. *Visual surveys* are performed by direct observation. The site of the proposed microwave-receiver antenna structure is marked by a large flag or brilliant light. If great distances are involved, the light may be generated by carbon-arc equipment whose beam is directed towards the site of the observer. The light or flag may then be searched for with binoculars while the observer is standing at the transmitter site.

The visual method is somewhat limited by the fact that radio waves bend more than light waves; but since antenna towers have not yet been erected, the survey may be conditionally positive in spite of minor obstructions partially blocking off the path of signal propagation.

2. *Aerial surveys*, being an extension of visual surveys, commonly make use of a small helicopter. The craft is used to position the observer at a height relative to that of the final supporting structure for the microwave antenna. Photographs will help to reinforce the observations made.

3. *Map surveys* are path determinations derived from a study of topographic maps. A *profile* of the propagation path is drawn on special graph paper, and the amount by which the line of sight clears terrain obstacles may thus be determined.

Data derived from such surveys is valid over terrain which is not commercially built up. Over city areas, this type of survey tends to become invalid due to interference by large buildings and other structures.

Although map surveys are inexpensive, it should be realized that many pertinent maps are twenty or more years old. Recent detail maps might show intervening structures, but the older ones will not.

4. *Photogrammetric surveys* subscribe to the use of stereoscopic aerial photographs of the signal-path line. The basis of this method is a series of photographs in which the same area is "shot" from two different angles. The pictures are then viewed through special optics which can indicate the relative height of obstructions in the projected transmission path.

5. *Electromagnetic surveys*. Whereas survey methods (1)

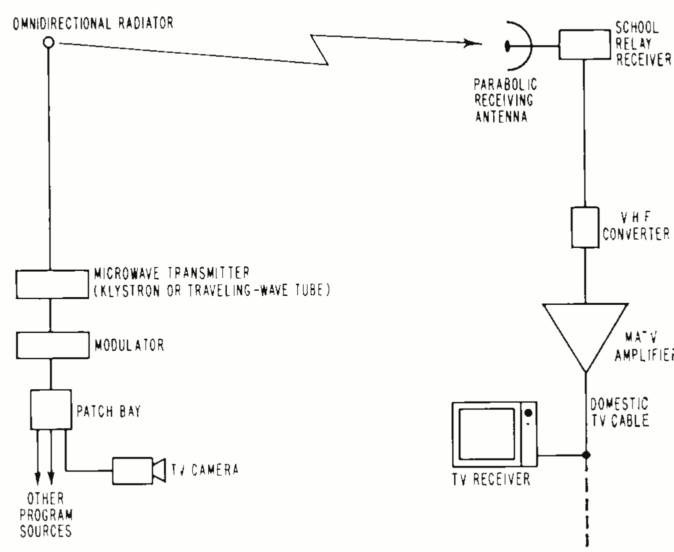


Fig. 2. Basic components of 1-channel, 2.5-GHz ETV system. Receiver output is heterodyned to v.h.f. and fed to MATV system.

through (4) deal with various optical observations that are conditionally acceptable, for precise determination of effective transmission-path characteristics, the electromagnetic simulation process is used. In this case, a small, portable microwave transmitter is taken to the chosen site of transmission, a simple antenna structure elevated, and a modulated signal transmitted to a field-strength meter located at the receiving end.

This method, although more expensive to apply, can provide excellent data under various conditions. If, for example, the local atmospheric situation is such that the air density increases with height, the earth between transmitter and receiver appears to bulge up into the wave fronts. If this bulge reaches the line of sight between transmitter and receiver, microwaves *of any frequency* will be attenuated

Fig. 3. Weather-shielded microwave antenna housing for studio-to-transmitter microwave relay, photographed at Mt. Wilson, Calif.

about 20 dB. This, in turn, decreases the receiver's signal-to-noise ratio and, for all practical purposes, the picture might be lost.

If the terrain between transmitter and receiver is a good reflector, the cancellations may be severe and very deep fades will result. High-frequency waves tend to cancel each other more often than low-frequency waves because smaller changes in *refraction* are required to cause a difference in paths of one-half wavelength. The 2.5-GHz system might have more fades than a lower frequency system, but these fades will be of shorter duration.

The equipment required for electromagnetic surveys consists of a 2.5-GHz transmitter and a microwave field-strength meter, including suitable antennas for both instruments.

Another electromagnetic method of gathering field-performance data is to substitute for the field-intensity meter an actual microwave receiver. The direct substitution method has proved successful in standard v.h.f. surveys, but, unfortunately, the bulk and weight of the microwave antenna does not invite its enthusiastic use. The method is a valid one, however, and should be employed if at all possible.

Antenna Requirements

Path distances to 12 miles would typically require a two-foot parabolic dish, while a one-foot parabolic dish is typical for 5 miles line of sight. Distances beyond 12 miles must be considered as a non-standard type of installation, requiring antenna-size determinations.

Table 2 gives some rule-of-thumb values for frequencies of 1 GHz and 6 GHz. In both cases, a range of 25 miles has been chosen. It should be noted that the gain of a parabolic antenna increases with antenna area as well as with operating frequency. But for a given microwave path with fixed-size antennas, the path attenuation increases with frequency. Hence, as is so often the case, one effect tends to offset the other.

Simple, unprotected parabolic antenna structures suffice for most purposes. Special considerations are introduced, however, if the service area is subject to extreme weather conditions—especially high winds, freezing rains, and the like. Aside from the possibility of off-target operation due to excessive movement and weight, the dish can be subject to severe electrical damage.

To mitigate such disadvantages, the antenna(s) can be housed in a window-equipped structure erected atop one of the higher school buildings. Fig. 3 illustrates an excellent installation of this type used for commercial studio-to-transmitter use. It contrasts with the less elaborate but more common educational system illustrated in Fig. 4.

Even though microwave ETV systems are fairly maintenance-free, unpretentious designs, a few simple accessories may be called for. An inexpensive monitor, which not only provides a continuous record of transmitter performance but also gives an acoustical alarm if the apparatus starts to malfunction and/or drifts off frequency, may be added. One such monitor, shown in Fig. 5, can be mounted in a 19-inch rack and connected to the transmitter by way of rear terminals.

The information given in this article is primarily intended for simplified situations. Experience has shown that each ETV system is somewhat unique and must be tailored to suit individual needs. At the present time, the systems are fairly new and much experience is yet to be gained in their use. ▲

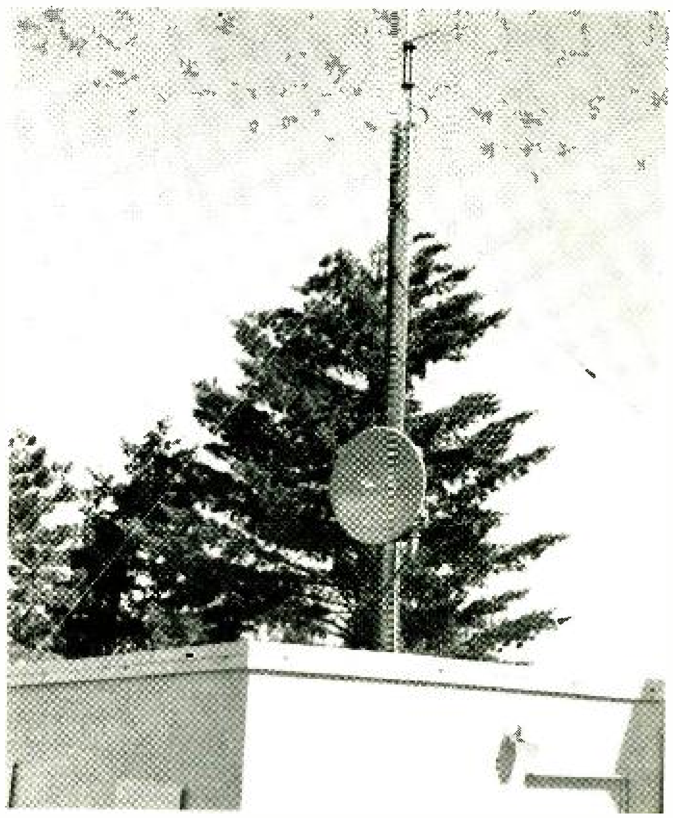
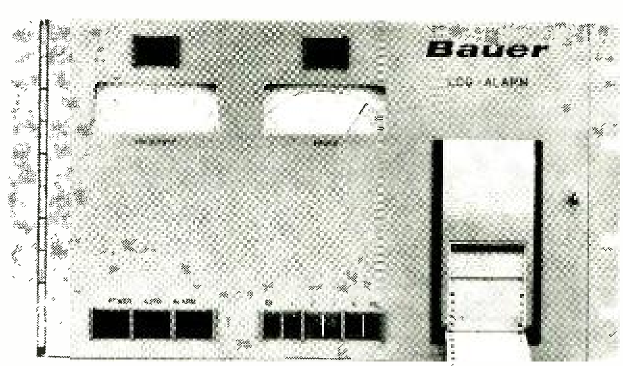


Fig. 4. A simple pole-mounted microwave antenna dish is shown.

Fig. 5. A recording monitor used to log transmitter performance.



IC Engine Tachometer and "Red Line" Indicator

By ROBERT A. HIRSCHFELD / Microcircuit Engineering, Amelco Semiconductor

In this, the first application of integrated circuits to automotive electronics, a red warning lamp comes on at some predetermined value of engine rpm, enabling the driver to shift gears at the correct rpm or indicating that his engine is now hitting its rpm limitations.

DESPITE the increasing popularity of automotive tachometers, their indications are of only academic interest under typical driving conditions. The most useful information a tachometer imparts to manual-shift drivers is the optimum "shift point," and this may be read as known speeds for each gear on the car's speedometer. A meter with a marked red line unfortunately requires the driver to divert his attention from the road in order to read relative pointer position at the critical time when the engine is developing nearly maximum power.

The tachometer described in this article includes an rpm sensing circuit, which can illuminate a warning lamp (electronic "red line") bright enough to signal the driver without distracting him from road conditions. The heart of the circuit is a new dual one-shot microcircuit flip-flop, which works directly from 12-volt auto batteries.

Basic Operation

The block diagram of Fig. 1 illustrates the basic operations performed by the tachometer. Ignition pulses at the distributor points are irregular, usually containing large inductive spikes and r.f. ringing. These pulses are filtered and clipped to prevent damage to low-voltage components of the microcircuit. Each pulse triggers a one-shot multivibrator, causing it to produce an output pulse of fixed width and height. If a metered readout is desired, a d.c. milliammeter is attached at this point. The meter acts as an integrator whose deflection is proportional to the average d.c. value of the pulse train. Since the one-shot pulse duration remains constant and the repetition rate depends upon engine rpm, the average d.c. value and hence meter deflection are accurately proportional to rpm.

The standardized pulse train is fed to a sensitive frequency discriminator, which will be discussed in detail. If the repetition rate exceeds the set threshold, the discriminator drives a saturating switch transistor which lights the indicator lamp.

The frequency discriminator outlined in Fig. 2 requires just the type of standardized output provided by the one-shot tachometer. The waveforms in Fig. 4 illustrate how the discriminator is able to critically sense very small variations from the set threshold. Capacitor $C4$ is charged, through $D4$, every time a pulse appears at point A and begins to discharge through $R8$, $R6$, and $R7$. If this process went unchecked, $C5$ would soon charge to the same level as $C4$. But potentiometer $R7$ and resistor $R6$ are driving a voltage threshold detector, which goes "on" whenever the voltage at point B drops below a set limit. This causes a switch to short out $C5$, making it lose its just-acquired charge. Note that for given values of $C4$, $R8$, $R6$, and $R7$ the discharge curve at point B always looks the same. Whether or not it

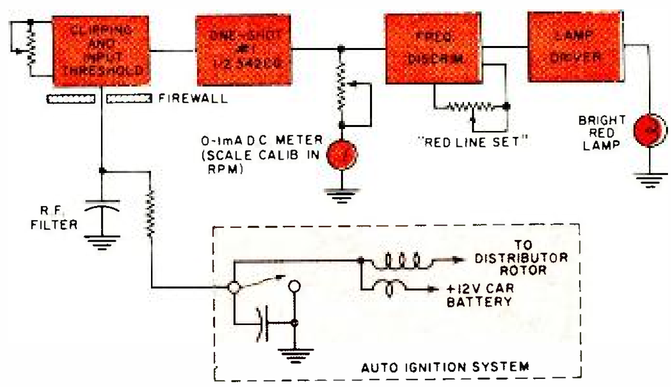
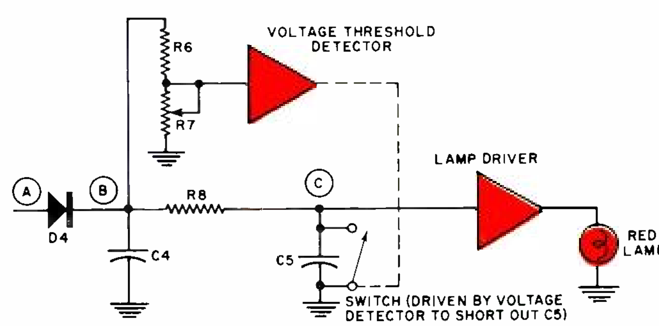
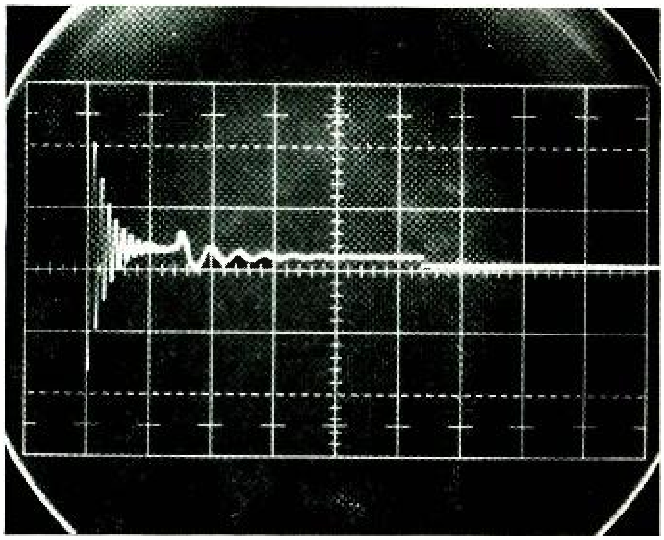


Fig. 1. Basic block diagram of the electronic "red-line" tach.

Fig. 2. Operation of the basic frequency discriminator. Capacitor C5 is kept discharged below preset rpm. When the rpm exceeds the predetermined limit, the red warning lamp glows.





Typical waveforms as measured across the breaker points at idle. Horizontal scale 5 ms/div, vertical scale 100 V/div.

reaches threshold voltage V_T depends upon the time between tachometer pulses. The action of the voltage threshold detector is positive: if V_T is crossed even for a very short time, C5 is completely discharged; if V_T is barely missed, C5 continues to accumulate charge. Thus, the waveform at point C is either a series of abortive charging pulses, for rpm below the threshold, or a fast, steady charge upwards, for rpm above the threshold. This means that the discriminator is able to sense excessive rpm within 4 or 5 ignition pulses of the time it occurs, which is an 8-cylinder engine at 5000 rpm, for example, is about 1.5 milliseconds.

Actual Circuit

A practical complete circuit combining the previously discussed circuits is shown in Fig. 3. Bear in mind that this circuit is a compromise based upon a commercially available microcircuit that was designed for digital computer use (*Amelco* 342CG). For mass production, a completely monolithic tachometer circuit could be designed containing most of the components external to the present microcircuit, including a voltage threshold detector better suited to compensating for the effects of varying temperatures and supply voltages.

Components *R*2 and *C*2 are mounted at the ignition points in the engine compartment. They have no adverse effect upon spark performance and perform several functions. First, they reduce r.f. transients that could damage the microcircuit; second, they reduce the amount of r.f. radiated in the passenger compartment from the tachometer input lead, a serious problem in most commercial tachometers (this r.f. appears as interference to the car radio); and third, *R*2 limits the d.c. current that can be driven into the microcircuit trigger input, even if *R*11 is set at zero ohms.

The "on" time of one-shot #1 must be small enough so that adjacent pulses cannot overlap at high rpm. Consequently, at low speeds, the inherent "ringing" of the ignition system could cause multiple pulses for each ignition pulse, making the meter inaccurate. A characteristic of these "ringing" oscillations, however, is that they are damped; that is, the first is always larger than subsequent ones. Potentiometer *R*11 and resistor *R*3 set an input threshold which assures triggering only on the first part of each ignition pulse. Diode *D*1 prevents the voltage at the trigger input from going more negative than ground, which would forward-bias certain components of the microcircuit with respect to their common substrate, damaging the circuit.

The "high" output level at pin 2 can vary with changes in auto battery voltage. To maintain constant height, and hence meter accuracy, *R*4 and *D*3 clip the pulse train. *R*5 is used to calibrate the full-scale meter reading; hence, the exact value of *D*3's zener voltage is not critical as long as it remains constant.

Pin 13 is used as the input to a voltage threshold detector made from part of the second complete one-shot. Pin 11 goes "low," discharging C5 only when the voltage at pin 13 drops below 2.1 volts; this occurs only at rpm below the level set by *R*7.

Because of diodes necessary in the "switch" used to discharge C5, this capacitor remains at +1.6 volts at rpm lower than the threshold. Thus, *D*5, *D*6, and *D*7 are used to assure that Q2 and therefore Q1 remain off until the "red line" is reached. If an inexpensive *p-n-p* germanium power transistor is used for Q1, very bright 12-volt lamps may be driven, provided that the current gain of Q1 is high.

Operation of the "red line" circuit is similar to that of a Schmitt trigger. A certain amount of hysteresis is built in, due to different charging conditions in the regions above and below the threshold. Thus, the rpm level at which the lamp goes off is lower than the critical "on" level, a desirable characteristic since an engine hovering around the threshold rpm would cause a "red line" circuit without hysteresis to flicker erratically.

Construction

Circuit construction is relatively non-critical and may be suited to the particular vehicle in which the tachometer is to be used. An accurate, easily read milliammeter is desirable, and the circuit may be constructed on a board attached to the meter terminals. Owners of cars with built-in tachometers may want to use the circuit for its "red line" function only; in this case, *D*2, *D*3, *R*4, and *R*5 may be eliminated, as well as the milliammeter itself.

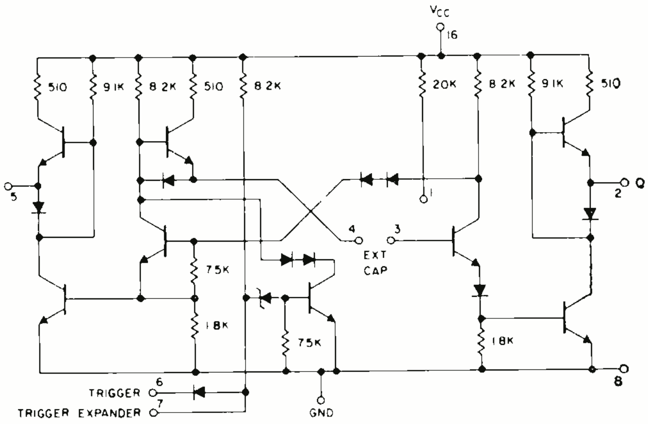
Note that Mylar capacitors are specified for C1 and C4 and that, despite the presence of a built-in diffused resistor (20,000 ohms) within the microcircuit, an external film type is recommended. These measures were found to improve the reading consistency of both metering and "red line" circuits over a wide temperature range. While the internal resistor could be used, its temperature coefficient is large enough to cause discernible shifts in accuracy at relatively high or low temperatures.

It may also be noted that pulses from pin 2 to the "red line" circuit are not directly clipped by *D*3. This is done to partially compensate for changes that occur in threshold level at pin 13 as battery voltage varies and therefore improves the accuracy of the "red line" limit under these conditions.

Engines having different numbers of cylinders produce

Table 1. Capacitor values for full-scale meter indications.

Engine Type	Typical Max. RPM / Freq.	C1-C4 (μF)
1 cyl. 2 stroke 2 cyl. 4 stroke (motorcycle)	10,000 / 166.6 Hz	0.2
4 cyl. 4 stroke (imported compact or sports car)	6000 / 200 Hz	0.2
2 cyl. 2 stroke (motorcycle)	10,000 / 333.3 Hz	0.1
6 cyl. 4 stroke (domestic or imported 6) 3 cyl. 2 stroke (Saab, Goliath)	5000 / 250 Hz	0.15
8 cyl. 4 stroke (V-8 engine)	5000 / 333.3 Hz	0.1
12 cyl. 4 stroke (V-12, etc.)	6000 / 600 Hz	0.05



One of two identical M-V's in the integrated circuit.

different numbers of pulses per revolution. The rpm/frequency equation is plotted in Fig. 5 for applications varying from a 1-cylinder, 2-stroke motorcycle engine up to a 12-cylinder racing engine. Optimum values of C1 and C4 for various full-scale tachometer readings for the various engines are given in Table 1.

Calibration

Calibration of the tachometer and "red line" is best done with an audio oscillator of known accuracy. An oscilloscope is useful for verifying that waveforms appear correctly throughout the circuit but is not mandatory. Full-scale markings of the milliammeter depend upon the type of engine with which it is to be used. The scale graduations will be linear. To calibrate, set the audio oscillator (connected to pin 6) to the frequency corresponding to full-scale meter reading, set *R5* to maximum resistance, and increase oscillator amplitude until meter deflection is observed. Adjust *R5* so that the meter reads exactly full scale. Then set the oscillator to the frequency corresponding to the "red line" (in some cases, this may be equal to the full-scale frequency). Adjust *R7* so that the "red line" lamp is off and then slowly readjust *R7* so that the lamp just lights. Check operation of the "red line" by moving the oscillator above and below the critical frequency.

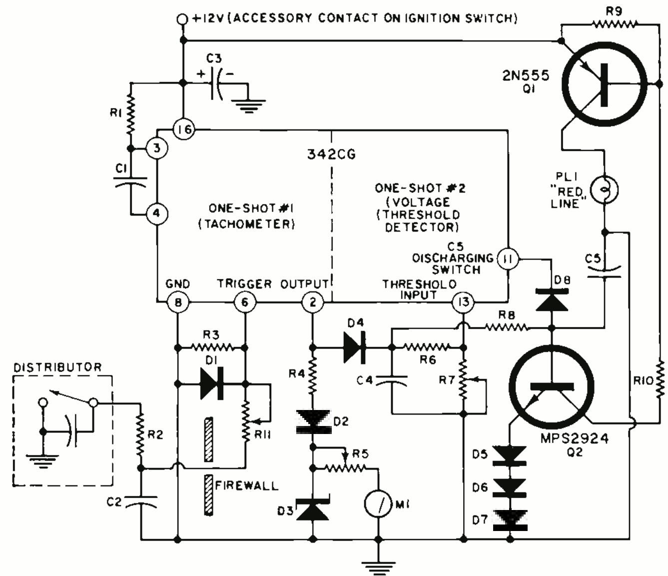
Recalling that there is some built-in hysteresis in the "red line," a check of the threshold rpm should be performed by starting at some lower frequency and increasing it until the lamp lights rather than by starting at a higher frequency and reducing it until the lamp extinguishes.

Once the initial calibration has been completed, the circuit may be installed in the vehicle. Set *R11* for maximum resistance before starting the engine. After starting, there may be no meter reading with engine idling; decrease *R11* until meter deflection occurs and adjust for steady reading at idle. This helps eliminate the "multiple pulsing" mentioned earlier. Checking "red line" operation in the car is best done with the engine warmed up, under actual accelerating conditions, as very high rpm in neutral may damage the engine.

The circuit of Fig. 3, as mentioned previously, is a compromise designed to use an off-the-shelf commercial microcircuit. Nevertheless, the meter and "red line" functions have measured accuracies, in the author's installation, of better than ±.2% from 0° to 50°C (typical passenger compartment temperature extremes, corresponding to the range from freezing to 122°F); accuracy is similar for battery voltage variations from 11 to 15 volts. At constant temperature and battery voltage, long-term accuracy is about ±.5%.

Hysteresis, in the author's 6000-rpm installation, amounts to about a 50 rpm difference between "red line" lighting and extinguishing speeds.

(Editor's Note: The 342CJ IC is now available at $6.90. This is a direct substitute for the 342CG unit.) ▲



R1—20,000 ohm, metal film res. (IRC CEC-T-O or equiv.)
R2—10,000 ohm, ½ W res.
R3, R6—4700 ohm, ½ W res.
R4—200 ohms, ½ W res.
R5—5000 ohm pot
R7—500,000 ohm pot
R8—100,000 ohms, ½ W res.
R9—1000 ohms, ½ W res.
R10—470 ohms, ½ W res.
R11—100,000 ohm pot
C1—Mylar cap. See Table 1
C2—.01 µF, 1000 V disc cap.
C3—100 µF, 15 V elect. cap.
C4—Mylar cap. See Table 1
C5—1 µF cap. (CDE MFP-1W1 or equiv.)
D1, D2, D4, D5, D6, D7, D8—1N4001
D3—Zener diode, 6.8 V
M1—0-1 mA d.c. milliammeter
PL1—12 V indicator lamp (type 1815, or any 12-14 V lamp up to 250 mA)
342CG or 342CJ—Amelco 11NIL dual one shot IC
Q1—2N555 or equiv.
Q2—MPS2924 or equiv.

Fig. 3. Schematic and parts list for the electronic "red line."

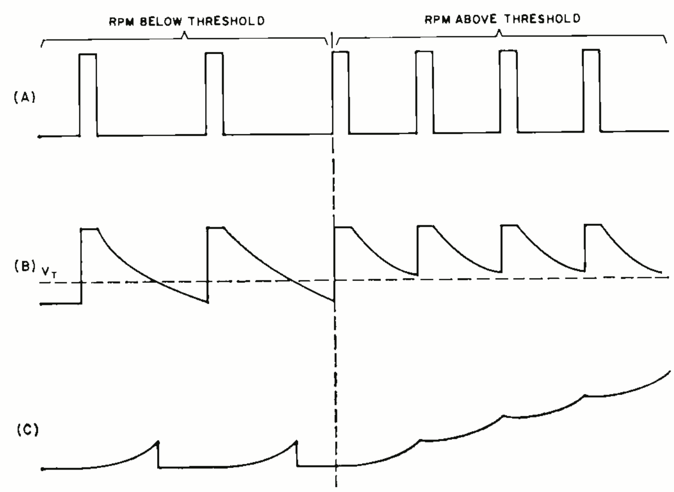
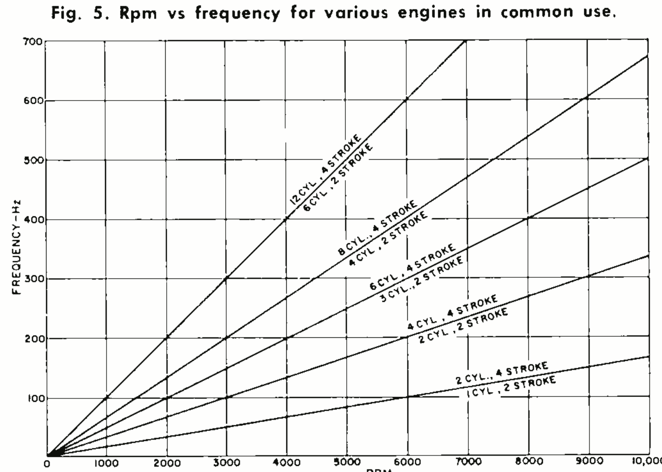


Fig. 4. Basic frequency discriminator waveforms keyed to block diagram of Fig. 2. Point V_T is the trigger level.

Fig. 5. Rpm vs frequency for various engines in common use.



Selecting Frequency and Time Standards

By IRWIN MATH/Project Engineer, Frequency Electronics, Inc.

How precision oscillators and clocks are rated and exactly what they are capable of. A discussion of stability and other important standard specifications.

HIGHLY precise frequency and time standards are becoming more and more widely used in today's sophisticated scientific world. The missile and space age demands, for example, are far in excess of the requirements of only a few years ago. In fact, the stability of the research laboratory's frequency standard of 10 years ago is now taken for granted in the oscillators of many types of modern industrial test equipment.

As a result, all too often the engineer or technician will specify a complex, ultra-stable frequency standard when a much less stable one would have been sufficient for his application. Similarly, he can often mistakenly interpret a lower order oscillator as easily as one of much higher quality. For these reasons, the engineer and technician as well as anyone with even a casual interest in the measurement field should have a good understanding of just how precision oscillators and clocks are rated and exactly what they are capable of doing.

Long-Term and Short-Term Stability

In the "good old days", it was enough to ask for a 1-MHz oscillator with a stability of ±0.001%. Anything better than 0.1% was considered rather good. But today things have changed. All but the simplest of oscillators that are used as standards are rated in parts per 10^9. For example, a 1-MHz oscillator with a stability of ±1 Hz is rated at 1 MHz ±1 part in 10^6 or 1 part per million. Similarly, a good frequency standard may have a stability of ±1 part in 10^{10}. The general expression for frequency stability is $S=\Delta F/F$ where F is the nominal frequency and ΔF is the allowable variation. Therefore, the actual frequency variation of our frequency standard (considering its output is 1 MHz nominal) is ±0.0001 Hz or $\pm 1 \times 10^{-10}$ of the nominal frequency.

However, this information is not enough. While it does indicate stability, it does not specify over what period of time this stability must be measured. The complete stability of a frequency-standard oscillator must be given in two parts: the long term and the short term.

The long-term stability of an oscillator is basically the average change in frequency over a long fixed period of time as compared to some absolute reference. Usually, long-term stability is measured in one of two ways. The first of these, as indicated in Fig. 1, depends on readings of frequency taken continuously for several days. The maximum peak-to-peak deviation over any 24-hour period is measured and the stability is then defined as ± one-half this maximum. For example, since both oscillators in Fig. 1 have a peak-to-peak variation of 1 part in 10^8 per day, their long-term stability would be specified as ±5 parts per 10^9 per day. Notice, though, that oscillator #2 has a much longer average rate of frequency change than does oscillator #1. Therefore, while they both are ±5 parts in 10^9 per day oscillators, oscillator #2 is obviously superior.

The second method, and by far the more accurate one, is based on the average change of frequency over a given

Fig. 1. Measuring long-term stability by means of peak readings.

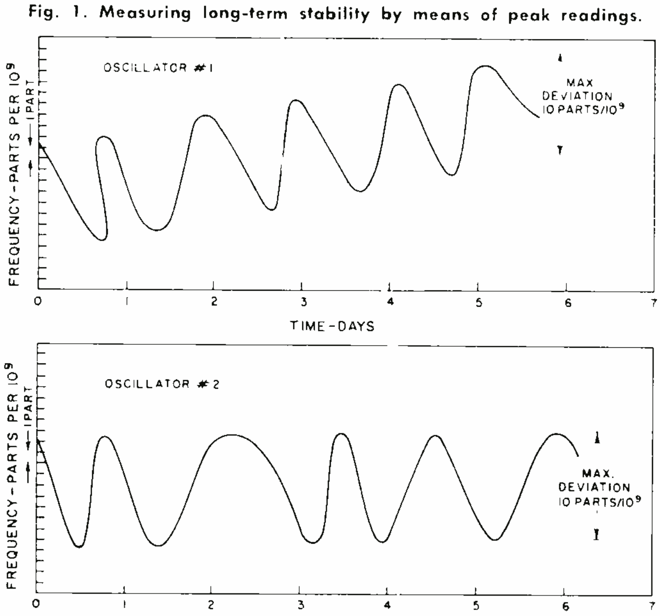
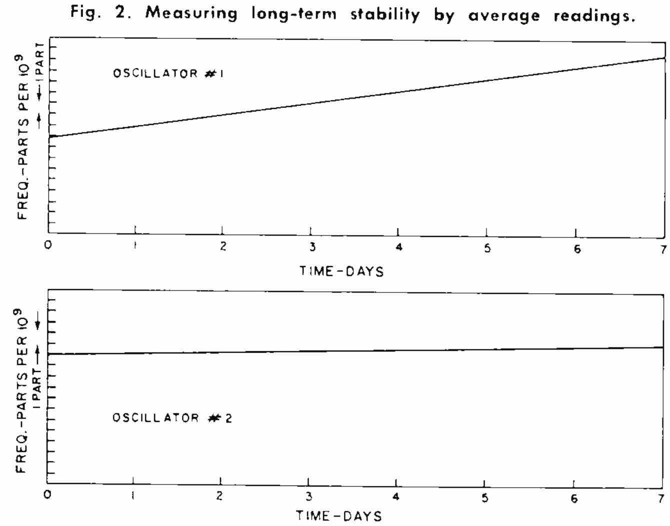


Fig. 2. Measuring long-term stability by average readings.



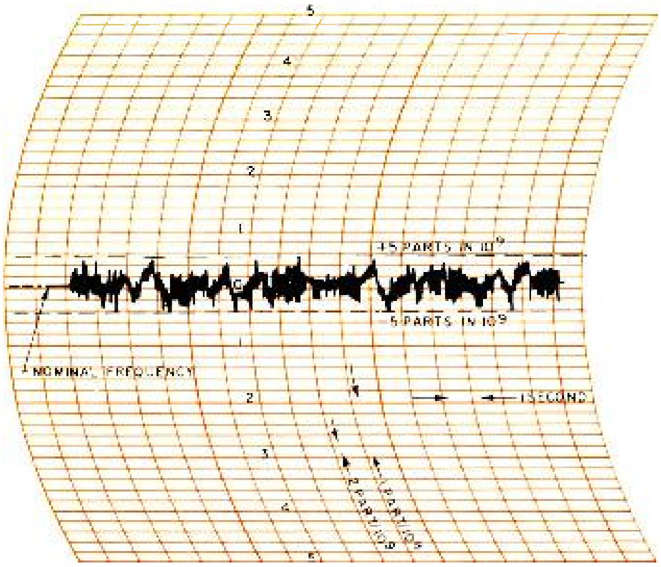


Fig. 3. Automatic recording of an oscillator with a short-term stability of plus or minus 5 parts in 10^9 per second.

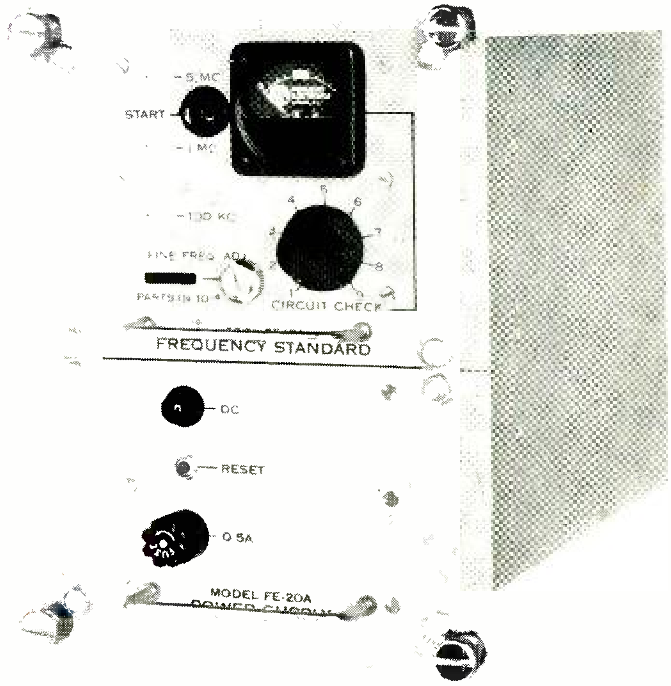


Fig. 4. A typical high-quality frequency standard which has a long-term stability of plus or minus 1 part in 10^{10}.

time interval. As shown in Fig. 2, the stability of oscillators #1 and #2 is now determined by the slope of their average frequencies. Now it is easy to see that oscillator #2 is substantially better than oscillator #1.

To further clarify the measurement and eliminate any remaining doubt, a few oscillator manufacturers incorporate both the average long-term frequency change and the day-to-day change in their long-term stability specification. For example, a 1-MHz oscillator such as the one shown in Fig. 4 with a rated long-term stability of ±1 part in 10^{10} is one whose maximum daily and average frequency will change by no more than ±1 cycle per 10 billion cycles per day or 0.0001 cycle per day.

The short-term stability of an oscillator is its frequency stability over periods of time from a few seconds to fractions of a second. This type of specification is important when the oscillator is used as the source for a frequency multiplication system, especially into the thousands of MHz. If, for example, a 1-MHz oscillator with a second-to-second variation of ±1 part in 10^6 were multiplied to 1000 MHz, the variation would now be ±1000 Hz per second.

As in long-term measurements, there are two general methods. One is similar to long term in that readings of frequency are taken. The time interval, however, is much shorter. Fig. 3 is a recording of an oscillator with a short-term variation of ±5 parts in 10^9 per second. Notice that in *any* 1-second interval, the frequency never deviates by ±5 parts in 10^9 from the nominal. This type of recording is used for intervals as low as 0.1 second. Smaller intervals require too fast a recorder speed and are measured by the second method.

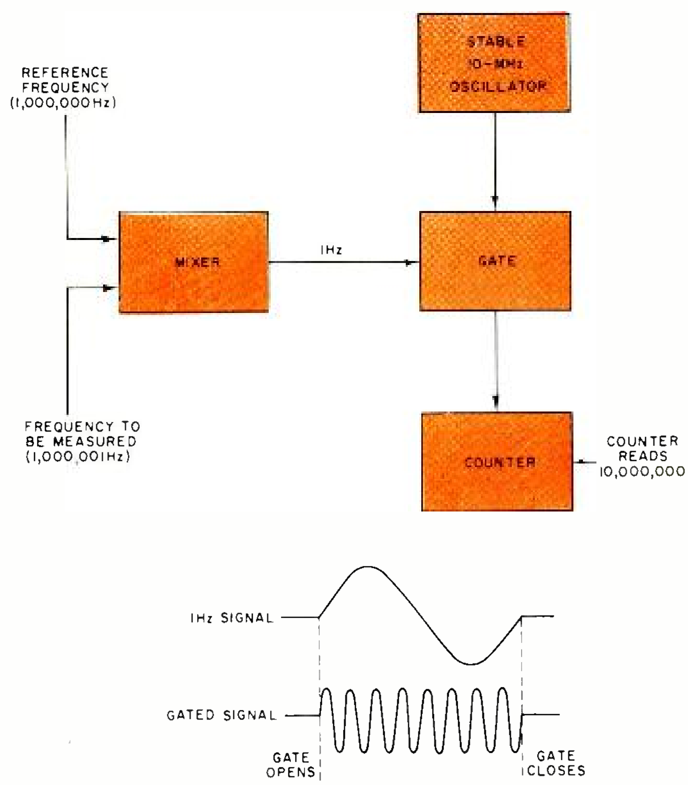
This method involves a statistical approach. The oscillator to be measured is fed to a low-noise mixer along with a very stable reference frequency.

The difference of the two signals is then fed to a counter which measures the period (or wavelength) of this signal. A typical setup is shown in Fig. 5. The difference frequency actually triggers a gate, allowing a very stable 10-MHz signal to drive the counter. Since the period of the difference signal determines how many cycles of 10 MHz will be fed into the counter, great accuracy can be achieved. Assuming that the difference signal is 1 Hz, this means that 10,000,000 cycles will pass into the counter through the gate for each cycle of input. Therefore, only 1/10,000,000 of a second change in the difference signal will cause the counter to indicate a change. Since such great resolution is possible by this technique, extremely short intervals of time can be measured and interpreted as short-term stabilities.

Usually an oscillator with good short-term stability will not exhibit a good long-term characteristic and *vice versa*. As a result, where both long- and short-term stability must be as good as possible, the technique shown in Fig. 6 is used. A very good long-term standard and a very good short-term standard are fed to a phase detector. The d.c. output of the phase detector is then fed back to a voltage-variable capacitor in the short-term standard which causes its frequency to "lock" to the frequency of the long-term unit. This "phase-locking" technique now produces an output with excellent long- and short-term stabilities.

The stability of an oscillator (*Continued on page* 68)

Fig. 5. Test setup employed for short-term measurements.



IC's Head For Industrial Market

As the price of IC's comes down, the area of application increases. The continuing trend toward ever bigger circuits in the same small package further eases IC use in many types of industrial equipment.

WITH integrated circuits setting the trend, electronic manufacturers look to industrial equipment as their next big growth market. One major producer, *Texas Instruments*, expects industrial electronics equipment to rise from a current level of $4.8 billion to $6.1 billion by 1970, with IC's accounting for some $400 million sales that year.

Charles Phipps, *TI* integrated circuits marketing manager, says, "Solid-state electronics is no longer restricted to TV, hi-fi, and sophisticated military hardware. Today, builders of machine tools, production-control equipment, and materials-handling machines are already making the switch from their traditional mechanical and hydraulic methods to electronics."

Besides lowering costs, IC's have cut size and weight of equipment by up to 75%, improved quality and reliability from three to five times, and reduced the number of components by a factor of 30.

In 1965, less than 10% of IC sales went to industrial users; in 1966 this figure rose to 20%. *TI* anticipates that by 1970, as much as 60% of the IC market will be industrial types. This dominance will be further reflected by IC's accounting for 40% of all small-signal (non-power) electronic circuits built in 1970. See graph below. This represents an eightfold increase over current levels, where discrete semiconductor circuits dominate and vacuum-tube networks are the "weakening" second.

The rapid price reductions for IC's and the resultant expansion in markets were possible because of the much shorter "learning cycle" for IC's than earlier semiconductors. IC producers were able to draw heavily on the basic technologies, production techniques, and testing methods developed for transistors. In fact, the "knee" of the price trend (as shown bottom right) occurred after only one million units were produced. Germanium transistors, the first semiconductor in high-volume production did not experience this price break until more than 100 million units were produced. Silicon transistors broke their price barrier at about 10 million units.

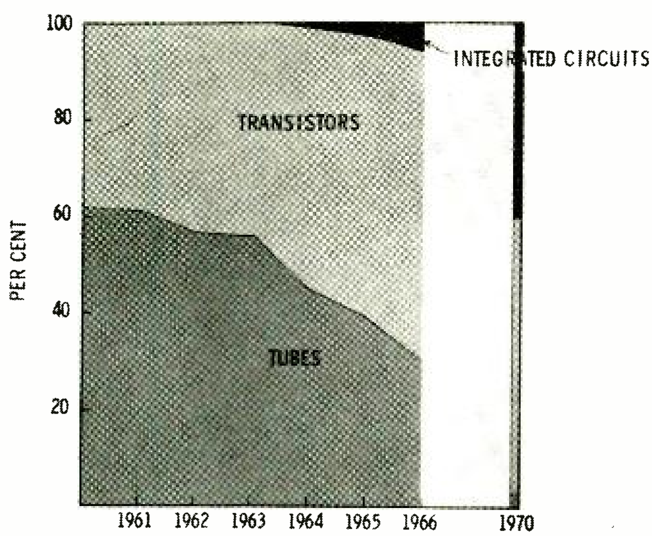
First-generation IC's were simple circuit functions, single logic gates which were the equivalent of 10 to 20 discrete components. The second generation, introduced in 1964, were multi-function units containing up to four gates. Today's complex-function networks include up to 10 to 20 circuits, the equivalent of more than 100 individual components. This trend is shown in the upper graph shown below.

The Future

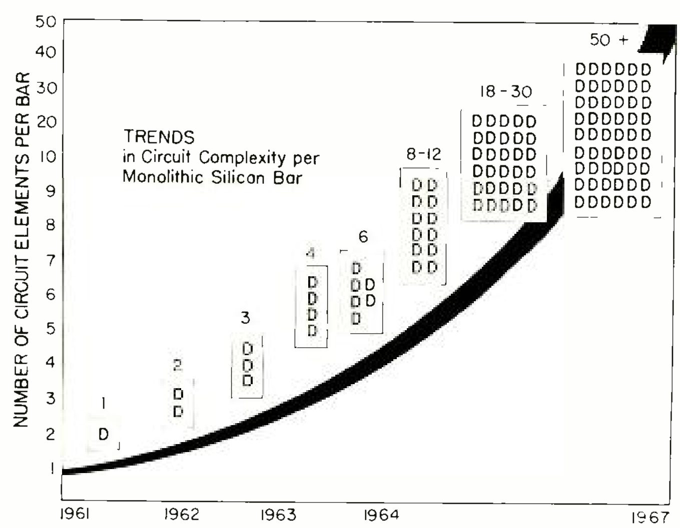
The major advances in the next few years will come from an acceleration of the trend to more and more complex circuits. Large-scale integration (LSI) holds bright promise of further magnifying the advantages of printed circuits.

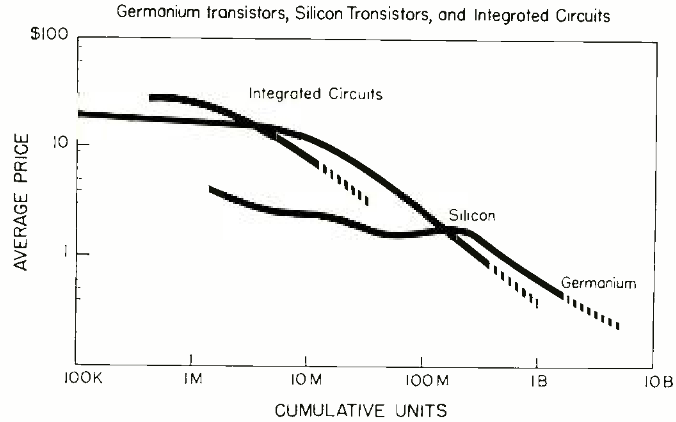
Today's circuits are batch processed on 1½-inch silicon wafer capable of holding as many as 2000 circuits. They are then sawed apart into individual circuit chips for packaging. In the advanced LSI approach, the circuits are not separated but interconnected right on the slice itself. The whole system is then packaged as a unit. *TI* has already developed 120-gate arrays and is actively working on 250- to 350-gate combinations. It is hoped that in the not too distant future, entire electronic sub-systems of 500 to 1000 circuits can be placed on a slice of silicon, a little larger than a half dollar.

Although this thinking seems to be mainly in the digital computer area, it does not rule out the possibility of entire radio, TV, or FM sets on a single slice. ▲



DISTRIBUTION OF TUBES, TRANSISTORS, AND INTEGRATED CIRCUITS
SMALL SIGNAL CIRCUITRY
U. S. A.





Selecting and Using

PULSE GENERATORS

By JOHN D. LENK

Basically a laboratory version of the square-wave generator, but with adjustable on-off times, this instrument has many uses in developing digital circuitry, in checking diode and transistor switching times, as a klystron modulator, and for impulse testing.

THE output of a pulse generator is similar to that of a square-wave generator. The fundamental difference between the two concerns the signal duty cycle. Square-wave generators have equal "on" and "off" periods, this equality being retained as the repetition frequency is varied. On the other hand, the duration of a pulse generator "on" period is independent of pulse repetition rate. The duty cycle of a pulse generator can be made quite low so that the pulse generator is usually able to supply more power during the "on" period than a conventional square-wave generator.

Pulse generators with fast rise times are widely used in the development of digital circuitry. Teamed with a suitably fast oscilloscope, these generators enable evaluation of transistor and diode switching times. Pulse generators can be employed as modulation sources for klystrons and other r.f. sources to obtain high peak power while maintaining low average power. Pulse generators are also used for impulse testing. A very short pulse is rich in harmonics so that input testing amounts to simultaneous frequency-response testing of components or systems.

Important Characteristics

To adequately describe the characteristics of a pulse generator, it is first necessary to establish uniform terms for pulses. These terms are illustrated in Fig. 1. When actual pulses are very irregular (with excessive tilt, overshoot, or rounding), the definitions may become ambiguous, requiring a more complete description.

The following are typical characteristics of a laboratory pulse-generator output:

Leading Edge Only:

- *Rise time* (T_r): <1.0 nanosecond (ns) (10 to 90%).
- *Overshoot and ringing:* overshoot $<5\%$ peak; ringing $<\pm5\%$ of pulse amplitude.
- *Corner rounding:* occurs no sooner than 95% of pulse amplitude.
- *Time to achieve flat top* (T_a): <6 ns.

Trailing Edge Only:

- *Fall time* (T_f): <1.0 ns (10 to 90%).
- *Overshoot:* $<5\%$.
- *Rounding:* occurs no sooner than 95% of fall.
- *Time to settle within 2% of baseline* (T_b): 10 to 25 ns, varies with setting.

Baseline shift: $<0.1\%$ under all conditions.

Preshoot: $<1\%$.

Perturbations on flat top: $<2\%$ of pulse amplitude.

Peak voltage: >10 volts into 50 ohms, >20 volts into open circuit.

Polarity: positive or negative.

Pulse width (between 50% points): continuously adjustable, zero to 100 ns (zero ns width occurs when 50% points meet, creating an impulse of one-half the amplitude of wide pulses).

Repetition rate (internal): <100 Hz to >1 MHz in 4 ranges.

The quality of the output pulse is of primary importance in the selection of a pulse generator. If the displayed pulse is degraded, a high-quality test pulse will insure that the cause is in the test circuit alone. Rise and fall times should be significantly faster than the circuits or systems to be measured. Any overshoot, ringing, or sag in the test pulse should be known so that these faults will not be confused with similar results caused by the test circuit.

The range of pulse-width control should be wide enough to fully explore the range of operation of a circuit. Narrow pulse widths are useful in determining the minimum trigger energy required in some circuits.

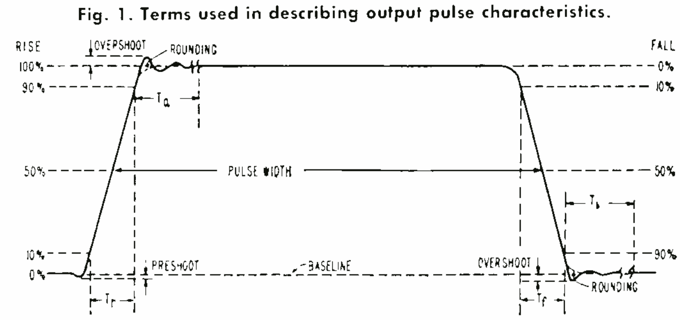
Maximum pulse amplitude is of prime concern if appreciable input power is required by the circuit under test, such as a magnetic core memory. At the same time, the attenuation range should be broad enough to prevent overdriving the test circuits as well as to simulate actual circuit operating conditions.

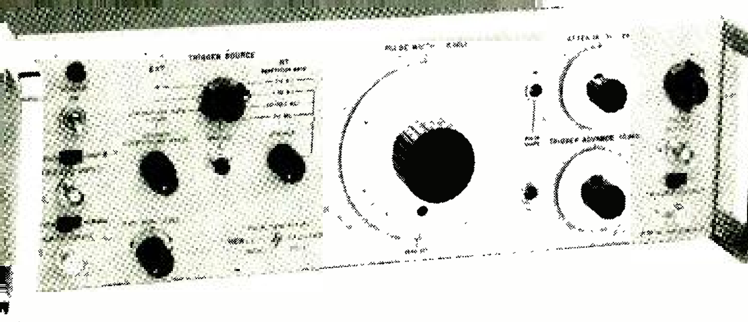
The range of pulse repetition rates is important if the tested circuits can operate only within a certain range of pulse rates or if a variation in the rate is needed. In some systems, methods of external triggering are also significant. In fast pulse systems, the generator source impedance is an important consideration because a generator which has a source impedance that is matched to the connecting cable will absorb reflections resulting from impedance mismatches in the external system that is used.

Basic Precautions

1. Use proper types of cables, terminations, attenuators, and impedance-matching networks. Always match impedances unless the test circuit specifically calls for a mismatch.

Fig. 1. Terms used in describing output pulse characteristics.





Hewlett-Packard Model 215A pulse generator is shown above.

H-P 213B produces pulse with under 0.1-nanosecond rise time.

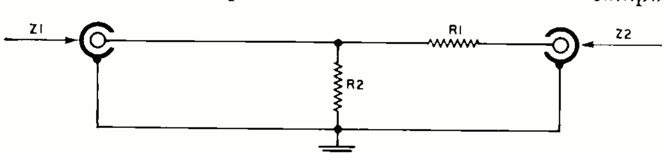
2. Keep ground-return paths short and direct. Use heavy conductors to provide low impedance in the ground return.

3. Make sure that all connections are tight and that all connectors are securely assembled.

4. Shield measuring-equipment leads to prevent undesired coupling to other parts of the circuit. Shielding is especially required where pulse radiation is a problem and particularly where high-impedance dividers or circuits are involved.

5. Consider the effects of secondary parameters in components, such as inductance in resistors and in capacitor loads.

6. Consider the possible non-linear behavior of components due to changes in either voltage or temperature.



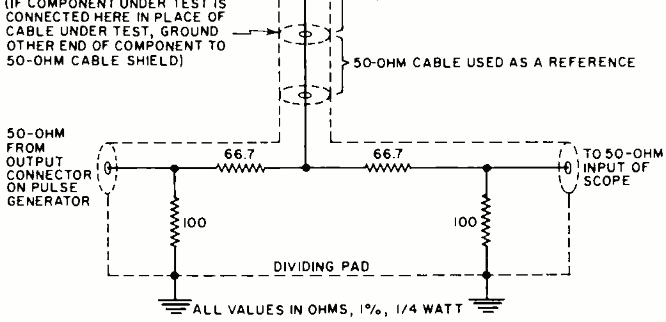
TO MATCH IMPEDANCES:
$R1R2 = Z1Z2$ AND $R1Z1 = R2(Z2-Z1)$ OR: $R1 = \sqrt{Z2(Z2-Z1)}$ AND $R2 = Z1\sqrt{\frac{Z2}{Z2-Z1}}$

VOLTAGE ATTENUATION SEEN FROM Z1 END:
$A1 = \frac{R1}{Z2} + 1; \quad 1 < A1 < 2$

VOLTAGE ATTENUATION SEEN FROM Z2 END:
$A2 = \frac{R1}{R2} + \frac{R1}{Z1} + 1; \quad 1 < A2 < 2Z2/Z1$

Fig. 2. Resistive impedance-matching network and formulas.

Fig. 3. Three-way dividing pad circuit for Z measurement.



7. Select components which function properly at the frequencies and rise times expected to be encountered.

Obviously, the accuracy of rise-time measurements can be no greater than the rise time of the pulse generator. If a pulse generator with a 20-nanosecond rise time is used to measure the rise time of a 15-nanosecond oscilloscope, the measurements would be hopelessly incorrect. Also, if the same pulse generator and oscilloscope were used to measure the rise time of another system, the fastest rise time for accurate measurement would be something greater than 20 nanoseconds.

As a general rule, if the rise time of the test device is at least ten times as long as the rise times of the generator, oscilloscope, or cables, the error introduced will not be more than 1%. If the rise time of the device under test is less than ten times that of the test equipment, it will be necessary to calculate the rise time. The most common method involves finding the square of all rise times associated with the test, adding these squares together, and then computing the square root of this sum. For example, using the 20-ns pulse generator and the 15-ns oscilloscope, the calculation would be: $20 \times 20 = 400$; $15 \times 15 = 225$; $400 + 225 = 625$. $\sqrt{625} = 25$, so 25 nanoseconds is the fastest possible rise time capable of measurement.

Another rule of thumb applying to rise times is that if the equipment being measured has a rise time three times slower than the test equipment, the error is only slightly less than 6%.

If there are significantly long lengths of coaxial cable in the signal path, the above method can be used only as an approximation, since the "skin-effect" losses in coaxial cables do not add properly with this method.

Connecting Pulse Generators

1. In most measurements involving pulse generators, a complete d.c. return path must be provided between the device under test and the pulse-generator output connector.

2. If the pulse is applied to a load which has a d.c. potential across it, the actual amplitude of the pulse is equal to the voltage set by the pulse-generator amplitude control less one-half the d.c. voltage across the load.

For example, assume that the pulse-generator output is connected to a load which has +10 volts across it and that the pulse-generator amplitude control is set to +1 volt. The actual amplitude is found by substituting these values as follows: $V_a = V_s - (V_l/2)$ or $+1 - (+10/2) = -4$ volts where V_a is the actual pulse amplitude, V_s is the voltage setting of the amplitude control, and V_l is the d.c. voltage applied across the load.

3. If it is impossible to use an impedance-matching network, one possible solution is to employ a long coaxial cable between generator and load. This will delay the load's reflections until after the time of interest.

The pulse-generator output can be supplied with an impedance-matching network that will produce a smooth transition of power (no reflections) with a minimum attenuation. Such a network is shown in Fig. 2. To match impedances with the illustrated network, the values of $R1$ and $R2$ must be selected carefully.

For example, to match a 50-ohm system to a 125-ohm system, $Z1 = 50$ ohms and $Z2 = 125$ ohms. Therefore, $R1 = \sqrt{125(125 - 50)} = 96.8$ ohms, and $R2 = 50\sqrt{125/(125 - 50)} = 64.6$ ohms.

The attenuation as seen from one end of the network does not equal that seen from the other end. Using the equations shown in Fig. 2, it will be noted that a signal applied from the lower impedance source Z1 encounters a voltage attenuation A1. Also, a signal applied from the higher impedance source Z2 will encounter a greater voltage attenuation A2.

For example, with an $R1$ of 96.8 ohms and an impedance Z2 of 125 ohms, $A1 = (96.8/125) + 1 = 1.77$.

With an $R1$ of 96.8 ohms, an $R2$ of 64.6 ohms, and an impedance Z1 of 50 ohms, $A2 = (96.8/64.6) + (96.8/50) + 1 = 4.44$.

Measuring Impedance

A pulse generator can be used to determine impedance of an unknown device by comparing the reflected pulse with the incident pulse on an oscilloscope. This can be explained as follows.

As a signal travels down a transmission line, each time it encounters a mismatch or different impedance, a reflection is generated and sent back along the line to the source. The amplitude and polarity of the reflection are determined by the value of the impedance encountered in relation to the characteristic impedance of the cable. If the mismatch impedance is higher than that of the line, the reflection will be of the same polarity as the applied signal; if it is lower than that of the line, the reflection will be of opposite polarity.

The reflected signal is added to or subtracted from the amplitude of the pulse if it returns to the source before the pulse has ended. Thus, for a cable with an open end (no termination), the impedance is infinite and the pulse amplitude would be doubled. For a cable with a shorted end, the impedance is zero and the pulse would be canceled.

The following procedure provides a practical method of determining impedance with a pulse generator and scope.

1. Connect the equipment as shown in Fig. 3.
2. Observe the incident and reflected pulses on the oscilloscope. Using Fig. 4 as a guide, determine the values of V_o (incident) and V_x (reflected). (This method is generally limited to the first reflections unless the deviations are small, due to multiple reflections and reflection losses.)
4. Using the following equation, calculate the unknown impedance: $Z = 50/(2V_o/V_x - 1)$ where Z is the unknown impedance, V_o is the peak amplitude produced by the 50-ohm reference impedance, and V_x is the peak amplitude at the time of reflection.

Using Conventional Oscilloscopes

A pulse generator is often used with a sampling oscilloscope, and generator and oscilloscope manuals describe the procedure. However, a pulse generator can also be used with conventional triggered oscilloscopes. Fig. 5 shows the test connections.

Internal triggering is convenient since no external triggering connections are required. However, with external triggering it is possible to observe the shaping and amplification of a signal pulse in the circuits of a device under test without resetting the oscilloscope triggering controls for each observation. If the external triggering signal is derived from the waveform at the input circuit of the device under test, the time relationship and phase between the output and input waveforms may be seen and compared on the oscilloscope screen.

If the signal from the test device is fast-rise non-repetitive or has a low duty cycle, the oscilloscope used in this setup must have an internal delay line so that the leading edge of the single waveform can be readily observed on the scope. (*Continued on page* 76)

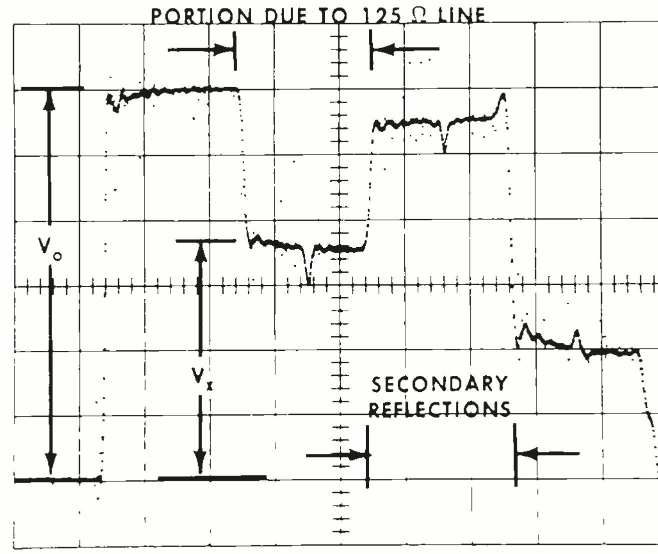


Fig. 4. Waveform obtained with 125-ohm cable and 50-ohm system.

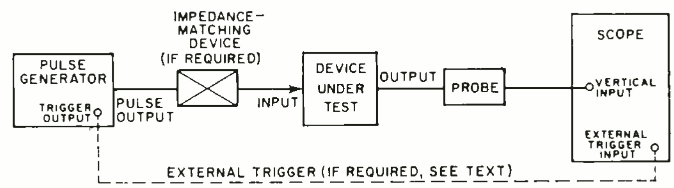
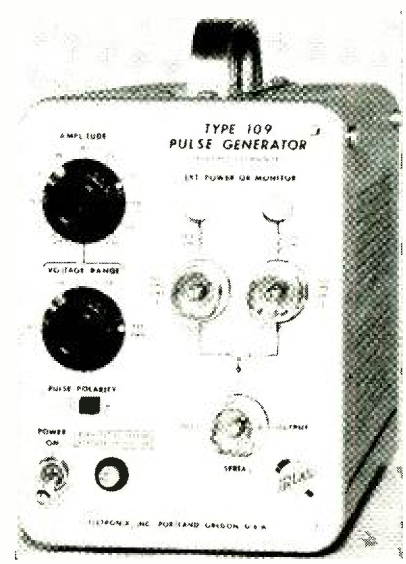
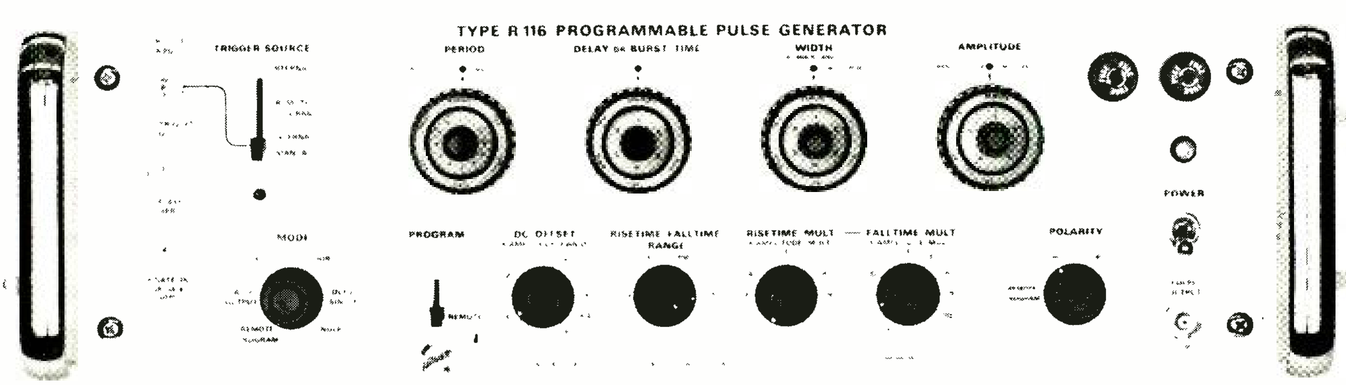


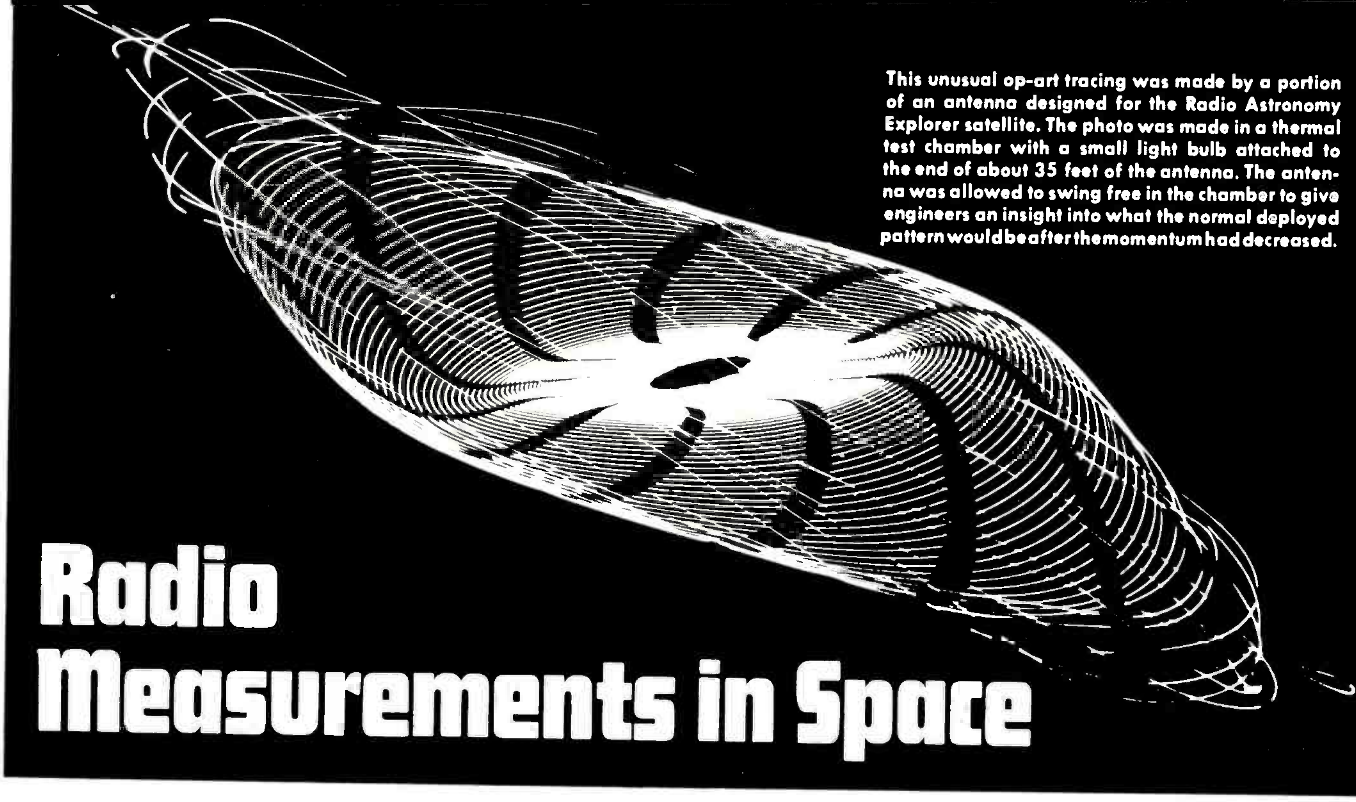
Fig. 5. Test connections using generator with conventional scope.

(Right) Tektronix Type 109 pulse generator has rise time of under 0.25 nanosec.



(Below) Tektronix Type R116 pulse generator.





This unusual op-art tracing was made by a portion of an antenna designed for the Radio Astronomy Explorer satellite. The photo was made in a thermal test chamber with a small light bulb attached to the end of about 35 feet of the antenna. The antenna was allowed to swing free in the chamber to give engineers an insight into what the normal deployed pattern would be after the momentum had decreased.

Radio Measurements in Space

By JOSEPH H. WUJEK, Jr.

Scheduled for an early launch is a satellite to be used for radio astronomy purposes only. An array of space antennas having 750-foot elements will be used.

WHEN the brilliant Scots physicist James Clerk-Maxwell (1831-1879) published his classic "A Treatise on Electricity and Magnetism" in 1873, very little was known about the nature of electromagnetic (EM) radiation. Although Maxwell predicted the existence of EM waves, it was not until after 1885 that high-frequency EM waves were generated in the laboratory. Heinrich Hertz (1857-1894) is generally acknowledged to be the first to generate these waves and was recently honored by having the unit of frequency—"hertz"—named for him. The theoretical work of Maxwell and the subsequent experimental research of Hertz thus paved the way for the technology which we now know as radio. We use the term "radio" here to include that region of the EM spectrum which extends from a few hertz to the edge of the infrared region, which is about 1000 gigahertz (1 million megahertz or 1 terahertz).

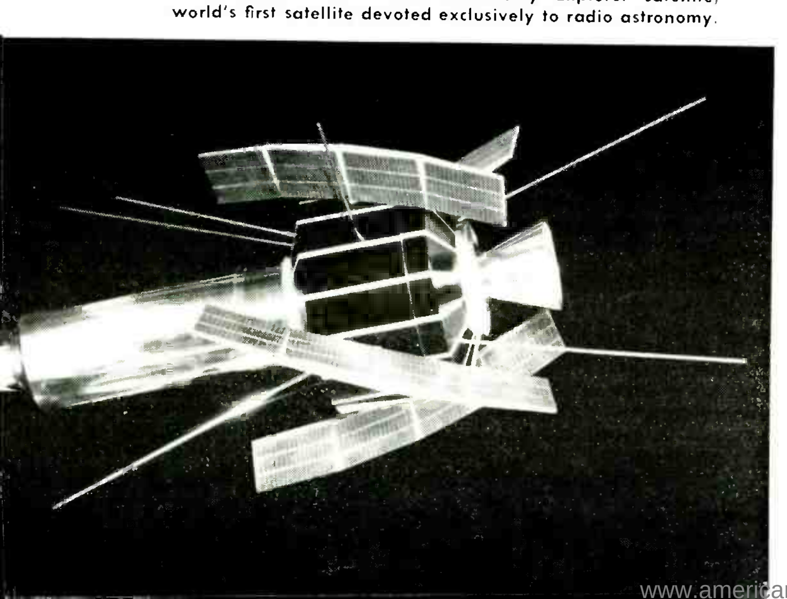
With the development of radio communications in the twentieth century, major emphasis was placed on gaining a better understanding of the nature of radio propagation and noise. Measurements of radio propagation and noise characteristics were, and continue to be, made with international cooperation. The National Bureau of Standards (NBS) of the U.S. Department of Commerce guides this effort in the United States with technical coordination maintained among NBS, other government agencies, universities, and industry.

A natural outgrowth of propagation and noise studies was the detection of radio-frequency noise from deep space. Until the recent advancements in space technology, measurement of space r.f. signals was confined to the ground or to those altitudes accessible to aircraft. This was, of course, also true of r.f. propagation studies. While ground-based and aircraft measurements have contributed much to our understanding of these phenomena, measurements from space vehicles enhance these results. Since the earth's atmosphere acts to severely attenuate certain r.f. frequencies, a measurement of r.f. signal strength taken above the atmosphere provides added information regarding the source, strength, and character of these signals.

The science of radio astronomy has also benefited from space r.f. measurements. It has been known for some time that stars, galaxies, and some planets emanate EM waves. The star nearest earth, our sun, exhibits increased flare, or sunspot activity, on a somewhat regular basis. In particular, the occurrence of these flares increases to a maximum every eleven years (Fig. 1). Radio communications in certain frequency bands are severely affected during such increased solar activity.

By studying the nature of the r.f. emanations of the sun and other stars, scientists are able to better understand the energy processes which occur in these bodies. The solar flares, which are believed to be reactions similar to those of a fusion or hydrogen bomb, release enormous amounts of energy. Swarms of charged particles and EM waves are discharged from these reactions. The earth is about 93 million miles or 8 light-minutes from the sun, yet some of these particles and waves find their way through the atmosphere and ultimately reach the earth. In an earlier article ("Radia-

Scale model of the Radio Astronomy Explorer satellite, world's first satellite devoted exclusively to radio astronomy.



tion Measurements in Space", August 1966) we showed how energetic particles are detected and measured. Here we will discuss systems used to measure r.f. energy in space.

Space Radiometry

Instruments used to measure radiation in the EM spectrum are called "radiometers". Many different kinds of radiometers exist; the type used will depend on the portion of the spectrum to be measured. In this article we shall be concerned only with radio-frequency systems.

Radiometers have been used in space experiments from the very beginnings of space exploration. These systems generally consist of an antenna, an amplifier, and a telemetry readout system. The amplifiers are usually of the frequency-selective variety so as to amplify and pass only those frequencies of interest, while all other frequencies are rejected. Some systems use several amplifiers and/or antennas which are shared by means of automatic switching controlled by a programmer subsystem. Ground commands may also be used to select a particular channel when the payload is traversing a given region of space.

As in the case of ground-based systems, antenna design depends on the range of signal frequencies to be gathered. Space radiometers have been developed which have input sensitivities as low as 0.1 microvolt per meter. For some perspective, remember that in order to obtain a good-quality TV picture on most commerical receivers, a signal strength of 100 microvolts per meter is required with a signal-to-noise ratio of at least 30 dB. Space systems can yield higher sensitivities because they are far removed from high-level man-made signals and interference. These higher sensitivities cannot, in general, be verified experimentally in the laboratory due to the high level of surrounding interference.

Radio Astronomy Explorer Satellites

The first Radio Astronomy Explorer (RAE) satellite has been tentatively scheduled for launch this year. This will mark the first time a satellite has been designed and developed for radio astronomy purposes exclusively. Due to be another first in space technology is the array of antennas, each of which is 750 feet in length.

These antennas were first developed by *The de Havilland Aircraft of Canada, Limited*. In addition to functioning as antennas, the long tubular sections provide gravity gradient stabilization of the spacecraft. The principle by which these rods are fabricated is designated STEM, from the name Storable *T*ubular *E*xtendable *M*ember. STEM devices have been used successfully on such space missions as Gemini (16-foot antenna), the Canadian Topside satellite (60-foot antennas), and the TRAAC satellite (60-foot gravity stabilizing boom).

The STEM device consists of a strip of thin material, usually stainless steel or beryllium-copper alloy, which has been preformed to a tubular configuration. The strip is then wound on a drum or compressed in telescope fashion into a canister. In the case of the longer element lengths, a drive motor rotates the drum to unfurl the STEM device (Fig. 2). The canister-version boom is expanded by removing the canister lid, resulting in a jack-in-the-box unfurling. An explosive bolt or squib is usually detonated by an electrical signal to shear a pin or latch and thus open the canister.

While the principles of antennas are familiar to all of us, the notion of gravity gradient stabilization is perhaps not so familiar. The physics involved here is not too different from the tightrope walker who carries a long pole for balance. In the case of spacecraft stabilization, the small difference in gravity over the length of the rod produces a torque which tends to align the rod parallel to the gravitational field, as shown in Fig. 3. The addition of more long rods to the spacecraft produces more torque which yields a spacecraft attitude which is stable with respect to earth.

Because of the great length and thin walls of STEM devices, several problems appear with their use. The vacuum of space is a cold void except when matter is present to be heated by the sun's radiations. As a result, that side of the STEM device which faces the sun is much warmer than the side which looks away from the sun. Due to contraction and expansion of materials with heating, the element tends to bend under these temperature conditions. Thus, the tip of such an element of 300-foot length, with ½-inch diameter and 0.002-inch walls, may deflect more than 100 feet. The deflection may be reduced by using thicker walls in the tubing, but if this is done, weight is also increased—which is a great disadvantage in a good many space applications. (*Continued on page* 67)

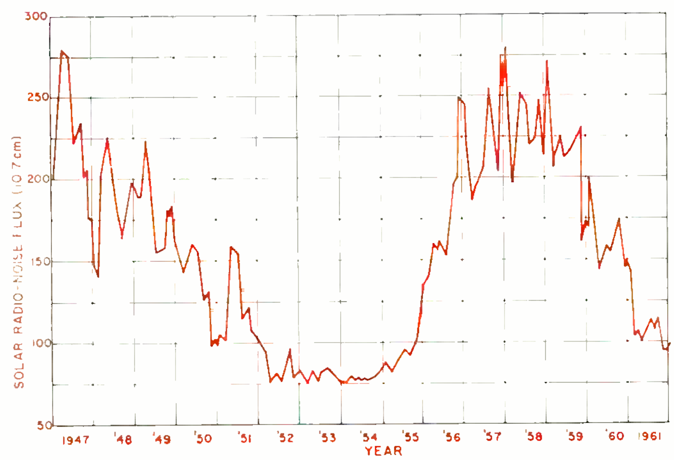


Fig. 1. Graph of noise from solar activity at 2.8 GHz showing the last complete eleven-year cycle. Right now solar activity is on upswing and new peak should occur around 1969.

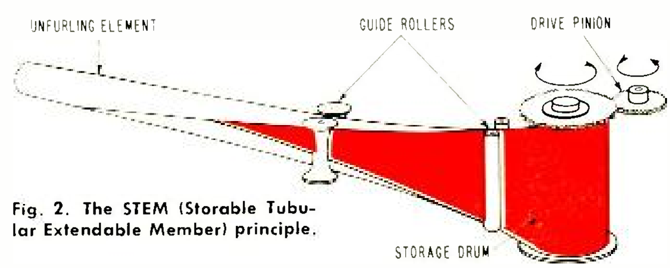


Fig. 2. The STEM (Storable Tubular Extendable Member) principle.

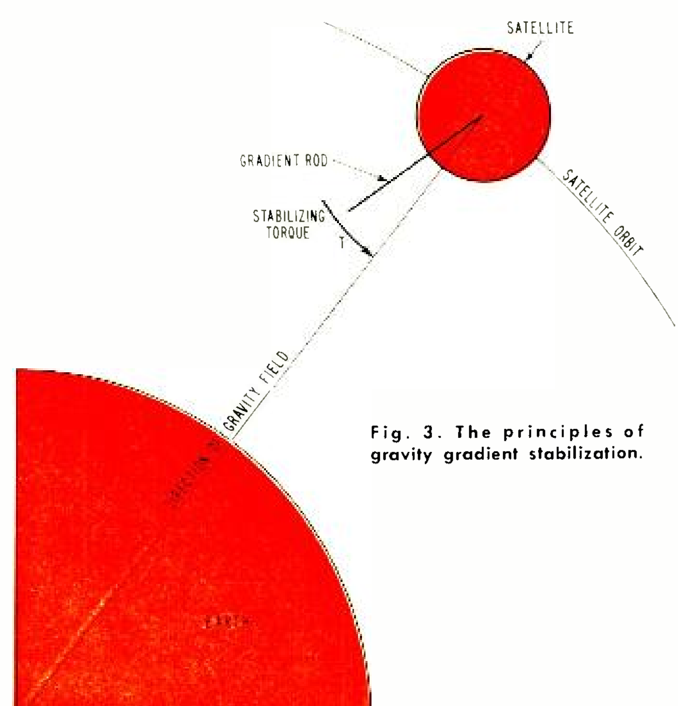


Fig. 3. The principles of gravity gradient stabilization.

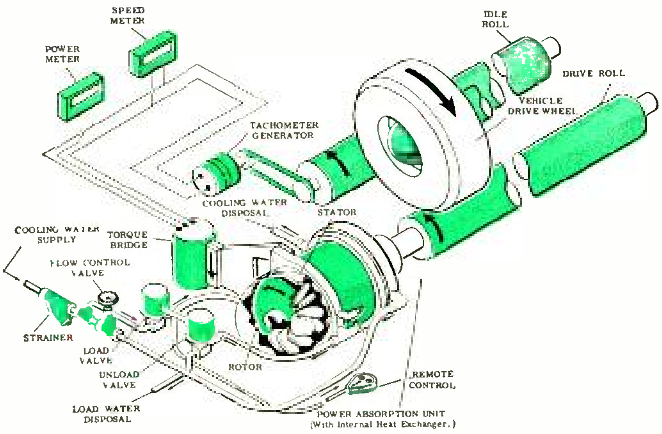


Fig. 4. On this dynamometer (only one side shown), the car can be "driven" at speeds to 70 mph while all tests are being performed. The dynamometer can also be "driven" by the car so that the vehicle's actual road horsepower can be determined. In essence, an instrumented road test.

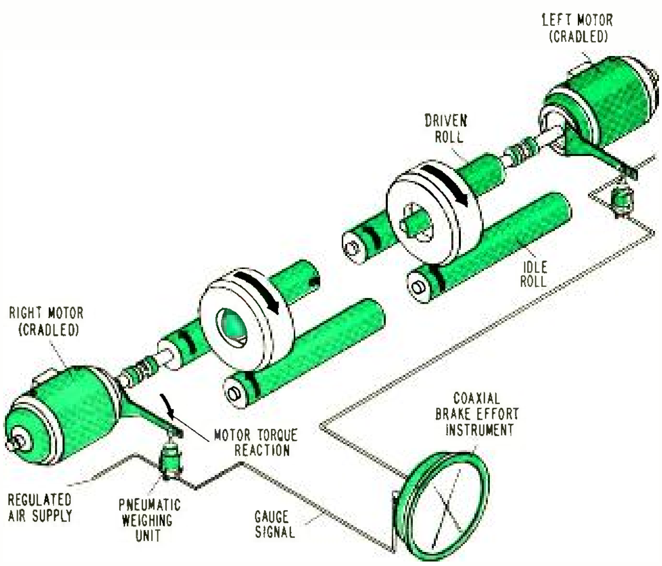


Fig. 5. The brake analyzer is electrically driven but uses hydraulic readout. Almost all rolling tests are performed.

by the automobile manufacturer for that particular model.

We will now take a closer look at each piece of test equipment and explain its basic operation.

Dynamometer

The dynamometer is primarily a hydraulic energy-absorbing device which is able to measure and indicate the power transmitted from the wheels of the vehicle under test. The device may also have the additional capability of providing driving power to the wheels by means of two motors connected to the right and left rollers independently. In use, either the front or rear wheels of the vehicle are cradled between the dynamometer rollers, and when the rollers are rotating, various transducers transmit the torque and speed signals to appropriate readout meters which, in turn, indicate road speed and road horsepower. The dynamometer may also include a declutchable inertia weight to allow simulation of actual road load during acceleration and deceleration operations. Fig. 4 illustrates operation of a typical (in this case, a *Clayton*) dynamometer. The front and rear rollers cradle the drive wheels of the vehicle. The drive roll is coupled to the power-absorption unit shaft. The idle roller drives a tachometer generator that furnishes the current for the dynamometer electrical readout instruments.

The power-absorption unit consists of a shaft, rotor, stator, and heat exchanger, all enclosed within a housing and mounted on cradle bearings. The operator uses the remote control to increase or decrease the load imposed on the vehicle by operating the load or unload valves. Opening the load valve allows additional water to enter the power-absorption unit housing, increasing the load presented to the vehicle's wheels. Opening the unload valve allows water to leave the housing, thus decreasing the load.

The force of the load water thrown into the stator from the rotor tends to rotate the cradled power-absorption unit housing. This movement is restrained by the torque bridge attached to the outer end of the power-absorption unit torque arm.

Current, proportional to wheel speed, is supplied by the tachometer generator to the speed meter and to the torque bridge. The torque bridge measures the torque (the force with which the power-absorption unit tends to rotate) and electrically combines the measurement of torque and speed to actuate the power meter, which is calibrated to indicate in horsepower.

As the power is absorbed, the load water temperature increases. The pumping action of the rotor causes a constant circulation of the load water across the tubes of a heat exchanger where the heat is transferred to cooling water.

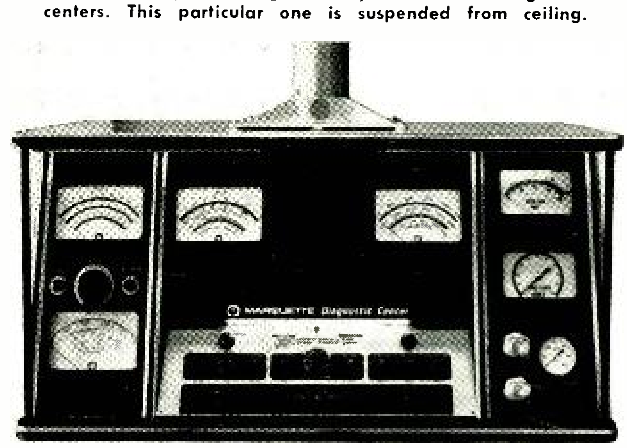
Brake Analyzer

A typical brake analyzer, such as shown in Fig. 5, consists of two assemblies, each containing two rollers mounted in ball bearings. Attached to each roller section is a cradle-mounted 20-hp electric motor. Each motor is coupled to its rear roller through a flexible coupling.

The vehicle wheels are cradled between the rollers and the rollers are then accelerated to produce an equivalent road speed of about 45 mph. When the brakes are applied, the torquing reaction of each motor is measured by a pneumatic weighing unit and read out on a special large-scale gage. One needle is supplied for each right and left wheel. The instrument readout is calibrated to read in pounds of force exerted on the tire tread by the roller surface.

The brake analyzer will also indicate the rolling resistance of the vehicle. With no brakes applied and the wheels rotating at about 45 mph, the dials will indicate the amount of force required to overcome any resistance caused by tire pressure, tread depth and design, bearing lubricant, and the weight supported by the wheel. Usually, the driver's weight creates a higher rolling resistance on the left wheel and will cause a slightly higher reading on that gage. Differences in rolling resistance between wheels rarely exceeds 6 pounds if tire conditions and pressures are equal and if a brake shoe is not dragging on one wheel. If unbalance is over 11 pounds and is reduced with a light jab on the brake pedal, a sticky shoe condition is indicated, but the test

Fig. 6. One type of engine analyzer found in diagnostic centers. This particular one is suspended from ceiling.



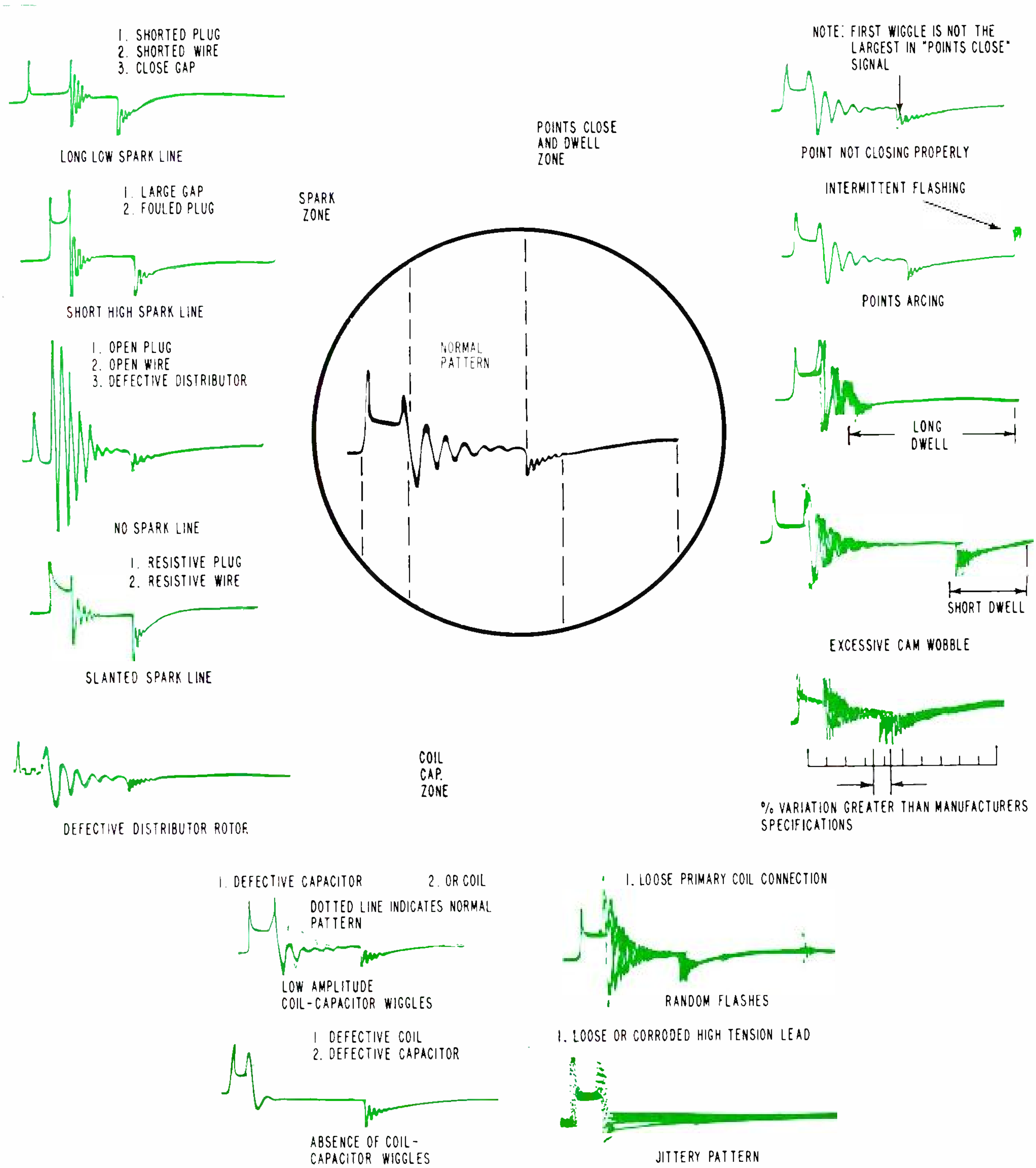
can be continued. Rolling resistance decreases as the tire and wheel-lubricant temperature changes. This change is gradual and is not significant in the tests.

Engine Analyzer

The most electronically complex device in the diagnostic center is the engine tester which includes a variety of meter readouts such as a voltmeter, ammeter, dwell angle, engine rpm (tachometer), and an oscillosope-like device called an ignition analyzer. A typical unit is shown in Fig. 6. These meters are usually duplicated at the customer's location together with a brief explanation of what is being measured and what each meter reading means. Some consoles also include one or more hydraulic readout meters that operate in conjunction with the dynamometer or brake tester.

The voltage-measuring section is a basic voltmeter usually having switchable ranges from zero to about 2 volts and zero to about 20 volts. The lower range is used to measure small voltage losses which may have become excessive due to increased electrical resistance in the wiring or components associated with the primary ignition circuit. Examples of circuit points at which these voltage-loss measurements may be taken are battery cables, distributor points, ignition switch, and starter switch. The higher voltage range is used to measure battery voltage, voltage-regulator output, voltage drop across ballast resistor or primary resistance wire, and ignition-coil primary voltage.

Fig. 7. How various types of ignition problems show up on the engine analyzer scope. These are all secondary-voltage patterns.



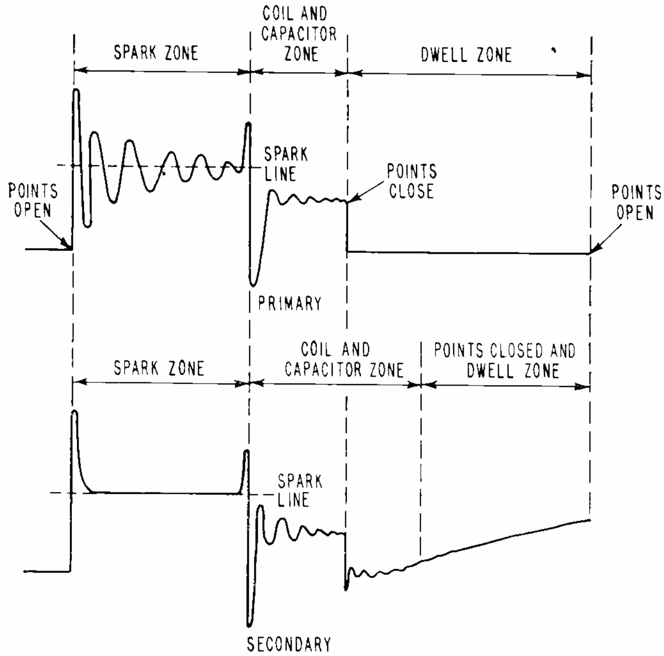


Fig. 8. Ignition coil basic primary and secondary patterns as shown on engine analyzer scope. Variations from these basic patterns may indicate problems. See chart of Fig. 7.

The current-measuring section is a basic ammeter having switchable ranges from zero to 500 amperes and is used for making measurements of battery charge discharge rates, generator/alternator outputs, and voltage-regulator operation. The higher range (500 amperes) is used only to check operation of starting motors.

The first of the actual electronic units, the dwell-angle meter, is the readout for an ohmmeter-type circuit that measures the time that the distributor points are closed during each ignition cycle. The number of degrees indicated on the meter is compared with the dwell time provided by the car manufacturer for that type of engine. A wider ignition-point setting will result in less dwell, while a closer point setting results in increased dwell.

The engine rpm meter (sometimes called tachometer) is the readout for an electronic circuit (usually a one-shot multivibrator) that indicates the average of the circuit's on-to-off time. The circuit is triggered *via* the distributor points, so as the engine is speeded up, the multivibrator switches on and off more rapidly; therefore, the average time, as indicated on the meter, is increased. Conversely, as the engine speed is reduced, the multivibrator switching time decreases, and the meter indicates a lower value. Most engine rpm meters have two or more switchable scale ranges, indicating to about 1200 rpm on one scale and to about 6000 rpm on another; in some cases, a third range is provided from about 2000 to 12,000 rpm. The tachometer is used in conjunction with tests of the carburetor settings, automatic gear-box changeover, ignition timing, and any other tests which may affect engine speed.

Probably the most complex piece of electronic equipment in the display console is the oscilloscope-like engine analyzer. This instrument changes the electrical pulses of the ignition system into a visual display from which almost all engine operating parameters can be measured. These parameters include shorted or open spark plugs, defective distributor points, defective wiring, coil and capacitor problems, incorrect point adjustment (dwell), cracked distributor cap, cracked or burned rotor, worn distributor parts, corroded high-tension wire terminals, reversed polarity, lean fuel mixture, and cam wobble. The ignition analyzer also enables a close "look" at the primary or secondary ignition patterns without changing the hookup to the engine.

Switching is arranged so that the waveforms from a multicylinder engine can be displayed either "parade" fashion (one following the other across the width of the screen) or "superimposed" (one on top of the other) so that a comparison may be made among all cylinders at once in order to display any discrepancies in the firing waveforms. In the parade mode, the first waveform on the left is the one to which the cable has been attached. The other cylinders follow in the manufacturer's prescribed firing order.

The scope screen is usually calibrated with four different measuring scales. The vertical scale at the left of the screen is used to measure ignition pulses in the range of magnitude from zero to 18 kV, such as spark-plug firing-voltage requirements. The vertical scale at the right of the screen is used to measure ignition pulses in the higher range of magnitude from zero to 36 kV, such as ignition-coil voltage output.

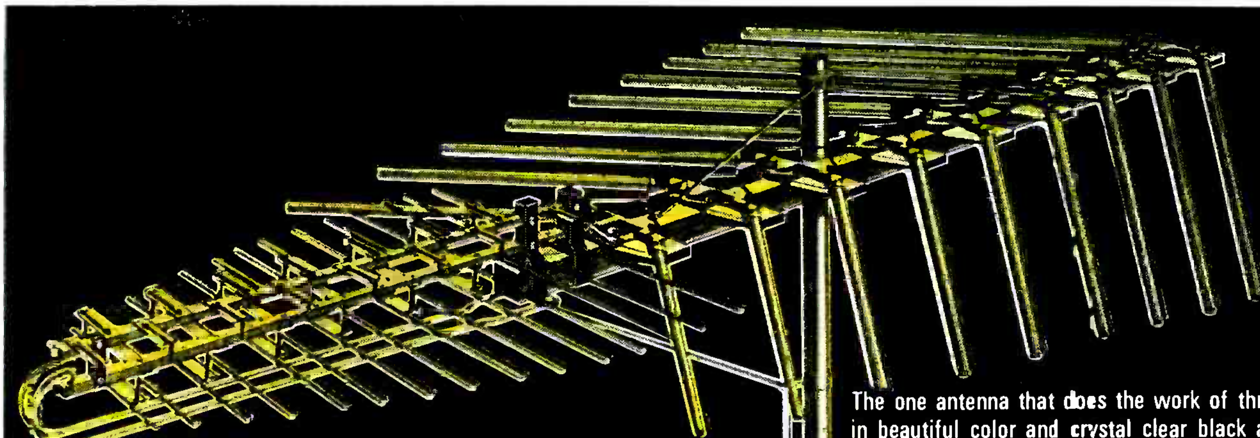
The two horizontal scales at the bottom of the screen are calibrated in degrees and are used to measure the distributor dwell or cam angle. The cam angle is a measurement of the time during which the ignition breaker points remain closed. The upper scale is used to measure cam angle of an 8-cylinder engine, while the lower scale is used for 6-cylinder engines. The 8-cylinder scale reading is multiplied by 2 for measurement of a 4-cylinder engine.

Since a properly operating ignition system presents a characteristic pattern, any deviation from this pattern would indicate some type of difficulty. Therefore, it is necessary to know how each portion of the ignition system affects the normal pattern.

Fig. 8 shows two patterns—the ignition coil primary and secondary. Although both traces are similar and both convey useful information, the secondary trace is more sensitive and informative. The primary trace is typical for one cycle of operation of a normally functioning ignition system and represents the voltage across the breaker points. When the points open, the ignition coil generates the voltage required to make a spark jump across the plug gap. As soon as the spark is initiated, coil-capacitor oscillations take place in the coil primary and continue, diminishing in amplitude, until the spark ends. A slight burst of oscillation appears again when the spark ends, due to the energy remaining in the coil. These oscillations soon die out and are closely followed by the points' close signal shown by the rapid change as the voltage across the points drops to zero. The dwell zone or length of time the points remain closed is the length of the line up to the points' open signal, indicating the start of another cycle.

As shown in the secondary trace of Fig. 8, note that the first voltage peak is developed when the points open. This high voltage causes the initial spark to jump across the plug gap. Once started, the voltage reduces, but enough is left to sustain the spark at the point called the "spark line." Deviations from this spark line will point out difficulties in the high-tension circuits. The secondary coil-capacitor zone is similar to the primary zone. The secondary points' close zone is somewhat different from that of the primary trace due to the removal of the d.c. component by the coil transformer action. When the points close, there is a voltage induced in the secondary winding that oscillates for a short time. This is important since it shows proper closing of the points. The dwell zone, as in the primary trace, shows the length of point dwell time. The height of the initial spark voltage can be read off the right- or left-hand voltage scales on the scope. The waveforms shown in Fig. 7 illustrate the various patterns that can be observed on the scope.

In some consoles, a "power-check" measurement readout is provided. This is an electronic compression check that shows how the engine rpm changes when a selected cylinder does not fire. In the electronic system associated with this test, a timing circuit is so arranged as to prevent the spark plug from firing at the preselected (*Continued on page 90*)



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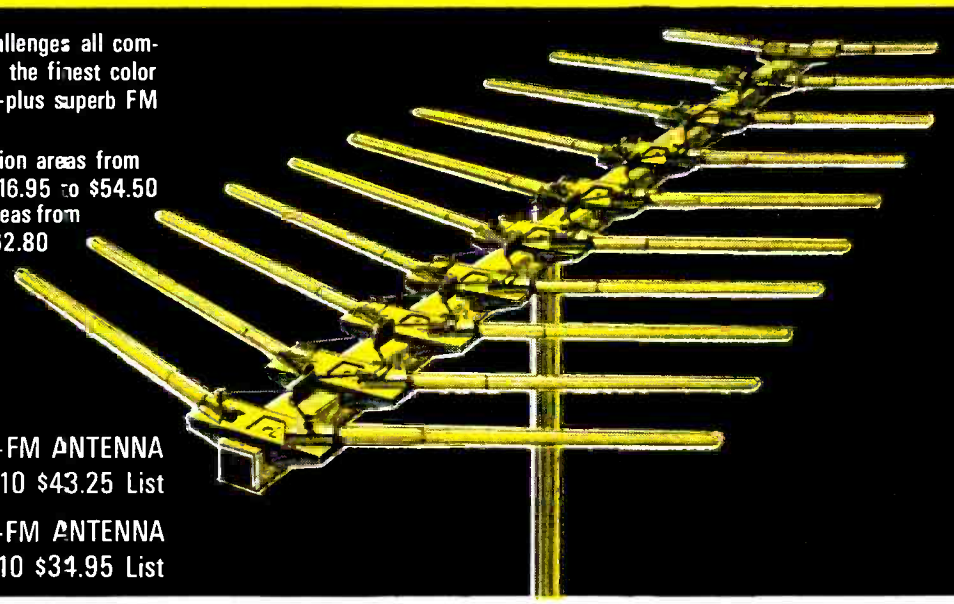

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Camera Tube Uses Solid-State Target Electrode

Advanced silicon technology helps create a new TV camera pickup tube that alleviates problems found in the conventional types.

WITH the constant improvement in diffusion techniques, and the many advances made into the understanding of semiconductor action, completely new concepts have evolved in electronics. The latest is a solid-state TV camera pickup tube target electrode to be used in a high-grade vidicon.

In conventional camera tubes (vidicon, orthicon, etc.), bright light or long exposure to fixed scenes can cause a tube defect called optical burn-in. This results in a lingering ghost pattern superimposed on the displayed image. Such optical burn-in can be so severe as to limit the lifetime of the tube. Conventional tubes also exhibit a defect called raster burn which is caused by the continuous pattern produced by the scanning electron beam. This also restricts the lifetime of the tube.

A new TV camera tube, developed at *Bell Telephone Labs.*, combines the best features of a vidicon with the latest in silicon technology. Like most camera tubes, this new one converts an optical image into a pattern of stored electrical charges on the target structure, with the pattern of charges periodically scanned and erased by the scanning electron beam. The video signal is generated as the charge pattern is erased. However, in this new tube, performance is not degraded or modified by exposure to bright light sources, or by electron beam bombardment.

The heart of the new tube is a new type of target structure consisting of a silicon wafer the size of a nickel, containing over a quarter-million silicon photodiodes in an area less than one-half inch square. A section of this target is shown in Fig. 1. The target is fabricated using masking and diffusion techniques identical to those used in making silicon integrated circuits.

The target structure of one experimental version of the silicon camera tube is a 540 by 540 array of electrically isolated, reverse-biased, silicon photodiodes. To make this structure, one side of a thin substrate of *n*-type silicon—with a sensitive area about .001-inch thick and slightly less than one-half inch square—is oxidized to form a silicon dioxide film (see Fig. 2). Photolithographic processes are used to create an array of holes in the silicon dioxide film, forming a diffusion mask. Boron is then diffused through the array of holes forming islands of *p*-type silicon on one side of the *n*-type substrate. The resulting *p-n* photodiodes are .0003-inch in diameter. The islands have a center-to-center spacing of .0008 inch. The effective beam landing area of each *p*-type island is increased by a gold overlay which produces separate islands of gold centered on each *p*-type region. Finally, the opposite side is coated with an antireflection material that is similar to the type used on high-quality optical lenses.

In normal operation, the *n*-type substrate is held at a positive potential of up to 30 volts. An electron beam scans the photodiode side of the substrate and deposits electrons on the gold surface covering the diodes, thereby charging the islands down to cathode (ground) potential and reverse biasing the diodes. The silicon dioxide coating between islands isolates the *n*-type silicon from the scanning beam and the gold overlay.

The incident light associated with the image penetrates the opposite side of the substrate and creates hole-electron pairs in the *n*-type material. Almost instantly, the holes diffuse through the substrate to the *p*-type islands. There they combine with electrons, discharging the *p-n* photodiodes by an amount proportional to the original light intensity.

This process occurs during a time interval of 1/30th second between successive scans of each frame. The video signal is created as the scanning electron beam recharges successive diodes along the scanning path.

As shown in Fig. 2, the discrete nature of the target does not limit the resolution of the new camera tube since the scanning electron beam is much larger than the diode-to-diode spacing. ▲

Fig. 1. Section of the photodiode array (white circles) showing their size compared with an ordinary human hair.

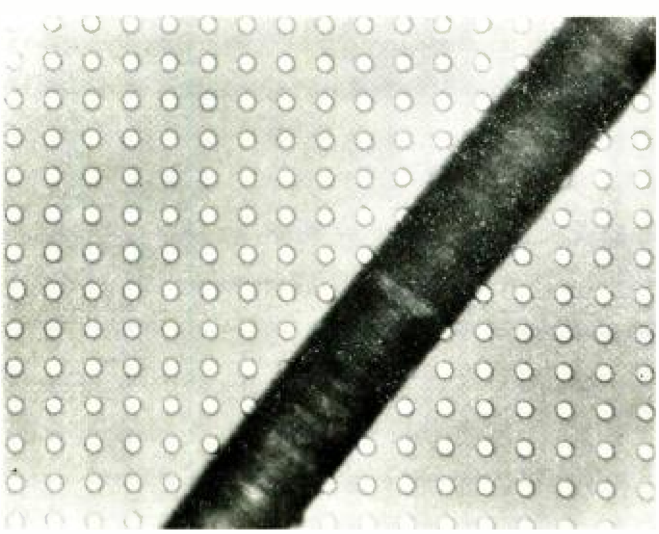
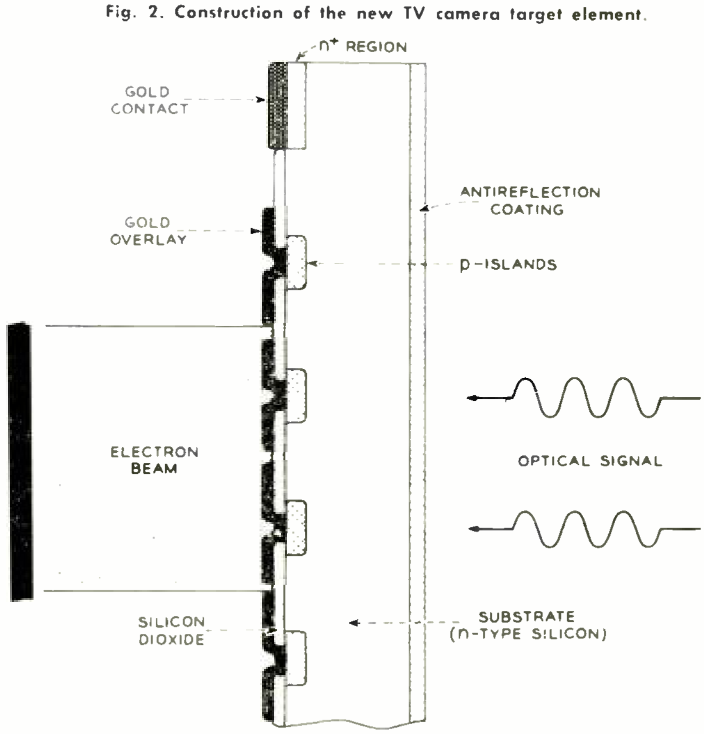
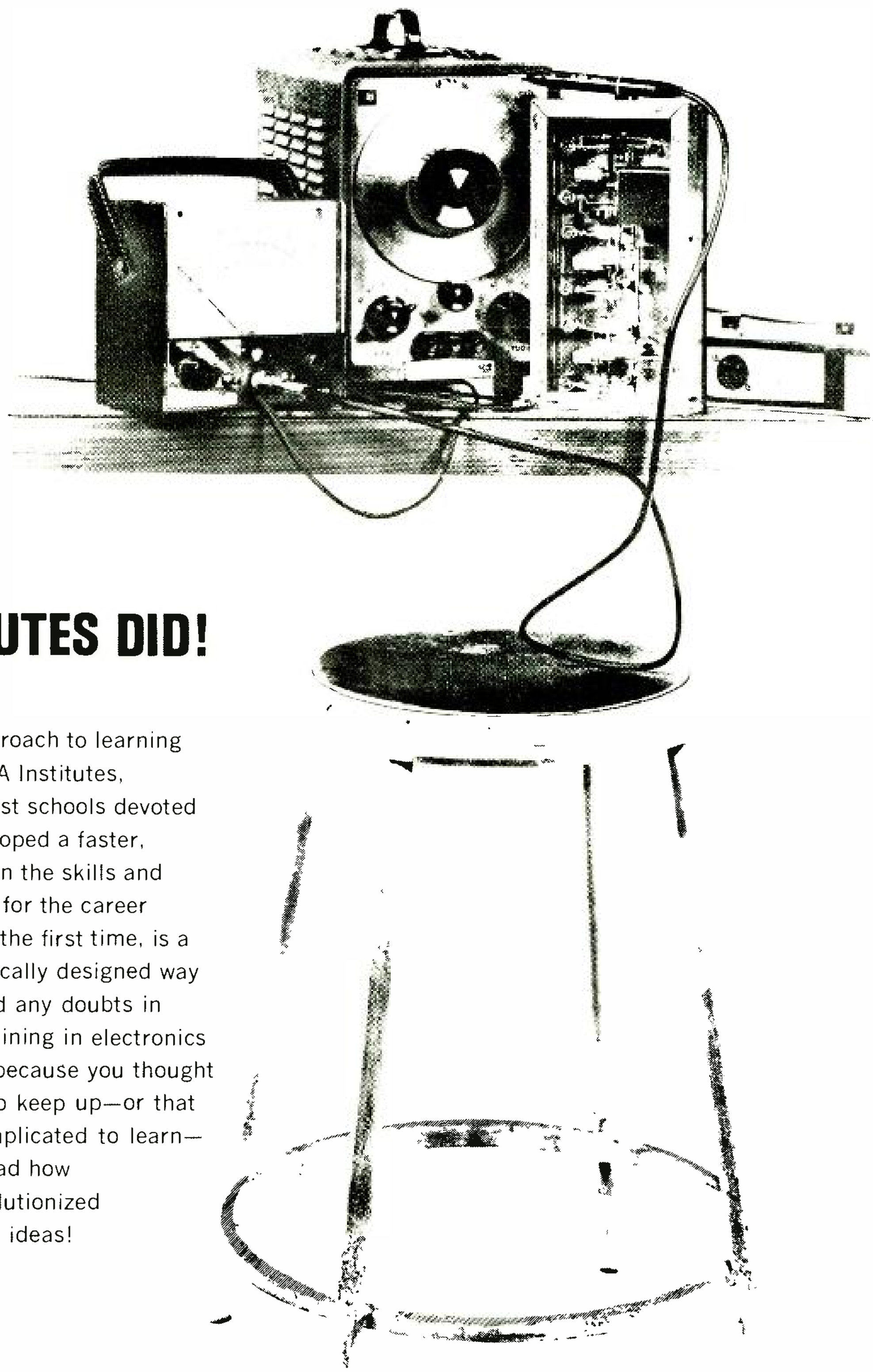


Fig. 2. Construction of the new TV camera target element.



SOMEONE SHOULD DEVELOP AN EASY WAY TO LEARN ELECTRONICS AT HOME



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JOHN FRYE

With air pollution rising at an alarming rate, it is time to call on electronics in an effort to solve the problem.

ECOLOGY AND ELECTRONICS

"UM-M-M boy, that fresh air smells good!" Barney exclaimed as he stood in the open doorway of the service shop sniffing the washed air resulting from a sudden May shower. "Enjoy it while you can," was the dour comment of Mac, his employer.

"What's that crack mean?"

"Just what it says. We ecology students know pure air is becoming harder and harder to come by."

"May I be so bold as to ask what you 'ecology students' study?"

"Interrelationships between organisms, such as men, and their environment. Right now we're particularly interested in what men do to the air they must breathe and what it does right back to them."

"You could, you know, just say you were talking about air pollution. Why are you interested in that?"

"Because I hope to keep on breathing. Can you think of a better reason?"

"Not offhand, but is the pollution picture as black as it is painted?"

"Every bit. On October 26, 1948, a temperature inversion clamped a lid over Donora, Pa. and stopped convection air currents that ordinarily carry away air pollutants. Of the 14,000 residents of the city, 5910 became ill and 20 died—along with several dogs, cats, and canaries. On December 5, 1952, an inversion formed over London that lasted five days. Deaths during that period were 4000 above normal, and 8000 excess deaths occurred during the ensuing two months, most of them apparently caused by respiratory diseases. A thousand more Londoners were killed by extreme air pollution in 1956 and 300 more in 1962. A ten-day inversion over New York City in 1953 produced 200 excess deaths, and another smog ten years later killed 400. Just last Thanksgiving a four-day siege in that city caused 80 excess deaths. The U.S. Assistant Surgeon General warns that these episodes of smog killing people are going to become more and more frequent."

"I suppose that's because the air is becoming more polluted."

"You suppose right. In 1966 the air contained 20 million more tons of air pollutants than it did in 1963, the year Congress passed the Clean Air Act. That makes 145 million tons of man-contributed air pollutants swirling around us."

"Boy! I didn't know the stuff was measured in tons! Where does it come from?"

"Actually, man isn't responsible for all air pollution. Nature produces some of it. When Krakatoa, an East Indies volcano, blew up in 1883, dust from the explosion spread around the globe. The blue haze often seen over large fir forests consists of volatile hydrocarbons called terpenes emitted by the trees. Flowers saturate the air with pollen. Decaying plants and animals give off gases. In fact, the first air-pollution casualty on record, Pliny the Elder, died in 79 A.D. after breathing in too many sulfur oxides from erupting Vesuvius.

"But natural pollutants never increase beyond the capacity of the air to cleanse itself. The big trouble began when prehistoric man first rubbed two sticks together and started a fire. The combustion principle he discovered is just dandy for polluting the air, and men have been 'combusting' ever since to heat their homes, cook their food, forge their metals, make their machines, generate electricity, and finally power their automobiles.

"Most fuels consist of carbon, hydrogen, oxygen, and nitrogen, together with a little sulfur. Solid fuels also contain incombustible mineral ash. No fuel emits smoke under complete combustion because the final products are carbon dioxide, water vapor, and free nitrogen—all, in themselves, innocuous gases. But for complete combustion to take place, a fuel must be kept in constant contact with enough air for full oxidation while being maintained at a sufficiently high temperature—and that's not easy to do in actual practice.

"Insufficient air results in imperfect combustion of fossil fuels—coal and oil—and particulates and gaseous intermediate products such as carbon monoxide and unsaturated hydrocarbons are released. Particulates, the visible ingredients of smoke, constitute only about 10% of the pollution over the U.S. A full 90% consists of mostly invisible but potentially lethal gases that are *not* removed by air conditioning. More than half the pollution over this country consists of colorless, odorless carbon monoxide exhausted by automobiles, trucks, and buses. A full tenth of the air pollution consists of hydrocarbons, most of which emanate as gaseous compounds escaping from automobile fuel systems. It's estimated that the average car loses a gallon of gasoline a month through evaporation from carburetor and gas tank, and that totals up to 1,000,000 gallons a year releasing contaminating hydrocarbons into the atmosphere.

"The second most plentiful gas pollutant consists of oxides of sulfur produced by home, power-plant, and factory burning of coal and oil. These react with moisture to produce a dilute but corrosive sulfuric-acid mist. This was the chief lethal ingredient of the London smog. Los Angeles smog, on the other hand, contains nitrogen oxide, hydrocarbons, ozone, and peroxyacl nitradge, called PAN. The first two react with sunlight to produce a photochemical smog. Ozone (a very active and poisonous form of oxygen) discolors and disintegrates clothing and causes rubber to become brittle and crack."

"Apparently the pollution we see, those smoke particulates you talk about, don't do any harm," Barney observed.

"Not so!" Mac quickly denied. "They make things dirty and grimy. It has been estimated that smoke costs the American people $2.5 billion annually. Ordinary room air contains 50,000 to 100,000 of these condensation nuclei per cm^3, and bacteria is directly proportional to their number. By contrast, air over the open sea usually contains less than 400 nuclei per cm^3. Carbon particles that blacken the lungs carry gases absorbed onto their surfaces deeper into the lungs than the gases could make it on their own. Other particulates act as catalysts in the air to speed up the conversion of sulfur dioxide into sulfuric acid.

"Fortunately, these particles are comparatively easy, although expensive, to control. Properly installed venturi


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scrubbers, sonic-wave precipitators, cyclonic dust collectors, and electrostatic precipitators can do a good job of preventing particles from reaching the open air. *Bethlehem Steel Corporation* has spent $90 million the past fifteen years on pollution control. A $2 million installation in its Los Angeles facility collects about 125 tons, or two railroad carloads, of dust a week that formerly was discharged into the air. The Riverside, California *Portland Cement Company* installed a Cottrell electrostatic precipitator that removed 98% of the 100 tons of dust a day the firm had been discharging. It found it could use the collected dust, and at one time the company was making more profit from the recovered potash than from its cement!"

"If we could just make it more profitable *not* to pollute the air, we'd be home safe," Barney observed.

"Now you're talking! That's probably why the Government is stressing the amount of gasoline the motorist will save through the 90-95% efficient anti-evaporation controls it is demanding on 1969 cars. But it will not always be possible to show an individual profit on the installation of air-pollution control equipment. Regard for the common good has to be the motive. While 37 companies sold $53 million worth of particle-collection equipment in 1965, this is only a fraction of what should have been installed."

"Maybe we need more laws."

"Not according to Mark Henry Holzer, a New York lawyer. He says the common law of nuisance covers every conceivable case of pollution. Lawyers call this the principle of *sic utere tuo*, or 'Use your own property so as not to injure that of another.' We don't need more laws; we need more enforcement of laws and ordinances already on the books."

"The automobile seems to be the chief sinner in air pollution. That's bad. Americans will never give up their cars."

"Let's hope they don't have to, but HEW Secretary John Gardner recently warned, 'The day may come when we have to trade convenience for survival.' Lest you dismiss this as crepe-hanging, listen to what a top official in California's public health department says—and don't forget California is leading the battle against air pollution: 'It is clearly evident that between now and 1980 the gasoline-powered engine must be phased out and replaced with an electric-power package.' He wants legal notice served *now* that after 1980 no gasoline-powered vehicle will be permitted to operate at all in the state of California."

"Can't we stop gasoline-engine pollution?"

"California has tried. Cars sold there from 1964 on had to be equipped with 'blow-by' connections to feed unburned gasoline in the crankcase back into the intake manifold. All 1966 cars sold in the state had to have devices to reduce carbon monoxide emitted from the tailpipe 50%, and a further reduction in tailpipe emissions will be required in 1970. The Federal government has ordered similar improvements on all 1968 cars. Four types of devices have been approved for use in California. One 'after-burner' type is the only kind of installation on used cars. The other three use catalysts to precipitate the pollutants.

"Unfortunately, tests on cars so equipped that have been driven 20,000 miles show that 87% fail to meet state requirements for the suppression of hydrocarbons and carbon monoxide. The devices become less and less efficient with age and with improper maintenance."

"So now what?"

"So now I believe the electronics industry is faced with a challenge worthy of its youth and power. Can it keep humanity from suffocating in the by-products of civilization—without sacrificing progress? No matter how things go, electronics will be drawn into the battle. It can and should devise new and better instruments for detecting, measuring, and identifying air pollutants. It should find out more about the part that atmospheric static electricity plays in condensation and precipitation. Perhaps the electronics engineer and the meteorologist working together can aid nature in cleansing air that has already been polluted. Or the electronics engineer and the chemist may work out better filters to remove particles and gases from smokestacks and tailpipes. Maybe electronics can improve the combustion of gasoline through better ignition and automatic control of carburetion.

"If the gasoline engine must go, electrical and electronics engineers will work hand in glove with other engineers to produce electric-powered cars. Even now, while *General Motors, Ford,* and *Chrysler* are experimenting with electric cars, *General Electric, Westinghouse, General Dynamics,* and *Union Carbide* are doing research on electric power.

"Stopping air pollution demands the utmost cooperation of individuals, engineers, companies, and nations. While highly industrialized nations contribute most of the air pollution at present, air recognizes no boundaries, and pollution falls equally on the innocent and the guilty—hey, where do you think you are going?"

"Out to get a breath of fresh air," Barney retorted; "you have me gasping like a goldfish that's jumped out of its bowl!" ▲

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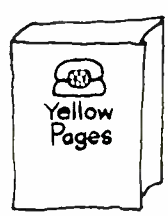

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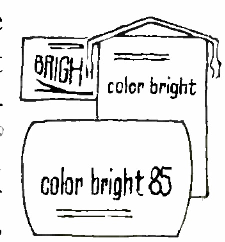

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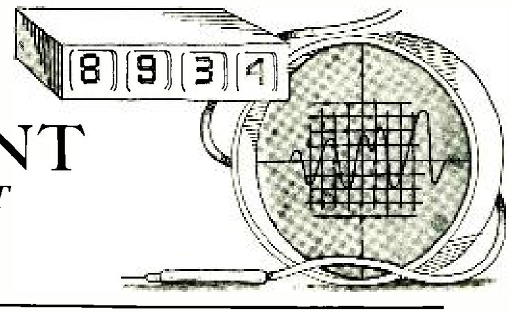
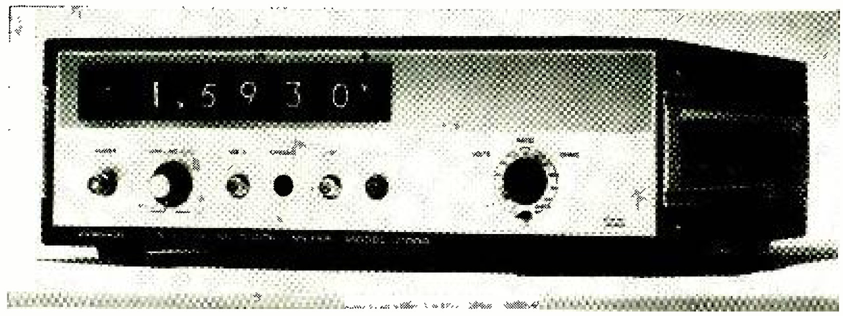
TEST EQUIPMENT
PRODUCT REPORT



Fairchild Model 7100A Digital Voltmeter

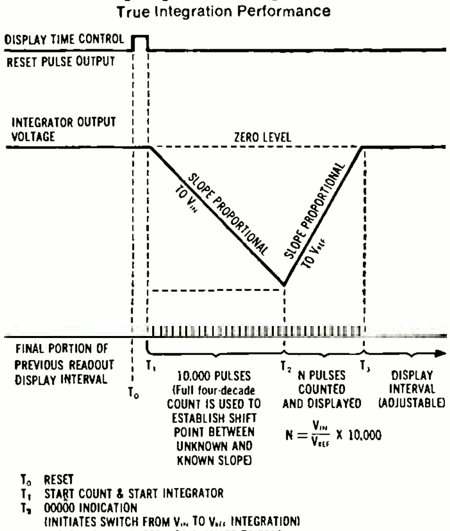
For copy of manufacturer's brochure, circle No. 156 on Reader Service Card.



THIS new digital voltmeter combines the precision, sensitivity, and versatility required by many laboratory applications with the reliability and stability needed for production and system use. The 7100A dual-slope d.v.m. measures voltage, resistance, and ratio. The high accuracy of this instrument, ±0.01% of reading ±1 digit, makes it suitable for use in many applications where more costly five-digit instruments were previously required. The new voltmeter is priced at $2075 and it offers features formerly found in $4000 instruments. The features and price are the result of using integrated circuits in the design. These circuits, already used in a few consumer electronic products, will shortly find their way into other pieces of less expensive test equipment.

Special design features include dual-slope integration and a fully guarded input which provide excellent performance even in the presence of severe noise. The dual-slope integration principle is illustrated below.

Timing Diagram Illustrating Dual Slope True Integration Performance



First, the unknown input is fed through an operational amplifier to an integrator. The integrator output is an increasing negative voltage with a slope that is proportional to the input. The integration time is controlled by counting 10,000 pulses from a crystal oscillator. Second, the integrator input is switched to an internal reference and the integrator output is driven back to zero. The slope of the decreasing voltage is proportional to the reference, and the time required to return the voltage to zero is directly proportional to the unknown input. This is measured by counting pulses from the same oscillator used in step one. The count is displayed as the digital readout.

Since the same integrating components and oscillator are used in both steps, any shift in value of components due to temperature changes or aging becomes self-canceling. Also, since the second step is a direct comparison with the internal reference voltage, the instrument has excellent long-term stability. No hourly or daily calibration adjustments are required. The reading represents the unbroken, true average. All hum and noise components, up to full bandwidth of the input amplifier and integrator, are integrated and effectively reduced to zero.

A bonus of the technique is the ability to make ratio measurements by substituting one of the inputs for the reference voltage. Precision resistance measurements are similarly accomplished.

Another feature which contributes to the noise rejection is guarded construction. The guarded circuit, which is a box within a box, virtually eliminates the errors caused by common-mode pickup and allows the voltmeter to measure low-level signals from thermocouples, strain gages, etc.

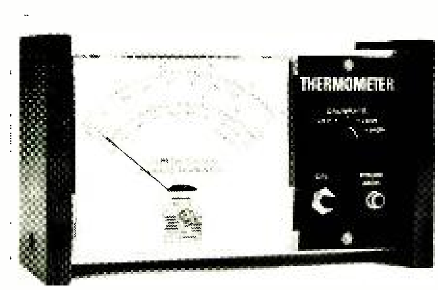
The instrument has five voltage ranges from 160 mV to 1100 V, and this latter voltage can be applied on any of the lower voltage ranges without damage. Input impedance is greater than 1000 megohms. ▲

Basic Science Industries Model 100 Electronic Thermometer

For copy of manufacturer's brochure, circle No. 28 on Reader Service Card.

THE introduction of the Model 100 thermometer by *Basic Science Industries* represents an attempt to meet the need for a low-cost laboratory-quality electronic thermometer for general educational, testing, and research use. This combination of economy and quality is accomplished through ingenious design in electronic circuitry and case construction coupled with standardization on a single general-purpose temperature range.

The thermometer utilizes a calibrated thermistor sensor housed in a nickel-plated brass cylinder as one arm of a Wheatstone bridge. A unique meter-calibration procedure, along with an optimum bridge circuit, makes possible a meter scale which is very near



to being linear and has an accuracy of ±1° Celsius (centigrade). Readings in terms of relative changes in temperature have even greater accuracy.

A high degree of temperature stability over a wide range of environmental conditions is accomplished by the use of 1% precision carbon-film resistors. All components are mounted on a single-sided printed-circuit board, permitting low cost, quality manufacture.

To match the circuit performance a quality d'Arsonval meter movement with characteristics approaching laboratory instruments is used and a 4½"-wide meter dial with knife-edge pointer permits small changes in temperature to be noted.

In a departure from industry practice of offering a wide variety of temperature ranges, the Model 100 has been standardized at 0° to 100° Celsius. This was done to keep cost low. The limitations of the single range are offset to a great extent by the ability to switch between a low range of 0-50 degrees C and a high range of 50-100 degrees C. This dual-range feature, along with provision for scale markings in both Celsius and Fahrenheit, has made the instrument a useful one in various areas ranging from photographic or electronic labs to field studies on the skin temperature of snakes.

The ability to provide almost instantaneous remote temperature readings has always been the area in which the electronic thermometer has found its greatest usefulness. The Model 100 with a seven-foot-long sensor cable and a response time of 5 seconds maximum can be used to measure a variety of solids, gases, and liquids. Specific applications are in batch testing of chemicals and monitoring of environmental chambers.

Power for the Model 100 is provided by a common "C" flashlight cell. A minimal current drain enables continuous use of the instrument for over 600 hours before battery replacement is required. Much greater battery life is possible with intermittent use, and in instances where continuous usage for more than 600 hours is desired, an alkaline battery may be used.

The Model 100 thermometer sells for $35.00, with general-purpose and surface-type thermistor sensors available at $6.00 and $7.00 each. ▲

Hewlett-Packard Model 211B Square-Wave Generator

For copy of manufacturer's brochure, circle No. 157 on Reader Service Card.

A NEW all-solid-state square-wave generator from *Hewlett-Packard* produces square waves of exceptionally clean shape over a wide frequency range, from 1 Hz to 10 MHz. Square-wave rise and fall times are less than 5 nanoseconds while overshoot, preshoot, and ringing are less than 5%. There is no sag, and jitter is less than 0.2% of waveform period at any repetition rate.

Small in size, the new Model 211B takes only half the height of the 7-

inch-high space when rack-mounted. It is also light in weight—only 9 pounds.

Square waves are useful test signals where transient response is important and where the phase-delay characteristics of a device or circuit are just as important as gain and frequency response. Distortion in the square wave at the output of a device under test clearly shows any departure from linearity in phase delay *vs* frequency characteristic.

The extremely fast rise time of the Model 211B reveals frequency response well beyond 50 MHz at the same time that transient response and phase characteristics are examined. Simultaneously, low-frequency response is checked because of the substantial low-frequency content of the square waves.

The new generator supplies 5-volt pulses into a 50-ohm load (10 V open-circuited). A second output, matched for 600 ohms, supplies 30-V peak into 600 ohms or 60 V open-circuited. (Rise time at this output is 70 ns across 600 ohms.) Both output waveforms are d.c.-coupled negative-going but differ in time phase by 180°.

Source impedances are matched to 50 and 600 ohms respectively, to absorb returning signals, thus eliminating reflections that could degrade the waveform. Shorting either output causes no harm, hence the instrument can function as a square-wave current generator for testing low-impedance circuits.

A third output supplies 2-volt trigger pulses into 50 ohms, either positive or negative as selected by a switch, coincident with the leading edge of the 50-ohm square wave. These pulses are useful, of course, for synchronizing an oscilloscope and they also make the new generator useful as a controllable-rate trigger source.

The symmetry of the output waveform (ratio of "on" time to waveform period) may be varied from 25% to 75%, which allows the instrument to function as a rectangular pulse generator. The repetition rate is not affected by the symmetry control and *vice versa*.

Price of the 211B is $375.00. ▲

"I don't care what it says. You can't have any credit!"

Radio Measurements in Space

(Continued from page 47)

Testing of long STEM devices is also a problem since a low-gravity environment is required. This is particularly a problem for the longer elements. How does one create a low-gravity, high-vacuum, sun-simulating environment for testing? The mechanical forces which act during unfurling are quite complicated and testing is demanded. Engineers at NASA's Goddard Space Flight Center have provided at least a partial solution by using cameras and photographing the trace created by a small lamp attached to the tip of the antenna. Some very interesting light patterns are produced during such tests. One of these is illustrated in the lead photograph on page 46.

The RAE will probably be assigned a three-stage improved Delta launch vehicle with an over-all length of 91 feet. The first stage Thor rocket develops 346,000 pounds of thrust. Recall that jet engines, as used in commercial transports today, typically develop 16,000 pounds of thrust. The second stage develops approximately 7000 pounds of thrust, with the third stage (which carries the spacecraft) producing about 2000 pounds thrust. It is anticipated that an orbital altitude of about 300 kilometers (186 miles) will be used.

The RAE Mission

The mission of the RAE satellite may be categorized by five scientific objectives.

1. To observe low-frequency radio storms on earth. These storms are believed to be interactions between particles emanating from the sun and earth's radiation belts.
2. To monitor large radio noise sources, such as the constellation Centaurus A.
3. To study Jupiter, which is the only planet other than the earth which is known to occasionally emit low-frequency noise bursts.
4. To obtain an EM map of our galaxy (the Milky Way) in the frequency range from 400 kHz to 10 MHz.
5. To gather data on low-frequency bursts of EM energy which emanate from the sun. This data should provide added insight into the nature of the sun's reactions.

In order to achieve orbit and deploy the four 750-foot antennas, a sequence which will require about two weeks will be initiated by ground command from Goddard Space Flight Center, Greenbelt, Maryland.

The data gathered by RAE satellites and their successors may provide space scientists with enough information to formulate new theories concerning the earth and its surroundings. ▲

Frequency & Time Standards

(Continued from page 41)

with changes in ambient operating temperature is another important factor to consider when specifying high-stability oscillators. Fig. 7 is a curve of the temperature *vs* frequency characteristics of a typical high-quality crystal. It can be seen that changes in crystal temperature result in significant changes in frequency.

It is therefore extremely important to isolate the crystal from the effects of varying temperatures. Vacuum bottles (dewars) are often employed in the highest stability units and, in most cases, the crystal itself is in a well-regulated, temperature-controlled oven.

Similarly, changes in operating voltage, line voltages, and load impedances are all important and should be considered when choosing oscillators. The effects of these parameters are stated in terms of the maximum frequency changes they produce in the oscillators' output.

Other Important Criteria

Some of the other more important criteria which should be considered when selecting equipment of this nature are:

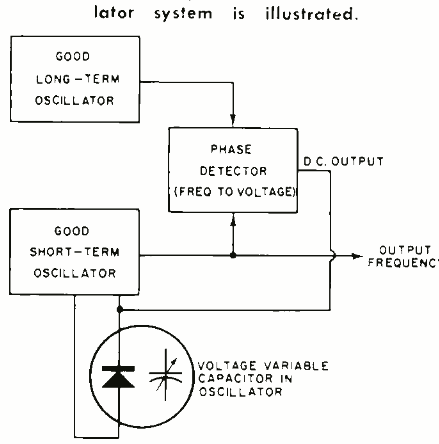
1. Construction — the equipment should be able to withstand mechanical shock and also occupy the least amount of space, especially where it is to be part of a physically complex system.

2. Power consumption—in portable, airborne, or other such applications, it is desirable to obtain the lowest power consumption of the oscillators in order to realize the longest usable life.

3. Measurements should be the result of exhaustive tests on many units of the type to be used, where possible.

Finally, perhaps the most important "specification" to many technical personnel is cost. While mechanical construction and ambient temperature isolation will determine the cost of a unit to an extent, the primary cost factor is the ultimate stability of the unit. The greater the stability required (both long- and short-term) the more elaborate the circuitry required and the better the crystal must be. For example, while a ±1 part in 10^8 oscillator is available for $200, a ±1 part in 10^{10} oscillator can easily cost $2000. ▲

Fig. 6. A phase-locked oscillator system is illustrated.



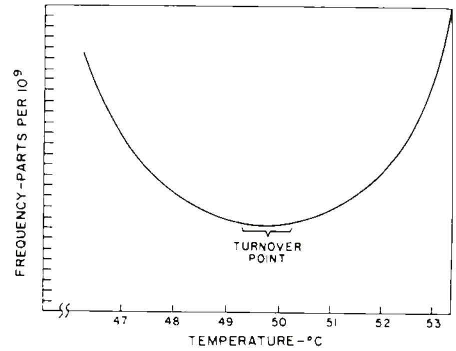


Fig. 7. Typical frequency vs temperature characteristic for a high-quality crystal. Oven is set to "turnover-point" temperature.

REMOVING SOLDERED PARTS

By IRWIN MATH

WHEN disassembling a chassis for the purpose of salvaging components, it is often a difficult job to remove parts affixed to lugs on transformers and tube sockets. Most such connections are made by threading the wire through and around the lug with the result that the heat applied to loosen the wire leads more often than not destroys the component or solder lug in the bargain.

An easy method of removing these leads is to first heat the lug and remove excess solder either by a rapid flick of the component, or with the aid of an inexpensive ear syringe, modified to use a small piece of plastic tubing as the nozzle.

Cut off the top of the lug (so that it now appears U-shaped). The lug can then be heated so that the wires can be slid off the tine of the lug. Enough of the surface will remain so that the lug can be used again. ▲

"It'll interpret from any language in the world—once we figure out how to program it."

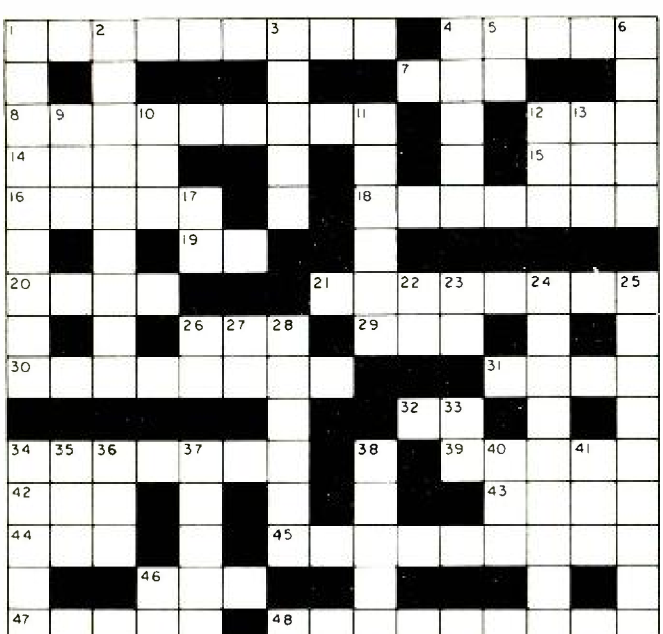
ELECTRONIC CROSSWORDS

By JAMES R. KIMSEY

(*Answer on page* 90)

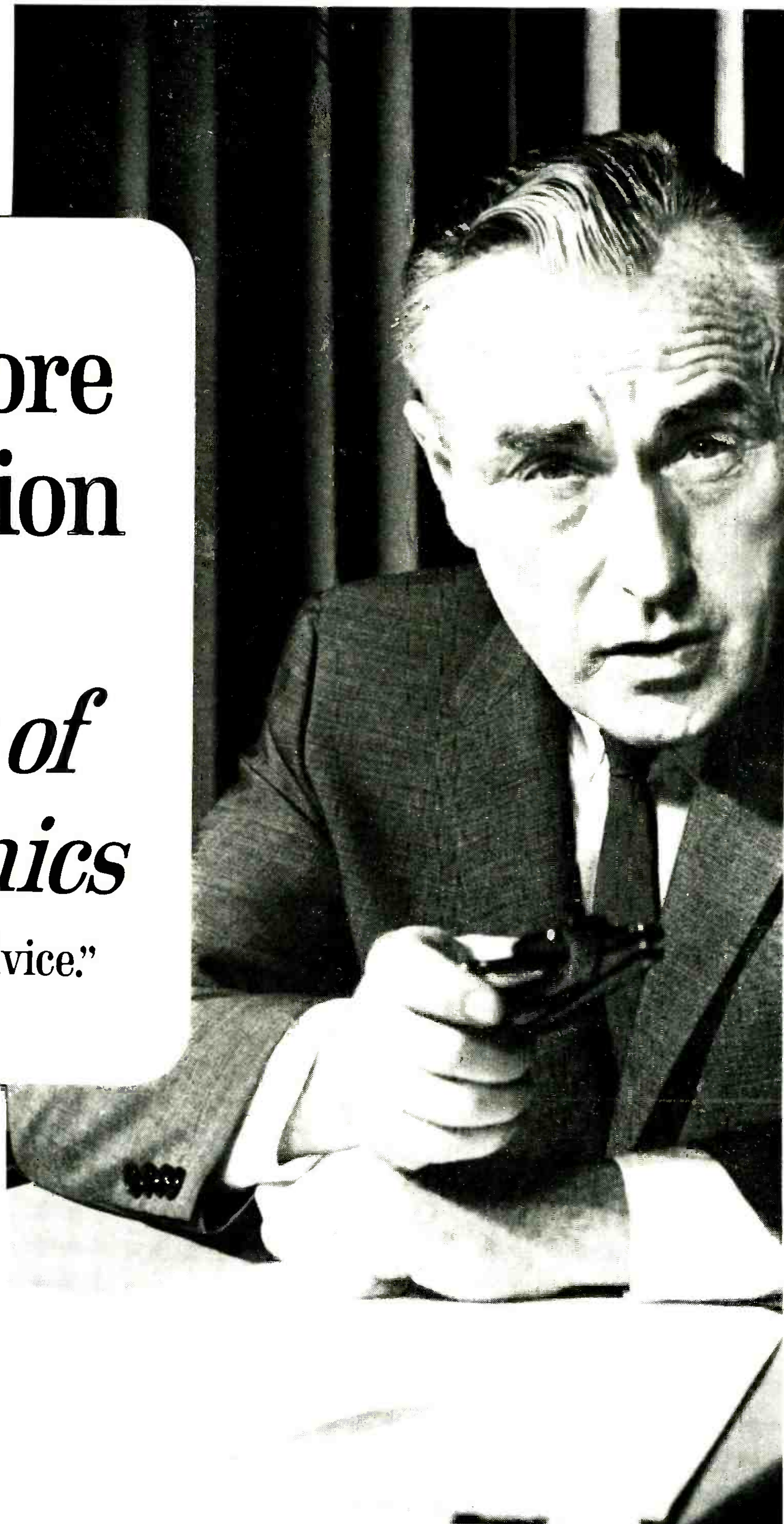
ACROSS
1. One of the essential components in a vacuum tube.
4. Greek letter designating "ohm".
7. Malt beverage.
8. Device used to increase power, voltage, or current of a signal.
12. Familiar trio in Ohm's Law.
14. Mighty African river.
15. Move a TV camera to keep it trained on the subject.
16. The tube electrode to which the main electron stream flows.
18. The prevention of vibration by some means.
19. Mutual conductance (abbr.).
20. Part of the eye.
21. To vary the amplitude, frequency, or phase of an oscillation, usually at a signal frequency rate.
26. Mimic.
29. The male heir.
30. A term used to describe a terminal which has more electrons than normal.
31. A small spring-like clamp.
32. Plate current, in the tube manual.
34. An antenna which is an integral part of a radio or TV receiver.
39. Keyboard instrument.
42. Request.
43. Paddles.
44. deForest.
45. Type of insulation.
46. Resistance network used in coupling two impedances.
47. Miniature receiving tube having nine pins.
48. Water-cooled tetrode capable of providing continuous operation at 50 kW or more in the u.h.f. region.

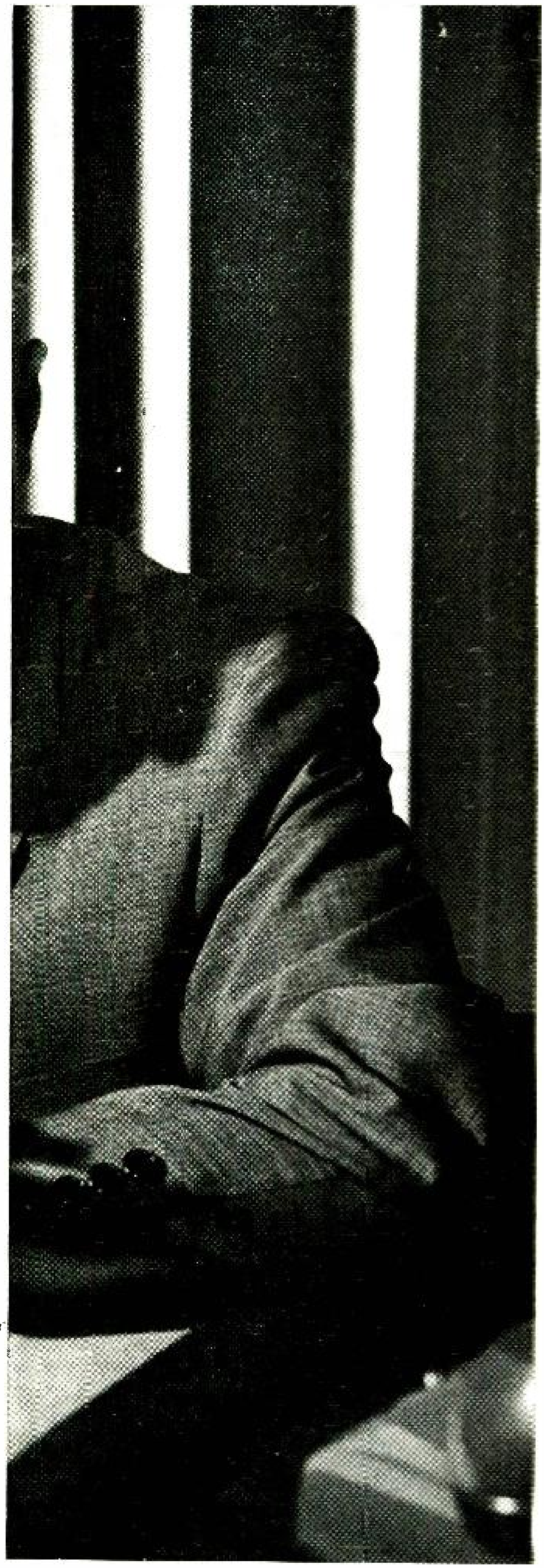
DOWN
1. Gaseous radioactive products formed by the expulsion of an alpha particle from radium, thorium X, or actinium X.
2. Small coil used to measure a magnetic field.
3. An element combined with oxygen.
4. An oil used in medicine.
5. Myself.
6. Storage of components until their characteristics have become stable and constant.
9. Period of time (abbr.).
10. Guided.
11. General term applied to receivers.
12. Prefix meaning "on".
13. Moved rapidly on foot.
17. For example (abbr.).
22. Perform.
23. World peace-keeping organization (abbr.).
24. Long-nosed metal clip.
25. Widening the volume range of an audio-frequency signal.
26. Cut of type of crystal used for r.f. transmitters between 500 kHz and 10 MHz.
27. 3.1416.
28. Happenings.
33. Massive government agency (abbr.).
34. Antenna matching device used to permit efficient coupling of transmitter having unbalanced output to antenna having balanced transmission line.
35. Employ.
36. General and ex-President.
37. A test.
38. Connecting wires.
40. Fish eggs.
41. Skill.
46. Type of communications system (abbr.).



"Get more education or *get out of electronics*

...that's my advice."





Power Output of Solid-State Receivers

ED Miller of *Sherwood Electronic Labs, Inc.*, has just called our attention to inconsistencies in the IHF dynamic power outputs (W ch) appearing in our solid-state receiver chart in the March, 1967 issue. Although we originally requested from manufacturers power output figures for 8 ohms, it is now apparent that quite a few of them inadvertently supplied 4-ohm figures instead. Below is a corrected chart showing both 4- and 8-ohm characteristics where they are available.

It should be pointed out that most advertising departments quote 4-ohm output figures in all of their promotion material and advertising, since it is usually the larger of the two figures. On the other hand, engineering departments usually do all of their designing based on 8-ohm figures.

This is another case where standardization within the industry would be most helpful. ▲

MODEL NO.	4 ohms	8 ohms
ALTEC LANSING		
711A	50	35*
AUDIO DYNAMICS CORP.		
ADC-606	45	35
ADC-600	30	30
BOGEN COMMUNICATIONS		
RT-8000	35	22
RT-7000	32.5	22
TR-100X	30	24
TF-100	30	24
CHANNEL MASTER CORP.		
6606	**	30
6602†		
EICO		
3566	56	37.5
ELECTRO-VOICE		
EV1177	32.5	25
EV1179	27.5	20
FISHER RADIO CORP.		
700-T	60	45
500-T	45	35
440-T	35	25
220-T	27.5	20
GROMMES, PRECISION ELECT.		
C-503	35	30
HARMAN-KARDON, INC.		
SR900B‡	50	35
SR600B‡	40	30
SR400B‡	30	22.5
SR300B‡	30	22.5
720††	40	30
210††	25	18
200††	25	18
HEATH CO.		
AR-15	50	75
AR-14	13	15
AR-13A	12	33
KENWOOD ELECTRONICS		
TK-140	65	50
TK-80	45	40
TK-60	30	25
TK-50	30	25
TK-40	18	15
KNIGHT, ALLIED RADIO		
KN-376	30	25
KN-351†		
KNIGHT-KIT, ALLIED RADIO		
KG-964	37	32
LAFAYETTE RADIO		
LR-1200T	§	60
LR-900T	§	32.5
LR-450T	§	15
OLSON ELECTRONICS		
RA-862	§	20
RA-860	§	40
RA-845	§	22.5
RA-830	§	25
RA-806	§	10
PIONEER ELECTRONICS		
SX-1000TA	55	45
RCA		
MHT67‡	**	25*
MHT60‡	**	10
H.H. SCOTT INC.		
388	60	50
348	60	50
344B	42.5	32.5
342	32.5	25
SHERWOOD ELECTRONICS LABS		
S-8800	70	50
S-8600	35	25
S-7800	70	50
V-M CORP.		
1489	**	10
1484	**	37.5

FOOTNOTES:
*Figure differs from that published in March, 1967 issue
**Not recommended for 4-ohm load.
†Discontinued
††New receiver
‡New model number
§Figure not available

FET Circuits

(*Continued from page* 33)

with voltage gain greater than unity. The bandwidth is dependent upon the impedance of the driving source. When driven by a 600-ohm test oscillator, the upper 3-dB point is 2 MHz. Bandwidth *decreases* as the driving source impedance *increases*. At low frequencies the amplifier input impedance is about 100 megohms and the output impedance is less than 2000 ohms.

Fig. 6 shows a stretcher which senses the peak amplitude of a pulse and holds this voltage level for a time much longer than the width of the pulse. The diagram includes a pushbutton to provide the pulse, but of course the pulse could be coupled in from a suitable external source.

Transistors Q1 and Q3 provide impedance transformation and isolate the FET from both the source and the load. When the input pulse appears, the capacitor is charged through Q1 and the diode. After the input pulse terminates, Q1 is cut-off and the diode is back-biased. The input impedance of Q2 is very high so that the charge leaks off the capacitor mainly by leakage current through the diode and the capacitor. The FET (Q2) then presents the d.c. level to Q3 which acts as an output driver. Fig. 6 also gives the duration of the output obtained with four different FET's. (Note that the FET is connected in reverse in order to make the drain negative.)

The time constant can be increased by using an FET having a very low gate leakage and by selecting a diode and a capacitor with very low leakage. By using these more expensive components, FET stretcher circuits with output pulse times as long as *30 hours* have been built. The circuit can be used as a peak-amplitude detector or to obtain a required time delay. Reset is accomplished by either allowing the output to decay or by shorting the capacitor to ground.

The FET can also be used as a linear gate or electronic switch as shown in Fig. 7. The resistance between source and drain with the switch "closed" is approximately $1/g_m$. With the switch "open", only a small leakage current flows between source and drain. This type of circuit can also be used as an amplitude modulator.

We have presented six simple, low-cost circuits that illustrate many of the principles of FET operation. These circuits are designed to furnish an understanding of the devices and to stimulate thinking toward other applications.

The authors wish to acknowledge the cooperation of Mr. Charles MacDonald of *Siliconix, Inc.* and Mr. Al Kenrick of *General Electric Company*. ▲

Pulse Generators

(*Continued from page 45*)

One of the drawbacks to a conventional oscilloscope is that the frequency response of the test device may fall outside the bandwidth limitations of the vertical amplifier system of the oscilloscope. In some cases, the output signal from a device under test can be observed by direct connection through coupling capacitors to the vertical deflection plates of a conventional oscilloscope. Thus, the limited bandwidth of the oscilloscope vertical amplifier can be bypassed.

The following factors pertaining to the vertical deflection-plate system must be considered for pulse measurement: d.c. operating potential of the plates, lead inductance, deflection-plate capacitance, transit-time limitations, delay lines, and deflection factor.

A typical circuit for direct a.c. coupling to the vertical plates is shown in Fig. 6. This circuit permits the internal vertical amplifier of the oscilloscope to be bypassed but still allows the normal d.c. operating and positioning voltages to be applied to the deflection plates from the internal vertical amplifier. However, when using this circuit, a high-quality external delay line must be used. This will retard the pulse sufficiently to get it on the scope screen.

The values of $R1$ and $R2$ are found by solving the equation given in Fig. 6. The resonant frequency (F_o) of the leads and the capacitance of the deflection plates (C_D) for use in the equation may be determined by the following procedure:

1. Turn off the oscilloscope power.
2. Disconnect the vertical amplifier leads from the CRT neck pins. (A convenient method of connecting to the deflection-plate pins is to use clips removed from a miniature tube socket.)
3. Cut a wire loop equal in length to the total length of $C1$, $C2$, $R1$, $R2$, $R3$, and $R4$.
4. Temporarily substitute the wire loop for the components between the vertical deflection-plate pins.
5. Bring a grid-dip meter near the loop and measure the resonant frequency (F_o).
6. Remove the wire loop.
7. With a capacitance meter, measure the total capacitance between the plates (C_D) at the deflection-plate neck pins. (Capacitance between the plates can also be found by referring to the specifications of the oscilloscope.)

Since the deflection plates are located close to the path of the electron beam, a small amount of current will flow in the deflection-plate circuits. The values of $R3$ and $R4$ must be low enough so that this current will not produce a large voltage drop at the deflection plates. If the resistors are too large, distortion, defocusing, or positioning difficulties may be experienced. Since the deflection-plate current varies non-linearly with the position of the beam, the effects are most noticeable when the beam is positioned near the top or bottom of the screen. The approximate value of 100,000 ohms that is given for $R3$ and $R4$ will probably be satisfactory in most cases.

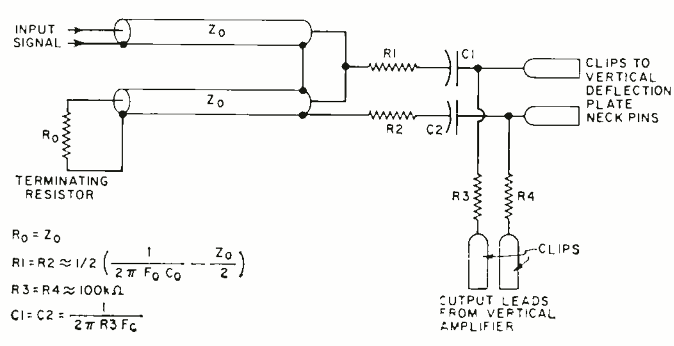
$C1$ and $C2$ should be physically small to minimize lead inductance. The values of $C1$ and $C2$ are selected on the basis of the required low-frequency response and may be calculated from the equation given in Fig. 6. (F_c is the low-frequency cut-off.) For example, if $R3$ and $R4$ are 100,000 ohms and if the desired F_c is about 1.6 kHz, $C1$ and $C2$ should be 0.001 μF.

The stub cable that connects to terminating resistor R_o should be long enough so that if a double-transit reflection appears, it can be easily identified and corrected by adjustment of the termination.

For making vertical measurements with the test setup, the deflection factor of the oscilloscope must be known. This can be measured as follows:

1. While the leads from the vertical amplifier are connected to the deflection-plate neck pins, connect a d.c. voltmeter between the pins.
2. Measure the voltage change as the beam is positioned vertically over the full height of the graticule.
3. Divide this voltage excursion by the graticule height in divisions to obtain the deflection factor in volts/division. ▲

(*Many of the diagrams and techniques described above are based on information from* Tektronix, Inc. *and* Hewlett-Packard.—*Editor*)



$R_0 = Z_0$

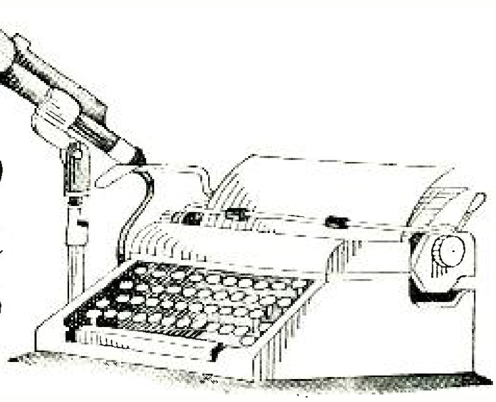
$R1 = R2 \approx 1/2 \left(\frac{1}{2\pi F_0 C_0} - \frac{Z_0}{2} \right)$

$R3 = R4 \approx 100k\Omega$

$C1 = C2 = \frac{1}{2\pi R3 F_C}$

Fig. 6. Circuit for coupling to vertical deflection plates.

RADIO & TV NEWS



APROPOS the electronic eavesdropping situation, the Senate is soon to consider Bill S.928 "Right of Privacy Act of 1967" sponsored by Sen. Long (D. Mo.).

The heart of the bill is Section 3. It establishes a new chapter, composed of Sections 2510-2515 in Title 18 of the U.S. Code. Section 2510(a) is a blanket provision prohibiting wire interception without the consent of one of the parties to the communication. The disclosure or use of any information so obtained is also barred. The sole exception from this far-reaching prohibition in Section 2510 is the minor exclusion in Section 2510(b) for routine activities by employees of a communication common carrier or the FCC. The maximum criminal penalty for violation of Section 2510 is a $10,000 fine or five years imprisonment, or both.

Section 2511 deals with eavesdropping. It contains a series of provisions which, taken together, constitute a comprehensive ban on the use of electronic, mechanical, or other devices to eavesdrop on a private conversation without the consent of a party to the conversation. It also bars the disclosure or use of any information so obtained. As is the case with Section 2510, the maximum criminal penalty for violation of Section 2511 is a $10,000 fine or five years imprisonment, or both.

In order to cut off the source of supply of the devices used by wire-tappers and eavesdroppers, Section 2512 contains sweeping prohibitions banning the manufacture, shipment, or advertisement of devices useful for the purpose of wire interception or eavesdropping. Violations of this Section carry a maximum criminal penalty of a $25,000 fine, or one year imprisonment, or both.

Section 2513 is a confiscation provision. It authorizes the seizure and forfeiture of any device used, shipped, or manufactured in violation of Sections 2510, 2511, or 2512.

The above material is directly quoted from a letter to the Vice President from Ramsey Clark, the Attorney General of the United States.

Senator Long concluded his preface to the bill as follows: "It is my hope that in the very near future there can be brought before the Senate, the soundest bill possible to regain and maintain that right referred to by Justice Brandeis as the right most valued by civilized men, the right of privacy."

Germanium IC's

Until now, all integrated circuit technology has been confined to silicon devices. This is because during certain steps in the fabrication of the IC, selected areas of the wafer must be protected by some sort of easily formed, chemically impervious layer. In silicon, this protection can be provided by forming a silicon dioxide (glass) layer over the to-be-protected area. In germanium, such a layer has been difficult to form because easily formed dioxides of germanium are chemically unstable. This is the chief reason why silicon has completely dominated the IC field, despite the inherently higher operational speeds of comparable germanium devices.

Scientists at the *IBM* Research Division Labs. have reported the successful creation of germanium IC's, which despite their relatively early stage of development, are already faster than the fastest silicon circuit thus far reported. These circuits take advantage of the inherently greater speed, or mobility, of the electrons and holes in germanium, which permits switching speeds about three times faster than those of silicon devices of comparable size.

The experimental germanium IC's have measured switching delays of 350 picoseconds (trillionths of a second). This includes an estimated 100 picoseconds delay due to the test package, and an isolation capacitance delay of about the same amount. It should also be pointed out that the germanium devices were about three times larger than the smallest silicon devices.

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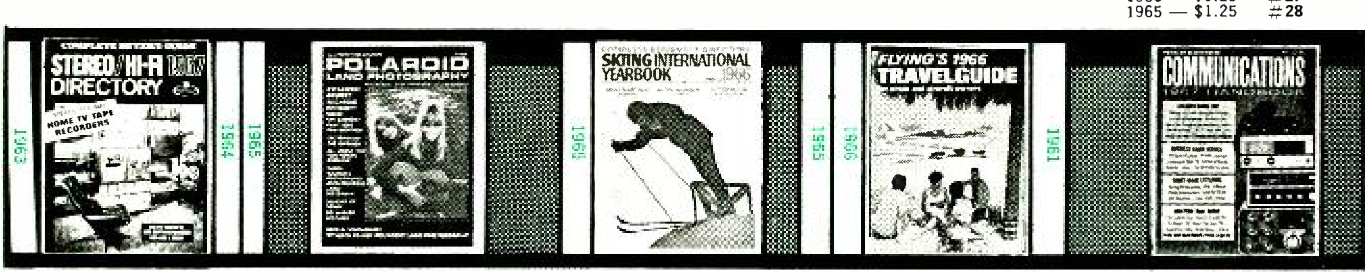

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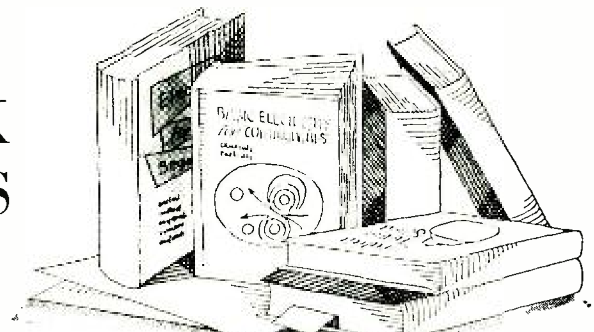
BOOK REVIEWS



"RCA RECEIVING TUBE MANUAL" compiled and published by Electronic Components and Devices, *Radio Corporation of America*, Harrison, N.J. 597 pages. Price $1.25. Soft cover.

This revised and updated tube manual introduces several new features which users—including engineers, service technicians, educators, experimenters, hams, hobbyists, students, and others—will find helpful and informative.

One change is that the Technical Data Section has been restricted to coverage of active *RCA* tube types while the basic data for replacement and discontinued tubes has been shifted to a "replacement use" table. Included in the listings are all types of home-entertainment-type receiving tubes, black-and-white and color-TV picture tubes, and voltage-regulator and voltage-reference tubes.

There is also a revised circuit section which includes detailed write-ups of many practical tube applications. These write-ups explain the function and operation of individual stages and complete circuits so that students and experimenters can understand and construct the circuits.

There is new text material on basic system functions, tuned amplifiers, wide-band amplifiers, and TV scanning, sync, and deflection circuits.

* * *

"INTRODUCTION TO DIGITAL ELECTRONICS" by Arthur W. Lo. Published by *Addison-Wesley Publishing Company, Inc.*, Reading, Mass. 01867. 220 pages. Price $10.75.

The author, professor of electrical engineering at Princeton, has addressed this text to seniors and or engineering graduate students. It is designed to serve as an introduction to the digital operation of solid-state electronics devices and circuits as used in digital computers and other digital devices.

In addition to its application as a textbook, the information will be equally helpful to those working with digital systems, solid-state electronics, or computer sciences. The text is divided into six chapters dealing with the basic concepts, transistor logic circuits, cryoelectric and optoelectric circuits, magnetic logic circuits, logic circuits using negative-resistance switching elements, and random-access memories.

Math is used as required to amplify the text but anyone with a grasp of college algebra will be able to handle the equations and perform the requisite operations.

* * *

"TRANSFORMERS FOR ELECTRONIC CIRCUITS" by Nathan R. Grossner. Published by *McGraw-Hill Book Company*, New York. 311 pages. Price $14.00.

As a consulting engineer specializing in transformer design, the author is aware of the information gaps which exist in this area. This book, although addressed to those who use transformers whether in circuits, systems, or as standards, is not intended to make a transformer designer out of the reader but rather to equip him with an understanding of transformer functions so that he can use any type of transformer to best advantage.

There are eleven chapters devoted to a survey of transformers, the power transformer, reliability and environment, temperature rise and thermal design, ratings and sizes of power transformers, inductance and losses, polarized transformers and inductors, wide-band transformer analysis, wide-band transformer synthesis, and analysis and synthesis of the pulse transformer.

The author uses charts, graphs, formulas, line drawings, and schematics with a lavish hand to provide the maximum amount of useful data in a book of reasonable size.

* * *

"ANALYSIS AND SYNTHESIS OF TUNNEL DIODE CIRCUITS" by J. O. Scanlan. Published by *John Wiley & Sons*, New York. 268 pages. Price $9.75.

The author, lecturer in the Department of Electrical and Electronic Engineering, The University of Leeds, Leeds, England, has placed his emphasis on circuit principles rather than the practical applications of tunnel diode circuits and has limited his discussion to sinusoidal applications of the diode.

Because of this application and the mathematical treatment of the subject, only practicing engineers and physicists or graduate students will derive full benefit from this text. For those engaged in tunnel diode circuit design or application, the author's thorough coverage of tunnel diode physics, equivalent circuits, tunnel diode amplifiers, broadband tunnel diode amplifiers, and non-linear sinusoidal applications offers a wealth of basic background material with which to work.

* * *

"CIRCUIT DESIGN FOR AUDIO, AM/FM, AND TV" by Engineering Staff, *Texas Instruments Incorporated*. Published by *McGraw-Hill Book Company*, New York. 344 pages. Price $14.50.

This is the fifth book in *TI*'s practical handbook series for circuit designers. Special emphasis has been placed on both cost-saving and time-saving procedures throughout the step-by-step analysis. The examples cited by the authors incorporate the most modern devices available from the transistor industry.

For example, in the audio section, the authors discuss output and driver design and input design. The AM-FM section deals with amplifiers, tuners, and applications, with special emphasis on the practical design of i.f. strips. Topics in the TV section include v.h.f. tuners, video i.f. amplifiers, a.g.c., the audio amplifier system, sync separators, and vertical and horizontal oscillators. The examples used to demonstrate the various designs were selected to suggest the broad applications of the procedures.

Since this volume is written by engineers for engineers there has been no attempt to simplify the treatment or offer concessions in the matter of a non-mathematical approach. For those with the requisite engineering and mathematical background, this book should provide needed stimulation and much worthwhile information on designing with transistors.

* * *

"PRINTED CIRCUITS HANDBOOK" edited by Clyde F. Coombs, Jr. Published by *McGraw-Hill Book Company*, New York. 536 pages. Price $15.00.

This is a detailed how-to-do-it guide representing a compilation of valuable material contributed by experts in the various fields. The editor is manager of Corporate Process Engineering at *Hewlett-Packard* and he has called on engineers from *Fairchild*, *Westinghouse*, *Insulectro*, *Universal Instruments*, *Alpha Metals*, *General Electric*, *Consolidated Electrodynamics*, and his own firm to provide authoritative data on various phrases of PC processes.

The text covers the entire scope of printed-circuit design, fabrication, assembly, and testing. It is written for both engineers and production personnel, with information on all phases of the printed-circuit process to permit the establishment of a production facility and control of the process.

There are five main sections covering engineering, fabrication, assembly, soldering, and testing. Recent developments such as multilayer printed-circuit processing and automatic component insertion are covered along with basic information on the entire technique.

* * *

"WORLD RADIO TV HANDBOOK" compiled and published by *World Radio-Television Handbook Co. Ltd.*, Denmark. Available in North America from *Gilfer Associates*, P.O. Box 239, Park Ridge, N.J. 07656. 304 pages. Price $4.95 postpaid. Soft cover.

This is the 21st edition of the handbook that SWL's have come to depend on as much as their short-wave receivers. It lists all broadcasting facilities (AM, FM, TV, and short-wave) for 193 countries with details on frequencies, call-signs, slogans, power, operating hours, languages transmitted, interval signals, personnel, addresses, and verification.

In addition to the listings, the book contains a table of abbreviations, DX clubs, charts, and a table of world time in all countries to help the SWL in scheduling his listening. It is hard to see how any SWL hobbyist could get along without the handbook especially one that is as up-to-the-minute and complete as this one. ▲

CHICAGO TO BE "ELECTRONICS CAPITAL"

IN June, Chicago will be the "Electronics Capital" of the United States when manufacturers of everything from the latest in electrified harmonicas and pianos to giant community antenna systems will converge on the city for a series of trade shows, conventions, and business sessions expected to attract an estimated 40,000 persons.

The electronics gatherings will begin with the National Electronic Distributors Association (NEDA) annual meeting on June 18th and continue to the end of the month with the closing of the five-day 66th annual Music Show sponsored by the National Association of Music Merchants.

The NAMM Music Show and the annual convention of the National Community Television Association will open on Sunday, June 25th, with the CATV sessions closing June 28th.

Following the opening of the NEDA meeting, the Electronics Parts Show will run from June 19th to 21st, heralding the return of this event to Chicago after an absence of two years. Concurrently with the Parts Show, five big electronics associations have scheduled joint meetings on June 21. Included are Association of Electronic Manufacturers, EIA, WEMA, ERA, and NEDA.

On Friday, June 23, the annual meeting of the All-Industry Electronics Conference is scheduled while on the following day there will be a session of the executive board of NATESA.

Meetings the following week, in addition to the Music Show and CATV convention, include the Radio Old Timers and the Electronic Young Tigers. ▲

EW Lab Tested

(*Continued from page 16*)

trol voltage and signal-strength meter operation, a conventional i.f. amplifier is included, together with separate amplifiers and detectors for a.g.c. and meter operation.

The interstation squelch circuit of the AR-15 is unusually elaborate and effective. It uses a total of 11 transistors and 6 diodes, more than the total complement of many FM tuners. Most squelch circuits operate on the reduction of noise when an FM station is tuned in. This invariably results in a burst of noise when the squelch goes in and out of action. In the AR-15, the noise reduction is not sufficient to turn on the receiver. In addition, the receiver must be tuned to nearly the center of the channel, as indicated by the center-zero tuning meter. Since the quieting is already effective when the squelch operates, there is no noise burst. Signals appear and disappear abruptly as the receiver is tuned. Only when two signals are on adjacent channels (200-kHz apart) can an occasional noise burst be heard when tuning between them.

There is also an adjustable stereo threshold circuit which switches the receiver from stereo to mono when the signal strength falls below a predetermined level. Normally, stereo mono switching is fully automatic, but the receiver can be controlled manually or set to respond only to stereo signals if desired. A switchable FM-stereo noise filter reduces noise on weak stereo signals, with no loss of high-frequency response but with a noticeable reduction of channel separation.

The AR-15 AM tuner is a basic design, with one r.f. amplifier and one i.f. amplifier. It lacks a 10-kHz whistle filter and while its sound is pleasant, it does not match the quality and performance of the FM tuner section.

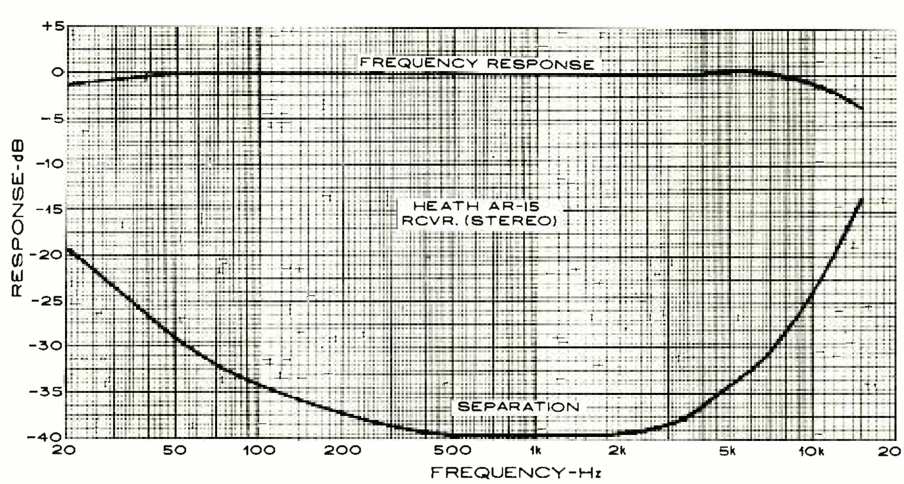
Our laboratory measurements confirmed the specified performance of the receiver in all essential respects. When delivering its rated continuous power output of 50 watts per channel, the distortion was under 0.33% between 20 and 20,000 Hz. At half power, the distortion was 0.15% between 20 and 20,000 Hz. The 1000-Hz harmonic distortion was under 0.15% at any power up to 50 watts and the IM distortion averaged a few tenths of 1% at any power up to 50 watts. These measurements were made with 8-ohm loads. (*According to the manufacturer, the maximum music power output of 75 watts channel is obtained at this impedance. At 16 ohms, music power drops to 45 watts, and at 4 ohms it drops to 50 watts.—Editor*)

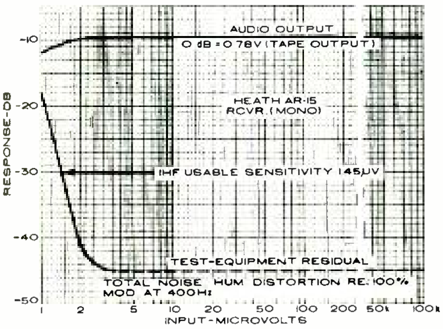
The tone controls had adequate range, with the desirable property of not having any effect on middle frequencies between 700 and 3000 Hz. The RIAA phono equalization was very accurate, within ±1 dB from 20 to 20,000 Hz.

The most impressive part of the receiver was its FM tuner. Featuring outstanding sensitivity and an excellent limiting characteristic, its IHF usable sensitivity was 1.45 microvolts, and limiting was complete at 2 microvolts. We were unable to find any stations which did not limit fully, with silent backgrounds. We also were able to receive stereo broadcasts from a distance of 70 miles, only 200 kHz from a powerful local station, without interference, a remarkable feat. For this we used a moderately priced 8-element yagi antenna, only 25 feet high.

The FM-stereo separation was about 40 dB at middle frequencies, reducing to 23 dB at 30 Hz and to 13.5 dB at 15 kHz. The frequency response was very flat to 10 kHz, rolling off slightly at 15 kHz. This was evidently due to the low-pass filters which removed any ultrasonic signals which might cause beats when tape recording FM-stereo broadcasts.

The unit we tested was an engineering model. We have not seen the kit construction manual, but it is obvious that this is a complex unit and probably not for the neophyte kit builder.





It is constructed on seven printed-circuit boards and inter-cabling is minimized by mounting most front-panel controls and their rear input connectors directly on their associated circuit boards. The signal meter is used as a voltmeter and ohmmeter for checking out the receiver as it is constructed and no additional test equipment is needed for alignment. Most of the normal alignment procedures are eliminated by the use of the crystal filters in the i.f. and by a pre-aligned front-end. (*Estimated construction time, according to the manufacturer, is expected to be around 35 hours.—Editor*)

We found the AR-15 easy to operate and easy on the ears. Its enormous reserves of clean power make for effortless listening at any level, and the FM tuner brought in more listenable FM broadcasts, as many as 15 to 20 on a single sweep of the dial, than we had realized existed in our area.

The few amplifiers which can match or surpass the AR-15 in power or ultra-low distortion cost considerably more than the entire AR-15 receiver. The tuner portion is among the most sensitive we have ever checked. Considering these facts, this is a remarkable value at $329.95 in kit form. We noticed a reaction of several people to the effect that they could buy a very good factory-wired receiver for that price. So they could, but it would be hard to find one which would match the over-all performance of the *Heath* AR-15. ▲

Shure Model 565 "Unisphere I" Microphone

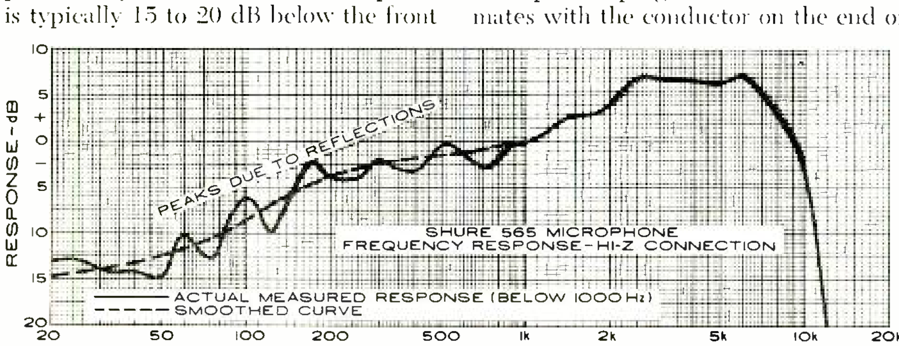
For copy of manufacturer's brochure, circle No. 27 on Reader Service Card.

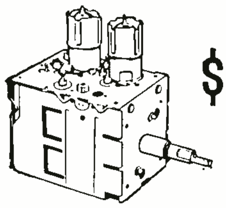
PUBLIC-address microphones require certain performance characteristics not needed in recording or broadcast applications. The proximity of loudspeakers, usually operating at high volume, makes acoustic feedback a potentially serious problem. Speakers or vocalists have a tendency to perform very close to the microphone, many of which are prone to unnatural "bassiness" under these conditions. Obviously, a microphone which will be held close to the user's face should be reasonably small and lightweight.

The *Shure* Model 565 "Unisphere I" microphone represents an effective solution to these problems. It is a unidirectional, cardioid-pattern dynamic microphone, only 6½ inches long and weighing 10½ ounces (less the detachable cable). The active element of the microphone is enclosed in a 2-inch diameter wire mesh sphere. The response of the 565 is uniform in the plane at right angles to its axis due to its symmetry of construction, but it strongly rejects sounds coming from the rear of the microphone. Its side cancellation is approximately 6 dB and its rear response is typically 15 to 20 dB below the front response. The polar pattern is essentially uniform with frequency.

The spherical mesh screen serves a dual purpose. It prevents the user from getting too close to the dynamic element and serves to protect the diaphragm from wind and breath noises. The cardioid pattern makes it possible to orient the microphone so as to reject sound coming from the loudspeakers which it drives, permitting operation at relatively high volume levels without acoustic feedback.

The 18-foot shielded three-conductor cable supplied has an *Amphenol* MC4M microphone plug on the end which mates with the conductor on the end of





the microphone. By a simple change of cable connections in the 5-pin plug, either low-impedance (150 ohms nominal) or a high-impedance, 40,000-ohm output may be selected.

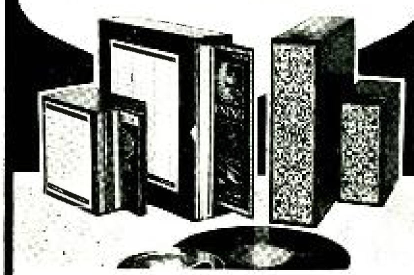
The nominal frequency response is 50 to 15,000 Hz. We were able to make an approximate measurement of its frequency response by comparison with our calibrated capacitor microphone, by locating the microphone about two feet in front of the loudspeaker and then making a frequency-response plot. We made automatic plots, on the same chart paper, of our standard microphone and of the Model 565, with both positioned identically with respect to the speaker. Since the reference microphone is essentially flat in the frequency range we covered, the difference between the two curves is an indication of the response of the microphone.

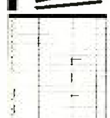
We used the term "indication" intentionally. Since the reference microphone is non-directional and the 565 is sharply directional, one would expect to find some differences between their outputs from the test signal source. The test was not made in anechoic surroundings, although the proximity to the speaker minimizes the effects of room resonances. The curve we obtained had a series of small ripples below 1000 Hz, which were evidently due to reflections from the front of the speaker cabinet and surrounding objects. Drawing a smooth curve through these points, we found a rising response curve quite smooth and free from peaks or holes, increasing at about 3 dB/octave from 20 Hz to 6 or 7 kHz. It fell off quite rapidly at higher frequencies and the upper limit was, for all practical purposes, about 10 kHz.

Bearing in mind the inevitable increase in bass when close-talking, one might expect the response of the mike under these conditions to be relatively uniform over the entire range. We verified this by recording with it on one track of a stereo recorder and with another microphone lacking the spherical windscreen, but with comparable overall frequency response, on the other track. The 565 was clearly superior in this test, both in close-talking, where it excelled, and in more distant pickup where it still had a live, natural sound free from the heaviness which characterizes some microphones whose response measures "flat".

Subjectively, the mike was slightly bright in comparison with the other microphone, but when listened to by itself it sounded "just right". A practical test with a small combo confirmed the effectiveness of its cardioid pattern in avoiding feedback and its generally excellent sound. It is compact and unobtrusive and well suited to this sort of musical pickup as well as for speech.

The *Shure* 565 microphone sells for $95 (list). ▲





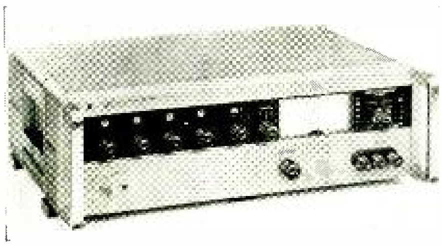
NEW PRODUCTS & LITERATURE

Additional information on the items covered in this section is available from the manufacturers. Each item is identified by a code number. To obtain further details, fill in coupon on the Reader Service Card.

COMPONENTS • TOOLS • TEST EQUIPMENT • HI-FI • AUDIO • CB • HAM • COMMUNICATIONS

10-Hz TO 1-MHz OSCILLATOR

Frequencies between 10 Hz and 1 MHz can be selected with four-place precision on the new Model 4204A test oscillator. Frequency selection is made with detented rotary controls. Each of four selects a decimal digit of the de-



sired frequency and a fifth control selects one of the four decade ranges. A vernier frequency control provides infinite resolution where needed between digital steps.

The fifth control, in selecting a range, sets the decimal point and displays the units of measurement, i.e., Hz or kHz. With the 4-place numerical readout, this results in a complete in-line display of frequency selected and assures that there can be no ambiguity in its reading.

The new unit is designed for use in production testing and other repetitive measurements where certain frequencies are selected over and over again. Frequency resettability is better than 0.01%, assuring consistence where measurements are repeated. Over-all frequency accuracy is 0.2%. Hewlett-Packard

Circle No. 126 on Reader Service Card

MIL-SPEC SWITCHES

A complete series of push-button switches certifiable to the new MIL-S8805/3 specification is being marketed as the Series W190. The new series includes 110 moisture-proof push-button switches rated for loads of 10 amperes resistive, 5 amperes inductive, and 3 amperes lamp at 28 volts d.c. or 115 volts, 60 and 400 Hz a.c.

The line includes five different circuit arrangements, seven different mounting styles, and a choice of red or black push-buttons in two styles appropriate to either momentary or push-pull action. Designed to withstand shock, vibration, and other critical standards, the switches have an electrical endurance in excess of 25,000 operations at rated loads. Controls Co. of America

Circle No. 127 on Reader Service Card

WIRELESS REMOTE-CONTROL UNIT

The new "Teleswitch" is a wireless, remote "on-off" switch which can be used to operate such devices as lamps, fans, hi-fi equipment, radios, or TV sets. The unit is in two parts—

a miniature battery-operated ultrasonic transmitter and a receiver. The device will operate at distances up to 40 feet.

There is no installation involved. The device to be controlled is plugged into the "Teleswitch" unit which is then connected to any 117-volt, 60-Hz wall outlet.

The unit is fully transistorized and requires no warm-up. The relay contact rating is 7½ amperes, 860 watts maximum. The transmitter is housed in a contoured plastic enclosure which is easy to handle. Euphonics

Circle No. 1 on Reader Service Card

THERMOCOUPLE ASSEMBLY KIT

A thermocouple assembly kit which permits the assembly of a wide variety of thermocouple probes in only minutes has just been announced.

The kit contains all necessary components to construct the probes from cryogenic through high temperatures. A complete instruction manual, giving important thermocouple data, accompanies each kit.

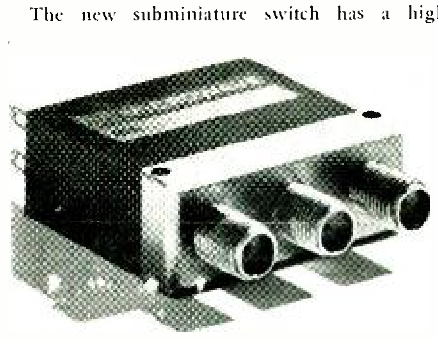
A product bulletin (#965) giving complete information on the kits will be forwarded on request. Omega Engineering

Circle No. 128 on Reader Service Card

BROADBAND COAXIAL SWITCH

A new high-performance s.p.d.t. coaxial switch which is less than half the size of its predecessor and weighing less than 1¼ ounces is now available as the MA-7530.

The new subminiature switch has a high



isolation of 60 dB minimum and low (typically 1.3:1 max.) v.s.w.r. over the frequency band from d.c. to 12.4 GHz. Over-all volume of the switch is less than 0.75 cubic inch.

This level of performance, not previously attainable in the X-band, is provided in combination with switching time of 20 msec maximum and an r.f. power rating of 15 watts c.w. Actuation is remote, by 22-30 volts d.c. Microwave Associates

Circle No. 129 on Reader Service Card

COLOR GENERATOR

A new deluxe color generator featuring an automatic timer heating element and movable single dot and single vertical and horizontal line patterns has been introduced at the CG141 "Color King".

Compact and completely portable, the unit is housed in a mar-resistant vinyl-clad steel case with removable protective lid. A plate-glass mirror is shock-mounted in the lid for convenient set-up and convergence in the home.

The automatic timer heating element is thermostatically controlled to maintain a mini-

mum operating temperature of 80 degrees. Stability is thus assured whether the outside temperature is 20° below or 140° in the shade.

The new movable single patterns, exclusive in this instrument, make it possible to follow the set manufacturer's convergence recommendations without the confusion sometimes caused by multiple lines and dots. The single dot and single vertical and horizontal line patterns can be positioned at any point on the CRT screen. Sencore

Circle No. 2 on Reader Service Card

SQUARE TRIMMER

A new line of commercial, wirewound ⅜" trimming potentiometers has just been introduced as the Series 3600.

These square trimmers will fit the cards of any standard ⅜" or ½" square trimmer. It is only 0.200" high for low card space applications.

The new design permits a longer mandrel than that of rectangular trimmers and thus offers up to 131% better resolution than that offered by ¾" rectangular trimmers, according to the company. The new design offers up to 85% better resolution than that specified by MIL-R-27208B, RT24.

Resistance values are available from 100 to 20,000 ohms. Power rating is 0.5 watt at 40°C. Operating temperature range is from −65°C to +125°C. The trimmers feature silver-brazed terminations, gold-plated terminals, and a damage-proof clutch. Amphenol Controls.

Circle No. 130 on Reader Service Card

PC ASSEMBLIES & KITS

A broad line of printed-circuit assemblies and kits designed specifically for the hobbyist and experimenter market is now available.

Designed for use in home entertainment equipment, ham gear, p.a. and intercom systems, units currently available include a wide choice of low-power amplifiers, preamps for ceramic cartridges, stereo tape preamps for 8-track cartridges, and a 20-watt mono amplifier. Details on the full line of available units will be supplied on request. Amperex

Circle No. 3 on Reader Service Card

LOW-COST INDICATOR LIGHTS

The new bi-pin cartridge lamps offer a choice of three transparent and two translucent lens caps. They may be mounted in a lampholder for easy replacement or, for maximum economy, may be permanently mounted to a panel with a Tinnerman nut and connected with a #499-058 connector. Voltage range in this line is 6 to 120 volts. Data sheet #6700 giving full details on this new line is available on request. Drake

Circle No. 131 on Reader Service Card

HEAT-SHRINKABLE TUBING

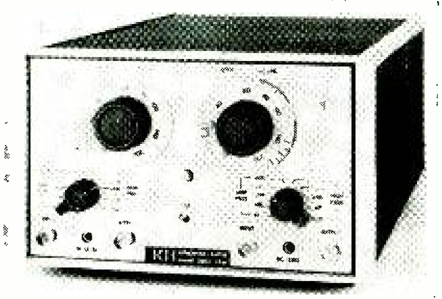
Two new types of heat-shrinkable polyolefin tube are now available: "Heat-Grip" 800, a colored, flame-retardant tubing and "Heat-Grip" 805, a nearly transparent tubing. The new tubing will shrink to half its original diameter upon heating to 250° F for several seconds or in less time at higher temperatures. The molecular cross-linking of the special formulations results in materials which become elastomeric. They do not melt or flow upon heating, have much longer heat life, and greater resistance to solvents, according to the company.

The tubing is available in black, white, red, yellow, blue, or clear in sizes from 1/8" to 1" i.d. Natvar

Circle No. 132 on Reader Service Card

SOLID-STATE VARIABLE FILTER

A highly flexible, all-solid-state variable electronic filter has made its appearance on the market as the Model 3202. Providing basic low-pass and high-pass modes, the unit can (by interconnecting its two channels) also be operated as either a bandpass or band-reject filter.



In addition, cascading the two channels can increase the basic 24 dB per octave attenuation slope to 48 dB per octave in the low-pass and high-pass modes.

The Model 3202 tunes continuously over the frequency range of 20 Hz to 2 MHz and is available in either bench or rack mounted versions. Krohn-Hite

Circle No. 133 on Reader Service Card

ANTENNA SYSTEMS FOR HOMES

A factory-engineered antenna system designed to be built into new homes is now being offered in kit form. The system permits up to eight TV/FM sets to operate simultaneously from one antenna without interaction.

The new system is offered in two versions: Model 1-4BK is for the 1-4 family unit and is designed for installation in new homes and small multiple unit dwellings. The Model 5-8BK 5-8 family unit kit is designed for apartment houses, motels, hotels, and larger dwellings.

These kits, designed for use with 300-ohm line, include a golden anodized TV antenna, the distribution system, and non-electrical outlets. Mosley

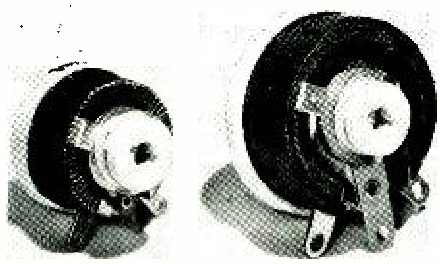
Circle No. 4 on Reader Service Card

POWER RHEOSTATS

A new line of power rheostat-potentiometers for industrial electronic applications has just been introduced as the Style MP.

Available in 25- and 50-watt sizes, the new units feature all-ceramic construction (core, base, hub), vitreous enamel bonding, self-lubricating shoe, compact design, and smooth high-resolution action.

Available in all popular resistances values to 5000 and 10,000 ohms for 25- and 50-watt sizes, respectively, the new units are directly



interchangeable with those of major manufacturers. Standard tolerance is ±10% and functional output is linear. Ward Leonard

Circle No. 134 on Reader Service Card

MOTOR SPEED CONTROLS

Three new models, Nos. 100, 101, and 102, of long-life motor speed controls are now available. Encased in an aluminum extrusion, the solid-state, full-wave circuitry used will control universal a.c.-d.c. motors from "off" to full speed. Output voltage may be adjusted from 5 volts to full a.c. line voltage and they may also be used to vary the speed of permanent split-capacitance type a.c. motors.

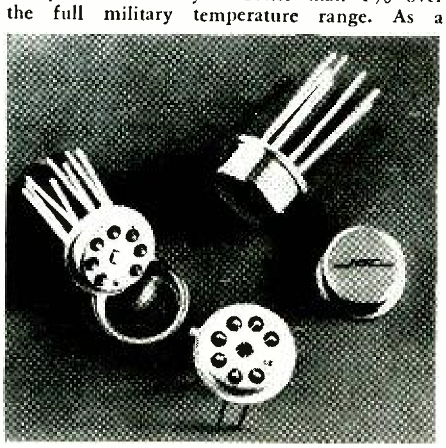
The Model 100 will handle a maximum of 600 watts at 5 amps, 120 volts a.c.; the 101 will control 1200 watts at 10 amps, 120 volts a.c., while the 102 is designed to control 1800 watts at 15 amps, 120 volts a.c. All models are fused for overload protection and all models measure a mere 2" x 3" x 5" long and weigh less than 2 pounds. Slocum Industries

Circle No. 5 on Reader Service Card

MONOLITHIC VOLTAGE REGULATOR

The new Type LM-100 monolithic voltage regulators are adjustable over a 2 to 30 volt output voltage range and are capable of handling output currents up to 5 amps by the addition of external transistors. The new units can be used either as a linear, dissipating regulator or a high-efficiency switching regulator with essentially the same performance in either application.

The units feature regulation better than 1% for widely varying load and line conditions. Temperature stability is better than 1% over the full military temperature range. As a



linear regulator, the design provides current limiting, excellent transient response, and unconditional stability with any combination of resistive or reactive loads, according to the company. As a switching regulator, the circuit will operate at frequencies up to 100 kHz with an efficiency of 85%. National Semiconductor

Circle No. 135 on Reader Service Card

HI-FI—AUDIO PRODUCTS

HIGH-GAIN FM-STEREO ANTENNAS

Three "Stereo-Probe" FM antennas designed to overcome the critical dB loss in multiplex reception in fringe areas have been introduced. The new antennas introduce the series-fed dipole concept to FM arrays. According to the company, this new phase relationship of end-fire, series-fed dipoles also results in high front-to-back ratios, minimizing stray pick up.

The Model 9 is designed for fringe to deep fringe, the Model 6 for near fringe to fringe, while the Model 4 is for suburban to near fringe area applications. Channel Master

Circle No. 6 on Reader Service Card

COMPACT STEREO RECEIVER

A bookshelf-size, solid-state FM-stereo receiver has recently been introduced as the Model 606. Measuring 9" deep x 17" wide x 5" high, the receiver is housed in a walnut case with large, sloping FM dial for easy station identification and a log-scale dial face for pinpoint tuning. Simple alignment of a pointer at the center of an illuminated tuning meter provides optimum visual tuning.

Other front-panel features include a stereo indicator light, tape monitoring facilities, two sets of speaker switches, a stereo headset outlet, input facilities for magnetic and ceramic car-

tridges, musical instrument, tape, or auxiliary program sources. The 606 will drive two pairs of stereo speakers, either as a single pair or in combination, with independent front-panel control. Other controls are tuner/phono, auxiliary/normal, tape/normal, stereo/mono, plus volume, bass/treble, and balance.

According to the company, frequency response is virtually flat to 20,000 Hz, FM stereo separation is in excess of 35 dB, total HD is 0.3%, and output is 30 watts per channel. ADC

Circle No. 7 on Reader Service Card

WIRELESS MICROPHONE

The Sony CR-6 wireless microphone features a battery-operated receiver with provision for a.c. operation. The system consists of a compact, lightweight, solid-state FM transmitter, capacitor microphone, solid-state a.c.-d.c. receiver, and two battery packs. The miniaturized transmitter and microphone are housed in a capsule less than 3 inches long. For hand-held use, power is supplied by a battery-contained capsule which is directly attached to the mike-transmitter or the separate battery pack connected by a small cable permits use as a lavalier.

The transmitter and receiver can be separated by distances up to 300 feet. A squelch circuit prevents interference. The monitor speaker and volume control are built in. The system operates at 42.98 MHz but 35.02 or 33.15 MHz operation can be provided if specified at the time the unit is ordered. Frequency response is 50-10,000 Hz, signal-to-noise ratio is greater than 35 dB. Superscope

Circle No. 8 on Reader Service Card

HANDSET MICROPHONE

A close-talking, noise-canceling dynamic microphone telephone-type handset is now available for use in "Vocoder" systems. It can be used in environments of high ambient noise and reverberant acoustics.

The microphone has a frequency response of 70 to 5000 Hz and noise discrimination averages 15 dB. Output impedance is 150/250 ohms. The unit is available in red (or black) for use in military and government "hot line" systems. Altec Lansing

Circle No. 9 on Reader Service Card

90-MINUTE BLANK CASSETTES

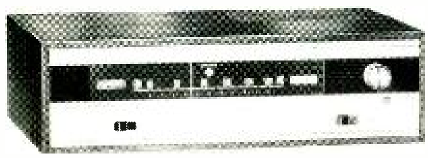
The C-90 cassettes which provide 90-minute recording time have been released for use with all tape recorders utilizing the cassette system.

The new blank units have the same physical dimensions as the original C-90 versions and are completely compatible and interchangeable on all mono and stereo cassette machines. The C-90 provides 45 minutes of recording time on each side because technological advances permit use of thinner tapes within the compact containers. Norelco

Circle No. 10 on Reader Service Card

FM-STEREO TUNER

The "Knight" Model KN-290 FM stereo tuner features all-silicon transistors, built-in a.f.c., built-in tuning meter for hairline tuning, and an



indicator light to signal a stereo transmission. A special feature, the automatic multiplex switch, activates the stereo sections of the circuit when a stereo signal is received and cuts off the areas not required for mono reception.

The tuner measures 13" wide x 10" deep x 3⅞" high. It is supplied with a brushed, extruded aluminum panel and simple controls. An oiled-walnut wood case is available separately.

Sensitivity is 1.5 μV for 20 dB quieting, 3 μV IHF; image rejection is over 90 dB and capture ratio is 3 dB. Response is 50 to 15,000 Hz $\pm$1.5 dB. The tuner is designed to operate on 110-130 V, 60 Hz a.c. Allied Radio

Circle No. 11 on Reader Service Card

BLANK TAPE CARTRIDGES

The new loaded blank "Audiopak" cartridges are designed to fit playback and recording systems for both home and automobile. Currently there are two continuous loop cartridge systems on the market which record as well as play back —the Roberts 1725-8L and Muntz. In addition, two other firms (Lear-Jet and Pioneer) have announced their intention to produce systems that will record.

The unrecorded "Audiopak" 4 contains 300 feet of tape while the 8 contains 150 feet of tape. The packaged tapes come with instruction booklet and two pressure-sensitive labels. Audio Devices

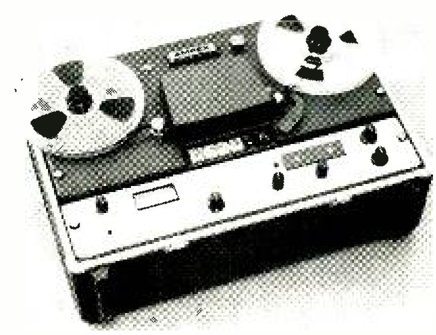
Circle No. 12 on Reader Service Card

PROFESSIONAL TAPE RECORDER

A new series of professional audio recorder/reproducers designed specifically for use by radio stations, small recording studios, government, and industry is on the market as the AG-500 Series.

Major features of the new series include solid-state electronics and a precision-milled, die-cast top plate which eliminates flexing problems and assures stability in the most demanding mobile applications. A new drive motor and an open-type motor flywheel for a cool operating drive motor are designed to improve operational reliability.

The new series is available in a one-channel



version, a two-channel stereo version, and a two-channel quarter-track stereo version. All three configurations have two inputs with built-in mixing facilities for each electronics channel. A one-channel portable model is 20" wide x 14" high x 9" deep and weighs 42 pounds. Tape speeds can be specified as 7½ and 15 ips or 3¾ and 7½ ips. Ampex

Circle No. 13 on Reader Service Card

AUDIO SYSTEM TEST SET

A sophisticated instrument for testing and measuring audio components and sound systems is now available as the Model 9704A transmission measuring set. The instrument will measure gain, loss, frequency response, and signal levels of individual audio devices or complete installations. It consists of two separate systems—one for signal source at a definite dBm level and one for signal output. Simultaneous input and output measurements may be made with the Model 9704A.

Frequency response of the unit is 10-20,000 Hz $\pm$0.2 dB; input impedance is 600 ohms from the oscillator. Source impedances are 600, 250, 150, and 50 ohms, terminated or unterminated, while load impedances are 500, 250, 150, 16, 8, and 4 ohms. Altec Lansing

Circle No. 14 on Reader Service Card

WIRELESS FM MIKE

The new Model 6433 wireless FM microphone operates within the commercial FM band with output power which meets FCC regulations. It is designed for p.a. and portable one-way communications as well as for home entertainment and recording applications in conjunction with any FM radio or tuner.

The 9-volt, solid-state, battery-powered unit is adjustable over a 90-106 MHz range in the FM band with the anti-capacity alignment tool supplied. The field strength is such that, at permissible transmission distances, its output will overpower a commercial station to permit break-

in communications in businesses using regular FM radio for background music.

Tuned out of the range of local stations, the mike can be employed by a roving speaker when used with a tuner and p.a. amplifier. Frequency response of the lightweight unit (under 4 ounces) is 100 to 10,000 Hz. Input is provided for an external low-impedance dynamic mike as well. Channel Master

Circle No. 15 on Reader Service Card

HIGH-VOLUME HORN TWEETERS

Two new speakers, designed to deliver sound at concert hall volume, have been put on the market as the Models CH26SQ08 and CH39SQ08. Both models have 2.5 ounce magnets, 8-ohm voice coils, and power handling capacity of 20 watts. The former is 2" x 6" in size and has a frequency response of 1500 to 20,000 Hz. The latter is a 3" x 9" unit with a frequency response of 900 to 20,000 Hz. Oxford

Circle No. 16 on Reader Service Card

MODIFIED TURNTABLE SUSPENSION

A new, improved type of spring suspension for installation on early models of the firm's TD-150AB turntables is now available. The new system is being incorporated in the current TD-150AB run and the free kit will be supplied to purchasers of the earlier versions. Franchised dealers will provide the kit consisting of rubber grommets, foam rubber discs, together with a set of step-by-step instructions. No special tools are required.

Owners of early models (prior to December 1966) should apply to their franchised dealers to obtain the kit. Elpa Marketing.

CB-HAM-COMMUNICATIONS

31-CHANNEL TRANSCEIVER

The "Poly-Comm 30" transceiver has now been modified to offer 31 channels instead of 30. This coverage includes all 23 channels for long-range mobile communications plus 8 additional Part 15 channels that can be used to monitor short-range walkie-talkie communications.

By using frequency synthesis, only a few crystals are required to achieve the new performance. The receiver is a dual-conversion superhet with nuvistor r.f. amplifier and mixer stages to insure 0.15 μV for 10 dB signal-to-noise ratio. Polytronics

Circle No. 17 on Reader Service Card

SOLID-STATE CB TRANSCEIVER

The new Model Y7050 CB transceiver transmits and receives up to 10 miles, depending on terrain and conditions. Either of two crystal-controlled frequencies—channel 11 or 16—may be used by simply flipping a channel selector switch.

A special feature of this new walkie-talkie is power source flexibility. It can be operated with standard "AA" penlight batteries or with rechargeable nickel cadmium batteries which are optional. With optional accessories, a.c. house current, a car cigarette lighter, or 12-volt storage battery can be used.

In addition to the 51-inch telescoping antenna, a jack is provided for connection to an external antenna. This feature, along with adaptability to a variety of power sources, makes the unit usable as a base station.

The set weighs 1.7 pounds with batteries and measures 7⅝" high x 3¼" wide x 1⅝" deep. Input power is 1½ watts. General Electric

Circle No. 18 on Reader Service Card

30-WATT TWO-WAY RADIO

A new 30-watt, two-way radio, FCC-type-accepted and powered for the business and commercial operator, has been introduced as the "Fleet Courier 30B."

The completely self-contained unit provides more usable channels and greater power input for increased range in the 25-35 MHz bands. Full technical specifications will be forwarded on request. Courier Communications

Circle No. 19 on Reader Service Card

CB BEAM KITS

Three CB beam kits featuring everything within a single package to do the entire stacking job (with the exception of lead-in coax) are now on the market as the "Stack'Its."

Included are two "Scotch-Master" beams, stacking harness, guy rope, boom, necessary hardware, and assembly instructions. According to the company, stacking their beams results in an additional 4 dB gain over a single beam. Kits available are the SKT-3 including two 3-element antennas and stacking kit; SKT-4 including two 4-element antennas and stacking kit; and the SKT-5 with two 5-element antennas and stacking kit. Mosley

Circle No. 20 on Reader Service Card

MANUFACTURERS' LITERATURE

ALKALINE BATTERIES

A new 8-page illustrated brochure (Bulletin KO-115b) describing the company's expanded KO series of rechargeable, pressure-vented, nickel-cadmium batteries has been issued.

Specifications are given for 16 types of cells which can be used in any position and which will not spill even when completely inverted. In addition, the booklet presents several graphs which illustrate charging characteristics. Gulton

Circle No. 136 on Reader Service Card

TOOL CATALOGUE

A new 24-page general catalogue of professional hand tools (No. 166) is currently available. Illustrated in full color, the booklet includes screwdrivers, nutdrivers, specialized automotive tools, service kits, pliers, snips, and adjustable wrenches. Xcelite

Circle No. 21 on Reader Service Card

POWER DRILLS

A new 4-page illustrated catalogue (Form 111) describing a line of nine electric power drills for home craftsmen and professional users has been issued. The line includes standard, deluxe, heavy-duty, and variable-speed models in ¼", ⅜", and ½" sizes. Also shown in the booklet is a sturdy plastic carrying case. Wen

Circle No. 22 on Reader Service Card

ELECTRONIC COMPONENTS

A new 26-page illustrated short-form catalogue (No. 67) covering a full line of electronic components has been published. Included in the booklet is a wide range of jacks, plugs, switches, connectors, and audio accessories. Switchcraft

Circle No. 137 on Reader Service Card

NEW ELECTROMETER

A new 6-page foldout brochure describing the company's newly announced Model 401 all-solid-state vibrating-reed electrometer has been released. Contained in the booklet is information on the unit's operation, features, electrical and mechanical specifications, and accessories. Applications include physical measurements, nuclear research, mass spectrometry, and biomedical research. Cary Instruments

Circle No. 138 on Reader Service Card

CARTRIDGE REPLACEMENT

A new 30-page 1967 cartridge replacement manual (No. SAC-25) has been released. More than 6600 cartridge listings are contained in the booklet, which is divided into two sections: Section I provides cross-references to cartridges manufactured by more than 60 competitors, while Section II lists replacements according to the phonograph model numbers of over 100 companies.

In addition, the manual includes a performance specifications chart covering the company's full line of cartridges. Sonotone

Circle No. 23 on Reader Service Card

SWEEP GENERATORS

A new 64-page 1967 catalogue covering a full line of sweep generators and accessories has been published. Contained in the booklet (No. 70) are descriptions and specifications of 30 sweep instruments, plus information on such accessory equipment as marker systems, attenuators, detectors, and coax switches.

Featured in the catalogue is a 23-page application section which discusses sweep frequency measurement in general, as well as specific techniques for testing crystal response, spectrum analysis, frequency identification, and alignment of color-TV tuners. Telonic

Circle No. 24 on Reader Service Card

"N-P-N" TRANSISTORS

Information on a complete line of high-voltage "n-p-n" transistors for military and industrial applications is contained in a new 6-page catalogue. Included are low-, medium-, and high-power devices.

All data is arranged in convenient tabular form, and four graphs illustrating typical "n-p-n" characteristics appear on the back page of the booklet. Industro

Circle No. 139 on Reader Service Card

RESISTOR-TRANSISTOR LOGIC

A comprehensive summary of milliwatt resistor-transistor logic with design rules for employing the company's Series US-0900 "Unicircuit" integrated circuits is now available in a new 20-page semiconductor application note (No. 25,075).

The illustrated engineering bulletin also contains information on noise margins, propagation delay, and power consumption. Sprague Electric

Circle No. 140 on Reader Service Card

MANUAL SWITCHES

Complete information on modular and integral types of push-button switches (with or without lighted display color) and toggle switches is contained in a new 44-page illustrated catalogue (No. 51).

The booklet, printed in full color, is divided into twelve sections, each covering a series of manually operated switching devices. Mounting instructions are provided, along with applications and detailed specifications. Micro Switch

Circle No. 141 on Reader Service Card

RELAY CATALOGUE

A new stiff-cover 48-page catalogue describing the company's line of relays and solenoids is now available. More than 40 types of devices are covered, including latch and adjustable time-delay relays. Information on applications and accessories is also provided. Mossman-Elliott

Circle No. 142 on Reader Service Card

PRESSURE TRANSDUCERS

A new 6-page condensed catalogue of pressure transducers for industrial and aerospace applications has been issued. Included in the illustrated booklet (No. SF-41) are linear variable differential transformer (LVDT) devices, d.c.-to-d.c. types, pressure transducers for severe environment, special-purpose units, and strain-gage transducers.

Featured in the catalogue is a quick-reference selector chart of the company's line. Consolidated Controls

Circle No. 143 on Reader Service Card

POWER MODULES

A new 24-page catalogue supplement (No. 142) on the "Transpac" line of solid-state power modules is now available.

The illustrated booklet covers silicon-repairable, germanium-repairable, and transparent-encapsulated d.c. power modules that meet applicable MIL Specs; standard silicon d.c. power modules, programmable models, and high-voltage types; and germanium low-cost d.c. power modules, high-voltage devices, and d.c.-to-d.c. converters. Electronic Research Associates

Circle No. 144 on Reader Service Card

THERMISTORS

A new 4-page illustrated application data bulletin (Section 3703) covering performance characteristics and applications of thermistors has been issued. Performance parameters include zero-power resistance-temperature, static volt-ampere, and current vs time; and applications discussed are measurement and control of temperature and other phenomena, temperature compensation, and applications using the current-time characteristic. General Electric.

Circle No. 145 on Reader Service Card

MICROWAVE COMPONENTS

A new 16-page illustrated brochure (No. W602) describing all the components required for a microwave communication waveguide system, from radio equipment output to antenna feed, has been published.

Entitled "Waveguide and Accessories for Microwave Communication Systems," the booklet presents data on a number of waveguide systems and also covers a complete line of circular waveguide components for single and dual polarized 6- and 11-GHz installations. Airtron

Circle No. 146 on Reader Service Card

FLEXIBLE CABLES

A new illustrated booklet on the manufacturing techniques and applications of flexible cables and circuitry has been released. Entitled "Techniques," the publication traces the history and manufacturing procedures to date in the development of flexible cables and circuitry and outlines advantages and disadvantages of their use.

Included in the booklet is a handy reference chart listing physical properties and limitations of the various cables. Methode

Circle No. 147 on Reader Service Card

FLASHING INDICATOR

Information on the company's new flashing indicator light is offered in a new illustrated catalogue sheet (No. L-202). Described in the data sheet are the device's solid-state circuitry, flashing rate, materials, and finishes. Dialight

Circle No. 148 on Reader Service Card

OPERATIONAL AMPLIFIERS

A new 6-page illustrated catalogue describing a complete line of solid-state silicon operational amplifiers has been issued. Specifications for 18 chopper-stabilized and differential amplifiers are listed, along with nine diagrams of case size and pin configuration. Fairchild Instrumentation

Circle No. 149 on Reader Service Card

SCR FIRING CIRCUITS

A new 16-page handbook (Bulletin No. 5001) on SCR firing circuits has recently been published. Containing over 50 diagrams, waveforms, and other illustrations, the booklet covers single- and three-phase systems, protection of the firing circuit from failure, on-to-off ratio, sensitivity, and gate pulses. Firing Circuits

Circle No. 150 on Reader Service Card

ROTARY RELAYS

Information on rotary relays for use in a wide range of environmentally severe signal-switching functions in military and aerospace applications is contained in a new 26-page illustrated catalogue.

Complete descriptions, mounting dimensions, contact rating curves, and coil data are provided for all devices listed. Couch Ordnance.

Circle No. 151 on Reader Service Card

TRANSFORMER CATALOGUE

Complete information on the company's expanded line of transformers and toroids is contained in a new 34-page illustrated 1967 catalogue. Featured in the publication is a new section listing commercial industrial transformers and reactors. Microtran

Circle No. 152 on Reader Service Card

CATV EQUIPMENT

A new catalogue supplement containing descriptions and specifications of the "Pacesetter" series of amplifying and control devices for CATV applications is now available. Consisting of seven separate data sheets, the supplement also includes connectors and terminator as well as a complete price list. Ameco

Circle No. 153 on Reader Service Card

MOTOR CATALOGUE

Complete information on a line of motors and related components is presented in a new 32-page illustrated catalogue No. G65-1266. Described in the booklet are stepper, synchronous, servo, viscous- and inertial-damped, braked, and special-purpose motors, as well as stepper driver and logic elements. Concluding the booklet is a section covering practical design formulas. Kearfott

Circle No. 154 on Reader Service Card

PANEL DESIGN SWITCH GUIDE

A new 20-page brochure entitled "Switch Guide for Panel Design" is now available. Printed in full color, the booklet stresses maximum design freedom in the use of lighted and unlighted push-button switches and indicators, switch display matrixes, toggle switches, panel meters, and various special-purpose switches. Micro Switch

Circle No. 155 on Reader Service Card

SOUND RECORDING TAPE

The 1967 "Audiotape" catalogue of professional-quality sound recording tape and accessories has been issued. Features of the company's five formulations—all-purpose, triple-recording, low-print, low-noise, and lubricated—are outlined in the 12-page booklet, along with a concise listing of the bases, lengths, and reel sizes in which each type is available. Audio Devices

Circle No. 25 on Reader Service Card

DEPOSITION CONTROL

A new 8-minute, 16-mm color sound movie describing the latest techniques for automatically controlling multi-layered, multi-source depositions is now available free on a one-week loan basis. The film traces a layered evaporation through pump-down, pre-heat, and degas cycles, automatic rate and thickness control, source switching, sequence recycling, and final venting.

The movie is available from Sloan Instruments Corp., Box 4608, Santa Barbara, Calif. Write the company for scheduling information.

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Answer to Puzzle appearing on page 69

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Diagnostic Center

(*Continued from page 52*)

cylinder. Since no firing pulse is provided, engine power is reduced, causing a drop in engine rpm. Further electronic circuitry then processes this information for a power-check readout.

Findings

The following is a *partial* listing of results obtained from tests performed on approximately 15,000 cars. (This information is contained in a survey conducted by Automotive Center Consultants, Inc., an industry-wide organization.)

In a general test, 71.72% of all cars tested had faulty headlight focus and light output, 61.35% had oil or coolant leaks, 25.13% had faulty tail/stop lights, and 20.02% had faulty exhaust systems.

As far as brakes were concerned, 28.14% had poor brake effort balance, 28.35% had brake-lining contamination, 21.96% had faulty brake-shoe action, and 16.96% had poor brake-pedal reserve.

In the tire department, 50.73% had poor wheel balance, 55.91% had improper caster, 49.40% had poor toe-in, and 32.96% had faulty shock absorbers.

In the battery-starter-generator area, 44.47% had cable problems, while 17.98% had poor voltage regulators. In the ignition-system tests, 49.08% had poor points, 53.95% had poor spark plugs, 43.57% were off in their basic timing, and 36.27% had improper ignition dwell time.

The Future

Ford foresees the time when test equipment will be modified to allow hookup to the vehicle without the necessity of disconnecting parts. The company also feels that car design will be altered so as to facilitate these tests.

In the area of test equipment, the firm believes that a computerized approach is obviously needed for speeding up operations. In this method, a computer will compare the car's "health" with the values recommended by the manufacturer and produce a printed-form readout.

Ford also suggests that some thought be given to test equipment that could actually identify potential component failures, thus allowing preventive maintenance before an actual breakdown.

Stanford Research Institute predicts that auto makers will wire their cars to facilitate analysis. They also feel that the diagnostic lane will be computerized, that analysis time will be cut in half, and that the diagnostician will become little more than a verbal expression of what the machines report about the condition of each car. ▲

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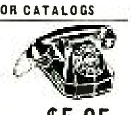

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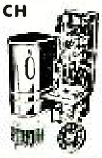

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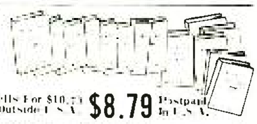

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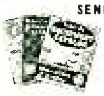

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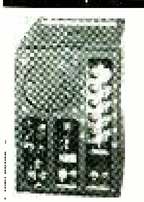

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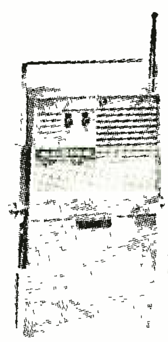

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51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75
76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120	121	122	123	124	125
126	127	128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143	144	145	146	147	148	149	150
151	152	153	154	155	156	157	158	159	160	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175
176	177	178	179	180	181	182	183	184	185	186	187	188	189	190	191	192	193	194	195	196	197	198	199	200

ONE MILLION OHMS PER VOLT

TRIPLETT

V-O-M

Model 630-M

VOLT-OHM-MICROAMMETER

$210.00

Suggested U.S.A. user net

Triplett Model 630-M features the input impedance of a VTVM with the convenience of a V-O-M. The 630-M's sensitivity is derived from the singular achievement of its basic 0-1 D.C. microampere movement. The 630-M incorporates no amplifiers, no warm-up, and no power requirements. Model 630-M is a true V-O-M whose engineering excellence is based on 60 years of instrument manufacturing, and contains the top quality associated only with Triplett.

1. 1,000,000 ohms per volt D.C. for greater accuracy on high resistance circuits. 20,000 ohms per volt A.C.
2. 1 ua Suspension Meter Movement. No pivots, bearings, or rolling friction. Extremely rugged. Greater sensitivity and repeatability.
3. 61 ranges, usable with frequencies through 100KC. Temperature compensated. 1½% D.C. accuracy, 3% A.C. in horizontal position.

TRIPLETT ELECTRICAL INSTRUMENT COMPANY, BLUFFTON, OHIO

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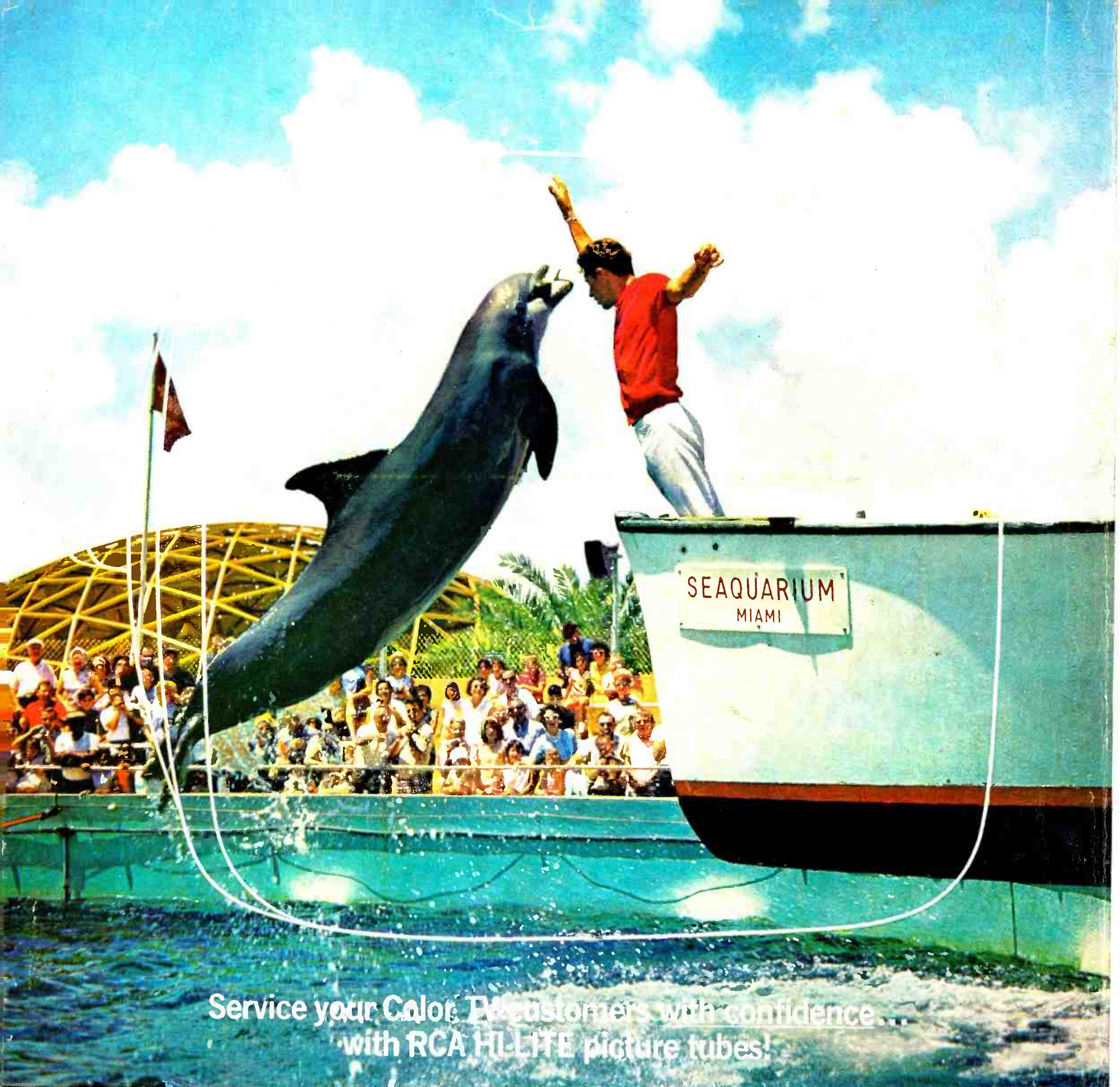
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