Electronics World

AUGUST, 1969
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SPECIAL REPORT:

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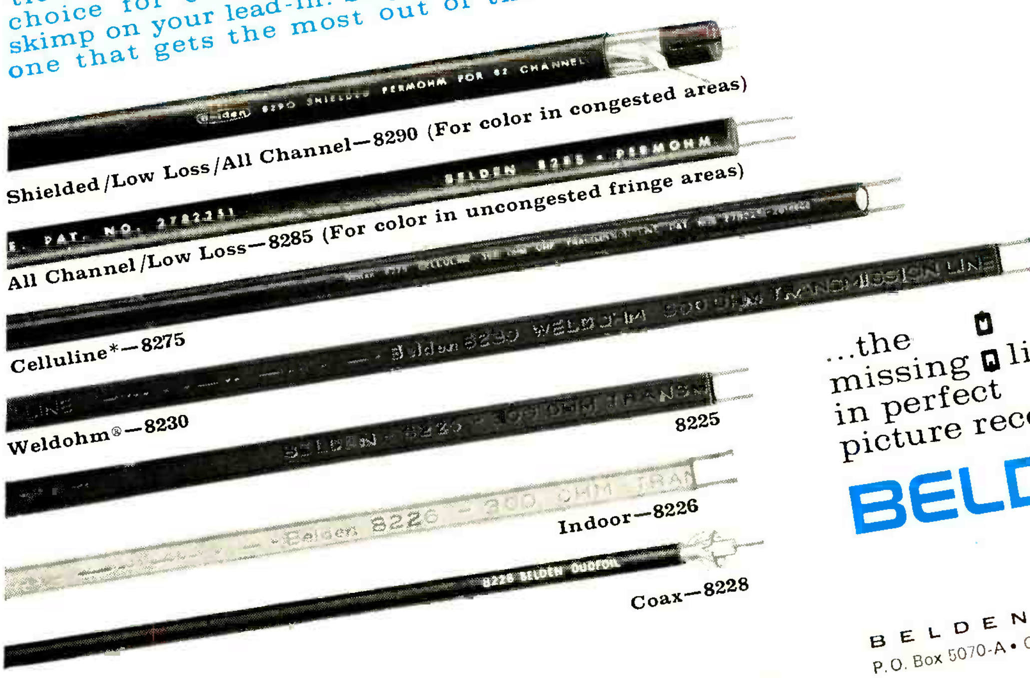

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In America's race to the moon and outer space, *more and more* engineers are needed. By becoming an electronics engineer, you can move into the forefront of technology and engineering, and be an important part of this exciting age. You can help make things happen and be properly rewarded for doing so.

The demand for engineers continues to increase; electronics engineers are needed in the space program and in many other military and domestic projects. In a recent survey conducted by the Engineering Manpower Commission of the Engineers Joint Council, it was found that engineering employment in the electrical and electronics industries is expected to increase by 40% in ten years. The need for engineers is increasing faster than the population as a whole. The survey report indicates that in the next decade, employers expect to need almost *twice as many* new engineering graduates as are likely to be available.

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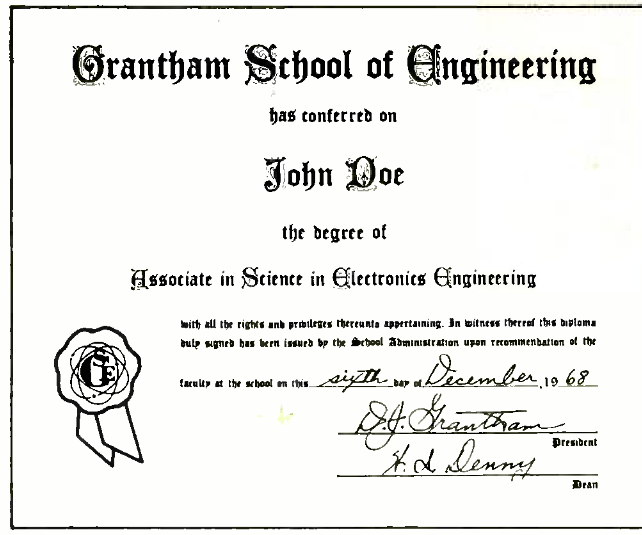
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John Doe
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D.J. Grantham President
K. L. Denny Dean

The Grantham *home study program* in electronics engineering consists of five "correspondence semesters" made up of a total of 370 lessons, followed by a two-week period of review and examination at the School. The prerequisite for enrollment in this program is high school graduation (or equivalent) and at least one year of experience as an electronics technician.

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CIRCLE NO. 124 ON READER SERVICE CARD

THIS MONTH'S COVER ties in with our lead story "Communications on the Moon." The artist's illustration shows two of our astronauts on the surface of the moon with the lunar module behind them and the command/service module orbiting above them. The astronauts can communicate with each other and with the third member of their team in the command module by means of v.h.f. radio. For communications directly with the Earth, the erectable S-band antenna in the left background is set up. This antenna can provide the link to carry voice, telemetry data, and live TV pictures from the Moon directly to the Earth. For further details refer to our lead story on page 23. . . . . Illustration by Rudy Baum.

Electronics World
AUGUST 1969 VOL. 82, No. 2

CONTENTS

MONTHLY FEATURES

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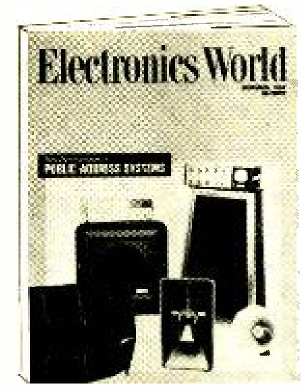
COMING NEXT MONTH



SPECIAL FEATURE ARTICLE:

PUBLIC-ADDRESS SYSTEMS

The first of a series of definitive articles on the design and applications of solid-state p.a. amplifiers, circuit analysis, input and output problems, and some of the new marketing approaches to modular designs. Al Zuckerman of Benjamin Electronic Sound Corp. leads off the series but will be joined in subsequent articles on speaker systems by Abraham B. Cohen of ICS/Telephonics.

MARINER SPACECRAFT—EXPLORERS OF MARS

Mariners VI and VII, launched early this year are adding to our knowledge of the distant red planet. Fred Holder of Bendix covers the scientific packages on board, explains their mission, and reveals plans for future Martian shots.

PALEOMAGNETISM & ARCHEOMAGNETISM—KEYS TO THE PAST

Permanent records of the strength and direction of the earth's ancient magnetic field lie buried in rocks and artifacts. New techniques are unearthing much of this heretofore hidden material and teaching us much more about our past.

MULTIPLEXING AUDIO ON THE BOEING SUPERJET

By using time-division multiplexing, passengers on the new jet will be able to enjoy 14 channels of audio and one announce channel—all carried over a single coax. Weight savings of 500 lbs per plane can increase the payload.

TV TUNER IMPROVEMENTS

This article supplies up-to-date information on the new front-ends which use diode or varactor tuning, detented u.h.f. operation, and integrated circuits. Forest Belt supplies the technical details.

All these and many more interesting and informative articles will be yours in the September issue of ELECTRONICS WORLD . . . on sale August 19th.

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GRA-295-4, Mediterranean Cabinet shown **$119.50***

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GRA-295-1, Contemporary Walnut Cabinet shown **$62.95***

Both the GR-681 and GR-295 fit into the same Heath factory assembled cabinets; not shown, Early American style at $99.95.*

NEW Deluxe Heathkit "581" Color TV With AFT

The new Heathkit GR-581 will add a new dimension to your TV viewing. Brings you color pictures so beautiful, so natural, so real . . . puts professional motion picture quality right into your living room. Has the same high performance features and exclusive self-servicing facilities as the GR-681, except with 227 sq. inch viewing area, and without power VHF tuning or built-in cable-type remote control. The optional GRA-227-6 Wireless Remote Control can be added any time you wish. And like all Heathkit Color TV's you have a choice of different installations . . . mount it in a wall, your own custom cabinet, your favorite B&W TV cabinet, or any one of the Heath factory assembled cabinets.

GRA-227-2, Mediterranean Oak Cabinet shown **$99.50***

Heathkit "227" Color TV

Same as the GR-581 above, but without Automatic Fine Tuning . . . same superlative performance, same remarkable color picture quality, same built-in servicing aids. Like all Heathkit Color TV's you can add optional Wireless Remote Control at any time (GRA-227-6). And the new Table Model TV Cabinet and roll around Cart is an economical way to house your "227" . . . just roll it anywhere, its rich appearance will enhance any room decor.

GRS-227-6, New Cart and Cabinet combo shown **$49.95***

Both the GR-581 and GR-227 fit into the same Heath factory assembled cabinets; not shown, Contemporary cabinet $59.95.*

NEW Heathkit Deluxe "481" Color TV With AFT

The new Heathkit GR-481 has all the same high performance features and exclusive self-servicing aids as the new GR-581, but with a smaller tube size . . . 180 sq. inches. And like all Heathkit Color TV's it's easy to assemble . . . no experience needed. The famous Heathkit Color TV Manual guides you every step of the way with simple to understand instructions, giant fold-out pictorials . . . even lets you do your own servicing for savings of over $200 throughout the life of your set. If you want a deluxe color TV at a budget price the new Heathkit GR-481 is for you.

GRA-180-1, Contemporary Walnut Cabinet shown **$49.95***

Heathkit "180" Color TV

Feature for feature the Heathkit "180" is your best buy in color TV viewing . . . has all the superlative performance characteristics of the GR-481, but less Automatic Fine Tuning. For extra savings, extra beauty and convenience, add the table model cabinet and mobile cart. Get the value-packed GR-180 today.

GRS-180-5, Table Model Cabinet & Cart combo **$39.95***

Both the GR-481 and GR-180 fit the same Heath factory assembled cabinets; GRA-180-2, Early American Cabinet $75.00.*

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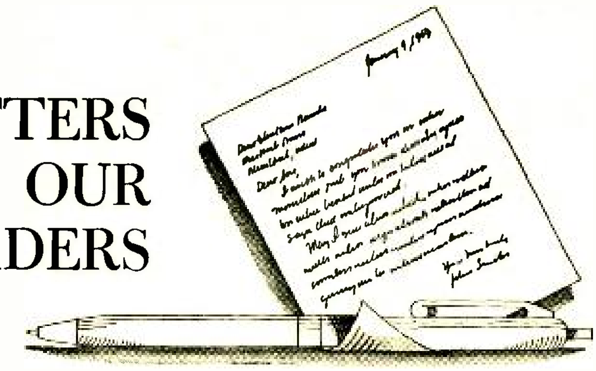
CIRCLE NO. 130 ON READER SERVICE CARD

LETTERS FROM OUR READERS



COLOR-ORGAN DESIGN

To the Editors:

This is to commend you on the continued excellence of ELECTRONICS WORLD magazine from month to month, and to comment on the very fine color-organ design furnished by *TRW* engineer J. M. Powell in the January, 1969 issue.

I speak from experience in that I have built several color organs since 1963. Mr. Powell's design is by far the finest I have worked with. It works on extremely low signal levels and provides a very pleasing display, either with the two display boxes I have built, or with colored spotlights.

I built the unit for stereo display—two independent four-channel circuits fed from a common power supply. It is housed in a case about 3½" x 8" x 9½" complete with copper heat sinks and a small blower.

I used relay switching for the main power and also used the "off-on" switch (three-pole/triple-throw) to switch a 56-ohm resistor into each audio circuit for either low or high audio input. (Those input transformers are mighty small, and the output of my stereo set automatically goes up 40 dB every time my son gets near the set.) The resistors, switched in for high audio, seem to make little or no difference in the operation of the color organ except to reduce its sensitivity.

CARL H. CLAWSON, JR.
Rockville, Md.

* * *

TAPE-RECORDER MAINTENANCE

To the Editors:

After reading Engineer Johnson's letter to the editor (page 16, March issue of ELECTRONICS WORLD) I find a number of items worthy of further comment.

The first tone on a 7½ in/s full-track alignment tape marketed by *Ampex* is a 700-Hz tone at a −10 dB reference level, rather than the 0 reference point quoted. Similarly, all of the tones with the exception of the last tone are also recorded at a −10 dB reference level. However, because of the difficulty in accurately reading a vu meter near the extreme left side (where the −10-dB point is located), any convenient reference point may be selected as long as the gain control is not moved during the remainder of the tones on the tape. *Ampex* has produced a number of test tapes using different tone arrangements and some of their tapes did indeed record the 0 reference tone first.

In regard to head demagnetization, failure to demagnetize the heads will undoubtedly result in partial erasure of the higher frequencies on valuable music tapes and of course on the alignment tape. In regard to scratched or otherwise damaged recorder heads, this used to be a terrific problem back in the early days when head demagnetizers were marketed without proper rubber or plastic covering. This is no longer the case and head demagnetization is now a common practice at the larger tape installations. As for magnetized tape guides, I shall be happy to point out a number of recorders whose guides will retain a small amount of residual magnetism after running a few miles of tape over them.

I would like to compliment Mr. Johnson's pointing out that record adjustments should be made at a slightly reduced level to prevent tape saturation. This was an oversight on my part.

LEONARD KUBIAK
Technical Director
Texas Dept. of Ed.
Tape Duplicating Lab
Austin, Texas

* * *

C-D IGNITION SYSTEM

To the Editors:

I am writing to you about your article "Unique Capacitor-Discharge Ignition System" which appeared in the January, 1969 issue. Since I have built the unit from your schematic, I thought you might be interested in how I built it, substitutions I made, and the results obtained.

The transistors *Q*1, *Q*2, 2N3235, were not available to me but I came up with a substitution that seemed reasonable and was also available from *Allied Radio:* it is a 2N3055 made by *RCA*.

For *SCR*1 I used the recommended *G-E* C30D but while waiting for this unit to arrive I temporarily used a *G-E* X-16, 7.4-amp unit. This worked beautifully but when the C30D did arrive I made the change because I believe in those derated components. *SCR*2 in my unit is a *Motorola* HEP #302, a 200-V, 5-A unit that I had on hand. For *D6*, *D7* I had to go the 1N4764 zener route, three wired in series as you suggested.

I wound *T1* exactly as you showed in the magazine and purchased the core from *Ferroxcube* to wind *T2*. But when I saw its tiny size I decided to purchase *T2* outright from *Pulse Engineering*, rather than end up in frustration.

My car is a 1968 *Ford* Galaxie 500 hardtop with the 302 V8 engine. I had a *Motorola* CDI ignition unit (the only one that *Motorola* markets at this time) that had been used on this car since it was new, and was completely satisfied with it on every count. Starting was extremely good and road trips at speeds up to but not exceeding 70 mi/h (and with an educated toe at the throttle) always result in 20 miles to the gallon . . . exactly; in town, 12 to 13 miles to the gallon. Since this unit was put on the car when the car was new and still in the process of being broken in, it is difficult to say exactly how much difference there was in fuel mileage between the original system and the CDI system. but I would estimate, as you say, between 1 and 3 mi/gal.

When I finished your C-D unit, the only thing that I had to test it with was my own car, so I unhooked the *Motorola* unit and hooked up this new unit temporarily.

Amazingly enough, I immediately noticed a marked difference in starting and performance. Although the car had always started beautifully before, now it started even better! Starting is absolutely fantastic! And, although I haven't made any comparison tests, performance seems better. So much so. in fact, that we have decided to leave this unit on the car and sell the *Motorola* one.

RAY E. TOLLEY
Missoula, Mont.

* * *

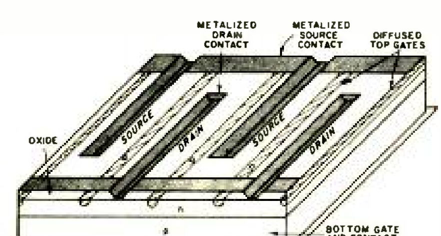
THE POWER FET

To the Editors:

I would like to correct two errors that occurred in my article "The Power FET" which appeared in your June issue:

1. In the fourth paragraph on p. 35, please change "approximately −0.7%/mA" to "−0.7%/°C."
2. Fig. 1 cross-section has been drawn improperly. The correct arrangement is shown below.

JOHN TAMOSAITIS
Applications Engineer
Crystalonics
Cambridge, Mass. ▲



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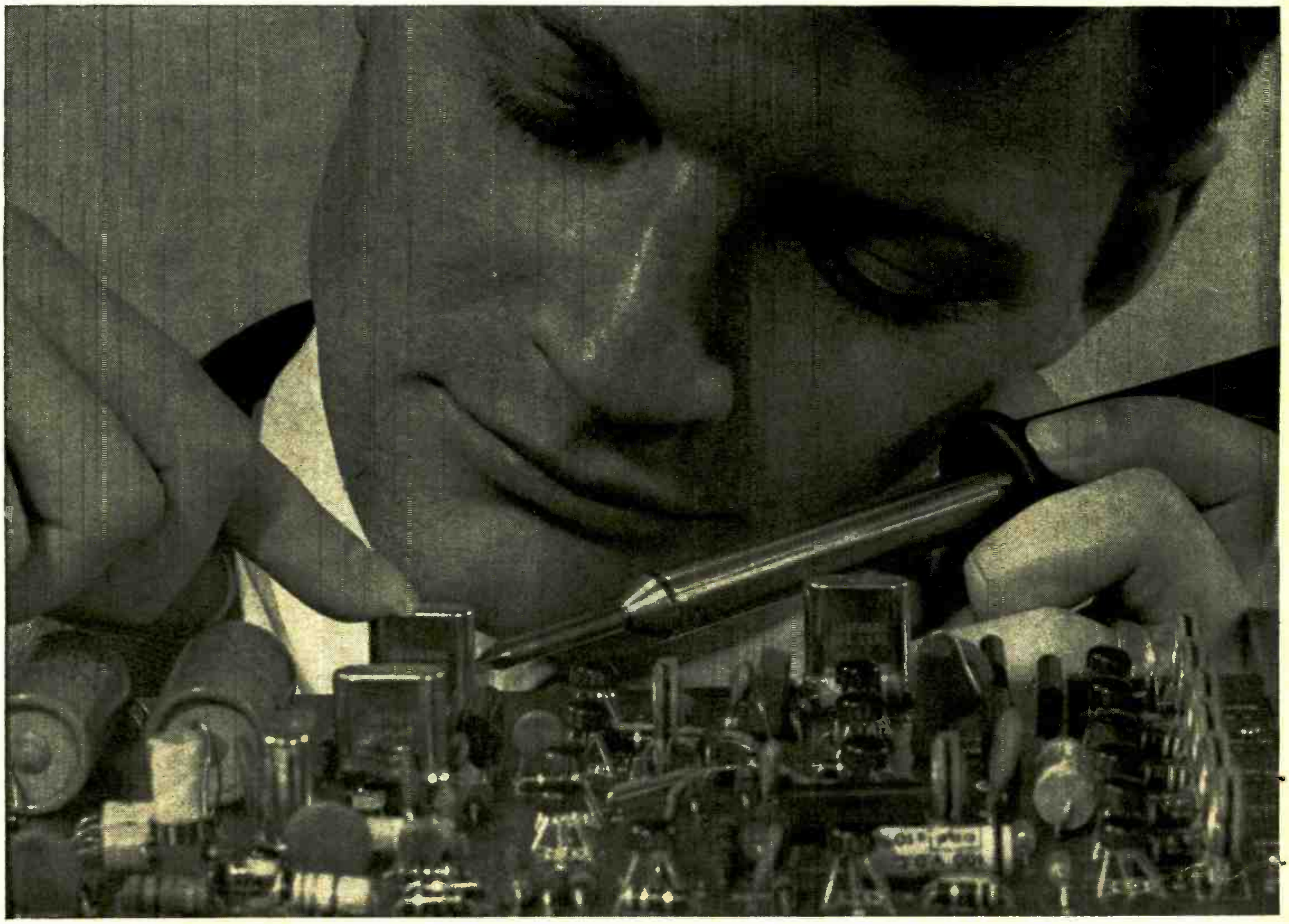

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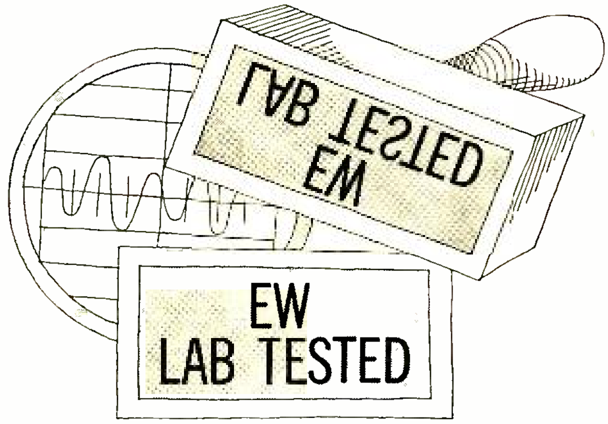


HI-FI PRODUCT REPORT

TESTED BY HIRSCH-HOUCK LABS

Hallicrafters CR-3000 Receiver
Miracord 620/630 Automatic Turntables

Hallicrafters CR-3000 Stereo/Communications Receiver

For copy of manufacturer's brochure, circle No. 30 on Reader Service Card.

INTEGRATED receivers are usually designed for FM (mono and stereo) reception, with coverage of the standard AM broadcast band sometimes included. A few models, principally of European origin, also cover some short-wave broadcast bands, and the long-wave band used by European broadcasters.

The continuing growth of international broadcasting and point-to-point radio communications makes the short-wave bands a fertile hunting ground for the curious listener, and the *Hallicrafters* CR-3000 receiver is designed to meet the needs of this group as well as those of the high-fidelity enthusiast.

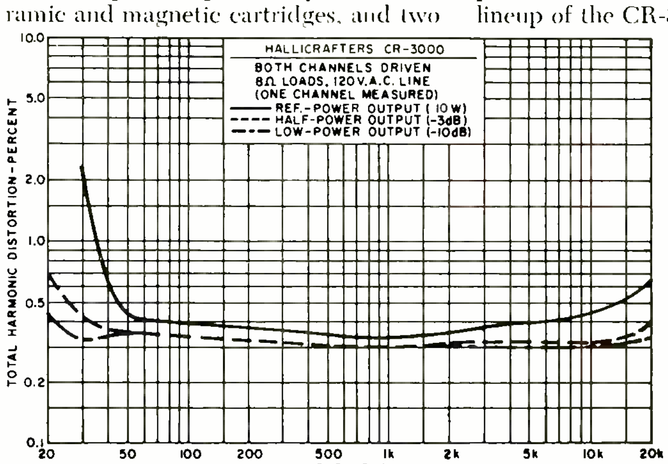
The CR-3000 (manufactured in Japan for *Hallicrafters,* an established leader in the communications field) is a solid-state stereo-FM receiver, including a pair of 10-watt (continuous power) audio amplifiers, phono inputs for ceramic and magnetic cartridges, and two high-level inputs for external sources and tape-playback amplifiers. It has outputs for connection to the inputs of a stereo tape recorder, which are unaffected by the receiver's volume control. Unlike many other stereo receivers, the CR-3000's Balance control does affect the tape outputs.

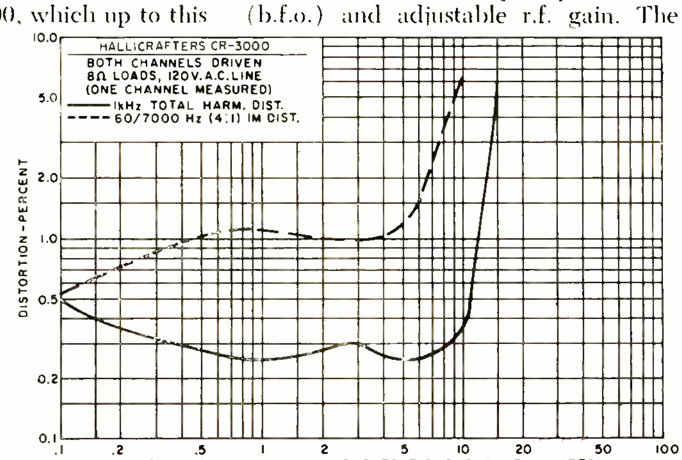
The receiver has automatic stereo-FM switching, with a red stereo indicator light, and a tuning meter indicating relative signal strength. The stereo demodulator circuits may be disabled by the Function switch, for noise-free mono reception of weak stereo signals. Non-defeatable a.f.c. is employed for FM reception. The volume control, although labeled "Loudness," is not a Fletcher-Munson compensated control. Conventional bass and treble tone controls, and a front-panel stereo phone jack, complete the normal stereo receiver control lineup of the CR-3000, which up to this point resembles that of most other stereo receivers.

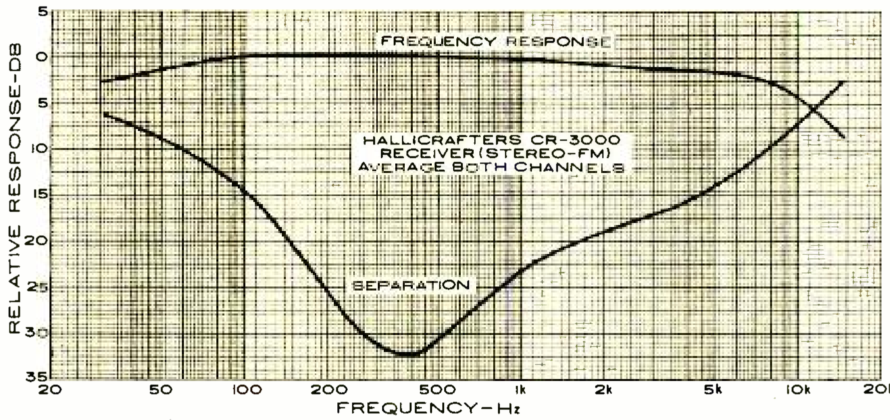
However, the Band Selector switch is a clue to the unusual character of the receiver. It changes the tuning band simultaneously rotating the drum dial so that only the calibrated scale for the selected band is visible. There are six bands: LW (185 kHz to 400 kHz), MW (530 kHz to 1650 kHz), SW1 (2 MHz to 4 MHz), SW2 (5.85 MHz to 10.3 MHz), SW3 (11.4 MHz to 18.2 MHz), and FM (88 MHz to 108 MHz). Even with a short indoor antenna, we were able to hear aircraft weather reports on the LW range, which should have a long outside antenna for best results. The standard broadcast band may be received well with the built-in ferrite rod antenna, but the short-wave bands require an external antenna. A built-in line-cord antenna suffices for reception of nearby FM stations, but here, too, a good antenna is advisable.

Tuning the crowded short-wave bands requires a fine tuning control, since the regular dial mechanism is not capable of sufficiently precise setting. A separate Fine Tuning knob, supplying an adjustable d.c. voltage to a voltage-variable capacitor, covers a range of several kHz, and makes the CR-3000 a practical short-wave receiver.

Some of the signals to be found on the short-wave bands use c.w. (code) or SSB (single-sideband voice) transmission. These are unintelligible unless the receiver has a beat-frequency oscillator (b.f.o.) and adjustable r.f. gain. The







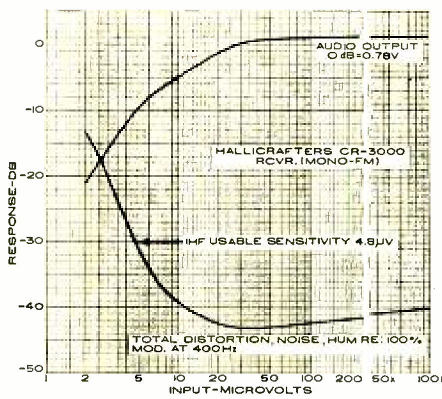
CR-3000 has a combined b.f.o. and r.f. gain control, enabling it to receive both c.w. and SSB signals.

Our laboratory tests confirmed the audio-amplifier rating of 10 watts continuous power per channel. We measured 12 watts per channel into 8 ohms, with both channels driven, at 1% harmonic distortion (1000 Hz). The harmonic distortion was under 0.5% up to 11 watts output. The IM distortion was about 1% up to 5 watts, increasing to 6% at 10 watts. At the reference power output of 10 watts per channel, the distortion was 2% at 30 Hz, under 0.5% from 45 Hz to 13 kHz, and 0.65% at 20 kHz. At half power or less, distortion remained between 0.3% and 0.4% over the full frequency range from 30 Hz to 20 kHz.

The RIAA equalization was accurate within ±1 dB from 30 Hz to 15 kHz, measured at the tape outputs. Through the speaker outputs, a mid-setting of the tone controls produced a roll-off below 200 Hz, to −7 dB at 20 Hz. The tone control characteristics were good, providing considerable control at the frequency extremes with little effect at middle frequencies.

The FM tuner was moderately sensitive, with an IHF usable sensitivity of 4.8 microvolts. Full limiting required about 20 microvolts input, and distortion was under 1% at 100% modulation. The FM frequency response was down 2.5 dB at 30 Hz and 8 kHz, and fell off to −8 dB at 15 kHz. Stereo separation was about 32 dB at 400 Hz, but reduced rapidly above and below that frequency to 15 dB at 100 Hz and 4500 Hz, and to 6 dB at 30 Hz and 11 kHz. It was adequate, however, for good audible stereo separation. The audio hum and noise were below audibility, being 66 and 68 dB below 10 watts. The CR-3000 is rated for 8-ohm loads only, and the output into 4- or 16-ohm loads is reduced about 30%.

In listening tests, the FM performance of the receiver was consistent with our measurements. It required a fairly strong signal for noise-free stereo reception, but the sound was always clean and undistorted. The strong non-defeatable a.f.c. made is impossible to



receive a signal between two strong stations, since the tuner jumped from one to the other as it was tuned. However, the tuning was non-critical for low distortion, which may have been to some extent due to the a.f.c. Moderately efficient speakers are a necessity with a low-powered receiver such as this. It can be used with practically any phono cartridge, since it requires only 2 millivolts input for 10-watt output, yet will not overload until 59 millivolts are applied.

The AM quality was good, and the broadcast band sounded quite free of the buzzes and whistles so often encountered with AM tuners. Short-wave reception was surprisingly good, even with a makeshift antenna, and we received many short-wave broadcast stations and amateur SSB transmissions with good listening quality.

The successful use of a receiver covering the frequency range of this one is largely dependent on the antennas employed. With good external antennas it should satisfy the needs of any casual or hobbyist listener. The CR-3000 obviously attempts to offer the capabilities of a stereo-FM receiver, a communications receiver, and a high-fidelity stereo amplifier in a single compact and inexpensive package. One cannot fairly compare its performance to that of a deluxe stereo receiver, or to an elaborate communications receiver, either of which costs considerably more than the CR-3000. However, it does a creditable job in all its operating modes, and represents an honest value at its price. Frankly, we see it

(*Continued on page* 83)

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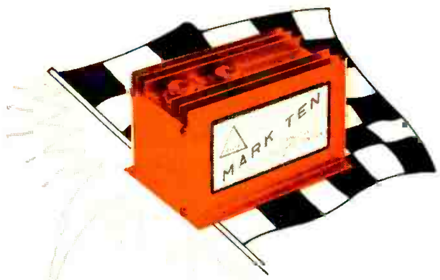

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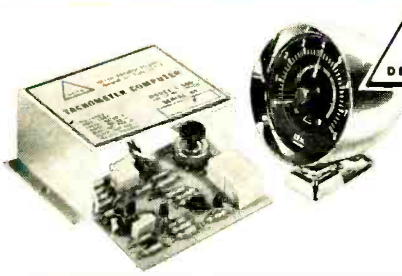

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CIRCLE NO. 138 ON READER SERVICE CARD

Radio & Television news

By FOREST H. BELT / Contributing Editor

CATV and the Broadcasters

The broadcasters and CATV folks have made peace, of a sort. After wrangling for years over what, where, and how cable systems should operate, the two major associations got together and sensibly talked out a cooperative future.

In a recommendation paper prepared for the FCC and Congress, the National Association of Broadcasters and the National Cable Television Association jointly concluded that "the two industries should have compatible interests." Some of the paper's highlights represent drastic compromises from past positions:

1. "Adequate" CATV service is defined as comprising stations affiliated with all three national TV networks, plus no more than three non-affiliated commercial TV stations. A CATV station should be compelled to render adequate service, even if it means importing signals by microwave. Moreover, a system must carry all local (grade-A and -B contour) signals.

2. CATV systems must protect a station from duplication of copyrighted programs, if the system is in the grade-A or -B contour of the station. There are several considerations, all spelled out in detail.

3. Systems already operating are excused from any of these requirements they don't already comply with.

4. A CATV system, upon new rulemaking by the FCC, will use only one channel for its own programs—for which it can sell commercials, just as any broadcast station does. In most matters, CATV will operate by existing FCC rules.

5. CATV systems won't interconnect to carry entertainment programming, except in specific situations, to be decided case by case.

6. Most CATV systems will make reasonable copyright royalty payments; small or remote systems may be exempted.

7. Carrying local FM broadcast stations on CATV hadn't been resolved when the paper was issued.

Probably most significant is the interconnection clause. Broadcasters see that as protection against a nationwide wired-TV system, which could evolve into a pay-TV network. Perhaps it is; but, within the framework of the agreement, a CATV operator (or group of them) can buy a syndicated pay-TV package for showing by video tape or film on its own entertainment channel. Pay-TV has been okayed by the FCC now, presumably for air or wire, although a court case is pending seeking to overturn the FCC's authority to approve pay-TV.

Educational TV isn't mentioned in the paper. But Fred Ford, president of NCTA, in an exclusive talk with this writer, says the ETV services by cable systems are among the most important. That's probably what those other five (v.h.f.) channels will be used for.

FCC rulemaking and Congressional copyright-lawmaking are necessary before the recommendations can take effect. But the main chasm has been bridged, and NAB and NCTA deserve congratulations for their statesmanship.

Satellites for Home TV

Some experts with companies making communications satellites are forecasting satellite transmission of TV programs directly to home TV receivers within 10 years. We have the technology to do it today with a little more satellite transmitter power and using an erectable dish antenna on the roof serving the home receiver. The antenna, somewhat like the one to be placed on the moon during the Apollo 11 flight, would be made of open metal mesh and very light in weight. The Apollo antenna pops open like an umbrella into a dish 10 feet in diameter; it weighs only 14 pounds; and it has a 32-dB gain. With such a system, the home TV receiver might have access to 20 or 30 different channels. Here, again, the economics of the matter will determine whether or not this system ever materializes. We feel there is a greater likelihood that individual cities or areas may put up their own receiving antennas to pick up satellite signals and then distribute them, perhaps by a wired CATV-type system, to individual subscribers' homes.

Color Sets for 1970

Radio, TV, and hi-fi all sport innovations in the new lines dealers are seeing now for late fall and early spring selling. There are the all-IC stereo sets announced by several Japanese companies; the electronic (varactor) tuning and slider controls in a *Panasonic* monochrome TV set; a little see-through cylindrical radio from *General Electric*; *Philco-Ford's* $4.95 AM portable; the thermometer-radio sold by *Sharp*; a clock-TV from *G-E*; the first medium-priced *Marantz* hi-fi components; a *Zenith* 11-band Transoceanic portable radio that can even receive single-sideband; and plenty more.

The emphasis is still on color-TV, though. And no wonder—that's still where sales dollars are. *RCA* and *Zenith* both have new "twice as bright" color picture tubes (see page 33 for details). *Sylvania* and *Philco-Ford* both have more transistors than ever in their hybrid color sets, and *Magnavox* has a new color chassis that is about half transistor.

Diode switching is getting the most fanfare. *RCA*, after months of "no comment," popped up with a really fancy version. The *RCA* v.h.f. tuner is remotely operated from a push-button transmitter. Four digital IC's in the front-end activate diode-switched tuned circuits in the transistor mixer, oscillator, and r.f. stages. The u.h.f. tuner is a motor-driven signal-seeking unit. To complete the remote-operation feature, a memory-module setup, reminiscent of *Motorola's* TRR-7 last year, controls volume, color, and tint without motors. All of this is used with an updated version of the solid-state color chassis—plus the new twice as bright "Hi-Lite Matrix" color CRT.

Electrohome (Canada) has a touch-tuned varactor-diode tuner on high-end color sets, and *Panasonic* offers a detachable varactor tuner. A *Panasonic* 15-inch model has an on-screen fine-tuning indicator, but no diode tuning.

Automatic Tint Control

For many years now, one criticism of NTSC color has been of the annoying change of flesh tones between stations, between programs, and often between cameras or tapes in the same program. *Magnavox* is the first set maker to offer a circuit that holds the face tones steady, even if chroma phase varies at the camera, network, or station.

Best flesh tones, a shade of orange, occur at 57 degrees in the *Magnavox* demodulation system. The new transistor circuit corrects errors as great as 30 degrees away. Admittedly, if the phase error originates outside the set, correcting any flesh-tone error also changes other colors near the flesh tones slightly. But you won't notice them unless you're watching another color set at the same time. (Complete details on the *Magnavox* automatic tint control, or a.t.c., in next month's issue.)

There are reports that new *Philco-Ford* chassis have a circuit similar to the a.t.c. An engineer from that company assures us that isn't true. *Philco-Ford* chassis, he tells us, have a very stable demodulation characteristic in the second (phase vector) quadrant, where flesh tones fall in the *Philco-Ford* demodulator; he says that stability obviates the need for any phase correction.

CET Worldwide

The Certified Electronic Technician program, initiated 2 years ago by National Electronic Associations and reported in this column, is suddenly growing by leaps and bounds. The total of technicians who have passed the 125-point theoretical and practical exam is nearing 1200. There are CET's now in 44 states and Canada. Overseas, Argentina, Chile, Germany, South Vietnam, and Guam all have CET's.

NEA certification chairman Leon Howland (4622 East 10th Street, Indianapolis, Ind. 46201) reports that technicians in Brazil, Puerto Rico, Spain, Thailand, and similar faraway places have written to ask how they can take the exam. Where no qualified CET is available to give it, NEA arranges with a local school administrator to monitor the exam and send the answers back to NEA headquarters for grading. The CET exam has now been translated into Spanish for technicians in countries using that language. No doubt about it, the certificate, card, and pin of the NEA Certified Electronic Technician is on its way to becoming a mark of service prestige the world over.

Flashes in the Big Picture

Another new name in color-TV: *Craig*, already known for its tape recorders. . . . *G-E* plans to make all its own color picture tubes. . . . *Sony/Superscope* is going into prerecorded tape business, starting with 50 cassette, 8-track, and open-reel albums. . . . Companies announcing 90-day labor-included warranty are *Philco-Ford, Magnavox, Sylvania*; more to follow. . . . *Hitachi* warranties transistors in its radios for 5 years. . . . New association for tape industry is MATE—Manufacturers' Association of Tape and Equipment; address is 42-20 Kissena Blvd., Flushing, N.Y. . . . *Cox Cable Communications* is second-largest CATV owner, reports "Television Digest," with 51 communities and 165,000 subscribers. *CBS* must be the largest; its cable systems serve more than 200,000 homes. . . . Reports indicate growing theft-wave of small parts from show-floor models—knobs, spindles, needles; tape players and tapes are disappearing from parked cars at alarming rate too. ▲

Reflections on the news

Apollo Eleven

Man's first venture toward surface of moon is triumph for electronics. Gravitometer and inertial data gathered during Apollo 10 moon descent in May cleared way for navigational guidance needed for lunar landing. Communications problems appear licked; with field sequential color camera proven, color program from moon surface is likely during Apollo 11. (For details, refer to lead article on page 23 of this issue.)

Landing radar system, made by *Ryan Aeronautical Co.*, remained most critical electronic item for Apollo 11. It worked okay during Apollo 10 descent and ascent, but there's no way to test it completely except by actual landing. Radar simultaneously uses Doppler (c.w.) mode to sense velocity and FM to sense distance and angle of descent. Readout is from guidance computer; output also updates inertial navigation unit, which otherwise has real-time error.

Acoustics Predict Heart Problems

Voice patterns during emotional stress may identify potential victims of heart attacks. *Lockheed Missiles & Space Co.* engineer, working with doctors at San Francisco Mount Zion Hospital, developed prognostic equipment. Neck mike picks up sounds as individual reads special emotion-arousing paragraph. Audio signals make oscillograms on specially marked paper. If patterns go outside limit lines, they signify personality traits that are common among known heart patients.

Laser Projects 3-D Movies

Still-holography is well established in industry. *North American Philips Corp.* recently demonstrated laser-lighted projector that shows holographic movies. Special film is 3 inches wide, with sequential holograms in strips about ½ inch apart. In "playback," film moves past shutterless aperture of projector. Successive holograms projected by laser beam create illusion of motion in regular 3-D holographic images. Company hopes to develop system further to use intense white light in place of laser, and to adapt system for TV holographic scanning that takes up less bandwidth than needed by schemes advanced so far.

Huge-screen color-TV (but not 3-D) projection with lasers is promised by *Hitachi*. Krypton-ion laser makes red, argon-ion lasers make blue and green. Dichroic mirrors sweep the beams, which are modulated with typical NTSC chroma and Y signals and projected on glass-bar screen. Promises to display improved version at Expo 70.

Satellite News

Airlines griping about foot-dragging in getting aeronautical satellites orbited and into operation. In new planes, companies are installing electronic gear for satellite communications and navigation, but can't use it. They blame FAA and Comsat.

Replacement for old Intelsat 3 is in position over Pacific Ocean and working. New one has more channels. Old one, slightly crippled with one weak channel but nevertheless usable, was moved to Indian Ocean. It will be used by European, Australian, East African, and some Asian ground stations.

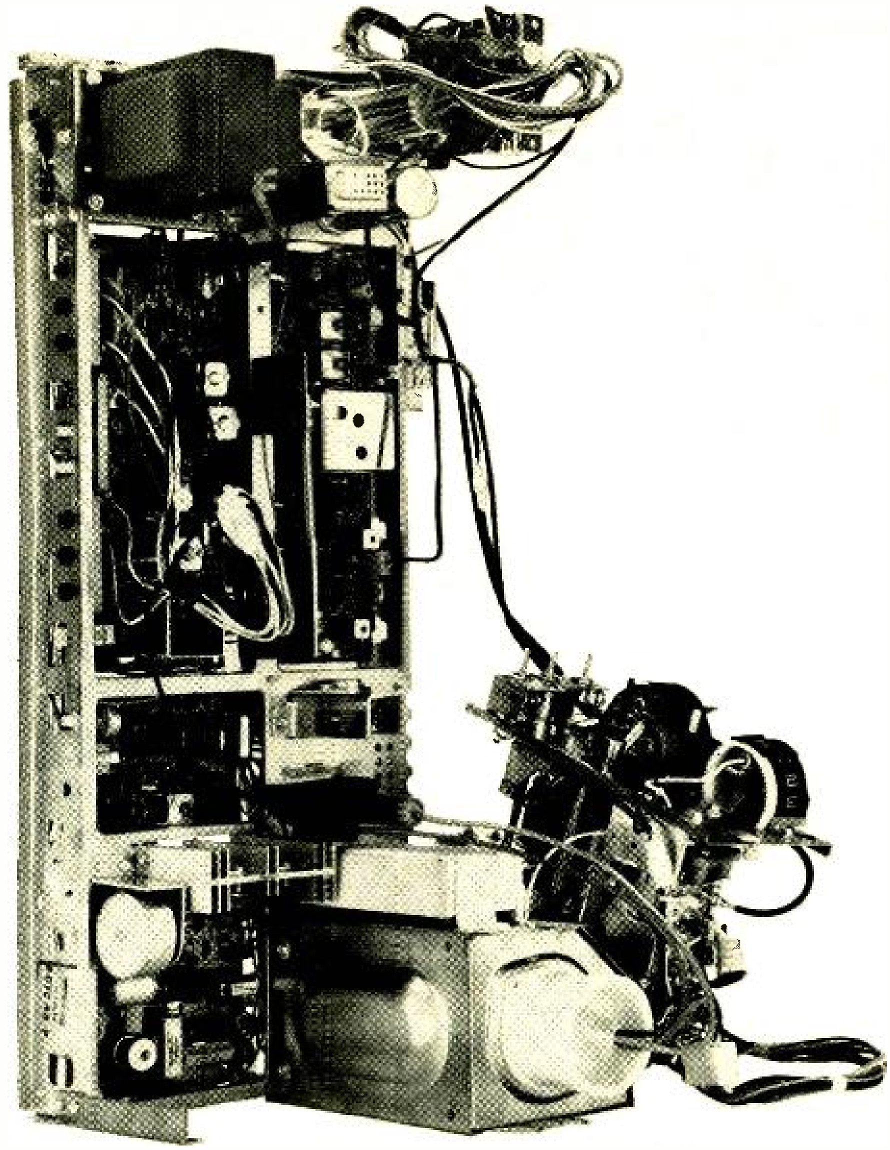
Space-station satellite, scheduled for 1975, is in study stage to decide what modular arrangement will be used. Modules for experiments and for living in by astronaut maintenance crews are part of plan. Some modules may operate remotely, few miles away from main space station.

Radiations from the Field

Belt of electrically charged atmosphere surrounding earth holds key to predicting thunderstorms over entire globe, reports oceanographic ship Discoverer. . . . "Polyconductors" may be next in technology parade after semiconductors; scientist at Yeshiva University in New York found way to electrically "switch" materials from insulators to conductors; says probably can use optical, thermal, magnetic, and acoustic switching to transfer conductivity characteristic; r. f. oscillators have been built using this principle.

▲

"Get more education or get out of electronics ...that's my advice."



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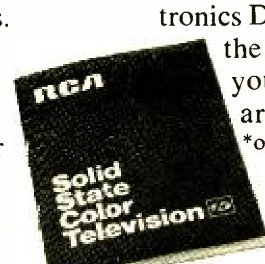


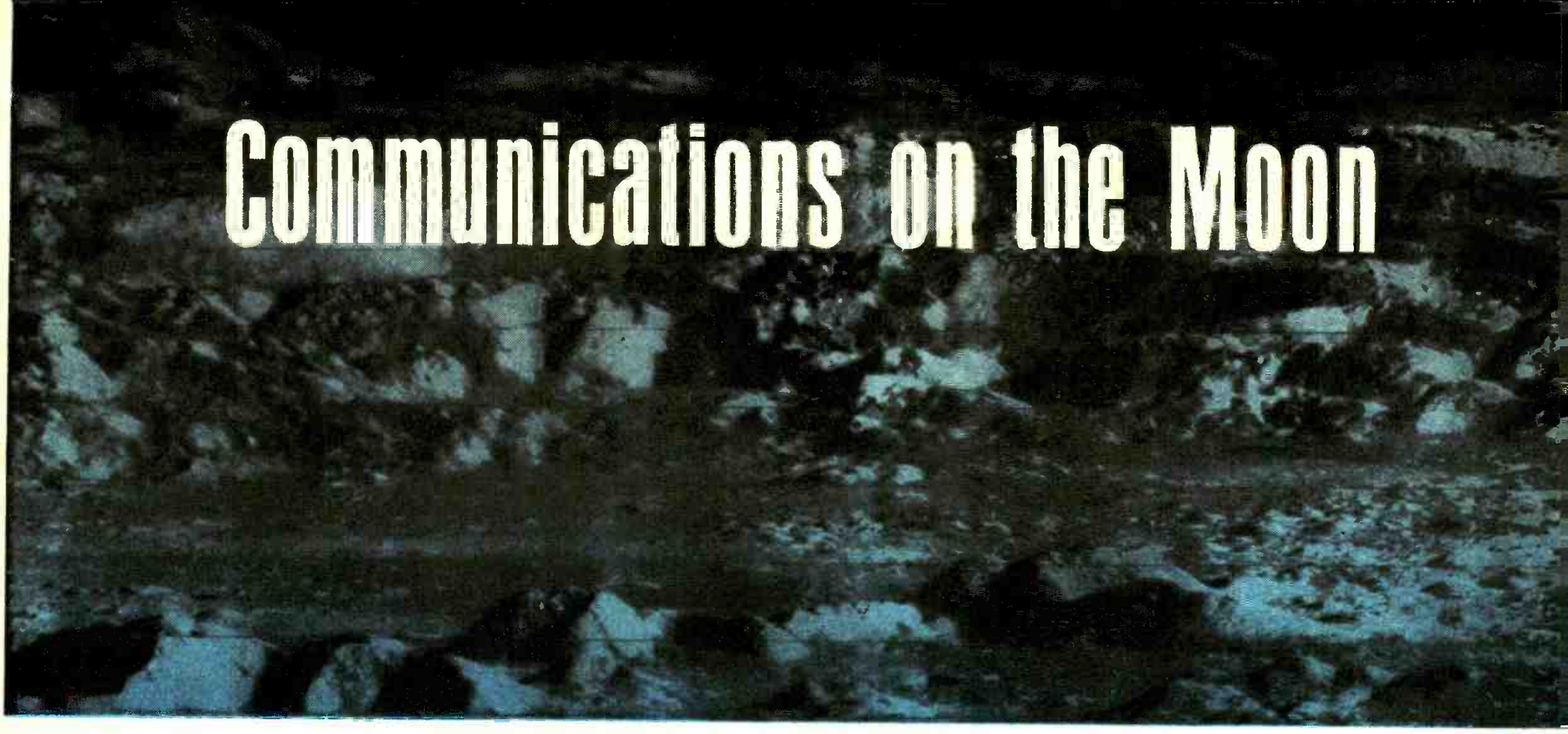
You can buy it from your RCA Consumer Electronics Distributor, but there's a better way.

Attend the next RCA Consumer Electronics Distributor CTC-40 Workshop and get the manual free. Our distributor can tell you when it will be held next in your area. See you there.

*one tube rectifier

RCA

Communications on the Moon



When men first walk on the Moon's surface, they will be able to communicate by v.h.f. radio with each other and with the command module orbiting overhead. They will also be directly in touch with Earth by microwave radio and will be able to send back live television pictures over the vast translunar distance.

WHEN Christopher Columbus sailed his way into history almost five centuries ago, he severed contact with civilization for the duration of his voyage. Except to the 90 sailors who manned the expedition, Columbus' trials and triumphs, including his discovery of a new world, remained unrevealed until his return.

On July 16, if NASA plans proceed on schedule, a new breed of explorers will embark on a voyage that will rank them alongside Columbus in the annals of mankind's great adventures. Yet, although their trip will traverse a distance 45 times that of Columbus' route, they will not, except for short intervals, face isolation from the civilization they leave behind.

A stream of electronic signals will flow from the two Apollo 11 spaceships. Gathered in by a world-wide tracking network, they will be relayed instantly to the NASA Manned Spacecraft Center in Houston, Texas, where a cadre of mission controllers will be supporting astronauts Neil Armstrong, Edwin Aldrin, and Mike Collins as they fulfill man's centuries-old desire to escape the confines of his native planet and alight upon another body in the Universe. A sharp contrast to the plight of Columbus, who had to do his own piloting and mission planning virtually alone.

Almost simultaneously as they are flashed before the NASA officials, the signals bearing in minute detail the progress of Apollo 11 will be broadcast internationally, allowing the entire world to share in the drama of the manned lunar landing.

Apollo 11 will begin from Cape Kennedy when a Saturn 5 rocket, thundering aloft with 7.5 million pounds of thrust, drives the Apollo command/service (CSM) and lunar (LM) modules, as well as its own third stage, into earth orbit. After less than two revolutions of the globe, during which the third stage and spacecraft systems will be checked out, the rocket will re-ignite to propel the astronauts on their way to a lunar touchdown.

Almost immediately after the translunar coast begins, the astronauts will separate their CSM from the third stage, turn it around, and dock with the LM. They will then extract LM from its adapter still attached to the rocket.

On the fourth day of the mission, as the CSM-LM combination swings around the Moon, the CSM service propulsion system engine will fire to brake the docked spacecrafts' speed and allow them to be captured in lunar orbit. A second engine burn later will circularize the orbit to approximately 60 nautical miles.

Then on the fifth day, astronauts Armstrong and Aldrin

The 7-lb TV camera that will send live TV pictures from Moon.

will transfer to LM from the CSM through the docking tunnel and power up the lander's systems to check them out. Following the checkout, Armstrong and Aldrin will separate LM from the CSM and fire their descent engine to lower the LM orbit nearer the Moon. As they approach closer to the lunar surface, they will begin terminal descent during which they will fire the engine almost constantly, throttling its power to achieve a landing in helicopter fashion.

On the Moon's Surface

The first order of business for Armstrong and Aldrin after the landing will be to check out the LM systems to make certain everything is ready for the lift-off that will return them to the CSM, piloted by Collins, in orbit around the Moon. That accomplished, they will don their portable life-support system backpacks, depressurize the LM, and open its door. Moments later, Armstrong will scale down the LM ladder and step onto the lunar surface.

Armstrong later will be joined by Aldrin outside the spaceship as they begin a modest exploration, staying within 50 to 100 feet of the LM. During this time—about 2 hours, 40 minutes of the total 22-hour lunar stay will be spent outside the spacecraft—the astronauts will stay in touch with one another, and with mission controllers on Earth, using a compact extra-vehicular communications system (EVCS) built by *RCA*.

The EVCS consists of a v.h.f. transceiver set in each astronaut's backpack. Although each measures only 14" x 6" x 1¼" and weighs only 6.5 pounds, it contains two AM receivers, two AM transmitters, either an FM transmitter or an FM receiver, plus telemetry instrumentation to transmit astronaut biomedical data and status of the spacesuit systems.

Use of an FM receiver in one EVCS unit and the FM transmitter in the other will allow the receiver-equipped extra-vehicular astronaut (EVA) to serve as a radio-relay point for voice and data between his partner and the LM. This arrangement has one EVA transmit *via* FM (279 MHz) to the second, which converts the transmission to AM (259.7 or 296.8 MHz) for relay to the LM communications systems. Both astronauts can also transmit directly to LM *via* AM.

The LM, in turn, will convert the v.h.f. voice and data transmissions to u.h.f. S-band microwave signals and transmit them to Earth on a carrier frequency of 2282.5 MHz.

The teaming of v.h.f. and u.h.f. S-band is characteristic of the entire Apollo communications scheme, which must link two spacecraft to Earth and to each other, and also make provision for astronauts exploring the Moon. S-band carriers are used for spacecraft-to-Earth links for both LM and CSM, and v.h.f. will be employed for communications between the two spaceships and for extra-vehicular activity on the Moon.

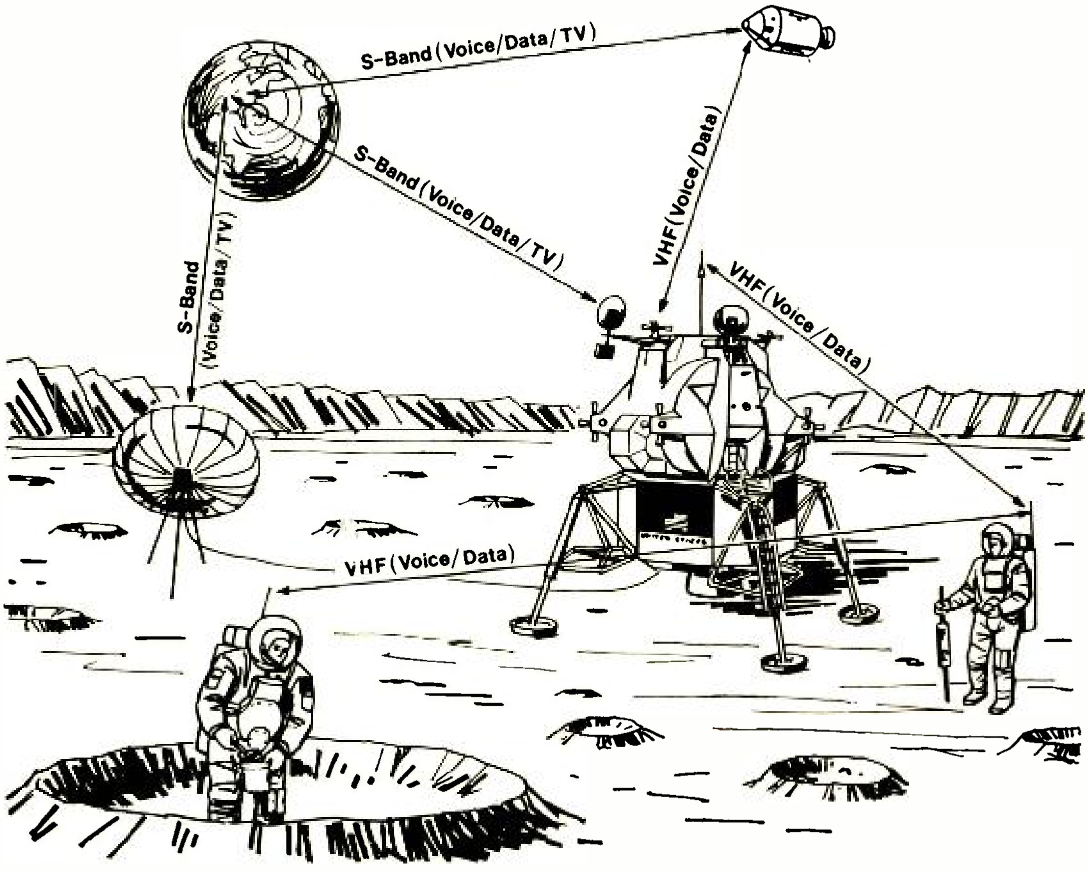
In all cases, the S-band and v.h.f. can be converted to one another, providing a number of communications paths to assure that everyone—the CSM, LM, and Earth—remains in contact.

An Umbrella Antenna

The u.h.f. transmissions to and from the Moon once LM lands can be conducted *via* a remarkable antenna. Called the "S-band erectable antenna," it is stored as a cylinder only 10 inches in diameter and 39 inches long. After the landing, one of the astronauts can remove the cylinder from the LM, set up its tripod, extend the telescoping feed, attach a cable from LM, and "pop" the antenna much like an umbrella so that it blossoms into a dish 10 feet in diameter. Total weight of the entire antenna is 14 pounds.

For Apollo 11 the erectable antenna will serve as a contingency item, although it is slated for prime use in future lunar landings.

The erectable antenna has 32-dB gain, about 12 dB more than the 26-inch steerable dish on the LM which will handle S-band transmission and reception when the spacecraft is in flight and after it lands. The erectable antenna focuses its energy so that its transmissions will cover the entire portion of the Earth facing the Moon at any given time.



Astronauts on the Moon will use v.h.f. radio to communicate with each other and S-band microwaves for Earth communications.

Stretched between the antenna's ribs, which are jointed with watch-spring metal so they can be folded, is an ultra-fine gold-plated wire woven into material resembling ladies' mesh stockings. The total result is a very flexible assembly that springs into a rigid structure when its opening mechanism is activated.

Live TV from the Moon

The most spectacular transmissions emanating from the lunar surface will be live TV beamed to an international audience by a 7-pound camera built by *Westinghouse*. The small camera will provide spectacular views of the astronauts as they move about on the lunar-scape to gather rock and soil samples and to set up scientific instruments.

The pictures will be received on Earth, scan-converted, and released to the commercial networks for broadcast to home TV sets. Scan conversion of the signals is needed because the TV camera, to conserve power and communications bandwidth, operates on standards markedly different from commercial TV.

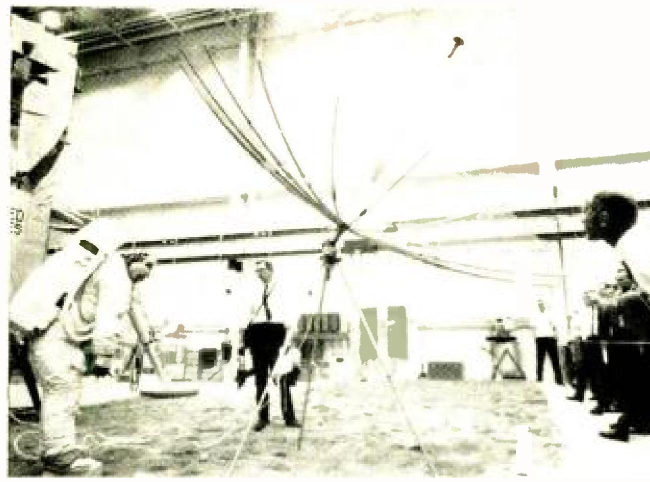
Instead of the 525-line TV pictures broadcast at 30 frames-per-second of conventional TV, the camera transmits 320-line TV pictures at 10 frames-per-second. This enables it to operate on a 500-kHz bandwidth as contrasted to 4.5 MHz for commercial TV. The camera also operates in a second mode, sending high-resolution "still" pictures of 1280 lines at one frame each 1.6 seconds.

In either case, the Earth-based scan converters, built by *RCA*, through a virtually instantaneous recording-playback process, transform the Apollo camera pictures to commercial standards so they can be displayed on conventional sets. Each converter employs a TV monitor, a vidicon camera, a video recorder similar to the "instant replay" devices used in sports telecasts, and pulse and timing units.

The lunar-surface camera is one of two that will be used for Apollo 11. A larger *Westinghouse* color camera identical to the one carried on Apollo 10 will fly in the CSM to broadcast TV during the trips to and from the Moon and perhaps while the CSM maintains its vigil in lunar orbit after the landing and during the exploration.

Both cameras already have made their space debuts. The amazing detail they provided of the astronauts at work, the Earth and Moon, and the spaceships in orbit spellbound TV viewers everywhere.

As spectacular as it will be, however, the TV will be only a small part of the total information that will be showered on Earth by the LM communications systems during the lunar visit. Vital astronaut physiological functions such as heart rate and temperature, telemetry on the spacecraft systems, voice conversations, and status of EVA spacesuit conditions (such as temperatures and oxygen supply), as well as the TV, will all ride to Earth simultaneously on the S-band carrier, producing thousands of bits of data each second.



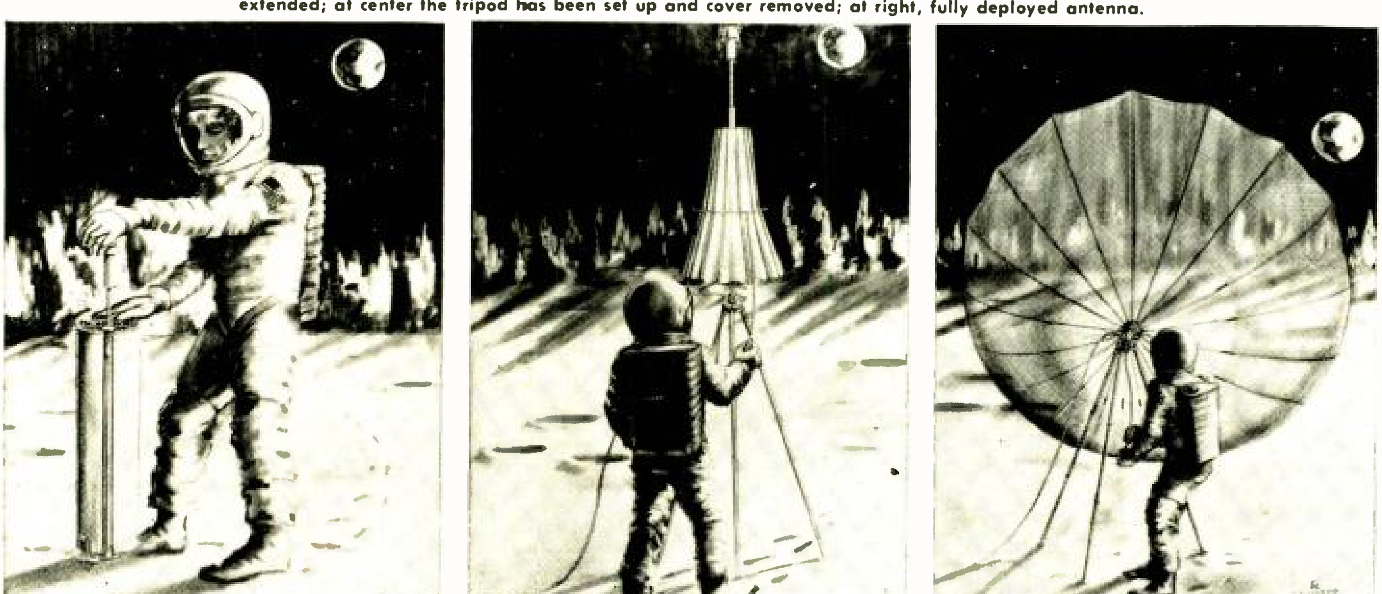
The erectable S-band antenna that will send microwave signals from the Moon to Earth is going through simulated lunar setup.

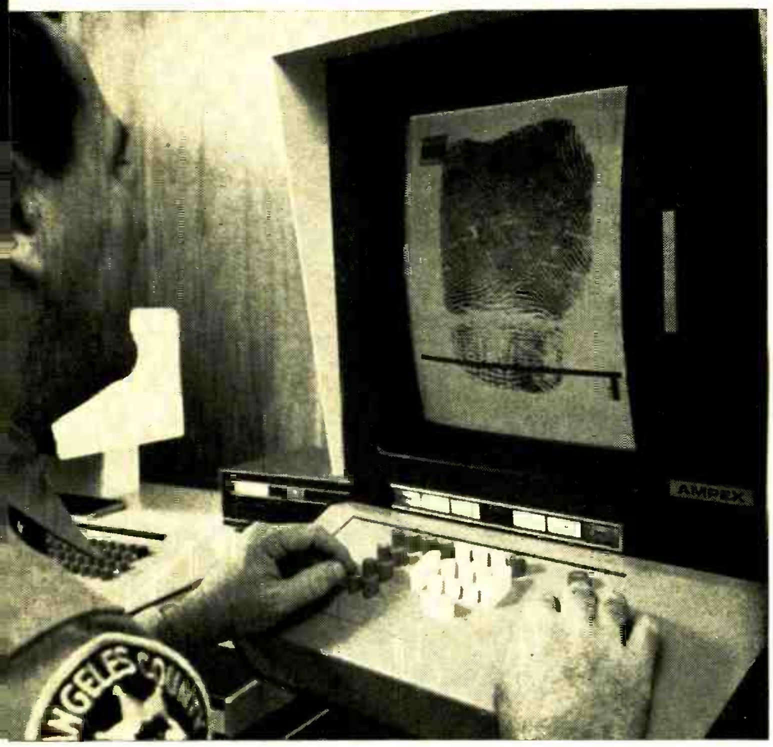
Ranging Data & Navigation

When the astronauts return to the LM and fire its ascent engine to climb back into lunar orbit and rejoin the CSM there, the LM communications system will take on an additional chore: receiving and retransmitting ranging signals from Earth. The range interrogations, like command and voice signals, will be received on 2101.8 MHz. They will then be turned around and transmitted on 2282.5 MHz, the carrier for all LM S-band transmissions.

As LM ascends, its v.h.f. set will be in action linking it with the CSM it is seeking. In addition to handling voice and low-bit-rate data, the v.h.f. radio will allow the CSM to compute distance between it and the LM. It does this by transmitting a series of tones, which are received and retransmitted by the LM. By measuring the time between transmission of the tones and receipt of the returns, the CSM-to-LM range can be calculated. The voice and the ranging functions can be per- (*Continued on page 56*)

The three steps required to set up the erectable S-band antenna. At left, the feed is being extended; at center the tripod has been set up and cover removed; at right, fully deployed antenna.





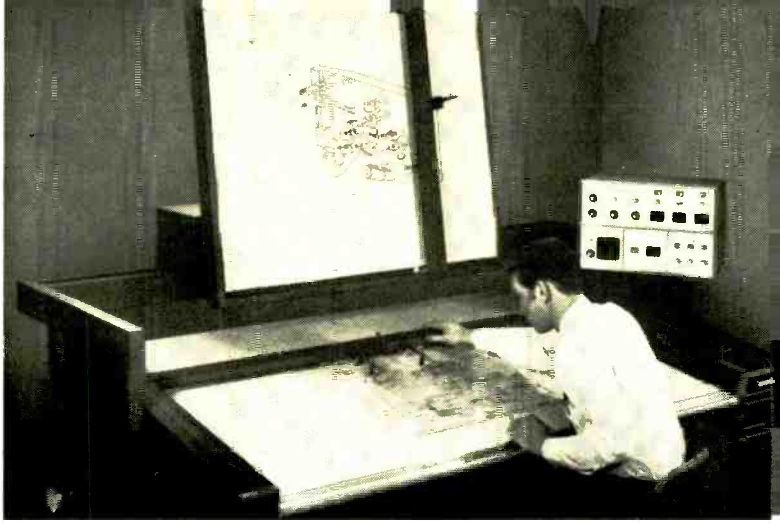
RECENT DEVELOPMENTS IN ELECTRONICS

Jobless Trained for TV Repair. (Top left) In Newark, N.J. a group of 80 formerly jobless men and about a half dozen hard-working, dedicated instructors are working together in classes of math, English, social development, but mainly color-TV repair. This program, which pays trainees $2 per hour, is also going on at Camden (80 students), Chicago, and Los Angeles (120 students each). After completing the 6- to 18-month full-day program, the graduates are expected to be placed with TV service companies where they will earn from $3 to $4 per hour as apprentice technicians. The graduate, who is not expected to be a bench man, is taught how to use meters and color-bar generators and will be able to do a complete convergence job in the customer's home. The program is operated by the RCA Service Co. under a $2.5-million contract with the Dept. of Labor. The company is contributing more than $1 million of its own. When we visited the Newark center, we saw a number of color sets being worked on by students, as well as color-TV course material from RCA Institutes. At Newark, 82% of the students are black, two thirds are married or the head of a household, 28% have had military service, and 14% have had some electronics background. Recruitment is by Total Employment and Manpower (TEAM) and N.J. State Employment Service.

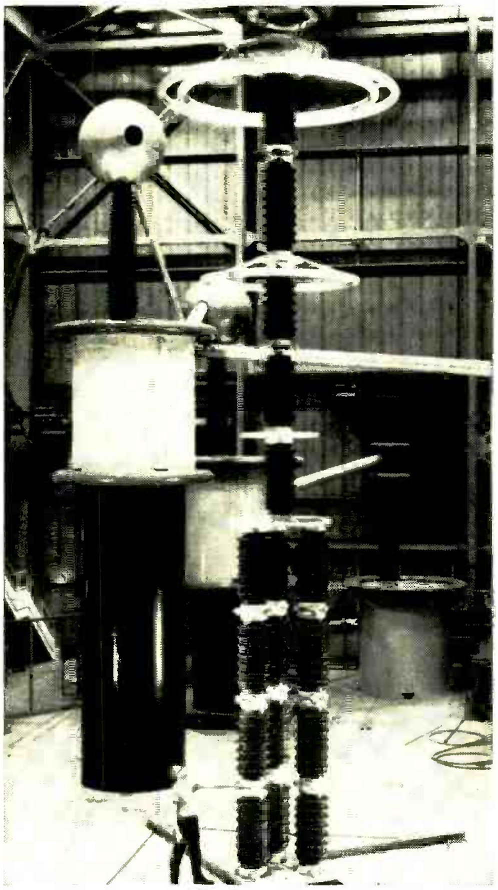
Video-Info System for Law Enforcement. (Center) Los Angeles County Sheriff's Department is installing a video-information system that will automate and speed the handling of law-enforcement records. With the new system, case records, fingerprints, photos, and related documents will be recorded on video tape and made immediately available for viewing on TV monitors at the Hall of Justice and in 15 sheriff's facilities throughout the county. The system, which uses the Ampex Videofile, stores about 125,000 document recordings in 3600 feet of two-inch-wide video tape on a 10-in reel. A comparable number of paper documents would require approximately twelve four-drawer file cabinets for storage.

New Optical Reader for Post Office. (Left) A New York City postal employee is shown monitoring the operation of an automatic address reader which can sort mail at the rate of up to 36,000 pieces per hour. The optical scanner, made by Philco-Ford, reads city, state, and zip code of an address and then routes the mail piece to one of 275 sorting bins. The reader can handle any common typewriter, computer, or addressing-machine type font, but it has trouble with italics and artistic fonts and cannot read handwriting. Hence, it can handle bulk mailings from business concerns, which is why the N.Y. installation is at a post office in the booming financial district. The Post Office Dept. now has ten of these readers in operation in Detroit, Boston, Philadelphia, Chicago, Houston, San Francisco, and Los Angeles. For this year, these machines are expected to process about 800-million pieces of mail.

Computer-Operated Drafting Machine. (Top right) This automatic drafting machine is creating a three-dimensional layout drawing from two orthographic plane views on the illustrator's drafting table. The draftsman uses two styli, one to set the axis about which the plane view is to be rotated and the other to trace the other plane view. The computer-directed machine does the rest, and in a fraction of the time required to do the job by hand. The drafting machine is a second-generation model of a less sophisticated and more expensive version that was introduced by Perspective Systems, Inc. four years ago. Previous model was priced at over $50,000, while this version, thanks to its modular design, is about half the price.



Giant Lightning Arrester. (Center) The size of the man at the bottom of the photo shows how large this lightning arrester is. Rated at 900 kV r.m.s., this freestanding arrester was built for ultrahigh-voltage electric-power transmission research. The unit surpasses by over 30 percent the highest arrester ratings now in world usage. The device, manufactured by G-E, will be used in the company's research project for Edison Electric Institute and Bonneville Power Administration. The program studies insulation performance, radio noise, and corona loss of 1000-kV to 1500-kV power transmission lines.



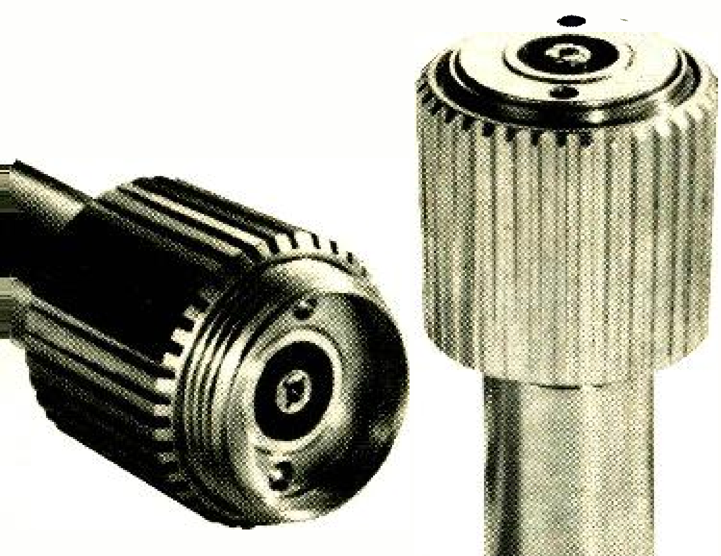
Personal Identification System Measures Hand. (Bottom left) No ID photo and no personal signature are needed to make a positive personal identification with this new system we saw demonstrated by Sibany Mfg. Corp. The user simply inserts a card with the measurements of his right hand coded on it by means of small punched holes. He then inserts his hand into the scanner, which then takes a number of measurements and compares them with the coded information. If the measurements check, the machine signals that the identification is okay. Units are being currently field-tested. The manufacturer foresees applications in hospitals, banks, industrial plants, military bases, and anywhere that it is necessary to identify a person.

Instrument Platform Checks Athlete's Thrust. (Bottom right) The forces that make one athlete jump farther than another are being measured electronically at the University of California. Using an electrographic recorder developed by Varian Associates, the device graphs the lift-off thrust exerted during 0.1 to 0.2 second. The recorder is triggered by photocells, and strain gages actually make the thrust measurements. The jumper's flight is recorded on video tape to correlate with the measurements. Studies are being conducted by Dr. Melvin Ramey, a 30-year-old assistant professor of civil engineering (left) who is still fit enough to better 45 feet in the triple jump himself.

New Coax Connector TOPS Performance Records

By HENRY PESSAH
Advanced Product Planning Mgr., Amphenol RF Div.

The price of some high-frequency connectors may seem ridiculously high but let's look at the performance one obtains. Let's also take a look at the design and manufacturing costs and the rather involved testing techniques.



Close-up of the new 7-mm, 50-ohm precision coaxial connectors. The 7-mm dimension refers to the inside diameter of the outer conductor of the matching rigid coax.

"THIRTY-FIVE dollars for just one coaxial connector? Why?" Many electronics engineers, used to paying 35 cents for a standard type of coaxial connector, ask this question. However, the one we are talking about is the 7-mm, 50-ohm "precision connector."

The key is performance. The connector offers constant impedance (50 ohms ±0.1 ohm) over a frequency range of 0 to 18 GHz, and s.w.r. (standing-wave ratio) for a mated pair is less than 1.003 + (0.002 × frequency in GHz). For example, 1.003 + (0.002 × 18) = 1.039 s.w.r. at 18 GHz. The connector also offers r.f. leakage better than 120 dB (this is the ratio of the leakage of a mated pair to the signal level), electrical length held to ±0.002 in, and low contact resistance: 1.0 milliohm for the inner contact; 0.1 milliohm for the outer. Insertion loss (dB) for a mated pair is less than $0.007 \sqrt{\text{freq.}}$ GHz. For example, at 16.0 GHz, loss is 0.028 dB.

"Yes, but who needs performance like that?" is the next question.

The answer is summed up by John Cardoza, product manager of *Hewlett-Packard's* Microwave Division:

"Rapid advances in microwave technology, triggered to a large extent by the application of solid-state devices and techniques, have brought about the need for measurement techniques and equipment which will give the microwave engineer more information about design—and with *significantly higher measurement accuracies*. With the advent of solid-state devices for microwave applications (such as "bulk-effect" oscillators, microwave transistors, thin-film amplifiers and mixers, etc.), the equipment or systems designer can now achieve his end product by combining or cascading smaller, "simpler" devices and networks. If the over-all design objectives are to be achieved, the designer must be able to completely characterize the individual elements or networks so that their performance in the final system is fully predictable, and he must be able to do this characterization simply, rapidly, and accurately over wide frequency ranges.

"One of the objectives of the *Hewlett-Packard* Network Analyzer, designed to fill this need, was to make it one of the most accurate phase and amplitude measuring instruments. For this reason it was decided to use the new precision connectors. These are some of the reasons for the choice:

"1. The connectors offer the lowest s.w.r. over the widest coaxial bandwidth now available. This results in lower mismatch errors when making transmission and reflection coefficient measurements.

"2. Phase measurements require a precisely determined reference plane. The connector's singular and nonambiguous mating plane makes it ideal for the precision now required in phase measurements.

"3. The connectors are also employed on high directivity broad-band couplers used in the reflection tests units for reflection-coefficient measurements. Again, the low s.w.r. was one of the critical characteristics in achieving the high directivity needed for accurate impedance measurements in broad-band coaxial systems.

"4. Because designers must often make measurements in other connector configurations, availability of low s.w.r. adapters is important. Adapters from precision connectors to type N, SMA, TNC, GR900, etc., provide the analyzer user this flexibility."

The applications horizon for the precision connectors is widening. It now appears on nearly all types of precision test instruments.

In equipping modern test instruments with these connectors, orders of magnitude improvement in residual error have been accomplished in the measuring system. Even for capacitance, resistance, and inductance standards operating at lower frequencies, the fixed plane and controlled residuals in precision connectors have added considerably to ultimate accuracy. In the microwave region, coaxial measurements can now be made with precision heretofore possible only in waveguide systems.

Achieving the Performance

To achieve high performance, mechanical tolerances required in the connector manufacturing process were carefully chosen. Both the inner and outer coaxial cross-section diameters had to be held to tolerances of 100 microinches. These tolerances were necessary to maintain proper impedance, electrical length, and to avoid excessive tolerance build-ups on assembled component parts which could result in the electrical degradation of the connector. Fits among the airline, connector body, bead assembly, and contact assembly have to be extremely close in order to avoid degeneration due to eccentricity of the center conductor.

For any connector manufacturer to achieve this, a properly controlled environment is necessary. For example, the 7-mm precision connectors are manufactured in a clean, positive-pressure area where temperature is maintained at 70° ±2°F.

To manufacture the connector economically, precision machining methods and instrumentation capable of holding close tolerances had to be developed. Included are Swiss *Bechler* automatic screw machines, *Kummer* automatic chuckers, and a *Harding* lathe with an automatic sequencing attachment. In the manufacturing process, every attempt had to be made to eliminate human variability in critical assembly operations. This was the purpose of the automatic devices. The utilization of automatic equipment not only lends itself to economic production, but assures a uniform product within the necessary close dimensional limits. The *Amphenol* production facility is capable of holding length and diameter dimensions within 0.0001 of an inch. And tolerances of this kind are a "must." Should they vary even slightly, the s.w.r. of the connector can jump drastically.

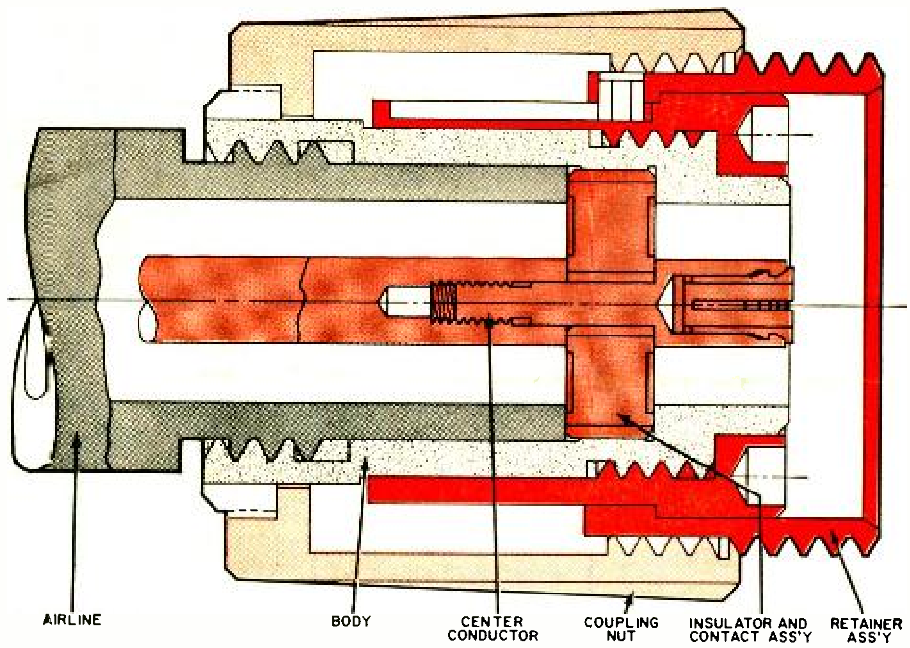


Fig. 1. Assembly drawing of the 7-mm coaxial connector. The mechanical tolerances are held to 0.0001-inch and manufacturing is done in clean room.

Critical Inspection

Naturally, the close tolerances of the 7-mm connector necessitate unusual inspection methods. Mechanical inspection of critical dimensions on connector parts is done with air gages, precision dial indicators, and by optical methods (comparator and microscopes).

In fact, the inspection comprises a large percentage of the total connector cost; but the use of air gages helps appreciably in keeping this cost down. These gages are capable of measuring dimensions to 50 millionths of an inch. One air gage has three outputs and is capable of measuring three separate dimensions simultaneously. Without these gages, it could take hours to make the measurements. However, measuring the three critical dimensions with an air gage takes only seconds, and is far more accurate. The air gages also enable technicians to measure TIR (Total Indicator Reading), or the concentricity of the connector. This is simply the relationship of one diameter to the other.

Electrically, the connector is tested using the half wavelength substitution method. A 5.9-in (electrical) length of 7-mm rigid airline with a precision connector at each end is used. At every gigahertz, this assembly is some multiple of a half wavelength; for example, two wavelengths at 1 GHz. Connectors are checked for s.w.r. at 4, 6, 9, 12, 15, and 18 GHz.

Each connector is individually tested in this manner, then packed with a test certificate in a special shock-proof container for shipment to the customer.

New Sexless Philosophy

One of the most interesting characteristics of the precision connectors, as contrasted with most coaxials, is its "sexless" design. Any 7-mm precision connector will mate with any other in the field. This design also eliminates the problem which most other connectors have to live with, that is, the problem of destructively interfering or distorting each other. For example, typical dimensional distortion occurs in type-N connectors. As the pin enters the contact fingers, it presses the fingers sideways or otherwise distorts the inner conductor of the contact. Another connector could have a pin within the tolerance range which could act in an entirely different manner.

One of the most important features of the sexless philosophy is that it provides a very precise electrical and mechanical reference plane for mating both the inner and outer conductors; and it is this feature which makes the precision connectors so attractive in the lower frequency regions as well.

How it All Started

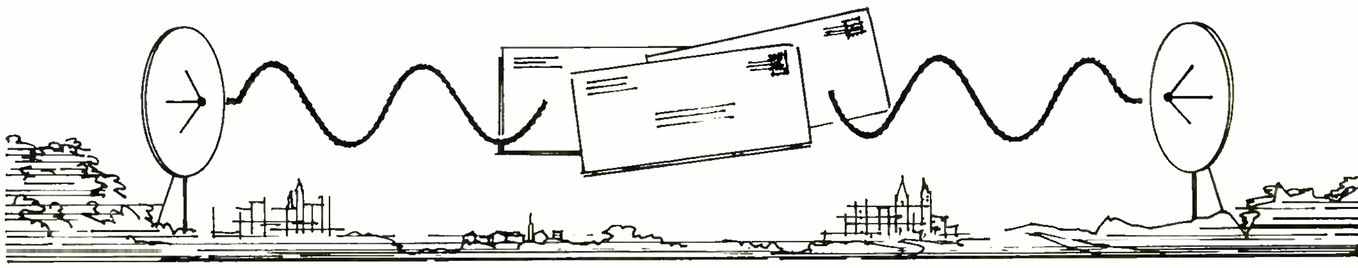
Obviously, the precision connector didn't just "happen." Credit should really go to the IEEE Committee on Precision Connectors, a part of the Group on Instrumentation and Measurements. This committee worked with both the test instrument and connector industries to develop specifications for an improved-performance connector, one which would be capable of true interface over a wide frequency spectrum with the broadest possible line of coaxial test instruments.

The committee set up the basic requirements for the connector, namely the "sexless" design, fixed the reference plane concept, and the specific electrical performance characteristics—s.w.r. and the like—which have been discussed in light of the *Amphenol* APC-7. (*Continued on page* 61)

Engineer uses special microwave network analyzer to check reflection coefficient of an X-band filter. The test instrument is equipped with the new APC-7 precision connectors.

Will there be—

An Electronic Mail Service?



By WALTER H. BUCHSBAUM / Contributing Editor

Will future mail be transmitted via microwave radio links? Can electronics bail out our postal system which is now staggering under a deluge of mail? What about the proposal for an "informal merger" between Western Union and the Post Office?

Editor's Note: At last year's National Postal Forum, a proposal was made to have Western Union join forces with the Post Office to transmit "telegramletters" over its facilities with final delivery being made by a local letter carrier. Recently, it was disclosed that a limited trial of the plan for several months is in the works. If the plan doesn't develop too many bugs, it could go into limited public use early next year. Legislation would be required, however, prior to final use. A "telegramletter" would be faster than regular mail but slower than a telegram. Its cost would be below regular telegraph but above mail rates.

FROM the days of the Pony Express until recent times our Post Office system has been considered a paragon of reliability, efficiency, and speed. During the past ten years this shining image has begun to tarnish and large deficits, combined with increasing rates and declining service, have made our once proud postal service the subject of many complaints.

If we skip over the next 10 or 20 years and assume that these problems will be solved by electronics, we should be able to again depend on the postal service to "get the mail through" with high speed and reliability. Instead of the mailman making his rounds, we can envision an attachment to the home TV set which will spew out personal letters, bills from the department store, or more likely, the daily computer output showing your financial standing in the universal, over-all, everywhere, and everything credit-card service. To answer personal mail, we will simply slip the reply into our TV attachment and press the "Mail Transmit" button. To pay our bills we will put our credit card into the slot and punch the amount to be transferred into the keyboard on the TV attachment. Only parcel-post deliveries may still be made in person.

How can this "electronic mail" service come about? Well, the beginnings of it are predicted in the not-yet-released report prepared by a 15-man interagency committee set up in 1967 by President Johnson to recommend new national communications policies. A brief paragraph released on December 8, 1968 recommended that *Western Union* be allowed to set up shop within U.S. Post Offices in various cities and some informal arrangement be provided to augment, complement, and merge some of these services. On the surface it is hard to see any great significance in this recommendation, but when we look into the operation of the Post Office and the services currently provided and planned by *Western Union*, it becomes apparent that a radical change in domestic communications services may result from such a marriage.

Communications Explosion

Before World War II mail deliveries two or three times a day were common in major cities and the time it took for a letter to travel from Washington to New York was measured largely by the railroad schedules. Since 1939 the volume of mail has increased astronomically and in 1968 the U.S. Post Office handled 79.5 *billion* pieces of mail. Little has been done in the postal service to introduce automation on a large scale and, by and large, the general routing process and delivery of mail is still the same as it was 30 years ago. The recent addition of zip-coding and some automatic sorting machinery in major post offices has done little to expedite the mail.

Western Union's basic telegram and telex service has also increased greatly. Between 1958 and 1967, the volume of messages has increased 789%. Not only are there more people in the country, but these people also communicate more, both by mail and telegram. The Post Office reports a 1.5% increase in mail volume between 1967 and 1968 and predicts a 7% increase in volume between 1968 and 1970. Although these percentages themselves do not appear dramatic, they indicate a spiraling trend which is a part of the so-called communications explosion.

A number of critics of the Post Office have advocated that the entire business of handling the mail be turned over to a non-profit, government-sponsored corporation which would remove the Post Office from its ties to partisan politics and put it on a more business-like, "efficient," and, conceivably profitable or at least deficitless basis. Could it be that the Presidential Commission had this type of thing in mind when it recommended the informal merger of postal and telegraph services?

We have long been intrigued with the potential of *Western Union* in terms of domestic record communications since, by act of Congress, this company has the charter for all non-voice communications within the U.S. By evaluating the growth plans of *Western Union*, the advanced communications services now in use by the military and some large corporations, we will predict what the "informal merger" of *Western Union* with the U.S. Post Office could ultimately mean to domestic communications. Many of the possible services and their implications will be controversial and subject to Congressional politics, compromise, and modification, but we believe that the combination of *Western Union's* electronic message transmission and the physical message transmission provided by the Post Office will spell out an entirely new era in communications for all of us.

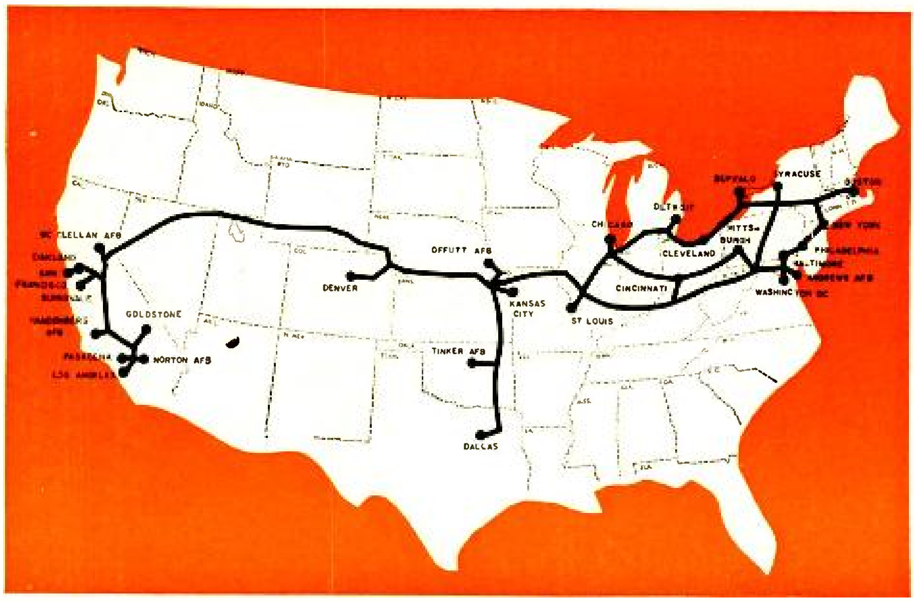


Fig. 1. Nationwide microwave system of Western Union is 7500 miles long and interconnects 267 stations. The main terminal points are indicated.

Western Union's Wide-Band Service

A basic principle of electronic communications depends on the fact that the bandwidth, in terms of frequency, required to transmit information is directly related to the amount of information it is possible to transmit within a given time. Until 15 years ago, the normal means of transmitting a telegram was the low-speed, 75-word-per-minute teletypewriter. The bandwidth required for this type of service was on the order of 150 Hz. An ordinary voice channel is 4-kHz wide and is generally used to transmit a frequency band of 3.8 kHz. By special techniques it is possible to transmit 4800 words-a-minute over this type of channel. TV transmission requires bandwidths of approximately 4 MHz although techniques are used to "bandwidth compress" video information into a 2.5-MHz channel. If you want to transmit more information faster you must increase channel bandwidth. Originally, *Western Union* transmitted only low-speed teletypewriter information and was therefore satisfied to lease long-distance lines at 4 kHz from the telephone company, or in some instances, provide its own wire network.

With the increase in traffic, and with the need to provide high-speed data communications, *Western Union* embarked on an ambitious program of installing a nationwide wide-band microwave system. At the present time this system is 7500 miles long and connects 267 stations, serving the major population centers and defense installations coast to coast. Fig. 1 shows the microwave network as it is currently installed. Initially equipped to provide 600 voice channels, or a bandwidth of approximately 2.4 MHz, the total capacity of the system is approximately 28 MHz.

The wide-band microwave system consists of point-to-point microwave communications with towers and repeaters stationed all over the country. Services within any given city make use of available *Western Union* cables as well as the leased facilities of the local telephone company.

How many private letters do you send and receive each month? Each year? The average U.S. citizen receives 407 pieces of mail annually. Clearly the vast bulk of this mail is not private correspondence. In fact, the Post Office has shown that most of the mail, and the vast physical bulk of the mail, consists of advertising matter, magazines, bills, statements, and corporate communications of various types. The bulk of this mail is further increased by the frequent addition of postage-free return envelopes, reader's reply cards, etc. Thus most of the mail carried by the Post Office contains printed rather than handwritten information. And much of this information is duplicated, that is, the same information is sent to many addressees.

The Post Office and the Paper Glut

The postal system's major problems fall into three areas: sorting the mail, transporting it between post offices, and delivering it to the individual addressee. Excluding parcel post, mail can be broadly divided into hand-addressed and machine-addressed envelopes of varying size. The problem of sorting hand-written mail automatically is difficult to solve and requires machines not currently available. Machine-addressed mail can be sorted by optical-scanning readers coupled to computers. Some test installations are underway and if such systems could be installed in all major post offices, this would greatly reduce the over-all sorting problem.

The problem of transporting mail between cities remains a major cost item. Some publications, particularly some nationally distributed magazines, have provided a partial solution to the problem by shipping their press plates and having the magazines printed in or near large population centers. In a few instances national magazines publish special Eastern, Midwestern, or Western editions. But most of the mail still has to be transported by train, truck, or airplane between major cities.

The most vexing problem facing the Post Office is delivery to the ultimate addressee. The individual mail carrier, bent under the ever increasing weight of his leather bag, is still the only available means of getting the mail delivered. Keep these problems in mind while we consider how information gets distributed in an advanced military communications system, such as the Autodin system described below.

Lessons Learned in the Autodin System

Autodin (Automatic Digital Network) provides only record traffic, that is, only messages in the form of teletypewriter printing, punched paper tape, or *IBM* cards. Controlled by a number of automatic, computer-controlled switching centers, the Autodin network makes use of all sorts of communi-

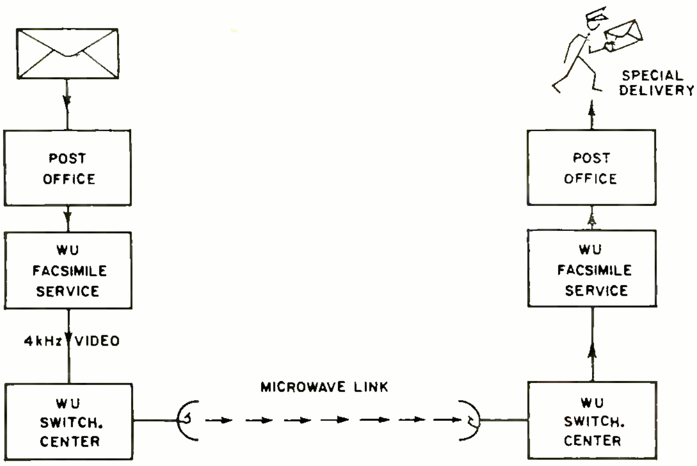


Fig. 2. Possible future high-speed letter-facsimile service.

cations links, from simple telegraph wire to microwave, troposcatter radio, and in the past few years, satellite communications. Because it serves the Department of Defense, various levels of security classifications are provided for different messages and for different channels. Similarly, a range of different priorities permits urgent messages to pass through faster than those of a routine nature.

Probably the most unique and vital feature of the Autodin system is the so-called "store and forward" message. This involves a technique of transmitting a message from the sender to the addressee without making a direct connection between two distant points. An air base in Okinawa, for example, wants to know if a certain spare part is available at a depot in Oklahoma. At the time this message is sent out, all of the circuits between Honolulu and the Mainland may be busy or else the equipment at the Oklahoma depot may be tied up. The Autodin system in Honolulu accepts the message from Okinawa and tries to forward it directly to the next switching center in line. If it is not successful in routing it *via* the shortest way, it will try a number of alternate routes. If the computer receives the information that all routes are busy, it will store the message for a short time, usually a few minutes, and will try again to transmit it. Thus the message is automatically passed on from one switching center to the next and is received in Oklahoma as soon as lines to that center are free. The great advantage of this technique is that the operator in Okinawa does not need to hold his circuits open but simply transmits his message to Honolulu and then continues to use his equipment to transmit other messages.

Each message has its own assigned priority. If a high-priority message is received at a busy switching center, all lower-level messages will be stored and the high-priority message will go through first. All this is accomplished within micro- or milliseconds by a complex computer-controlled switching system.

If the air base in Okinawa needs a specific spare part but does not know in which depot it is available, a message can be sent to all depots. This is accomplished by sending a single message addressed to all depots. Computer-controlled switching centers will automatically route the messages to their destinations. When an address is changed, the computer is informed and forwards the message automatically.

In addition to such messages as the location of spare parts, payroll information is sent from each installation to the paymaster's office half way around the world. This information is usually contained on *IBM* cards. Again information in a whole deck of *IBM* cards can be sent automatically over the Autodin system to a remote station, again using message store and forward techniques and automatic routing to produce a duplicate set of cards at the paymaster's office.

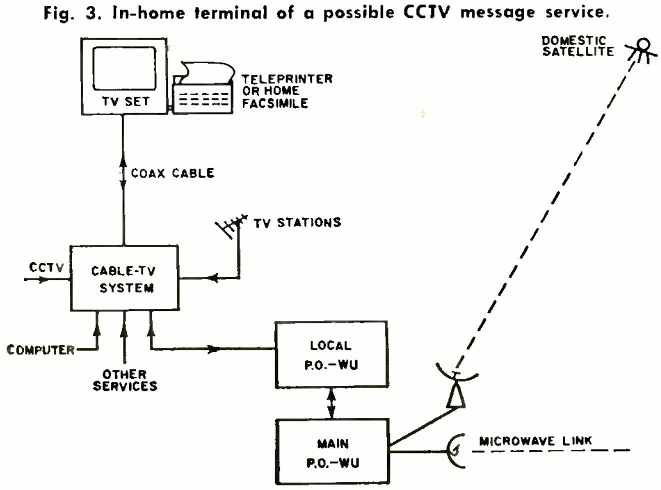
We have cited two typical uses of the Autodin system which are not subject to security classification and which are relatively routine, everyday type of communications services. In addition to these, a number of other, unique, services are available which are vital to the national defense and which permit high-speed record communications between locations all over the world. The key element of all this, however, and the element which is of the greatest value to the ultimate domestic communications of *Western Union*, is the use of computer-controlled automatic switching centers.

Some of the features of the Autodin network have already been applied by *Western Union*. It is, for example, possible to send a "multigram" by *Western Union*. This is a single message transmitted to a number of different addresses. Thus a corporation may send out a new price schedule to its sales offices all over the country. A company may call in its outlying dealers for an urgent meeting by a single multigram message, or organizations may use it to alert their members. It is only necessary to give *Western Union* the text of the message and a list of the addressees.

The Autodin network has a whole array of messages with a fixed content in which only dates, sizes, part numbers, or other detailed information vary. To transmit these, it is only necessary to send the message code number and the pertinent details. Similarly, *Western Union* has a series of prearranged messages, such as congratulations for all occasions, where only the name of the person need be inserted. *Western Union* also provides various services connected with goods and services of affiliated organizations, such as flowers-by-wire, candy-by-wire, money orders, and gifts-by-wire. *Western Union* provides the information link while local stores provide some of the merchandise.

A relatively new *Western Union* service is leased facilities for transmitting information on punched tape and *IBM* cards between computer centers. Also growing in popularity is Info-fax which is a facsimile transmission system, operating over a 4-kHz telephone channel and capable of transmitting a standard-size letter in about 3.6 minutes. In this latter field *Western Union* may be outpaced by *Xerox* and others who offer reproduction systems which the user can connect directly to the telephone line. In any event, much of the capability of Autodin is already available, and the interconnecting links within the United States, at least, are provided by *Western Union's* wide-band microwave system.

Fig. 3. In-home terminal of a possible CCTV message service.



Results of the WU-P.O. Combination

Aside from the convenience of having the *WU* office right in the post office, and the possible revenue from this to the Post Office, a number of new services could be made available almost at once. In many instances, telegrams are now phoned to the addressee with the copy sent later by mail. Some time can be saved if the *WU* office is part of the local post office. A more important advance would be the facsimile letter service illustrated in Fig. 2. At a special fee, possibly slightly more than (*Continued on page* 72)

BRIGHTER PICTURE TUBES for COLOR-TV

By MILTON S. SNITZER / Technical Editor

New 23-inch tubes with twice the brightness and improved contrast, but at no increase in high voltage, will be offered by Zenith and RCA.

ALTHOUGH many owners of color-TV receivers will say that their color pictures are bright enough, the fact remains that the light output of color tubes is far below that of black-and-white picture tubes. As a matter of fact, most color viewers use somewhat subdued room lighting when watching their sets in order to avoid picture washout or loss of contrast. The tube manufacturers have been working constantly on this problem, and all are using more highly efficient phosphors, especially the red, in order to get greater light output.

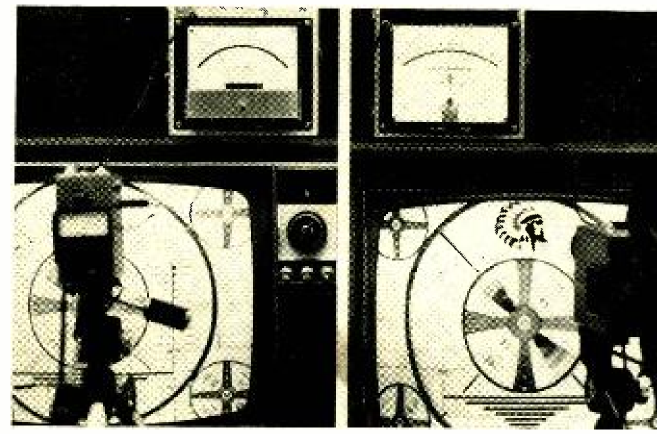
A somewhat different approach is now being taken by *Zenith's Rauland Div.* and by *RCA Electronic Components*. These two companies have approached the problem from mechanical and optical points of view, with improvements in shadow masks, in the phosphor-dot pattern forming the screen, and in the use of faceplates with greater light transmission. Both companies are claiming about twice the light output or brightness along with improved contrast and resolution. *Zenith* will be using their new 23-in tubes in much of the company's 1970 line of color sets. *RCA* will also be using their tube in some of their new sets as well as sampling the 23-in tube to color-set manufacturers by the end of the year. Incidentally, the price to set makers for the new *RCA* tube is $110 each.

Both tubes employ about 1,300,000 individual red, green, and blue phosphor dots on the screens, but the important difference from previous tubes is that the dots are smaller in size and are surrounded by an opaque, black matrix or surround. The electron beams that strike the dots are broken up into smaller beams by the tiny holes in the picture tube's shadow mask. In the case of the *Zenith* tube, these holes are slightly enlarged so that the entire area of the phosphor dots is excited rather than only about half the area as in conventional tubes. As a result a greater light output is produced.

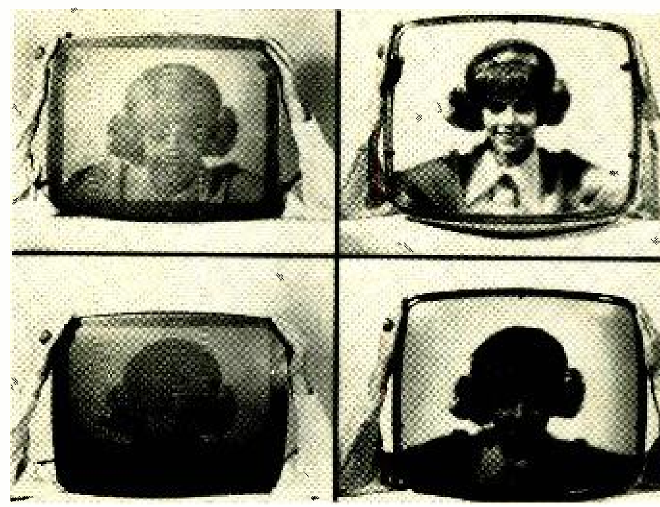
In previous tubes, the phosphor dots are about 17 mils (thousandths of an inch) in diameter, while the electron beams striking the dots are about 13 mils in diameter. In the new tubes, the phosphor dots are 12½ or 13½ mils in diameter, depending on the efficiency of the particular phosphor used, while the electron beams are about 16½ mils in diameter at the center of the tube.

The black surround or matrix has a number of important uses. It effectively absorbs room light so that room light reflections which cause picture washout are minimized. The opaque black material also absorbs light splash or scatter from adjacent phosphor dots. As a result, there is better resolution and improved picture details. *RCA* is also using a new, high-resolution electron gun.

By using the black surround it is no longer necessary to sacrifice picture brightness in order to keep the contrast good under normal or high room-lighting conditions. Previous color tubes employed low-light-transmission glass faceplates to cut down the glare from room lighting. The trouble with this is that the dark-tinted filter faceplates absorb more than half of the light from the screen, thus reducing picture brightness. Now a much lighter tinted filter can be used over the screen of the picture tube with the result that far more light is transmitted through the glass by the phosphors. ▲

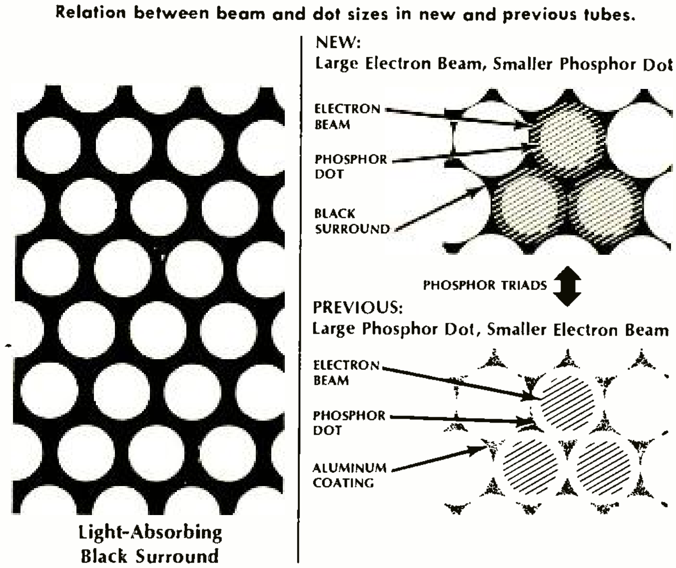


The highlight brightness of the previous 23-in Zenith color picture tube (at left) is being measured at 23 footlamberts. The new tube (right) measures just under 50 footlamberts.



New Zenith shadow mask (top left) has about 450,000 holes which are opened up to about 16 thousandths of an inch in diameter at the center. These holes are somewhat larger than the holes in older shadow mask (bottom left), thus allowing larger electron beams to pass through. Note how much brighter girl looks behind the new mask. The new glass faceplate is shown at the top right. It transmits much more light than low-transmission glass (below right) than was formerly used.

Relation between beam and dot sizes in new and previous tubes.



This uniquely equipped helicopter is flying over a portion of a forest believed to contain diseased trees. The copter helps U.S. Forest Service personnel find sick trees in Pacific Northwest forest. The trees can be harvested, preventing spread of disease.

INFRARED
Locates Diseased Trees

By ROBERT NEUBERT/Ampex Corporation

By combining IR sensing and video tape recording, the U.S. Forest Service is spotting distressed timber from helicopter.

JOHN F. WEAR is a space-age "doctor" who takes the temperatures of trees rather than human beings. And he does it hovering 150 feet above the forest in a helicopter. As a result of Wear's research, it is hoped diseased trees in Pacific Northwest forests can be located and harvested before they become economically worthless and before they have a chance to infect other trees. Wear, a research forester with the U.S. Forest Service's Pacific Southwest Forest and Range Experiment Station, heads the survey techniques study, which is financed by NASA.

A major forestry problem is the reduction of growth and extensive loss of timber due to forest diseases. Many richly wooded areas are far from established roads and detection of distressed timber is an arduous and impractical task from the ground. Aerial location of disease centers needs some means of reference, both for ground crews to make their way directly to pinpointed locations, and for logging firms to push their roads toward still salvageable timber.

The problem of detecting and recording these areas is being studied by Wear in his experimental program, which makes use of photographic and infrared-sensing techniques. Flying above a forest in a four-seat helicopter, Wear uses a heat-sensing device that transmits information on the amount of infrared radiation to a digital counter, which in turn combines with two TV cameras and a video-tape recorder to display, on a TV monitor, both the picture of a tree top and the tree's temperature translated into a series of three digits.

Trees, like humans, appear to have higher temperatures when "sick"—sometimes as much as 4° F above normal. The sicker a tree gets, the more infrared it emits.

By using video-tape recording, it is possible to locate a disease center precisely with aerial maps and provide the information to foresters and forest managers.

The study is currently focused on Douglas fir in Oregon and Washington. Douglas fir is the most important timber species in the Pacific Northwest, representing 57 percent of the total sawtimber volume in the region. *Poria weirii* root rot is by far the region's most destructive Douglas fir disease, ruining more than 170-million board feet of timber per year. There is still no known cure for this organic disease, so diseased trees must be cut down in order to prevent further infection.

By discovering and harvesting diseased trees, their lumber can often be salvaged commercially. Locating the disease center thus becomes very important financially, for almost half of the timber in the United States that is lost to insects, disease, and fire is due to some form of infection. Nearly 50 percent of the root-destroying diseases in the U.S. are attributable to *Poria weirii.*

Poria weirii research was started by Wear in 1966, when branchlet samples from 45 selected dominant trees were clipped by a pole pruner from a hovering helicopter. Old growth, second growth, and young growth samples were taken and spectral-reflectance curves from all sample trees were obtained with a spectrophotometer at the University of California's Illumination Laboratory at Berkeley.

The most encouraging preliminary result of the beginning research was that significant differences in infrared emissions occurred between healthy and diseased trees at certain times of the day. Temperature differences taken in the 8.0 to 14.0-micron band of the electromagnetic spectrum were highly significant in the early morning, even if disease symptoms were not always visible in the crowns of the trees.

Before beginning the video and heat-sensing survey, research was conducted into remote sensing of tree temperatures through several spectral areas. Aerial photography with color and infrared film was performed on the foliage of healthy and diseased trees in the 0.4 to 1.0-micron band of the electromagnetic spectrum.

In November 1967 it was decided that the addition of video-tape recording would fill out the missing link in the survey—that of providing exact visual references which would lead ground crews to diseased trees. By spring of the following year project specifications were completed, with welcome assistance from the Bonneville Power Administration substation in Vancouver, Washington. It was decided to rent the necessary equipment, and *Oregon Audio Video Systems* of Portland was awarded the contract after open bidding. The first test runs came in July 1968, and the first pilot survey began the next month.

The Equipment Employed

A helicopter capable of seating a pilot and three passengers was selected for the program. Housed in a long aluminum pod outside the copter, near its right skid, is an *Ampex* CC-6007 closed-circuit TV camera with wide-angle lens, and a *Barnes Engineering* PRT-5 infrared heat-sensing radiometer. The pod is attached by a pipe to a mount near the right door.

A cable attachment opens the bottom of the pod in flight, allowing the vidicon TV camera to record video images and the heat-sensing radiometer to measure infrared emissions from trees. The right door of the craft has been removed to facilitate operation of the outside pod's instruments, and to compensate for turbulent atmospheric conditions which caused the helicopter to bounce about. A clearer video image resulted.

Inside the craft at the pilot's right side is another aluminum pod containing a second CC-6007 camera focused on a digital counter. Bolted atop this pod is a 9-inch TV monitor and a TV control panel. The digital counter is fed *via* cable from the heat-sensing device outside.

The amount of infrared energy is displayed by the counter, and the TV control panel combines on the monitor's screen the video image of a tree with its digital readout. The composite picture shows the crown of a tree with the readout superimposed to the right of the tree. A black circle at the rear of the outside camera lens superimposes a bullseye on the middle of the screen. This bullseye represents the area covered by the PRT-5 radiometer and aids in pinpointing the target tree.

Also in the helicopter is an *Ampex* VR-7000 portable video-tape recorder, which records the image on the monitor. The video tapes may be replayed immediately in flight or later at the heliport or an office. A microphone permits recorded verbal commentary on the same tape.

Power for the video and heat-sensing system comes from a portable static inverter which draws 12-volt d.c. from the helicopter's generator and converts it to 110-volt a.c. required by the electronic equipment.

The video-tape recorder operates continuously while the helicopter follows its predetermined flight pattern. Following this exact line facilitates correlation of the tape with aerial maps. Each reel of tape plays for approximately one hour, and most flights in a survey area may be completed within this time.

Flights for the experimental forest surveys originate from a heliport on Swan Island, a man-made island in north Portland. After two years of various aerial tests, it has been determined that early morning flights provide the most significant results.

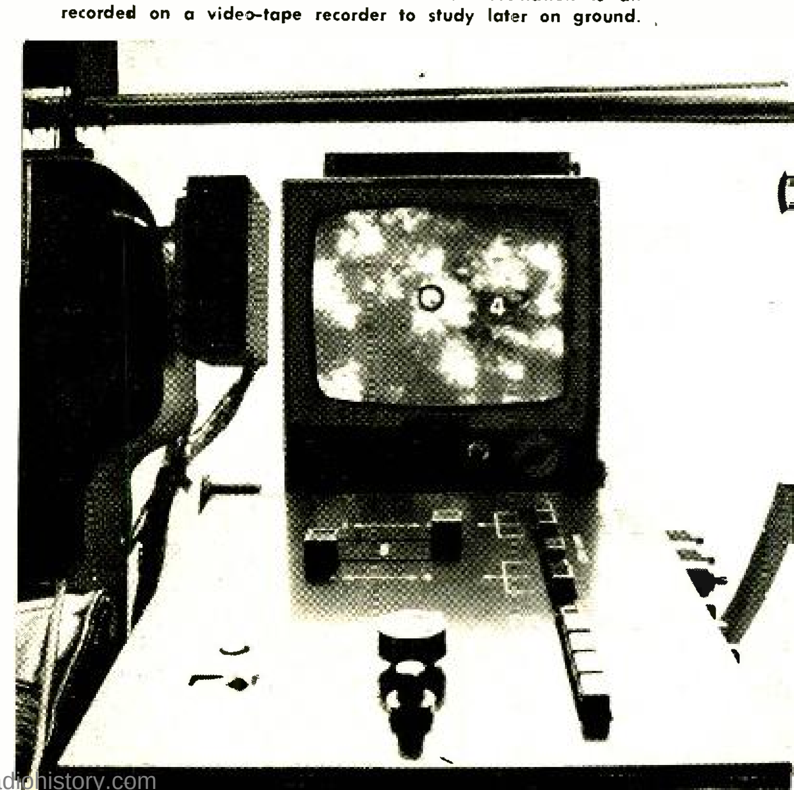
When the initial video and heat-sensing experiment began, specific samples of three known groups of trees were used to test the equipment. There were five healthy trees, five diseased trees with no visible damage, and five diseased trees with visible damage. To facilitate identification, the healthy trees were topped with a yellow streamer, the diseased trees without indications received orange streamers, and the diseased trees with indications were marked with red streamers. The helicopter cruised at about 25 miles an hour so that the heat-sensing device and video picture could capture and record the infrared energy emitted by individual trees in the stand.

John Wear of U.S. Forest Service's Pacific Southwest Forest and Range Experiment Station prepares equipment that will be used to take temperature of trees. The housing attached to the underframe of the helicopter contains heat sensor, TV camera.

The marriage of "instant replay" and infrared detection proved successful, and the surveys are continuing.

NASA is financing the survey research as part of its Natural Resources Program because it wishes to determine whether the method of locating forest disease centers might some day be carried out by satellite. The Natural Resources Program subsidizes surveys in such diverse fields as geology, geography, agriculture, and fire detection in the interests of generating other possible uses for satellites. ▲

Inside the copter a television monitor shows (circled) tree being measured for heat generation and the reading (the figure "4") indicated on the counter. This information is all recorded on a video-tape recorder to study later on ground.



Multiple-Function Remote-Control Relay Circuits

By H. R. MALLORY / Manager, Battery-Powered Equipment Lab, Mallory Battery Co.

Some ordinary relays and switches used in some extraordinary circuits make it easy to sense and control high-power circuits.

FOR safety's sake, control circuits should be isolated from power lines and operated at low voltages, such as those obtained from a battery or small filament transformer.

A battery-operated push "on", push "off" circuit is shown in Fig. 1. When the circuit is "off" and the relay is not energized, capacitor *C1* is charged to the battery voltage through resistor *R1* and the normally closed contacts of the relay. When any of the switches are momentarily closed, the energy stored in the capacitor is applied to the relay coil, pulling it in, and latching the relay through *R1* and the normally open contacts. As the relay switches, the holding voltage across the relay, through base resistor *R2*, forward-biases transistor *Q1* to saturation and rapidly discharges *C1*.

Again pushing any of the switches applies the discharged capacitor's voltage across the relay and decreases its voltage to zero. This releases the relay and opens the control and power circuit. *R1*'s resistance must be high enough to permit the discharged capacitor to release the relay yet be high enough to prevent the relay from reclosing as long as the switch is closed. Typical component values are shown in Fig. 1 for the 6-volt operation of a general-purpose d.p.d.t., 6-volt d.c. relay. This circuit and minor variations of it have been used successfully in several pieces of equipment, operating at "on-off" rates as fast as one per second.

If the power and control circuit are one and the same, the power switching and control functions can sometimes be combined in a single "Form C" arrangement, as shown in Fig. 2. This is essentially the same circuit as Fig. 1 but modified by diode *D1* to operate from a.c. rather than battery or d.c. Proper operation of the circuit depends on *D2*, which rectifies the a.c. for the load.

In this circuit, resistor *R1* is divided into two resistors, *R1A* and *R1B*. A relatively small (as compared to *C1*) capacitor, *C2*, filters the half-wave-rectified holding current as it is applied to the relay coil. Resistor *R3* prevents switch-contact welding or burning as the capacitors are paralleled by the switches. Fig. 2 includes component values for the 12-volt a.c. operation of a typical s.p.d.t., 12-volt general-purpose relay.

Remote-Sensing Switch Circuits

"Remote sensing" of the control circuit can be obtained by using momentary s.p.d.t. switches, such as the *G-E* RTS-6 rocker switch, or two separate switches at each control location. Toggling the switch up, or pushing the upper switch, always turns the power circuit "on" and *vice versa*. This type of remote-sensing control, using two wires, is only possible on a.c., as diodes are used to selectively polarize the control circuit and provide the sensed signal. As the diodes at the switches are in the circuit only momentarily, they may be of almost any size or type—such as selenium, silicon, germanium, etc.

In Fig. 3, diodes *D1* and *D2* are located at each remote-control switch. They polarize the control circuit in one direction to energize the relay and turn the power "on", and then in the other direction to release the relay and turn the power circuit "off." When the (*Continued on page 78*)

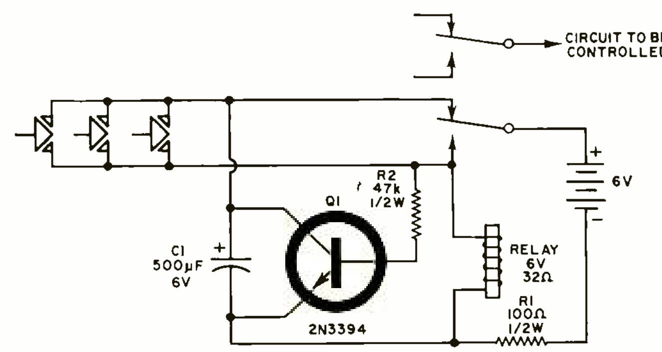


Fig. 1. Push-buttons turn the controlled circuit "on" and "off" by regulating the current flowing through the 6-volt relay.

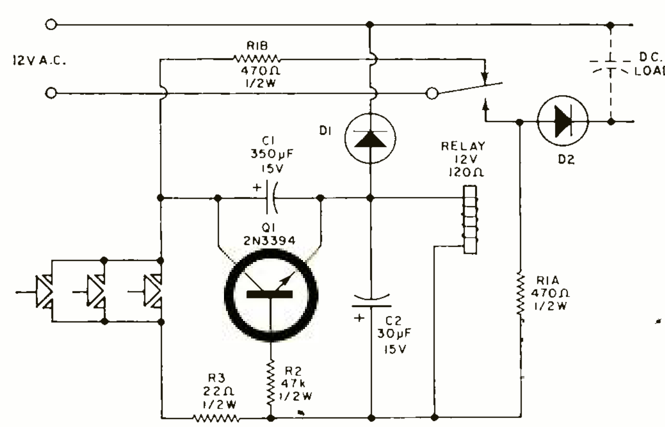
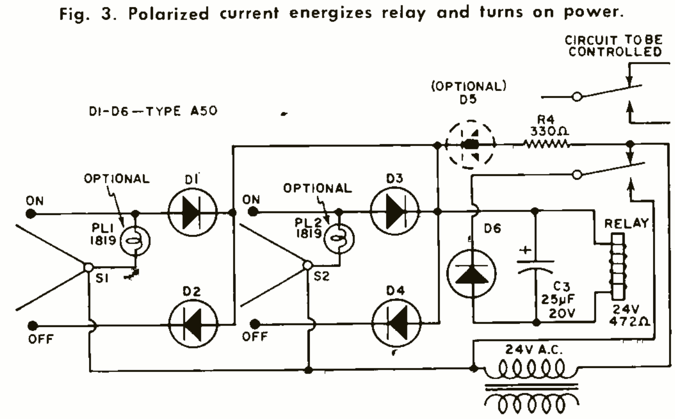


Fig. 2. In this circuit, the power switching and control circuits are combined. Resistor R3 prevents contact welding.

Fig. 3. Polarized current energizes relay and turns on power.



The Truth About FM

By THOMAS R. HASKETT

An attempt to clear up a few misconceptions about this important hi-fi medium. A description of the signals transmitted by FM broadcast stations, whether they are using mono, stereo, SCA, or any combination of these.

EVER since Major Armstrong demonstrated frequency modulation in 1936, technically knowledgeable people have been getting erroneous impressions of it. Simple monophonic FM—which went into commercial service as a broadcast medium in 1941—isn't too difficult to understand. But in 1955 a new technique was added to FM broadcasting —*subsidiary multiplexing*, also known as SCA or background-music operation. Then, in 1961, came stereo-FM broadcasting. The result is that today many engineers and technicians alike have little or no understanding of what sort of signal a modern U.S. FM broadcast station transmits.

Words and phrases relating to FM are often misused and misunderstood. *Simplex* means the transmission of a single program or channel of intelligence on a single carrier. *Multiplex* obviously means the transmission of two or more programs or channels of intelligence on a single carrier. *FM multiplex* means, then, the transmission of two separate programs—or channels of intelligence—by means of a single FM station. The phrase means *either* stereo or SCA operation—*or both*. People often say "FM multiplex" when they are talking about SCA; others use the same phrase to denote stereo operation. Stereo FM multiplexing is one thing; SCA FM multiplexing is quite another.

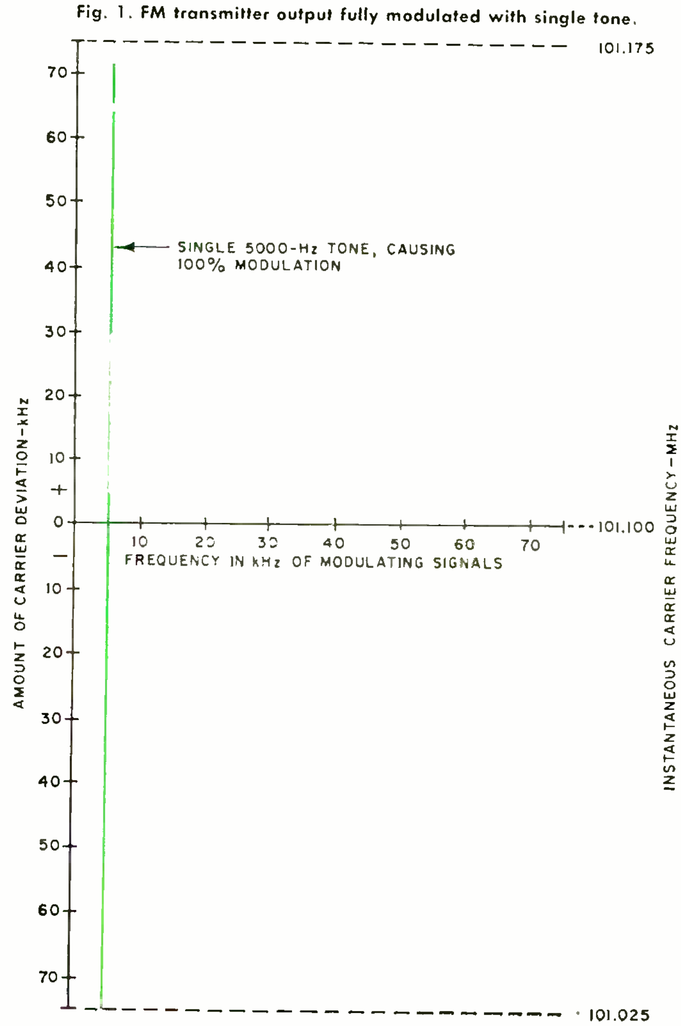
To understand what's transmitted by present-day FM broadcast stations, it's convenient to use five specific examples—the five possible modes of operation for any FM station in the U.S. These are: station A transmits a single monophonic program only; station B transmits a monophonic main-channel program and one SCA subchannel service; station C transmits a monophonic main-channel program and two SCA subchannel services; station D transmits a stereophonic program only; and station E transmits a stereophonic program and one SCA subchannel service.

Station A—Mono Only

When a transmitter is frequency-modulated, the modulating signal shifts the transmitter frequency. FCC rules define 100% modulation for FM broadcast stations as a transmitter frequency deviation of ±75 kHz. Fig. 1 illustrates this principle. Assume that station A is assigned a frequency of 101.1 MHz; that is the unmodulated or center frequency of the transmitter. Suppose a 5000-Hz sine wave is fed into the transmitter, modulating it to 100%. The transmitter frequency deviates ±75 kHz, or from 101.025 to 101.175 MHz.

By FCC rule, all FM broadcast stations are required to transmit main-channel (monophonic) programs with a frequency response of 50 to 15,000 Hz. Another FCC rule provides that the transmitter audio input contain a pre-emphasis network which boosts the audio frequencies above about 1000 Hz. Pre-emphasis provides better signal-to-noise ratio at high frequencies. To provide flat frequency re-

Fig. 1. FM transmitter output fully modulated with single tone.



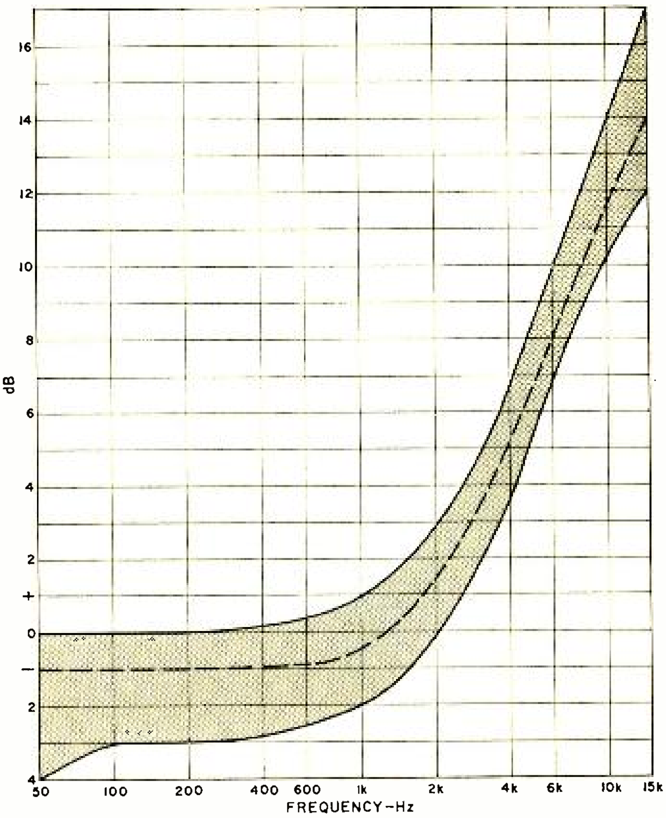


Fig. 2. Limits of standard FCC pre-emphasis curve for FM.

sponse for the listener, a complementary de-emphasis network is used in all FM receivers.

Fig. 2 shows the FCC pre-emphasis curve. The solid lines are FCC limits and the dashed line is an approximation of the typical main-channel audio-frequency response of an FM broadcast transmitter. Note that a signal at 15 kHz is boosted approximately 15 dB above signals at 500 Hz or less. Thus, if station program material contains signals at various frequencies from 50 to 15,000 Hz, only the 15,000-Hz signals modulate the transmitter 100%.

Now look at Fig. 3A, which shows deviation *vs* frequency for station A. Only program material between 50 and 15,000 Hz is being transmitted, and by using the pre-emphasis curve, you can see that only signals of about 15,000 Hz deviate the transmitter frequency ±75 kHz. Other program signals deviate the transmitter frequency correspondingly less. While some program material may contain little or no 15-kHz (or even 10-kHz) material, the pre-emphasis network is *always* in the circuit. Thus the transmitter audio input does *not* have flat frequency response.

At this point, many persons confuse two parameters—*amount* and *rate* of carrier deviation. The *amount* of carrier deviation, in kHz, is shown along the left side of Fig. 3A. To the right of Fig. 3A is shown the instantaneous transmitter frequency in MHz, which is the result of adding or subtracting the deviation to or from the carrier, or center frequency. The amount of carrier deviation is caused by the amplitude of the modulating signal—irrespective of its frequency.

Rate of carrier deviation is another thing. The instantaneous frequency of the modulating signal determines the rate of carrier deviation. For instance, in Fig. 1, a 5000-Hz sine wave is shown modulating the transmitter 100%, or causing a carrier deviation of ±75 kHz. Since the modulating signal is 5000 Hz only, it causes the transmitter frequency to deviate from 101.100 MHz to 101.175, and then to 101.025 and finally back to 101.100 MHz. That is one complete deviation cycle. Since the modulating frequency is 5000 Hz, the transmitter frequency changes or goes through that cycle 5000 times per second. Thus the *rate* of carrier deviation is equal to the *frequency* of the modulating signal.

Another point of confusion is the relationship between the frequency of the modulating signal and the carrier-frequency deviation. Two terms are used to describe the relationship—*modulation index* and *deviation ratio*. These phrases are not synonymous, as some literature indicates.

Modulation index (MI) is an instantaneous quantity in an FM transmission system. It is the ratio of a carrier-frequency deviation of the transmitter to the modulating frequency which causes that deviation. MI is a description of a process inherent in FM. Mathematically it is: $MI=f_d/f_m$ where MI equals modulation index (an arbitrary number), f_d equals carrier-frequency deviation and f_m equals modulating frequency, and where f_d and f_m are given in the same units (Hz, kHz, etc.). Obviously, MI can be changed by altering either f_d or f_m and holding the other constant.

Deviation ratio (DR), on the other hand, is an arbitrary limit. It is the ratio of the *maximum* carrier-frequency deviation to the *highest* modulating frequency. DR can be established, then, at any value one wishes. For FM main-channel monophonic broadcasting, the FCC has limited DR to 5. The maximum carrier-frequency deviation is 75 kHz, and the maximum modulating frequency is 15 kHz.

Modulation index and deviation ratio are important quantities in FM transmission because of the very nature of FM itself. In AM transmission, 100% modulation is not arbitrary but a real limiting factor. Modulation in excess of 100% in an AM system produces distortion, regardless of the receiver used to pick up the signal. The same is not true of an FM system.

The 100% modulation figure for an FM system is established by the FCC for the particular class of service. For FM broadcasting, the FCC defines 100% modulation as ±75 kHz carrier-frequency deviation. In various two-way radio services, the FCC defines 100% modulation as ±15 or ±5 kHz carrier-frequency deviation. No distortion is caused—at the transmitter or in free space—by exceeding any of these arbitrary modulation limits. The distortion is caused only at the receiver. If a ±5-kHz receiver is presented with an FM signal having ±15-kHz deviation, the receiver will produce distorted audio.

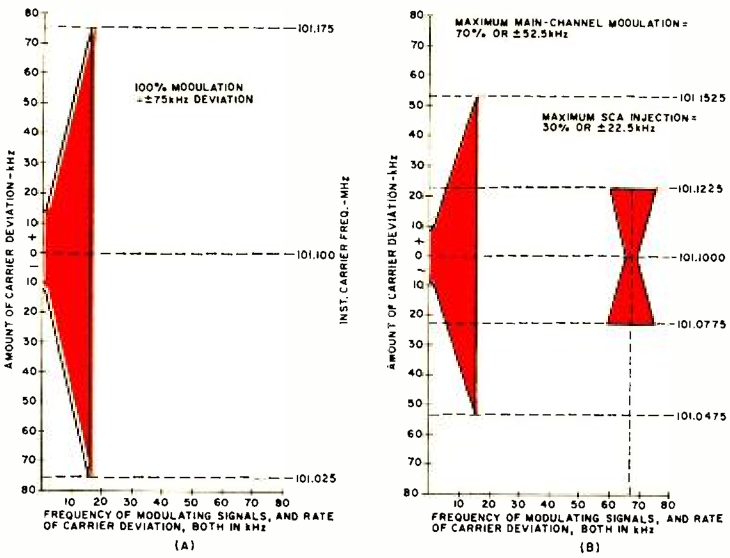
In a properly adjusted AM system, only two sidebands are generated, and the bandwidth required for distortionless reception is twice the highest modulating frequency. This is not true in an FM system; in FM *many* sidebands are generated. Their amplitude and number depend upon the frequency deviation and the modulation frequency. In other words, the sidebands depend on the modulation index.

At a monophonic FM station, if a sine-wave 15,000-Hz tone is transmitted at 100% modulation, it causes the carrier to deviate ±75 kHz. This tone causes eight significant sidebands to be generated on each side of the carrier frequency. For distortionless FM reception, any sideband greater than 1% of the peak carrier amplitude must be transmitted. Only the first eight sidebands meet this requirement. Others are generated, but they are too low in amplitude to be significant, so they may be ignored. The eight significant sidebands occupy a bandwidth of 240 kHz centered on the station carrier frequency.

For distortionless FM transmission, a bandwidth of 240 kHz is required. The same is true at the receiver.

Development of SCA Multiplex

Commercial FM broadcasting was authorized by the FCC in 1941 in the band from 42 to 50 MHz. In 1945, the FCC reassigned that band to other services, and allocated the present band of 88-108 MHz to FM broadcasting. Not many commercial FM stations were on the air from 1941 to 1945, due to wartime equipment shortages. Additionally, the change in frequency bands made existing receivers ob-



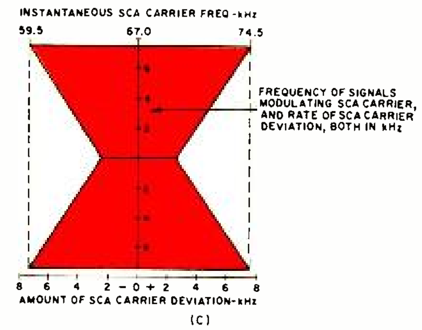


Fig. 3. (A) Station A output, mono only. (B) Station B output, mono plus one SCA channel. (C) Station B's SCA channel only.

solete. But, most of all, television was rapidly becoming the most popular broadcast medium in the U.S. during the years between 1946 and 1950.

Thus, by 1950, there were few FM listeners, and consequently few organizations willing to spend money to advertise on FM stations. As a result, many FM stations went off the air or curtailed their operations, usually duplicating the broadcasts of their AM affiliates.

Some stations, however, undertook a special form of service to bring in the revenue needed to keep themselves on the air. Various forms were used, called *storecasting*, *transitcasting*, *background music*, and *doctorcasting*. These services consisted of music and/or other material transmitted on the main channel, which was intended for reception in supermarkets, transit vehicles, restaurants, offices, and/or factories. A special technique was used to boost receiver audio for commercial announcements aimed at customers in supermarkets and other locations. The shopper-listeners would hear music at normal volume level, and commercials at a higher level. If the music were transmitted to restaurants, offices, and factories, the receivers there were muted during such commercials. All subscribing receivers were muted during station breaks and newscasts.

The special technique was simple. To boost receiver gain or mute the receiver speaker, sine-wave tones above 20 kHz modulated the transmitter. The station—or its legal agent—owned and leased special receivers to subscribers. In each receiver, resonant circuits responded to the particular tone and performed the designated job—boosting gain or muting the speaker. Receivers used by the general public did not respond to these supersonic tones, and so the public received all program material transmitted by the station. Since the control tones were ultrasonic, the public did not hear them, either. This technique was known as *simplexing*. It enabled many FM stations to stay on the air during those lean years from 1950 to about 1955.

Then the FCC decided that simplexing was not serving the public properly. A new technique—*multiplexing*—had been developed, which enabled an FM station to carry a main-channel program designed to appeal to the general public, and at the same time carry another channel of information which could not be received by the public. This secondary channel could be used by the station to appeal to private subscribers—*i.e.*, storecasting, transitcasting, or background music. The formal authority granted by the FCC to each station which wanted to carry this secondary, private service was (and still is) called a *Subsidiary Communications Authorization* (SCA). By obtaining an SCA, an FM station could continue to provide a private service to its paying subscribers, and still provide a service to the general public.

U.S. broadcast stations must, by law, serve the public interest, convenience, and necessity. *Broadcasting* is defined by federal law as the dissemination of radio communications intended to be received by the public. The main-channel programs transmitted by FM stations are broadcasting, since they are intended to be received by the general public. But federal law protects the privacy of radio communications of any type except broadcasting, amateur radio, and distress signals. Federal courts have ruled that SCA transmissions are private communications—not broadcasts—between the originating station and its subscribers. Such transmissions are not intended to be received by the public.

Station B—Mono and One SCA

Fig. 3B shows what station B transmits. The main-channel program is similar to Fig. 3A, except that modulation does not deviate the transmitter carrier frequency as much.

When SCA operations first began in 1955, various subcarrier frequencies were tried. Through the years, 26, 27.5, 32.5, 41, 42, 58, 65, and 67 kHz have been used. For this example, assume 67 kHz is the SCA subcarrier frequency.

At the FM station, main-channel audio is fed to the transmitter in the usual manner. But other equipment is used—called an SCA generator. This generator is actually a small FM transmitter. In the case of hypothetical station B, the SCA generator's center frequency is 67 kHz.

Assume for a moment that the SCA generator is simply putting out a constant-amplitude, constant-frequency signal at 67 kHz. This 67-kHz signal is fed to the station transmitter, along with the main-channel audio from 50 to 15,000 Hz. If the main-channel audio caused the transmitter to deviate ±75 kHz and the SCA signal were added, it would cause the transmitter to deviate farther, or in excess of the FCC-defined 100%-modulation limit of ±75 kHz. Therefore, the main-channel modulation level is backed off to allow the SCA some room for modulation. The amount of SCA signal fed to the transmitter is called *injection*, and the FCC limit on injection is 30% of total modulation—no matter how many SCA transmissions are being carried.

Fig. 3B shows the SCA carrier injection as 30%, or ±22.5 kHz; that is, the SCA signal causes the FM station's transmitter to deviate ±22.5 kHz from its center frequency. Since the SCA modulates the transmitter 30%, the main-channel audio modulation must be backed off to 70%, or ±52.5 kHz.

When audio is fed into the SCA generator, it deviates the generator frequency from 67 kHz. There are no industry standards or FCC limits on the amount of modulation or deviation of the SCA carrier, but the usual practice is to deviate the SCA carrier ±7.5 kHz. Similarly, there are no FCC requirements for frequency response of the SCA sub-

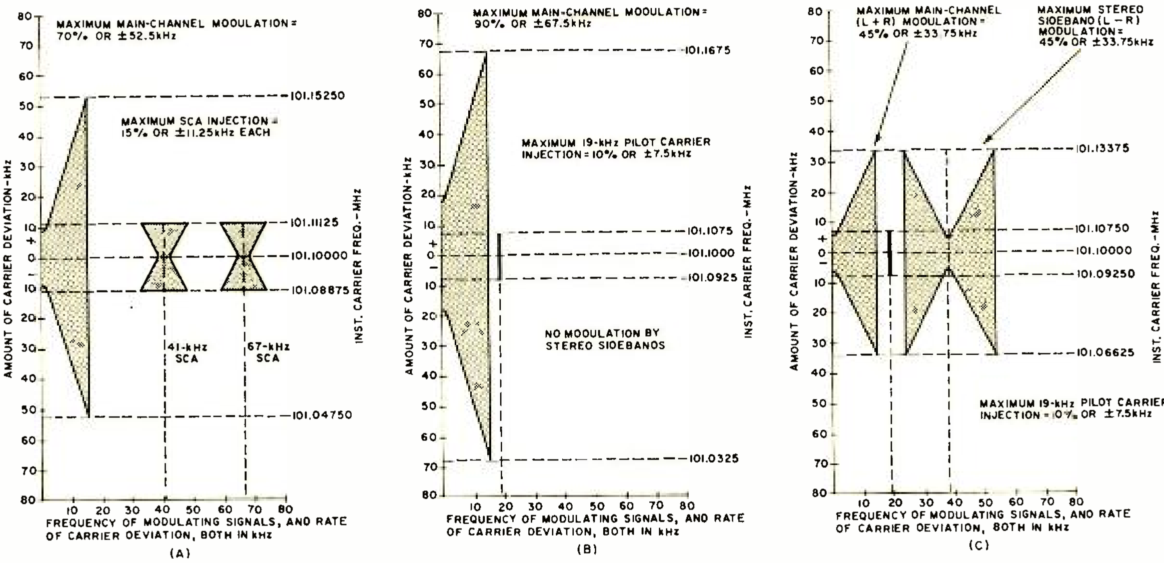


Fig. 4. (A) Station C output, mono and two SCA channels. (B) Station D output with its 19-kHz pilot signal and with all information in the main channel. (C) Same as part (B) except that sum and difference stereo signals are equal.

channel, but the usual practice followed by transmitter and receiver manufacturers is to limit frequency response to 30-7500 Hz. (Thus the SCA deviation ratio is 1.0.) Pre-emphasis is used, just as on the main channel, and for the same reason—improved signal-to-noise ratio. Again, there are no FCC requirements, and both 50- and 75-μs curves are used. (The FCC requires a 75-μs curve on the main channel.)

Refer to Fig. 3C, which shows only the SCA signal, as if the SCA generator output were being fed directly into an antenna. Actually, of course, the constant-amplitude SCA signal centered on 67 kHz is injected into the station transmitter. Now although the amplitude of the SCA carrier remains constant, its frequency does not. Modulating signals (usually audio) fed into the SCA generator cause the SCA frequency to deviate, and this deviation is shown at the bottom of the figure. The amount of maximum deviation is ±7.5 kHz. At the top you see the instantaneous SCA carrier frequency, which is 59.5 kHz at one extreme and 74.5 kHz at the other.

Since pre-emphasis is used at the SCA generator, high audio frequencies are boosted above the level of low audio frequencies. The vertical axis can be read as the frequency response of the SCA subchannel. As you can see, only 7500-Hz signals cause maximum 7.5-kHz SCA carrier deviation. Lower audio frequencies cause correspondingly less deviation.

Thus SCA operation is actually FM on FM. Inasmuch as SCA injection is held to a low value, this FM-on-FM feature is beneficial, as it betters the noise immunity of the SCA subchannel.

Station C—Mono and Two SCA's

It was found that two SCA subchannels could be transmitted by a single FM station. Thus a station may provide two separate private services to paying subscribers, increasing its revenue. And it can still provide public programming on its main channel. (Three SCA subchannels have been tried, but crosstalk problems became too severe. Thus, with only a few experimental exceptions, no station transmits more than two SCA subchannels.)

Fig. 4A shows what station C transmits. Main-channel audio is the same as in Fig. 3B; audio material between 50 and 15,000 Hz is transmitted with a 75-μs pre-emphasis curve. Maximum main-channel modulation is 70% or ±52.5 kHz.

Since the FCC limits total SCA injection to 30%, it's obvious that each SCA subcarrier can be injected to only 15%. Each subcarrier can cause the station transmitter frequency to deviate only 11.25 kHz.

As with station B, each SCA generator is modulated with its respective audio. SCA deviation is ±7.5 kHz, and the over-all frequency response is from 30 Hz to 7500 Hz.

Station D—Stereo Only

To more easily understand stereo FM, assume that station D is not transmitting normal program material, but sine-wave tones. To begin with, assume two identical audio generators each putting out 1000-Hz sine waves, representing the left and right channels of stereo program material. In addition, a stereo pilot carrier generator furnishes a constant-amplitude, constant-frequency signal of 19 kHz.

Assume that when 10 volts of audio in the range of 50-75,000 Hz is fed to the station transmitter, it causes 100% modulation, or ±75 kHz deviation of the carrier. By FCC rule, the 19-kHz stereo pilot signal is allowed 10% injection, which deviates the transmitter frequency ±7.5 kHz. Therefore, assume the pilot generator furnishes 1.0 volt to the station transmitter. That leaves 9.0 volts for all other modulation.

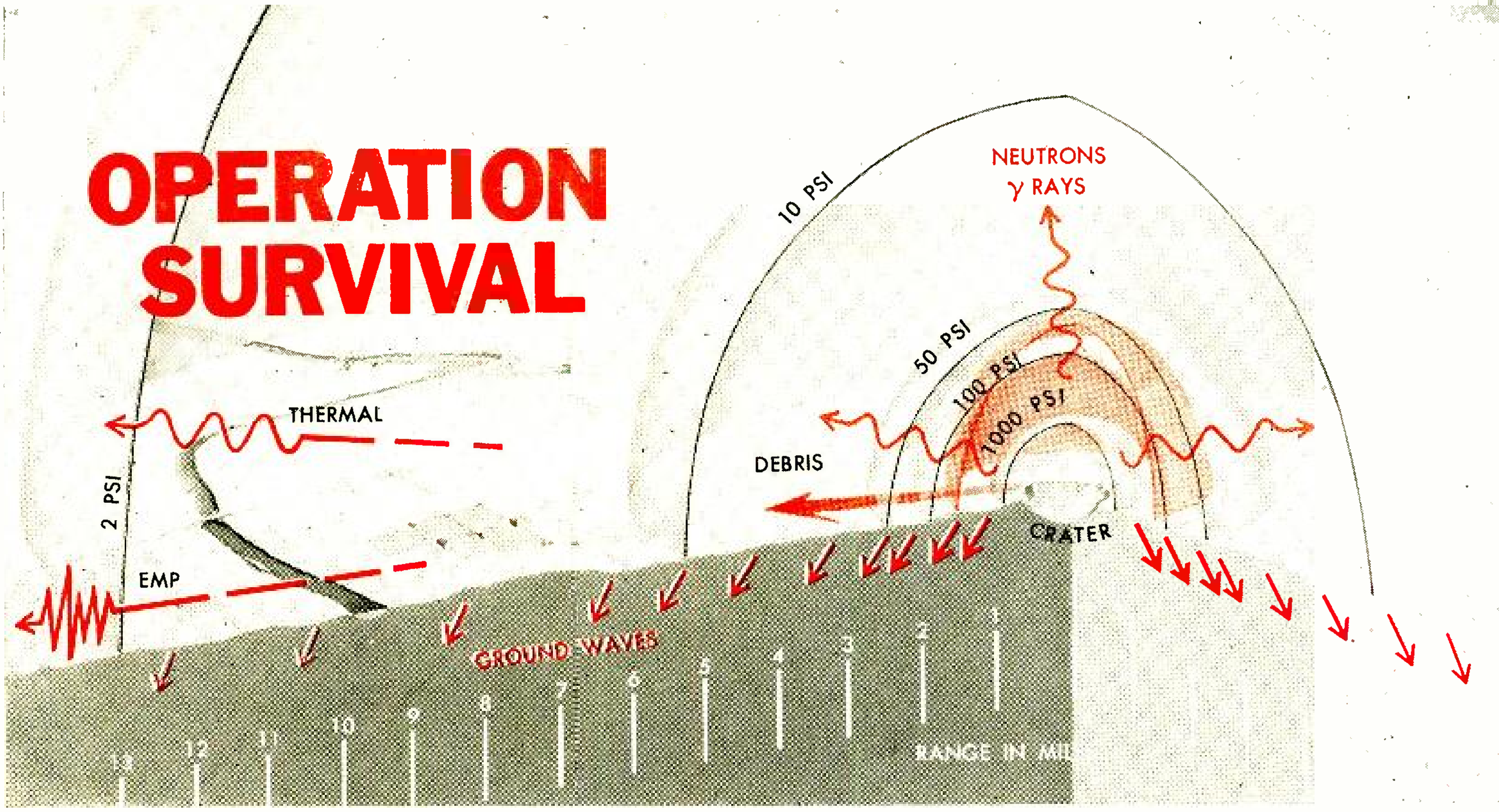
In order that the stereo-FM system be compatible, listeners with monophonic receivers must receive total program audio. Thus the 1000-Hz sine-wave tones from the left and right audio generators are fed to the stereo generator, where they are added together. This combination signal is fed to the station transmitter. Since the 19-kHz pilot is already modulating the transmitter 10%, only 90% is left for the main-channel signals. Therefore, assume that L is 4.5 volts and R is also 4.5 volts. When combined (L + R), they total 9.0 volts, which furnishes 90% modulation of the main channel.

Meanwhile, the stereo generator also subtracts the two signals (L − R) to form the stereo difference signal. The 19-kHz pilot signal is doubled to produce a 38-kHz carrier which is amplitude-modulated by the L − R signal. Then the 38-kHz carrier is balanced out and removed. (Since no balanced modulator is perfect, the FCC permits a residual 38-kHz subcarrier which causes no more than 1% modulation of the main carrier.) The remaining sidebands are injected into the station transmitter.

Remember that the main-channel signal—occupying the band of frequencies from 50 to 15,000 Hz—is composed of L + R. The stereo sidebands are composed of L − R. When L and R each equal 4.5 volts, L + R equals 9.0 volts. Thus main-channel audio modulates the station transmitter 90%, the stereo sidebands modulate the transmitter zero percent, and the 19-kHz pilot modulates the transmitter 10%. This situation is shown in Fig. 4B and is practically a pure monophonic signal.

In stereo program material, however, the L and R signals are not always equal in amplitude. Often one channel is quite loud with respect to be (*Continued on page* 58)

OPERATION SURVIVAL



Although the possibility of a nuclear explosion is an awesome thought, engineers must know and understand nuclear effects before they can protect people and equipment. The scope of the weapon effects of a 20-megaton surface burst are shown.

By J. W. FOSS and R. W. MAYO / Bell Telephone Laboratories

Bell Labs is responsible for designing reliable communications systems that will survive almost any catastrophe—even nearby nuclear explosions. Here's how such transcontinental and long-haul routes are being protected.

THE *Bell System* customarily designs, manufactures, and installs communications facilities which will withstand—or at least recover rapidly from—the effects of natural or man-made catastrophies. Today, the *Bell System* is preparing for the possibility, no matter how remote, of even greater damage from a nuclear attack on the United States.

Engineers at *Bell Laboratories* have studied such a nuclear threat so that communications facilities could be planned and designed to economically counter it. The results of many above- and below-ground test explosions of nuclear weapons, conducted by the Atomic Energy Commission, were analyzed by the engineers. Then, armed with this knowledge and additional studies of their own, the engineers accumulated enough predictable data to plan and design telephone facilities that would survive a nuclear attack.

The plan for survival makes use of the alternate routing flexibility which already exists in the network. As new installations are added, they are located away from target areas whenever possible. If installations must be located within "danger" areas, they are constructed in such a way as to "harden" them against the effects of a nuclear attack.

Some components of a conventional telephone plant are very sensitive to the effects of nuclear explosions even at considerable distances. Significant damage would be caused mainly by peak overpressure (pressure above ambient atmospheric pressure, caused by the blast wave) and a strong electromagnetic signal, commonly called the electromagnetic pulse (EMP). Ground shock and intense heat waves can cause serious damage to some elements of the conventional telephone plant. "Hot" radioactive fallout can also pose a problem to personnel and equipment. In general, the level of peak overpressure, in pounds per square inch (psi), is used to define the amount of protection provided for a facility in a given situation.

Two basic techniques are used to protect the communications network: either structures and equipment are initially designed or modified to tolerate specific assumed conditions, or sensitive elements in the system are shielded or isolated to reduce specific effects to tolerable levels.

Buildings which must resist overpressures of 10 psi or more are usually installed below ground, where many of the effects of a nuclear explosion are either eliminated or greatly attenuated. Shielding and isolation are the primary means of protecting against EMP and shock when the sensitive components of the communications equipment have not been specifically designed to resist these effects.

Typical examples of hardened plants in the *Bell System* are the L-3 and L-4 transcontinental coaxial-cable systems. Buildings for these systems are designed to withstand overpressures of 10 or 50 psi. (An installation built to withstand 50-psi overpressure would not be destroyed by a 20-megaton nuclear explosion as close as 2½ miles.) Many microwave radio-relay stations, which interconnect major cities along the way and provide alternate routing for the network, are designed to withstand 2-psi overpressure. In addition, the communications antennas and cable network which connect into military locations use tropospheric scatter and line-of-sight antennas and buildings designed to survive even higher levels of overpressure and other effects of nuclear weapons.

The coaxial-cable systems have manned, underground main stations located at 120-mile to 160-mile intervals

One of eleven bomb-resistant main stations (left) for the L-4 carrier system between Miami and Boston takes shape. The multistory, underground buildings are designed and equipped to operate for several weeks completely sealed off from the outside. Precast concrete manholes are used to house amplifying repeaters. A concrete roof and an 18-inch ground cover will protect the equipment from radiation. (Right) Coaxial cable is being buried to a depth of about 4 feet, where it can withstand overpressures in excess of 150 psi and where most weapon effects are either eliminated or substantially reduced.

along the entire route. The main stations are generally one- or two-story buildings which house amplifying and switching equipment, personnel, and enough supplies to last at least three weeks. Smaller power-feed stations are located at similar intervals at points where no switching is required. There are also repeater stations along the route which are unmanned. Some of the power-feed stations require operating personnel.

Because they are located away from potential targets, most L-3 and L-4 buildings require hardening only to 10 psi. The majority of these buildings are constructed entirely below ground except for small above-ground entrance structures and air intake and exhaust shafts.

Buildings designed to withstand an overpressure of 50 psi are constructed of reinforced concrete about two feet thick, and are topped with a four-foot blanket of earth for protection against nuclear radiation. Somewhat lighter construction can be used on buildings that need to withstand only 10 psi, and these do not require the earth blanket for radiation protections (a two-foot soil layer is normally provided, however, for grass).

Shock isolation is necessary in attended 50-psi stations to protect equipment against damage by ground-shock motion. Accordingly, shock mountings, similar in principle to the suspension systems on a car, are used to limit accelerations to 3 G's—a tolerable level for most communications equipment. Shock isolation is not required at sites built to withstand 10-psi overpressure.

The electronic equipment in main and power-feed buildings must be protected from the effects of EMP. Although devices for limiting both voltage and current can be used in individual circuits, reliability and economic considerations generally dictate that the complete structure be shielded. A metal shield completely enveloping the building provides this protection. Doors, air shafts, pipes, and cables that penetrate the building must be given special attention to ensure the integrity of the EMP shielding and for mechanical reasons. In addition, metal flashing surrounds each metallic line entering the building and is bonded to both the metallic line and the EMP shield. When this is not possible (as on individual communications wires and power lines), protectors or filters are used to eliminate damaging power surges. Inside the buildings, interconnecting cables are kept short and generally in straight runs.

An emergency power source is essential in hardened installations since it is virtually certain that commercial power service will be disrupted under conditions producing 50-psi overpressure. Since gas turbines or diesels used for emergency power require large amounts of air for combustion and cooling, they cannot be operated while blast valves are closed and the center is "buttoned up" (during the passage of the blast wave and until conditions clear). During this time batteries provide power. Gas turbines take over when the blast valves open. Communications equipment operates continuously despite these changes in the source of power.

Underground buildings are reached through an expendable above-ground entrance structure. Personnel must then pass through a hardened subterranean "blast lock." Emergency escape tunnels and shafts, protected by simple blast closures, are provided for alternate entrance or exit routes.

Fresh air for personnel and the emergency generators is supplied through air-intake shafts in the main centers. Exhaust shafts are positioned far enough away from the intake shafts to prevent contamination of the building's air supply by the exhaust gases. Each opening has a blast valve which closes automatically when remotely triggered by the air-blast pressure or by a radiation detector. The valves remain closed as long as dangerous radiation or dust is present outside, and are opened by remote control when conditions clear.

The L-3 auxiliary repeaters and the L-4 equalizing repeaters are located in underground manholes similar in structural design to the underground buildings. They are usually constructed to withstand overpressures of 50 psi. No shock mounting is necessary to protect L-4 repeaters, but steel apparatus cases are used to protect the electronic equipment from EMP. Auxiliary repeaters are powered from a main station over a cable so there are no generators or batteries in the manhole. Ventilation is required only when someone is working inside.

Buried and underground cables are sufficiently "hard" to withstand overpressures greater than 150 psi. But, in high overpressure environment, unless you do more than just bury a cable, it may be subject to shear failures at the entrances to manholes and buildings, under highways and the like, and from nuclear blast effects. If the cable has an earth cover of moderate depth, the only nuclear-blast effects that affect cable performance are nuclear radiation, EMP, and pressures and displacements in the soil.

Precautions have been taken to protect shallow buried coaxial cables. Long cable systems such as those used for the L-3 and L-4 systems will be reasonably safe from ground currents generated by EMP. Shield wires, buried above the cable to protect it from lightning, also tend to reduce the probability of damage to the cable because of EMP. In addition, an extruded plastic jacket (inside the metal sheath) keeps out moisture if the metal sheath is damaged. However, intense nuclear radiation can cause ionization and breakdown of the air-dielectric within coaxial cables to the repeaters. Fortunately, this effect lasts only for the very short time that intense radiation is present. Thus, communications are not significantly affected.

Coaxial cable is normally buried about four feet deep. At this depth, damage caused by plowing or road construction work is unlikely. When the cables must cross obstacles, either geological or man-made, special hardening measures are taken.

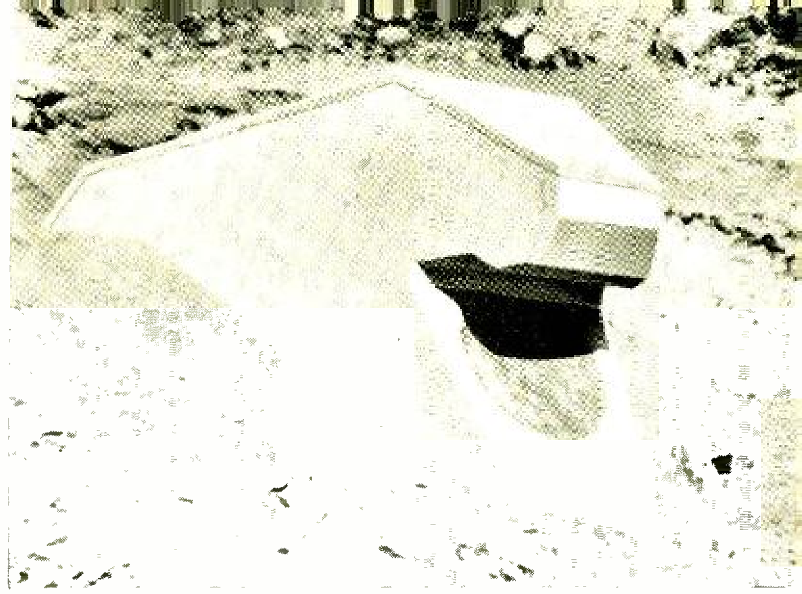
Certain above-ground facilities, such as microwave radio-relay stations, located some distance from potential target areas are only designed to survive overpressures of 2 psi. Although initial nuclear radiation, ground shock, blast, wind, and debris are not serious problems at this distance, EMP, heat, and fallout must be considered. In cases where facilities are not manned, fallout protection may be ignored. However, since the buildings are above ground, they are designed or modified to withstand moderate heat. Although the towers can survive overpressures somewhat above 2 psi without special strengthening, the antennas might be damaged by this blast overpressure and require hardening (or modification).

In certain critical locations, microwave antennas must withstand overpressures greater than 2 psi. Occasionally, these installations can be located so that topographic features help minimize blast and debris effects. Even so, some antennas must be designed to survive within the fireball of a nuclear explosion, where the intense heat would melt steel. Such an antenna, designed by *Bell Laboratories*, incorporates a reflector constructed of graphite-reinforced phenolic. Like an iceberg, the bulk of the antenna structure is underground to provide stability under blast loadings. Above ground, the antenna is streamlined to reduce air blast and shed debris. The antenna is fed from the underside of the overhang, to shield the coaxial feedlines from heat and debris. Moreover, this location protects the waveguide lines from immense reflected blast pressures.

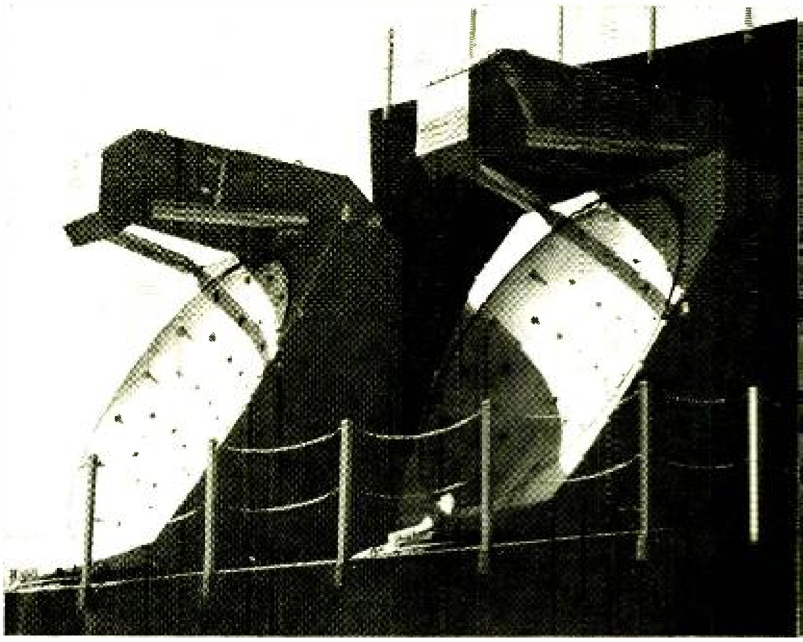
In many cases, surrounding terrain is too flat to afford any protection to an antenna site. For example, tropospheric-scatter antennas 30-feet in diameter are too large to expect much protection from surrounding terrain. In this case, nearly two-thirds of the antenna structure is below ground. This gives the antenna sufficient strength to resist rotation or tilt, which could result from the impact of a blast wave against the above-ground portion of the antenna.

Smaller, hardened antennas, used for side-leg interconnections to main radio-relay routes, have been designed to survive similar overpressures. The feed-reflector orientation on these antennas was also designed to shed debris. A flame-sprayed aluminum finish over the steel exterior reflects most of the heat. The rough surface texture of the coating on the reflector prevents heat from focusing at the feedhorn. A window of beryllia in the feedhorn keeps destructive blast pressures from entering the waveguide. The antenna shell is filled with concrete, providing a reaction mass to blast pressures. With this construction, lighter weight steel can be used on the shell.

Close cooperation between the *Bell System* and government agencies during the planning stages has produced a highly reliable communications system. This hardened communications network should provide the United States with communications during any natural disaster and even in a nuclear attack. The degree of protection and the plan for survival is under continuing study. The future philosophy will be strongly influenced by the estimated destructiveness of future weapons systems and the desired resistance of telephone plant to the effects of such weapons. ▲

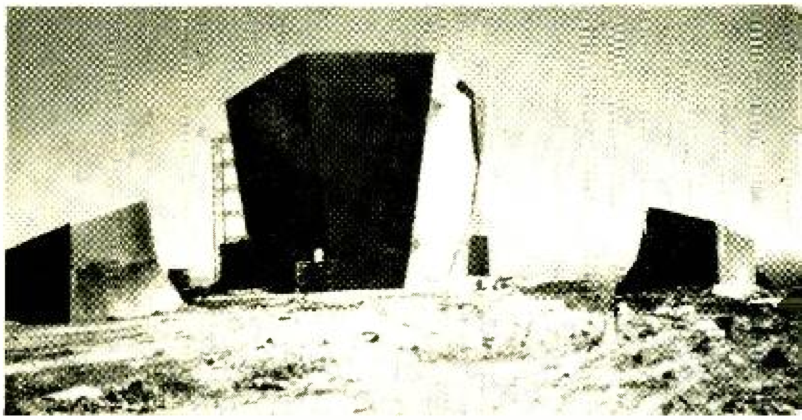


Resembling a monolithic vestige of some lost culture in a science-fiction movie, this microwave radio-relay antenna can survive within the nuclear fireball. Bulk of the structure extends deep underground, giving it great stability under blast pressure. Five-foot reflector is fed from beneath overhang so that feed-lines are shielded from heat, debris.



Small (5 to 8 ft in diameter) microwave antennas are used for side-leg interconnections to main routes and are designed to withstand very high overpressures. Concrete filled for stability, the antennas are also designed to shed debris.

The trophospheric-scatter antenna at this location is too large (30-ft in diameter) for topography to afford any protection. Almost two-thirds of structure is underground, giving it strength to resist rotation or tilting by blast pressures.



Communications Satellites—Success in Space

Part 2: Operational Satellites of Today and Tomorrow

By FRANCIS A. GICCA / Manager
Space Communications Systems, Raytheon Co.

Inaugurating a real revolution in the field of communications, our successful satellites promise even more startling advances in the near future. Description of the present Intelsat system, along with uses of satellites for aeronautical communications as well as domestic television and for telephone services.

PART 1 of this series traced the early history of communications satellites from Score to Intelsat II. All of these satellites were designed to be experimental but all provided valuable operating experience and confidence in communications satellites. This concluding article will examine the operational satellites of today and tomorrow.

Early in 1966 *Intelsat* awarded a $32-million contract to *TRW Systems* for six Intelsat III satellites, which were intended to provide the Global System envisoned by the Interim Agreement (see Part 1). Four times as heavy as Early Bird and with five times its capacity (see Table 1), Intelsat III is the first satellite specifically designed to be commercially profitable. For its first operational system, *Intelsat* attempted to maximize all satellite parameters that would affect revenue: including radiated power, usable bandwidth, capacity, and life.

Power radiated at the earth is maximized through the use of a de-spun antenna. As indicated in Part 1, this approach counter-rotates the antenna beam from the spin-stabilized satellite body thereby keeping the beam pointed at earth. Originally, Intelsat III was to use an electrically de-spun array, but a mechanically de-spun antenna was later substituted (see Fig. 1). As in NASA's experimental ATS-1, the electrical system proved to be lower in effective gain than the mechanical. Experience with OSO, ATS, and other NASA satellites with rotating parts indicated that reliable operation could be expected for more than five years. It was originally feared that the lubricants needed would either freeze or evaporate in space and bearings would seize. Special lubricants and lubricating techniques were developed to operate in the zero-G vacuum environment and have proved very successful. De-spun platforms weighing several hundred pounds are being designed into today's satellites.

Intelsat III Repeater

The total usable bandwidth of Intelsat III is 450 MHz, supplied by two 225-MHz-wide repeaters. This is a utilization of 90% of the 500-MHz bandwidth currently allocated for communications satellite use. The de-spun earth-coverage antenna and 6-watt traveling-wave-tube (TWT) amplifiers produce a radiated power of +22 dBW (158 W) from each repeater. This power and bandwidth are suitable for four TV channels, or two fully loaded carriers with 1200 telephone channels each, or up to 90 multiple-access carriers each with 24 telephone channels, or any equivalent combination of traffic.

While Early Bird was designed for an operating life of 1½ years and Intelsat II for 3 years, Intelsat III has a specified minimum life of 5 years. This represents almost a twenty-fold progressive increase in circuit-years from 1965 to today. This increase has been possible primarily because of the growing confidence in the reliability of communications-satellite components. While Early Bird was designed for a lifetime of only 18 months, it is still operating satisfactorily after four years. The next generation communica-

Table 1. Important characteristics of the entire series of Intelsat communications satellites.

Satellite	Launch Year	Comsat Weight (lbs)	No. of Repeaters	Repeater[1] Bandwidth (MHz)	Total Radiated Power (watts)	Antenna Type	Design[2] Capacity ("circuits")
Intelsat I (Early Bird)	1965	150	2	25	20	Cloverleaf	240
Intelsat II	1966	358	1	126	25-35[3]	Cloverleaf	240-480[3]
Intelsat III	1968	632	2	225	315	Mechanical De-Spun	1200
Intelsat IV	1970	2000	12	36	2400-18,400[3]	De-Spun: Earth/4.5°	5000-10,000[3]

NOTES: 1. Nominal bandwidth of each independent repeater; 2. Two-way telephone calls ("circuits"); 3. Depending on satellite antenna pattern.

tions satellite (Intelsat IV) will have a projected life of 70,000 circuit-years, a hundred-fold increase over Early Bird.

A simplified block diagram of Intelsat III's communications section is shown in Fig. 2. Communications signals from earth stations arrive at the satellite within either of two 225-MHz-wide bands; 5930-6155 MHz or 6195-6420 MHz. This leaves two outer 5-MHz guard bands and a central 40-MHz guard band which also contains redundant satellite-command signals.

After reception by the de-spun antenna, a filter-diplexer separates the signals into the two repeater channel bands. Linear r.f. amplification is accomplished by a series of low-noise wide-band tunnel-diode amplifiers (TDA's). An input of −65 dBm to the TDA's will produce a saturated TWT output of 6 watts; a net repeater gain of +103 dB.

The signals are then down-converted by 2225 MHz in a wide-band mixer. The two channels that are produced are now in the downlink bands of 3705-3930 MHz and 3970-4195 MHz.

The principal r.f. amplification is now accomplished in a cascaded pair of driver power TWT's. After each driver TWT, the redundant command signals are filtered out and removed from the communications channel. Telemetry signals are phase-modulated onto two beacon signals which are then inserted into the central 40-MHz guard band just prior to the 6-watt power TWT's. These redundant beacon signals allow the earth-control stations to track the satellite while it is being injected into orbit. After amplification to the 6-watt level, the two repeater channels are recombined in the transmit diplexer and transmitted by the de-spun antenna.

The block diagram of Intelsat III is deceptively simple. For the satellite to be efficient its capacity must be limited only by its radiated power and its effective utilization of bandwidth. The former is generally limited by the weight (and thus cost) of the satellite, and the latter by bandwidth allocation constraints (500 MHz at present). This implies that the system cannot economically tolerate any significant degradation of quality by the satellite. This, in turn, means that all forms of repeater distortion must be exceedingly low, typically 56 dB signal-to-distortion ratio, and this is far from simple in such a wide-band repeater.

Principal sources of distortion in the repeater include: 1. *intelligible crosstalk* (any amplitude variations in the repeater convert some of the FM modulations to AM, and the TWT converts these back to FM which intelligibly interfere with the original signal), 2. *delay distortion* (caused by lack of phase linearity which delays some frequencies more than others, causing a distorted signal), 3. *intermodulation* between multiple carriers (caused principally by the amplitude non-linearity of the TWT's plus those in the earth stations), and 4. *amplitude crosstalk* between multiple carriers (multiple carriers produce a composite signal of varying amplitude, the AM-to-PM characteristic of the TWT converts this to an interfering signal).

As a result, unless extreme care is taken, all elements of the repeater can produce major distortion. The microwave filters used for diplexing must produce extremely high rejection out-of-band (to eliminate signals that might cause intermodulation and amplitude crosstalk), but must be very flat in-band (to prevent intelligible crosstalk) and linear in phase (to prevent delay distortion). The TWT's have to be efficient (which means saturated operation) but

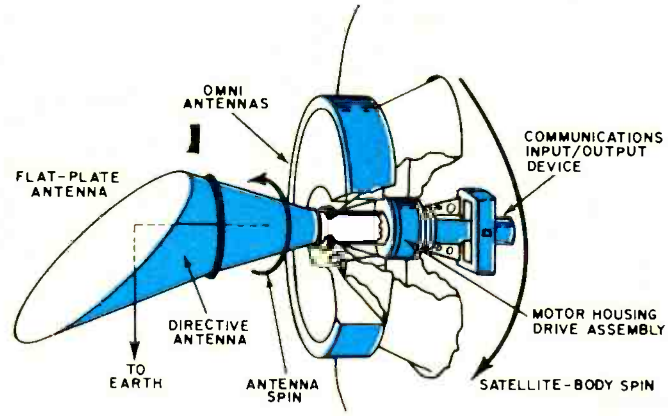


Fig. 1. Intelsat III employs a mechanically de-spun antenna.

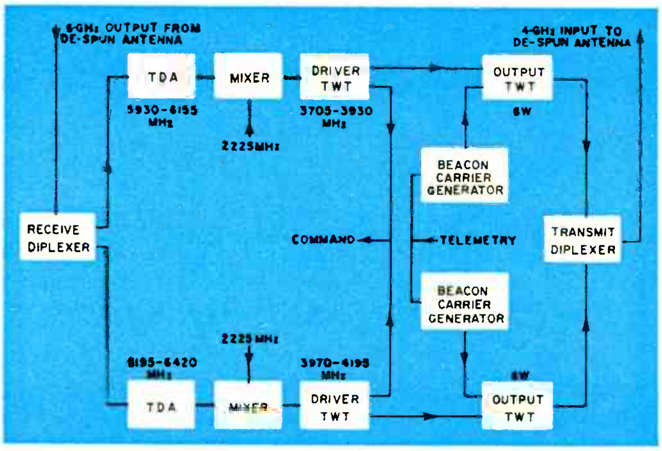
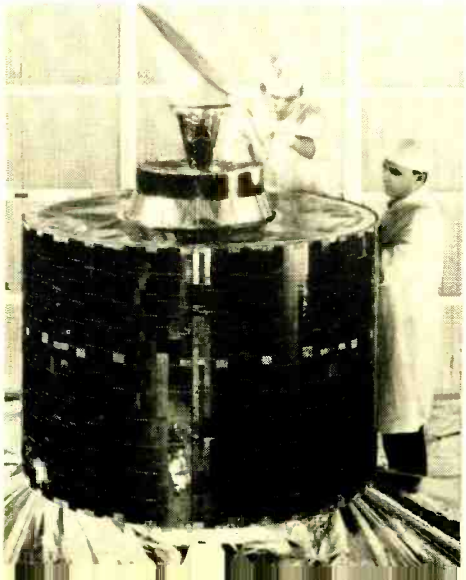
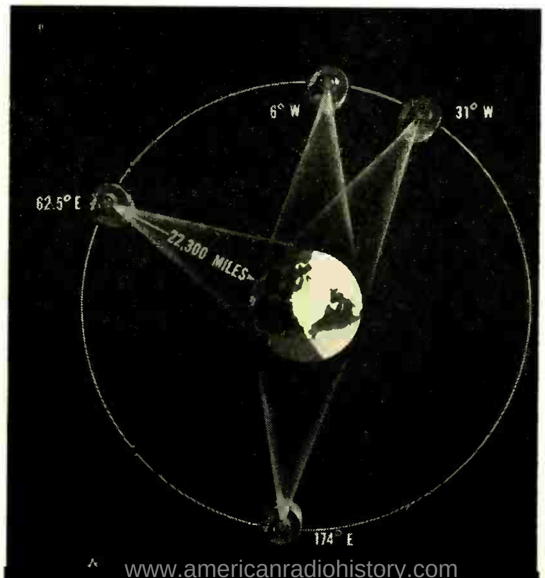
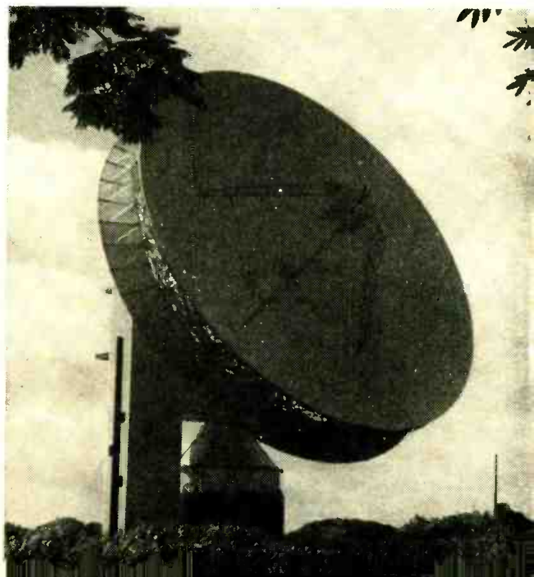


Fig. 2. Simplified block diagram of the Intelsat III.







(Left) An Intelsat III, with capacity of 1200 voice circuits, is shown here in test chamber. Satellite was successfully launched on Dec. 18, 1968 and placed in synchronous orbit over Atlantic from where it is providing commercial service. (Center) The Intelsat III global satellite system. Two (6°W, 31°W) are shown over Atlantic, one (174°E) over Pacific, and one (62.5° E) over Indian Ocean. Two are now in orbit, other two will be orbited shortly. (Right) Looming over nearby fields at Cayey, P.R. is this 97-ft parabolic antenna for satellite communications.

	1969	1970	1971	1972	1973
ATLANTIC OCEAN ZONE					
Earth Stations	22	34	38	46	46
2-way Circuits Req'd.	1300	1920	2708	3089	3436
Intelsat III Capacity	2400	2400	2400	2400	2400
Reserve Capacity	1100	480	(308)	(689)	(1036)
INDIAN OCEAN ZONE					
Earth Stations	10	19	21	22	22
2-way Circuits Req'd.	270	425	505	583	646
Intelsat III Capacity	1200	1200	1200	1200	1200
Reserve Capacity	930	775	695	617	554
PACIFIC OCEAN ZONE					
Earth Stations	12	17	18	18	18
2-way Circuits Req'd.	690	1000	1366	1896	2081
Intelsat III Capacity	1200	1200	1200	1200	1200
Reserve Capacity	510	200	(166)	(696)	(881)
TOTALS					
Earth Stations	44	70	77	86	86
2-way Circuits Req'd. (plus TV)	2260	3345	4579	5568	6163
Intelsat III Capacity	4800	4800	4800	4800	4800

(Source: Comsat and author's projections)

Table 2. Telephone traffic projections for Intelsat.

must have a low AM-to-PM characteristic (which requires linear operation far below saturation). It is the repeater designer's job to trade these sources of distortion against one another and produce a repeater which has the lowest possible over-all distortion.

The Network Goes Into Service

The first Intelsat III was launched on September 18, 1968. Shortly after lift-off the guidance system of the long-tank Delta malfunctioned and the launch vehicle was destroyed by the range safety officer.

The second launch took place on December 18, 1968 and successfully placed an Intelsat III at 31° west longitude over the Atlantic. Three more Intelsat III satellites will be at 174° east longitude (Pacific) (already in orbit), 6° west longitude (Atlantic), and 62.5° east longitude (Indian). All are to be in place by the end of this year thus completing the first global system (see Fig. 3). This system of four satellites will be able to handle a maximum of 4800 two-way telephone circuits or sixteen TV transmissions.

The standard earth station that completes the Intelsat III global system is an impressive terminal. All standard stations have an antenna at least 85 feet in diameter and many are larger.

Typical of the *Intelsat* earth stations is the new *Comsat* station at Cayey, Puerto Rico. The antenna, landmark of the station, stands taller than a 10-story building. Total weight of the Cassegrain antenna is about 470 tons. The surface of the reflector, 97 feet in diameter and weighing 45,000 pounds, was designed to an accuracy of better than 50 thousandths of an inch. The antenna and receiver were verified to meet the 40.7-dB gain-temperature sensitivity requirement by listening to the known radio emissions of the star Cassiopeia A.

To meet the required receiver noise temperature of 50° K, liquid-helium-cooled parametric amplifiers are housed in an equipment room behind the reflector. In operation, the earth station tracks any small motions of the satellite to 0.04°, using an autotrack system which is locked to the satellite beacon.

The Cayey station is one of six in the United States; Andover, Maine; Brewster Flat, Washington; Paumalu, Hawaii; Jamesburg, California; and Etam, West Virginia. By the end of this year 44 earth stations are expected to be in operation. By 1972, the number is expected to rise to 86. If these stations should each transmit only 100 telephone calls through the satellite, the capacity of all Intelsat III satellites would be exceeded by 80%.

Multi-Purpose Satellites

Because of the great expansion in the number of earth stations, it became clear early in 1967, two years before the first launch of Intelsat III, that the satellite's capacity probably would not be sufficient to meet eventual traffic demands. Thus, on March 23, 1967 two study contracts were awarded to investigate an advanced global satellite over three times as heavy as Intelsat III and capable of multiple communications missions, including domestic and mobile communications as well as international traffic.

Two types of stabilization were studied for this 2000-pound Multi-Purpose satellite; the familiar spin stabilization and a fully stationary satellite approach. In the latter, the vehicle is stabilized by an internally spinning inertia wheel and the satellite body is stationary. In effect, the entire satellite is "de-spun" with the internal inertia wheel supplying the necessary gyroscopic stability. This approach is interesting because all moving parts are in a sealed inertia wheel case and thus should be more reliable. The antenna and repeater are rigidly connected to the rest of the satellite thereby avoiding slip rings and power transfer joints, and solar paddles, which are pointed at the sun to increase the communications power available, can be used. Although *Intelsat* eventually decided this approach had too many technical risks for immediate commercial use, it is probable that future satellites will be fully stabilized. Europe is presently developing an experimental communications satellite, called Symphonie, which will use the inertia-wheel stabilization approach.

Maximizing Capacity

Because of the Multi-Purpose satellite's great weight, it became possible, perhaps for the first time, to seriously consider how this weight could be utilized to maximize the communications capacity of the satellite. Previous satellites were weight-limited to the point where such optimization was really not possible.

In retrospect, a principal deficiency of the Intelsat III design lies in its extremely wide repeater bandwidths for multiple access. Since multiple users must therefore share the same repeater, the TWT must be operated far below saturation to avoid distortions previously mentioned. This, in turn, is an inefficient use of the satellite's power and causes serious reduction of total capacity.

Another disadvantage of wide bandwidths is the requirement that each earth station accurately control the power that it sends to the satellite. Since a satellite's repeater power will be distributed among all users in proportion to the strength of the received signals, an improperly large signal from one earth station can capture all the repeater's power. To avoid this situation, each station must accurately monitor its power and control it in proportion to its traffic needs. This is both difficult and impractical. Experience with Intelsat III has shown that stations cannot easily maintain the required accuracy.

These considerations suggest that the available bandwidth should be divided into many little repeater bands and each earth station assigned its own exclusive repeater and saturated TWT. This is not entirely possible since each band must be set at least as wide as the widest bandwidth signal to be carried and it is likely that several users might still wish to multiple-access *that* band with small traffic. Still, this approach is a great improvement.

As might be expected, the widest bandwidth user is television, requiring a band of about 40 MHz in the Multi-Purpose configuration. Twelve such bands fill the available 500-MHz bandwidth. Twelve 8-watt or 12-watt TWT's would completely use the 2000 pounds available, depending upon

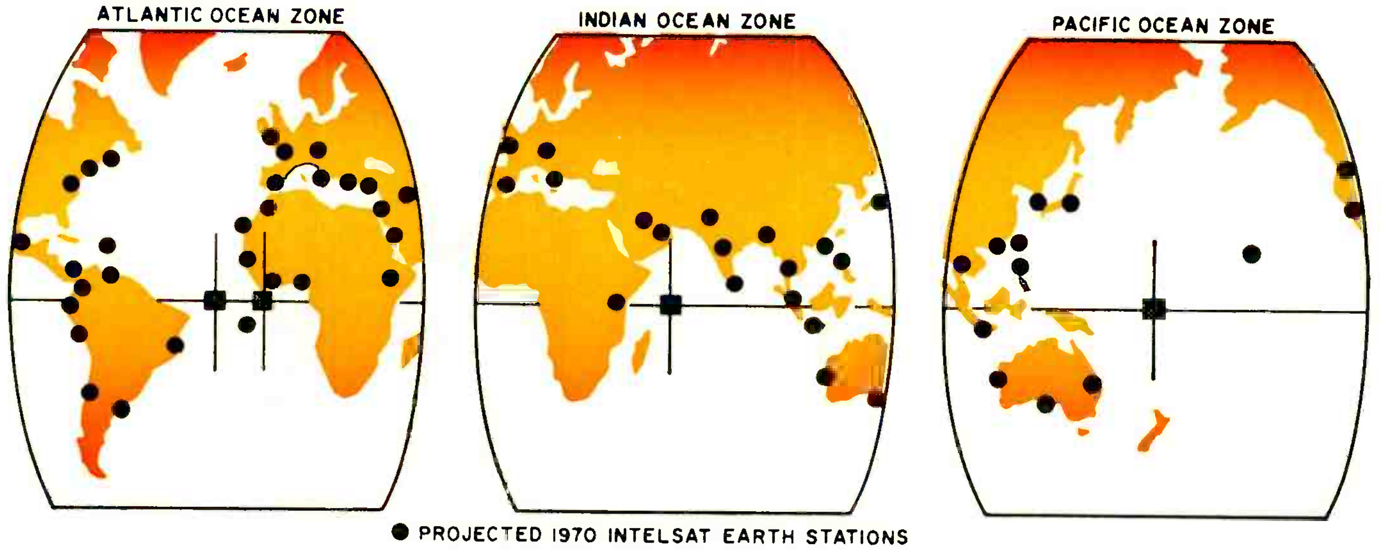


Fig. 3. The 1970 Intelsat III global system will consist of four satellites and a large number of ground stations. This entire system will be able to handle a maximum of 4800 two-way telephone circuits or 16 TV transmissions.

whether complete electronic redundancy is used or not. Since the capacity of the Multi-Purpose satellite is affected more by bandwidth limitations than power (it is bandwidth-limited), the lower power redundant configuration was chosen because of the significant increase in circuit-years for this choice (a lifetime of 7 years). With a repeater bandwidth of 40 MHz, 8-watt power, and earth-coverage antenna, each of the 12 repeaters can handle 1800 telephone channels or one TV channel.

Start of the Fourth Generation

By early 1968 international traffic projections were similar to those shown in Table 2. It was becoming clear that by 1971 Intelsat III's capacity in the Atlantic and Pacific would be exceeded. Furthermore, should any satellite fail, the system would be in serious trouble; adequate Intelsat III in-orbit reserve capacity did not exist and Intelsat I and II would be well beyond their design lives. After first considering the purchase of additional improved Intelsat III satellites (Intelsat III½), it was decided to proceed with the Multi-Purpose international design, which was named Intelsat IV.

A $72-million contract for four of these giant satellites was awarded to *Hughes Aircraft* last fall with the first two launches scheduled for early 1971 (Atlantic and Pacific). The third satellite will be placed over the Indian Ocean in 1972 (at Intelsat III end-of-life) and the fourth satellite will be kept as a spare.

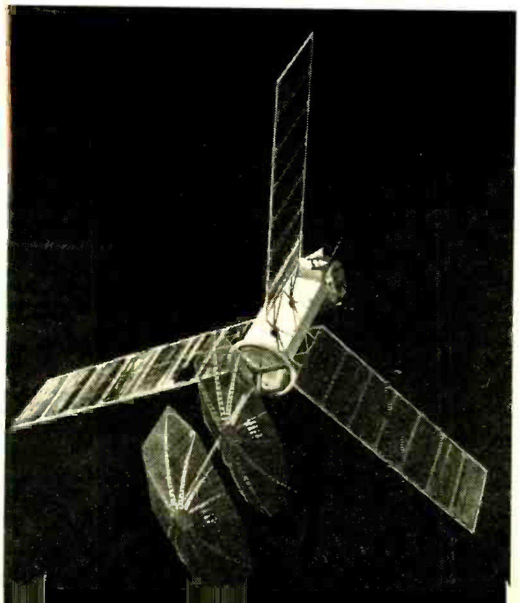
In addition to its earth-coverage de-spun antenna beam, Intelsat IV will also have two 4.5° spot transmit beams that can be aimed at high traffic points on the earth. Eight of the twelve 40-MHz repeaters (36-MHz usable bandwidth) can be connected to the spot beams, increasing their effective radiated power 15 times. The maximum capacity of Intelsat IV will be over 10,000 two-way telephone calls or twelve TV channels with greatly improved access.

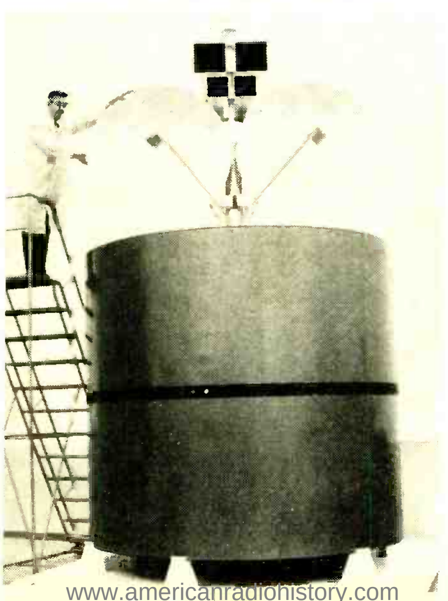
Aeronautical Communications

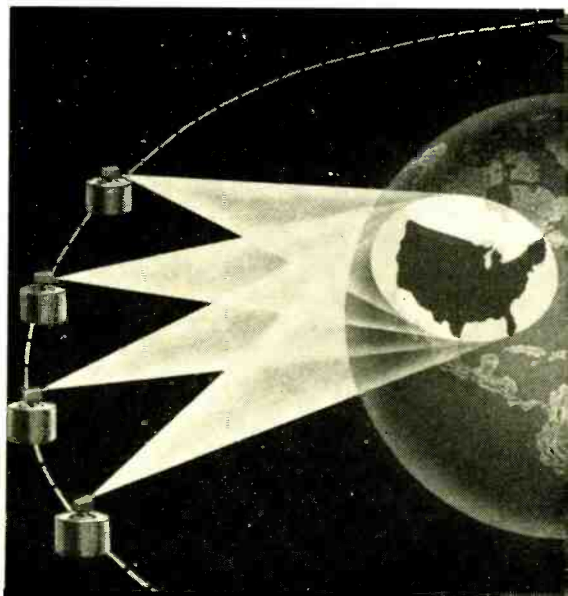
The Multi-Purpose study also was the first to investigate the use of satellites to communicate with aircraft. At present, transatlantic flights are out of range of shore-based v.h.f. communications for about 90 minutes. It is projected that during this year's August transatlantic peak, 85 aircraft will simultaneously occupy this 1000-mile-long "radio-silence" corridor in the North Atlantic. At about the same time, 40 aircraft will be out of radio contact over the Pacific as will 10 aircraft over the Indian Ocean.

This lack of communications is the principal reason for a required lateral separation of 120 miles between aircraft over the Atlantic. The restriction is expensive to the air-

(Left) Artist's concept of fully stationary Multi-Purpose communications satellite. Large antennas provide steerable spot beams for high-traffic areas. Entire vehicle remains pointed at earth at all times. (Center) Mockup of giant 2000-lb Intelsat IV, scheduled for service in 1970's. It has capacity of up to 10,000 telephone calls or 12 color-TV broadcasts. (Right) Several proposals have been made for the use of satellites for U.S. domestic distribution of TV and telephone calls. Satellites would either blanket U.S., as shown, or use spot beams to provide time-zone coverage.







lines because it prevents them from operating flights when passengers would like to fly, and forces them to schedule to meet the separation requirement. In ten years the transatlantic peak in the silent corridor is expected to exceed 150 aircraft and will consist of a mix of supersonic, jumbo, and conventional jets. To make this high density possible, lateral separation must be reduced to below 60 miles. If a recommended minimum safety criterion of less than one collision in 100 million flights (one incident per thousand years) is to be met for this separation, the position of each aircraft in the corridor must be known to better than 15 miles. Such accuracy requires that each aircraft be under surveillance at all times, and this can be done only by satellites.

Simplest would be an aeronautical comsat (aerosat) that interrogates aircraft for position information as well as air traffic control communications. An advanced approach would also verify aircraft position, using a ranging code.

From the airlines' point of view, the present 118-136 MHz v.h.f. aeronautical band would be ideal for such an aerosat since it would mean the least change. The v.h.f. experiments between ATS-1 and test aircraft over the Pacific, and Air Force experiments with LES have proved that a v.h.f. aerosat can be built today. The principal obstacle is that v.h.f. is not allocated for satellite use and government officials are reluctant to risk further possible interference in this congested band.

A possible alternative is the use of the aeronautical L-band (1540-1660 MHz) and the FCC has recommended that this band be used by aerosats on a shared basis. Since aircraft equipment is not currently available at L-band and practical aircraft antennas do not exist, airlines have not been anxious to proceed. Instead, the airlines are arguing internationally that a portion of the v.h.f. band should be allocated for this service and that L-band should be developed gradually. In any event, because of the urgent need, it is probable that some form of aerosat will be under development before 1970.

Comsats for Domestic Applications

But perhaps the most significant portion of the Multi-Purpose study was that concerned with the design of domestic comsats. If comsats have had such an impact on international communications, why not use such satellites for domestic transcontinental traffic?

It all started in 1966 with FCC Docket 16495 which was established after *ABC* and the Ford Foundation both filed for authority to orbit television-relay satellites. *ABC* applied on the basis of cost savings to distribute its TV programs, while the Ford Foundation argued that similar savings could help support educational TV. These applications were quickly followed by others including two from *Comsat* and *AT&T*, who argued that any domestic satellite should be designed for both TV and telephony. All proposals are still being evaluated by the government, for as FCC Chairman Hyde has stated, "No Commission task is more challenging . . . than the determinations to be made concerning the proposed use of satellites for domestic purposes."

The potential impact of these proposals also caused President Johnson in 1967 to establish a Presidential Task Force to review the entire national communications policy. This task force, under Presidential advisor Eugene Rostow, made its unreleased recommendations to President Johnson last December and it is likely that major reforms in the Communications Act of 1934 are being considered.

Although the value of distributing transcontinental TV signals *via* satellite is clear, the domestic distribution of telephone signals will ultimately prove to be a most significant development. At the moment, a domestic satellite would provide better transmission quality than any ground link longer than about 1500 miles. This is so because a satellite's signal quality is essentially independent of distance, while a terrestrial link deteriorates directly with distance. Further, since satellite cost compares favorably with ground links, there is little reason to develop new long-distance microwave ground links. However, traffic projections for the early 1970's show a need for additional transcontinental capacity. All these factors favor the early development of a domestic TV/telephony satellite.

In time, this situation is likely to produce more reliance on satellites and less on ground links. By the early 1980's, large-capacity domestic satellites could be handling messages over distances beyond 500 miles to open a new generation of inexpensive public communications.

In December, 1966 *Comsat* proposed to begin domestic service with a Pilot satellite designed to provide practical operational experience prior to the establishment of a full system. The Pilot satellite is essentially a 12-channel Intelsat IV satellite with the earth and spot beams replaced by a 3.5° × 7.5° beam that blankets the U.S. The Pilot system would employ two such satellites, two east-coast and two west-coast Intelsat-quality access stations, and about 30 midwest receive-only TV terminals (32-foot antennas).

Interest in domestic satellites is not confined to the United States. France has studied a domestic satellite (Saros) to connect continental France to colonies in the Caribbean and Africa. It has also studied a radio-TV satellite to link France and French-speaking Quebec in Canada. West Germany has studied a domestic satellite (Olympia) and proposed its use for TV distribution of the German Olympics in 1972. France and Germany agreed last year to join forces and construct a common satellite (Symphonie) to accomplish the previous Saros/Olympia missions. This satellite is under construction and scheduled for launch by 1972. Canada has just concluded two studies of a domestic satellite to help it distribute radio, TV, and telephony to previously isolated communities in the northern Provinces. India and Brazil are also considering domestic systems. Even with its relatively small area, Japan has studied the development of its own system, as has the State of California.

The operational successor to the Pilot satellite is likely to employ four 2° spot beams to illuminate the four U.S. time zones for more versatile TV distribution. This raises the interesting possibility of re-using the *same* 500-MHz down-link frequencies in every *other* time zone. The selectivity of the spot beams would keep these same frequency signals from interfering with each other. This would essentially double the TV capacity (*Continued on page* 71)

Table 3. Present and proposed frequency assignments for comsats.

COMMERCIAL	
Point-to-Point Service (Shared Bands)	
Satellite-to-Earth Stations	3700-4200 MHz
Earth Stations-to-Satellite	5925-6425 MHz
MILITARY	
Point-to-Point Service (Partially Shared Bands)	
Satellite-to-Earth Stations	7250-7750 MHz
Earth Stations-to-Satellite	7900-8400 MHz
FCC-RECOMMENDED COMMERCIAL ADDITIONS	
Mobile Service (Shared Bands)	
Satellite-to-Mobile Terminals	1540-1560 MHz
Mobile Terminals-to-Satellite	1640-1660 MHz
Point-to-Point Service (Exclusive Bands)	
Satellite-to-Earth Stations, or Earth Stations-to-Satellite	17.7-21.2 GHz 27.8-31.3 GHz
COMSAT-REQUESTED ADDITIONS	
Mobile Service (Shared Bands)	
Satellite-to-Mobile Terminals, or Mobile Terminals-to-Satellite	118-136 MHz
Point-to-Point Service (Shared Bands)	
Earth Stations-to-Satellite (as available)	10.7-11.7 GHz, 11.7-12.7 GHz, 12.7-13.25 GHz

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JOHN FRYE

It is foolhardy for radio/TV technicians to remain ignorant of the nature of electric shock and methods of resuscitation.

ELECTRIC SHOCK

"HEY, Mac," Barney said to his employer as the two of them sat side by side on the service bench drinking a couple of Cokes Matilda, the office girl, had brought in from the drugstore next door, "do you remember our talking two or three weeks ago about the alarming number of patients believed to be accidentally electrocuted in hospitals each year?"

"Yup," Mac answered with a mouth full of cracked ice.

"Well, that started me thinking: here we are working with all sorts of voltages and currents day after day; yet I know precious little about the nature of potentially lethal electric shock or methods of resuscitation. Suddenly that seemed about as smart as for a snakehouse operator to be ignorant of reptiles and to be without snake-bite serum."

"So what did you do about it?"

"Boned up on both departments. Reading helped a lot; but I also checked with Red Cross headquarters, the new intensive care ward at the hospital, and the emergency squad at the fire department. As a result, I now feel I know a lot more than I did about how electricity can injure the body and how to counteract the effect of such injury."

"And if I know you," Mac said with a pretended sigh of resignation, "I'm about to become the beneficiary of your new knowledge."

"You're darned tootin'," Barney said. "After all, it's more important that you know all this than that I should know it, because what *you* know may save *my* life."

"That's what I like about you: always looking out for the other fellow! But what does electricity do to the body?"

"Lots of things, mostly bad, at least when applied accidentally. A high-voltage current can arc at the point of contact and sear the flesh there. This you can see. But an autopsy often reveals that heavy current literally cooks the flesh along the entire pathway through the body. Currents heavy enough to raise body temperature appreciably produce immediate death. Relatively high currents may produce fatal damage to the central nervous system. Such currents flowing near the heart may cause cardiac arrest, and those flowing through other nerve centers can stop breathing."

"You're talking about heavy currents such as would be produced by contact with a high-voltage line, but a high percentage of electrocutions are produced by household voltages. How much current is really dangerous?"

"That's a good question, and C. F. Dalziel of the University of California and W. R. Lee of the University of Manchester tried to find some answers. Their findings are written up under the title 'Lethal Electric Currents' in the IEEE *Spectrum* for February, 1969. The first thing they wanted to find out was the let-go current for human beings."

"Hold it!" Mac interrupted. "What's a 'let-go current'?"

"It's the maximum current at which a person can still release a conductor by using muscles being stimulated by that current. It's very important because a person can withstand repeated shocks by current below this value—at least stand them long enough to turn loose—but a slightly higher current 'freezes' the victim to the conductor. Since the damaging effect of electric shock is a function of both the amount of current and the length of time the body is subjected to it, you can see the critical let-go current, which determines whether or not the victim can voluntarily free himself from the electrical circuit, is most important.

"Dalziel and Lee exposed 134 men and 28 women to increasing current to determine how much each could take and still be able to release the small wire carrying the shocking current to their hands. The average let-go current was found to be 16 mA for men and 10.5 mA for women. While physiological development, especially in the arms and wrists, greatly influenced the let-go current, psychological factors played a part, too. The highest let-go current was obtained on a physiology student who boasted he was as good as any engineering student."

"I'm not sure average values are of much use in a case like this," Mac objected. "I still remember the guy who drowned in a river that 'averaged' only a foot deep."

"The gentlemen doing the testing agreed with you; so they decided a reasonably safe limit for electric shock would be the 0.5 percentile let-go value. On this basis, it was found safe let-go currents could be considered approximately 9 mA for men and 6 mA for women. Incidentally, no essential difference was found between 50 and 60 Hz as far as let-go current was concerned.

"Next the gentlemen turned to finding the minimum fibrillating current. As you know, the several causes of ventricular fibrillation include the flowing of electric current through the heart muscle. While this current does not actually damage the heart, it deranges the functioning of that organ. Individual muscle fibers are thrown out of sync, so to speak, and are no longer coordinated. Instead of working together to produce the rhythmic, life-giving pumping of blood through the body, they contract individually and at random, resulting in a twitching, trembling of the heart that renders it useless for circulation.

"Ventricular fibrillation is considered the most dangerous electric shock hazard because once it starts in man, it practically never stops spontaneously; *yet the brain begins to die two to four minutes after it is deprived of a supply of oxygenated blood.* If the victim is to be saved, he must receive prompt rescue and immediate and continuous artificial respiration until other resuscitating measures are available."

"I'm curious as to how the minimum fibrillating current for human beings was determined. Sounds like a great place for non-destructive testing."

"You can say that again! Any current above the let-go value is considered dangerous; so the only recourse is to extrapolate results obtained on animals to man. This introduces uncertainties, but it's the best we can do. Most of our previous information came from work done by Ferris in 1936 at Columbia University and the *Bell Telephone Laboratories*; by Kouwenhoven in 1959 at Johns Hopkins University; and by Kiselev in 1963 at the U.S.S.R. Academy of Sciences, Moscow. In 1968 Dalziel and Lee presented a new analysis relating minimum fibrillating current to both body weight and shock duration.

"The experimenters electrocuted dogs, pigs, sheep, and calves totalling in the hundreds to obtain their information. The test procedure was to apply a series of well-spaced shocks of gradually increasing intensity until fibrillation occurred. Electrodes were applied to the right front limb and the opposite rear limb so current flowed through the animal's chest. The 0.5 percentile values were again used to indicate either the maximum non-fibrillating current or the minimum fibrillating current.

"I'll not try to tell you about the various individual findings, but they boil down to this: the minimum current causing ventricular fibrillation is proportional to body weight and inversely proportional to the square root of shock duration. In 50-kg mammals, the relationship is approximately 116 to $185/\sqrt{T}$ mA. It is believed unlikely that a normal adult will experience fibrillation if the shock intensity is less than $116/\sqrt{T}$ mA, where T is in seconds. For example, this works out to be about 58 mA for a four-second shock."

"So that's how you start fibrillation. I'm more interested in how you stop it, or rather how you revive a victim of electric shock."

Before answering, Barney fished a final piece of ice from his glass with his fingers and popped it into his mouth. "One of the best sources of that information I've found," he said, "is the *Resuscitation Manual, A Guide for Electric Utility Companies*, published by the Edison Electric Institute at 750 Third Avenue, New York City. It stresses that the victim should be freed from contact with the current as quickly as humanly possible with safety to the rescuer for two reasons: (1) the longer the current flows through the victim's body, the greater is the liklihood of irreversible injury, and (2) the sooner artificial respiration is started, the better his chance for survival. If he is not breathing or his blood is not circulating, the possibility of successful revival declines steeply with every passing minute and becomes extremely low after about four minutes of elapsed time.

"The actual method of artificial respiration used will depend on the victim's injuries. Mouth-to-mouth insufflation is the best because it assures positive movement of air into the lungs, but facial injuries sometimes make this impossible. By the same token a broken arm or fractured ribs may make the Back Pressure-Arm Lift method inadvisable. The point is that a person should be acquainted with two or three methods of artificial respiration, and an excellent step-by-step diagrammed source is that *Resuscitation Manual* I mentioned or *A Supplement on Artificial Respiration* issued by the American Red Cross. Better still is to attend a class on this subject put on by the Red Cross or some other safety organization where actual demonstrations on dummies or models are used. Seeing artificial respiration given by an expert or practicing it yourself under supervision is far superior to getting your knowledge from diagrams in a book, for this is a case where a little knowledge can be a dangerous thing. This also applies to external cardiac compression used to start a reluctant heart by compressing the chest with the heel of the hand so the heart is squeezed between the sternum and the backbone some sixty times a minute to provide artificial circulation of the blood because this should not be done if the victim has a pulse, if his ribs are broken, or if the pupils of his eyes remain widely dilated.

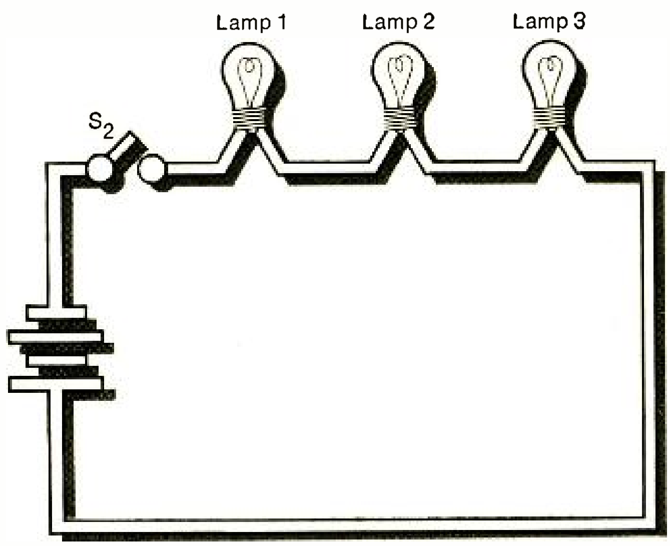
"The main thing is to keep artificial respiration going until the patient starts breathing on his own or until a doctor declares him dead. Rigidity is not necessarily a sign of *rigor mortis* because muscular tension is always present in electric shock cases. All else failing, a 'de-fibrillator' may be used by a doctor to stop fibrillation. This is a hair-of-the-dog-that-bit-him technique because it syncs the uncoordinated heart muscles with a current of up to fifteen amperes sent through electrodes attached to the chest and permitted to flow from 0.1 to 0.5 second."

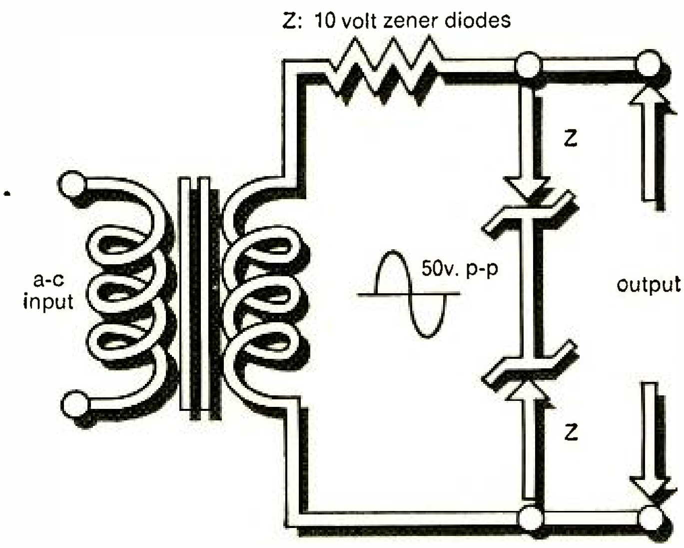
"Let's see if I have all this," Mac recapitulated: "A current as low as 9 mA can freeze a man to a current-carrying conductor. Slightly more current can start his heart fibrillating. If his heart is not freed from this condition by external means within four minutes, his chance of survival is very poor. Artificial respiration, external cardiac compression, and the use of a de-fibrillator comprise his best hope of being revived. But artificial respiration and cardiac compression techniques should be properly learned to be really effective."

"You get an A on the course!" Barney applauded. ▲

"We'll know in a few minutes whether they've decided to replace the high-voltage rectifier or the filter!"

Can you solve these two basic problems in electronics?





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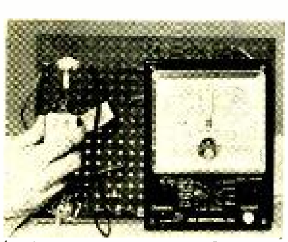

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Communications on the Moon

(Continued from page 25)

formed simultaneously. This is the first v.h.f. system ever created with this capability.

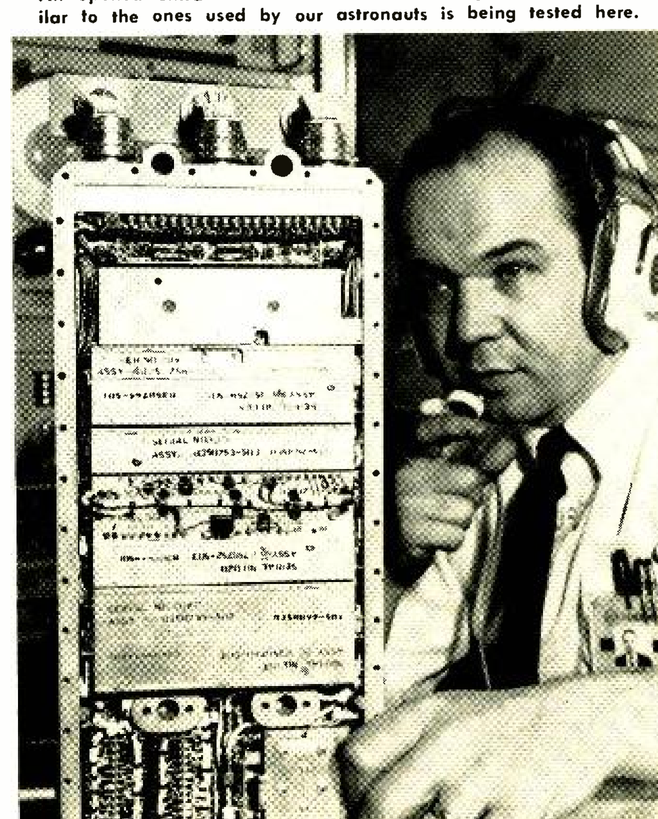
The primary source of range data between the LM and CSM when they are separated in space, however, will come from a silent communicator—the LM rendezvous radar built by *RCA*. The X-band instrument, the first gimballing radar ever flown in space, will track a transponder in the CSM to produce information on velocity and direction of the CSM relative to the LM, as well as distance between the two.

The radar and v.h.f. communications thus give Apollo 11 dual sources of information that will enable the LM to fly its way back to the CSM. The critical nature of the rendezvous and docking is underscored by the fact that LM is solely a spaceship that cannot re-enter Earth's atmosphere without being destroyed by the stresses of gravity and atmospheric friction. LM must rejoin the CSM after the lunar landing so that Armstrong and Aldrin can return safely to Earth with Collins.

The creation of the Apollo LM communications system has dipped deeply into the reservoir of America's electronic technology and experience. Although the systems design management task was performed by *RCA's* Defense Communications Systems Division in Camden, N.J., LM communications equipment builders read like an electronics "Who's Who:" *Collins Radio* for the S-band signal processor, *Motorola* for the S-band transceivers, *Raytheon* for the S-band power amplifier, and *Dalmo-Victor* for the S-band steerable antenna. *RCA* at Camden built the v.h.f. sets as well as the extra-vehicular radios, and its sister unit in Moorestown, N.J. developed the unique erectable antenna.

Except for the antennas, which serve as back up to one another, each item of LM communications equipment is redundant, providing an alternate means of accomplishing its task if the prime unit fails. Solid-state design and construction, except for an amplitron tube in the S-band power am-

An opened extra vehicular communications system radio similar to the ones used by our astronauts is being tested here.



plifier, are employed throughout the system.

The CSM's counterpart communications system, although the design of some equipment items are different, is a functional duplicate of the LM S-band and v.h.f. radio. With the LM system, it forms one-half of the Apollo communications complex.

The second half is the Earth-based Manned Space Flight Network (MSFN) managed by NASA's Goddard Space Flight Center. Strung around the globe are S-band receiving sites whose 30-foot and 85-foot antennas will peer spaceward throughout the Apollo 11 mission to receive the CSM and LM transmissions from the air, and to send voice and data to the spaceships. The stations are referred to as unified S-band sites since one antenna and one system handles all the communications functions; TV, voice, telemetry, and tracking.

Besides the sites based on land across the United States and in several foreign countries, Apollo receiving stations also ply the seas and the air in specially designed ships and converted jet aircraft. The ships and aircraft fill the gaps and provide coverage where no land stations can be situated.

Tieing all these stations together is the NASCOM network, a system of radio, satellite, and land-line communications that has the complex task of keeping the network linked together so that the Apollo voice, data, and TV will flow uninterrupted to the NASA Manned Spacecraft Center in Houston.

It is paradoxical that despite the capability of the Apollo spacecraft communications systems, and the huge complex on the ground, critical phases of the flight can occur when communications between the spacecraft and Earth are impossible. For example, the engine firing that will drive the CSM out of lunar orbit so the astronauts can return home will take place when the spacecraft is on the backside of the Moon and communications signals are blocked from Earth. Thus, as was the case in the Apollo 8 and 10 lunar missions, the world will have to wait until the spaceship swings around the lunar horizon to learn the success of the maneuver.

However, the first step onto the Moon by an American will be in clear sight of the Earth, electronically. When the moment comes, it will be remembered as long as civilization survives; the achievement alone is enough to assure that. Yet, the impact and accomplishment of the manned lunar landing surely will be felt more sharply on Earth because of the electronic beams that will span the void of space to bond Apollo 11 and astronauts Armstrong, Aldrin, and Collins to their native planet. ▲

The Truth About FM

(*Continued from page* 40)

other. At the extreme, one channel contains maximum signal while the other contains zero signal. Assume that L equals 4.5 volts while R equals zero volts. Then, L + R equals 4.5 volts, and L − R also equals 4.5 volts. Thus main-channel audio modulates the station transmitter 45%, while the stereo sidebands also modulate the transmitter 45% (Fig. 4C). Note that the main-channel modulation level is only 45% (deviation of 33.75 kHz). That is half the maximum modulation possible when L equals R, or a drop of 6 dB. Some stereo FM stations put the announce microphone on only one channel, with the result that mono listeners hear announcements 6 to 8 dB below the music. The announce-mike channel should be split equally between the channels.

The stereo difference (L − R) signal has the same frequency response as the main-channel signal, namely from 50 to 15,000 Hz. It also uses the same 75-μs pre-emphasis curve. It amplitude-modulates a 38-kHz carrier, which carrier is then suppressed to less than 1% modulation of the station transmitter. These AM sidebands occupy frequencies from 23 to 53 kHz, as shown in Fig. 4C.

Some articles show both the main channel and the stereo sidebands with maximum possible modulation of 90% of the station transmitter. This is erroneous and misleading. It is never possible for *both* the L + R and L − R signals to *simultaneously* modulate the transmitter 90%. If the station is operating properly (*i.e.*, not overmodulating), the L + R main-channel signal can modulate up to 90%. The L − R stereo sidebands can modulate *only* up to 45%. Such maximum modulation by the stereo sidebands is possible only for an L-only or an R-only signal. At the same time that the stereo sidebands modulate the carrier up to 45%, the main channel also modulates up to 45%—*and no more*.

It is technically possible for the stereo sidebands alone to modulate the transmitter up to 90%, but the station is then being operated improperly. Assume for a moment that L equals +4.5 volts, while R equals −4.5 volts. Obviously the main-channel L + R signal equals zero, so there is zero main-channel modulation. Also the stereo difference or L − R signal equals +9.0 volts. Thus the sidebands modulate the station transmitter 90%.

But if L equals +4.5 volts and R equals −4.5 volts, the stereo system at the station (or the program source) is out of phase. While the stereophonic listener will hear something, the monophonic listener will not. Thus 90% modulation by the stereo sideband signal is a technically improper condition which should never occur.

Station E—Stereo and SCA

It is technically feasible to transmit a single SCA subchannel (but no more than one, because of increased crosstalk) along with stereo programming from a single FM station. Fig. 5 shows the signals transmitted by station E. Since the stereo sidebands occupy much of the spectrum above the main channel, very little room is left for the SCA subchannel. Although the FCC does not specify 67 kHz, this frequency is probably the most widely used by stereo/SCA stations. (A few use 65 kHz.) Most stereo receivers use 67-kHz traps to prevent SCA crosstalk into the stereo channel, and most SCA receivers use 67 kHz as the first available frequency.

FCC rules permit only 10% SCA injection while stereo is being transmitted. Thus the SCA subcarrier deviates the main carrier ±7.5 kHz. Since the 19-kHz pilot is also injected to 10%, only 80% is left for both the main channel and the stereo sidebands.

As before, this 80% modulation is shared by both the main channel and the stereo sidebands. When L equals R the main channel modulates 80% and the sidebands modu-

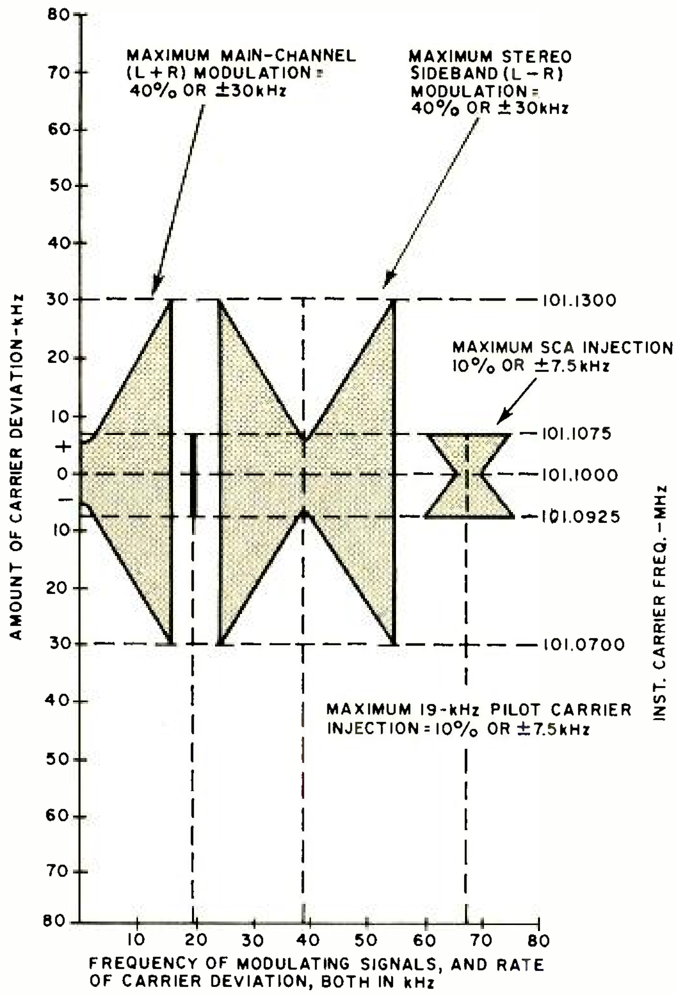


Fig. 5. Output of station E, transmitting stereo and SCA.

late zero percent. As mentioned before, however, this situation is practically the same as monophonic operation. When L equals its maximum voltage and R equals zero voltage, the main channel modulates 40% and the sidebands also modulate 40%, as indicated in Fig. 5.

Everything stated previously about station D is also true of station E, except that the modulation limits are now 80% (±60 kHz) for the main channel and 40% (±30 kHz) for the stereo sidebands.

Conceptions & Misconceptions

Many people have misleading impressions about the monophonic, stereophonic, and SCA signals transmitted by U.S. FM broadcast stations. Much writing on the subject ignores the effect of the pre-emphasis curve. This curve means that low frequencies in the program material can be transmitted as much as 15 dB below the highs—even if the transmitter is being modulated 100%.

That the deviation ratio changes when a station transmits SCA or stereo signals is also little known. Compare main-channel DR for the five examples cited above. Station A modulates 100%, deviating ±75 kHz, for a DR of 5 (75/5). Stations B and C modulate only 70% on the main channel, deviating to 52.5 kHz for a DR of only 3.5. Station D can modulate to 90% when L equals R, deviating to ±67.5 kHz, for a DR of 4.5. Station E can modulate to 80% when L equals R, deviating to ±60 kHz, for a DR of 4.0.

The stereo sideband signals transmitted by stations D and E have even lower deviation ratios. The stereo sidebands of station D can modulate its main carrier to only 45%, deviating it to ±33.75 kHz, for a DR of only 2.25. At station E, the figures are still lower—40% modulation, deviation of ±30 kHz, and DR of only 2.0.

A comparison of the volume levels heard by the listener with a monophonic receiver is also interesting. Station A is the reference, since it can modulate to 100%. Stations B and C can modulate to 70% (on the main channel), a drop of 3 dB from station A. (Of course, some stations use SCA injection of less than 30%, which allows them a correspondingly higher main-channel modulation level.) Station D can modulate its main channel to 90%, a drop of only 0.9 dB, and station E can modulate its main channel to 80%, a drop of only 1.9 dB.

But one thing must be obvious by now. In normal programming, FM stations don't transmit sine-wave tones, don't transmit white noise with full and flat frequency response from 50 to 15,000 Hz (for the mono and stereo) or from 30 to 7500 Hz (for SCA). And they don't transmit everything at the maximum allowable modulation all the time.

This discussion has cited the extremes, the limits, and the rules. The signals transmitted by most stations vary considerably in volume, frequency, and waveform. In particular, stereo program material more often has most of its volume in the main or sum channel, with correspondingly less in the difference or sideband channel. This is good for the mono listener, for he hears a relatively loud signal not much different in volume from what he gets from mono-FM stations. Furthermore, the mono signal-to-noise ratio is kept relatively high during such stereo programming.

But whenever stereo program material becomes too extreme ("leftish" or "rightish") the mono listener suffers. As the program material approaches L-only or R-only, main-channel and stereo sideband modulation levels both drop to near 45% (or 40% if SCA is being transmitted). That is a volume drop of 7 to 8 dB for the main-channel listener, compared to a monophonic signal. One might state a fundamental principle: Extremism in pursuit of stereo is a vice.

Confusion also abounds regarding the transmission of SCA signals as they affect mono and stereo listeners. One charge often leveled at FM broadcasters is that by transmitting SCA signals, they are degrading their public broadcast signals. The charge is true, but what is seldom pointed out is that such degradation is insignificant.

In the examples cited, stations B and C transmit one or two SCA subchannels, using up to 30% injection and backing off the main-channel modulation to 70%. At most, this is a drop of 3 dB, which is scarcely noticeable to most listeners. While the signal-to-noise ratio on the main channel has been lessened somewhat, the effect is so small as to pass almost unnoticed. If the transmitting equipment is adjusted properly, crosstalk from the SCA's into the main channel is negligible. The FCC, in fact, requires such crosstalk to be at least 60 dB below 100% modulation.

At stations D and E, the situation is more complex. To begin with, station D's main-channel signal is down 10% (0.9 dB) because of the pilot signal. At station E, adding SCA drops the main-channel level another 10%, making the over-all drop 1.9 dB. But note that a 0.9-dB drop is necessary just to transmit stereo, and the SCA service itself causes a drop of only 1.0 dB; both are barely noticeable.

Crosstalk from the SCA into the stereophonic sideband signals is also negligible at station E. Again the FCC requires such crosstalk to be at least 60 dB below 100%.

Finally, what about the SCA subchannel? The service is anything but high fidelity: Frequency response is 30-7500 Hz, and since deviation ratio is 1.0, signal-to-noise ratio is poor. In fact, most SCA generators mute themselves during near-silence on their audio inputs. This serves to mask main-channel and stereo crosstalk into the SCA channel. Dynamic range on SCA channels is also small, since high levels of audio compression and limiting are used in an attempt to keep the signal-to-noise ratio as high as possible.

The SCA, then, is a limited-range service which detracts only slightly from either mono or stereo broadcasting. Further, it doesn't require additional spectrum space. ▲

New Coaxial Connectors

(*Continued from page 29*)

The workings of a typical 7-mm precision connector are explained graphically in Fig. 1. Note that the retaining ring can be screwed forward by coupling-nut action. This provides the mating alignment sleeve for the other connector (which has its retaining ring stored in the coupling nut). In this fashion the "sexless" junction is achieved. The outer conductor is mated by a butt action and is constructed of a beryllium copper alloy to provide high tensile strength. It is also gold plated to yield good over-all conductivity. The inner conductor joint—the secret of precision connector success—consists of a spring-action collet which produces a spring-butt joint located at the inner conductor.

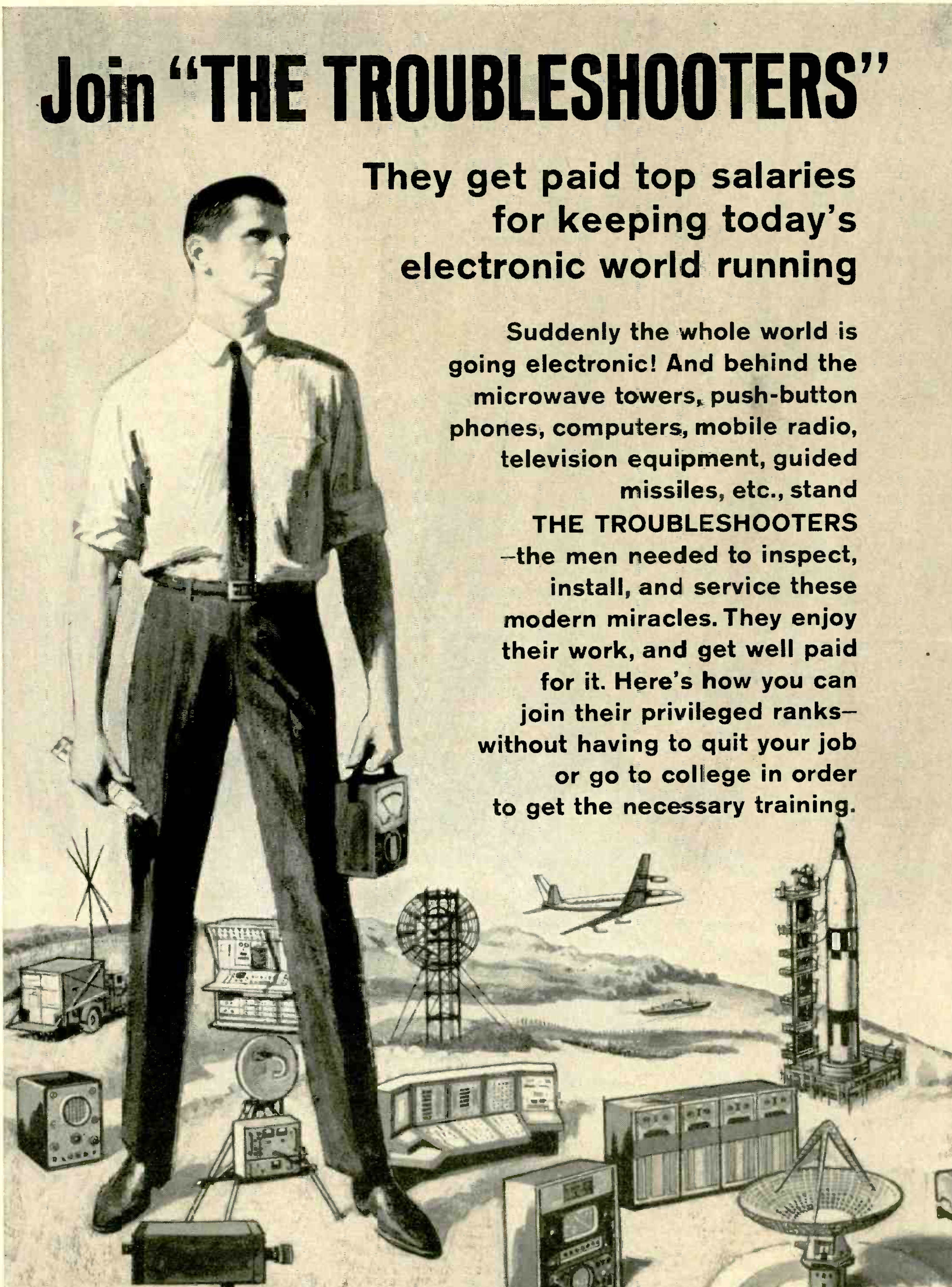
Precision Adapters Available

Precision APC-7 adapters for the more conventional connectors (such as type N, TNC, BNC, and the new SMA series) are now available. By using these adapters, the full potential of the connector series is obtained. Although the APC-7 precision connectors are intended mainly for use as instrument connectors mounted on airline or the equivalent semi-rigid precision cables, less-precise flexible cables have been fitted with APC-7 cable connectors to allow direct electrical connection to existing laboratory and permanent system test apparatus.

Also available are Economy APC-7 jacks, plugs, and flange-mounted receptacles. These designs have the same electrical performance as the APC-7, but the coupling mechanisms are not "sexless"; and while the signal-carrying portions of these connectors are identical to the APC-7, the mechanical-coupling arrangements are either male or female as in any series of threaded coaxial connectors. Prices for these high-performance connectors are only a fraction of the cost of the APC-7 precision connector described above.

Becoming a Standard

The frequency range of the 7-mm connectors—0 to 18 GHz—covers the bulk of the frequency spectrum which affects most electronics engineers both from an r.f. and a short-pulse standpoint. With increasing emphasis on extremely short pulses in new computer applications, coupled with better performance in the microwave region, it's not hard to understand why the precision connector is becoming a unifying force for the entire electronic instrumentation industry. This is especially true in those particular areas where very exact measurements must be made and very low standing-wave ratios must be maintained. ▲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Suddenly the whole world is going electronic! And behind the microwave towers, push-button phones, computers, mobile radio, television equipment, guided missiles, etc., stand THE TROUBLESHOOTERS —the men needed to inspect, install, and service these modern miracles. They enjoy their work, and get well paid for it. Here's how you can join their privileged ranks—without having to quit your job or go to college in order to get the necessary training.

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 servicing 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.

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Think With Your Head, Not Your Hands

As one of The Troubleshooters, you'll have to be ready to tackle a wide variety of electronic problems. You may not be able to dismantle what you're working on—you must be able to take it apart "in your head." You'll have to know enough Electronics to understand the engineering specs, read the wiring diagrams, and calculate how the circuits should test at any given point.

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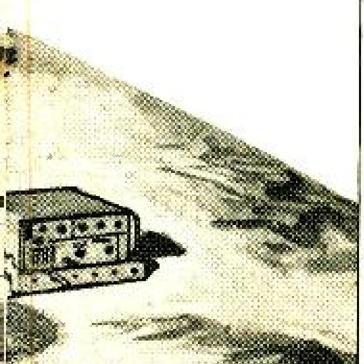

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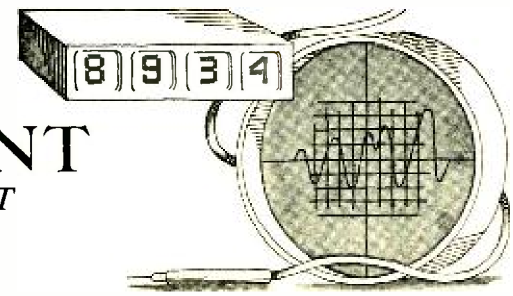
PRODUCT REPORT



Eico Model 385 Color-Bar Generator

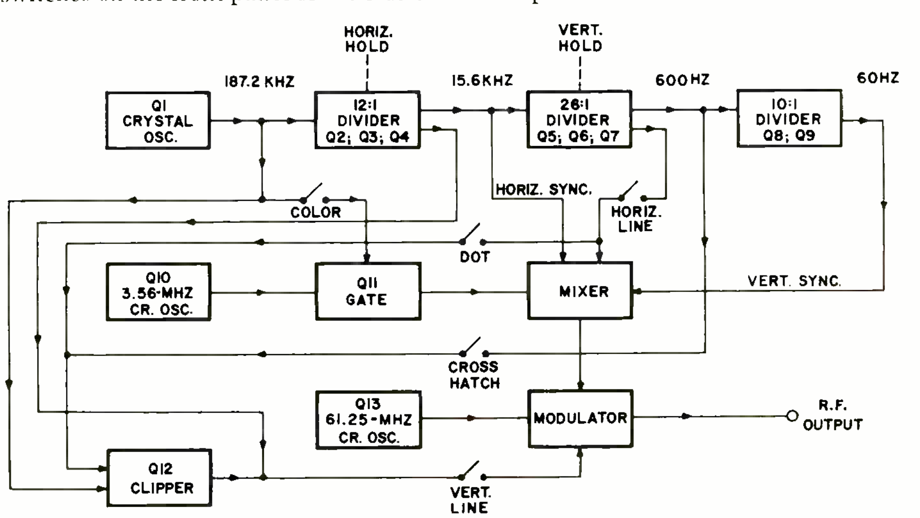
For copy of manufacturer's brochure, circle No. 32 on Reader Service Card.

FOR several years *Eico* was among the very few manufacturers who offered a color generator for the TV service technician that produced NTSC colors of exact phase and luminance level. This company has recently joined the ranks of the large majority of test-equipment manufacturers in producing the much more common, simpler, and less expensive gated-rainbow color-bar generator—the Model 385.

This generator is quite compact, measuring about 8½-in square by 2½-in high, and quite light in weight (about 4½ lbs). What's more, it is battery-operated from six "C" cells. Battery drain is fairly low so that the batteries won't have to be replaced too often. The unit we checked out drew about 40 to 50 mA, depending on function. Permanently attached to the Model 385 is an adapter cable with a conventional color CRT socket with built-in color-killer resistors. Each gun is controlled by switches on the front panel of the instrument. This cable is stored in the back of the generator. The arrangement does away with the need for insulation-piercing clip leads for color killing.

The generator produces the usual crystal-controlled patterns. These are color bars, seven horizontal lines alone, eight vertical lines alone, crosshatch pattern, and dot pattern. Output is on TV channel 3 (61.25 MHz), and this output is also crystal-controlled.

The circuitry uses 13 transistors, 6 diodes, and 3 crystals. The arrangement is shown in the block diagram below. Basic pattern timing starts with crystal-controlled oscillator Q1. The output of this stage drives a divide-by-12 counter (Q2, Q3, Q4). A front-panel control in this circuit determines the horizontal-sync frequency and the number of vertical lines displayed on the CRT. Next in the countdown chain is a divide-by-26 counter which generates the horizontal lines. Frequency here is adjustable by a front-panel vertical-hold control. Next



in line is a divide-by-10 counter that produces the vertical-sync pulse. Other transistors serve as crystal oscillators, gate, and clipper circuit.

Construction of the kit version of the generator is quite simple; all components including the two hold controls and printed-circuit function switch are mounted on a single large printed-circuit board. The ranges of the internal counter adjustments were quite large and, although it's a little difficult to count the 26 pips produced by the divide-by-26 circuit, we were able to set up the counters properly and get a good, stable test pattern on our color receiver.

Price of the *Eico* Model 385 is $80 in kit form, or $110 factory-wired. ▲

Sencore Model SM152 Sweep/Marker Generator

For copy of manufacturer's brochure, circle No. 33 on Reader Service Card.

THE test-equipment field is a pretty competitive one and each company keeps an eagle eye on his competitors. That's why we sometimes see developments in this field in spurts with several manufacturers producing their own versions of fairly similar types of test equipment for the TV service technician. For example, we know of at least four such manufacturers producing or about to produce new solid-state sweep generators with built-in facilities for adding a large number of crystal-controlled markers. One of these new units is the *Sencore* Model SM152.

This combination instrument consists of a v.h.f. sweep generator, a u.h.f. sweep generator, a crystal-controlled marker generator, and a marker adder—all in a single unit. Linear sweeps are available from 10 MHz for FM i.f. alignment all the way up to 920 MHz for u.h.f. TV r.f. alignment. Four overlapping ranges are used to provide this frequency range. The dial calibrations are in MHz as well as in channel numbers for easy use. Sweep width is calibrated from 0.3 MHz up to 15 MHz. In addition, there is a 3.58-MHz swept chroma signal that can be used to check the alignment of the video-frequency chroma circuits in a color-TV set.

There is a row of push-button switches across the entire front panel of the instrument for crystal-marker insertion. There are markers available for the i.f. response curve and the chroma response curve. There are even crystal markers for the r.f. video carriers on channels 4, 5, 10, and 13; when the 4.5 MHz push-button is depressed, the sound r.f. carrier is marked.

For the technician who wants to align FM-stereo receivers, there is a marker push-button that simultaneously inserts three crystal markers at 10.6, 10.7, and 10.8 MHz to permit seeing the center FM frequency plus markers 100 kHz on either side when viewing the detector S-curve or the i.f. response curve. This should certainly make it easy to do alignment with a minimum amount of wasted time.

There is also a variable oscillator tunable from 39 MHz to 48 MHz for i.f. spot alignment of older receivers.

The SM152 uses post-marker injection on all markers so that the amplitude and shape of the markers are not affected by the response curve of the set being aligned. The only other instrument needed to perform the alignment is an oscilloscope. The generator in a vinyl-clad steel case is $349.50. ▲

Sperry Model Ohm-25 Snap-Around V. O. A.

For copy of manufacturer's brochure, circle No. 34 on Reader Service Card.

THE snaparound or clamp-on a.c. ammeter has in the past been used mainly by electricians or high-current-appliance technicians. This is because the meter can be used to measure large values of a.c. current conveniently without interrupting the circuit. The user merely opens the jaws of the meter and

lets them snap closed around a single conductor carrying a.c. current. The magnetic field around the conductor induces a voltage into the single-loop conductor in the meter jaws, and current flows through the meter movement indicating the amount of a.c. current flow. The position of the loop is not critical as long as it encircles the current-carrying conductor. The meter, in effect, acts as its own instrument transformer.

The *Sperry* Model Ohm-25 a.c. volt-ohm-ammeter should be of interest to electronics and TV technicians too because of its low-current ranges. The two lower current ranges are 5 and 25 A full-scale, and when the Model E-1 line-cord adapter is used with the meter, these are cut to 0.5 and 2.5 A, respectively. The technician can then check on the amount of line current being drawn by a TV set and can often find leaky electrolytics, shorted rectifiers, and other causes of excessive line current or fuse blowing.

In using the snap-around meter you cannot get a current reading if you encircle a conventional two-wire line cord. Because the two conductors are carrying equal currents which are flowing in opposite directions at any one instant, the external magnetic field is largely cancelled. You have to split the conductors apart so that the transformer jaws are around one of the conductors, or you can use the line-cord adapter, which effectively splits the line for you. Also, of course, you cannot get a reading from BX or shielded cable.

The Model Ohm-25 has three a.c. current ranges (5, 25, and 125 A), two a.c. voltage ranges (150 and 300 V), and one resistance range (25 ohms mid-scale). The voltage and resistance ranges use conventional leads which plug into the meter. One of these leads contains a penlite cell and fuse for the resistance scale. The leads, incidentally, use threaded banana clips at one end and combination clips and prods at the other. Hence, the leads won't pull out of the meter if the user has to do some stretching while using the instrument.

The accuracy of the meter is specified as within 3 percent of full-scale. The one we checked out did considerably better than this. On the a.c. voltage ranges, line-voltage readings were within ±½ percent and on a.c. current, readings were within ±1½ percent of full-scale.

The v.o.a. has a bright yellow plastic case that can be swiveled around into five different positions while permitting the meter to always face the user. The instrument, imported from Japan by *A.W. Sperry Instruments Inc.*, sells for $40 including a carrying case. The Model E-1 line-cord adapter mentioned above costs an additional $5. ▲

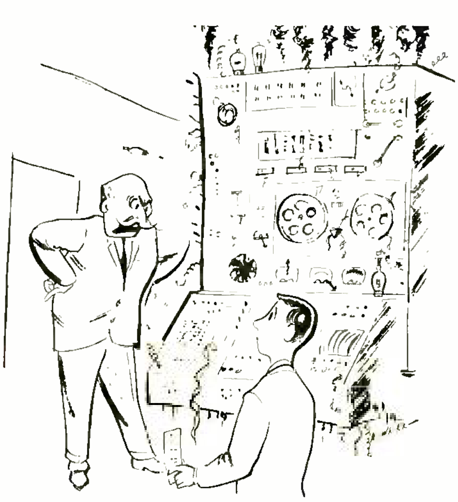
OPTO-ELECTRONICS MARKET BOOMING

ACCORDING to figures just released by the EIA, U.S. factory sales of semiconductor light-emitting and light-sensing devices amounted to $29 million in 1968.

The report attributes 63.4% of the 1958 LSD dollar volume to photoconductive devices, 27% to photovoltaic, and 9.6% to all others. The latter category includes multilayer, photoelectromagnetic, semiconductor emitters, photon isolators, semiconductor transducers, and various types of thermoelectric devices.

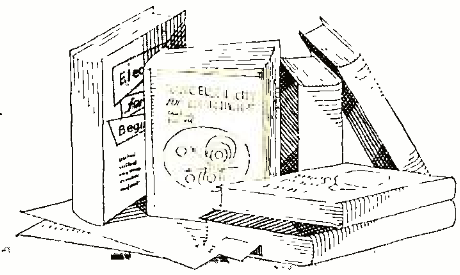
Over-all factory sales, excluding production of captive market companies, were 5,967,000 photoconductive, 2,946,000 photovoltaic, and 1,015,000 all other. The average value of the photoconductive devices was $3.08, photovoltaic $2.65, and other $2.76.

The EIA has estimated that 1967 sales were approximately $23 million, indicating an increase of about 26 percent from 1967 to 1968. ▲



"For the last time, Wilson, no more problems in feminine logic!"

BOOK REVIEWS



"LABORATORY COURSE IN PULSE CIRCUITRY" by Joseph B. Berkley, Sr. Published by *Prentice-Hall, Inc.*, Englewood Cliffs, N.J. 206 pages. Price $7.95 paper bound.

This workbook was designed for use in junior-college electronics-technician programs and is intended to be used as an adjunct to classroom lectures.

Prerequisites include an understanding of circuit fundamentals, reasonable mathematical skill, and a basic knowledge of vacuum tubes and semiconductor devices. The equipment required to perform the experiments is typical of that found in most school electronics labs.

There are 24 experiments including a "get-acquainted" session with the test equipment. Each experiment is designed to be completed in the normal three-hour lab session.

Each section starts off with an Information paragraph detailing the purpose of the experiment, a Preparation section, Performing the Experiment, a Review, a suggested topic for Discussion, and a listing of books from which additional information can be obtained.

* * *

"TRANSMISSION LINES FOR DIGITAL AND COMMUNICATIONS NETWORKS" by Richard E. Matick. Published by *McGraw-Hill Book Company*, New York. 354 pages. Price $14.50.

Subtitled "An Introduction to Transmission Lines, High-frequency and High-speed Pulse Characteristics and Applications," the title is virtually a review in itself. Written by a member of the Technical Staff of *IBM's* Director of Research, this volume provides all relevant information and important concepts required to understand and use transmission lines.

This book can be used either as a text to learn or relearn the subject or as a field reference book. Recent advances such as anomalous skin effect, superconducting lines, and directional coupling effects are covered, along with a discussion of the velocity of propagation. Special emphasis is placed on pulse characteristics and behavior.

The text is illustrated and the treatment is mathematical. For those with the requisite background, this should be a valuable adjunct to their professional or pre-professional training.

* * *

"AN INTRODUCTION TO ELECTRICAL ENGINEERING" by Allen E. Durling. Published by *The Macmillan Company*, New York. 451 pages. Price $10.95.

This is an orientation text which the author has prepared for a course given to all engineering students at the Department of Electrical Engineering, University of Florida in their sophomore year. The idea is to acquaint students in other engineering disciplines with things going on in the electrical and electronic areas.

To use this text, the student will need a background in differential and integral calculus plus some familiarity with basic engineering concepts. The author's style is informal and the material is presented in almost classroom lecture form. The twelve chapters cover a large-scale system, definition and ideal elements, signal description, elementary circuits and theorems, system response, system responses to sinusoidal excitation, superposition in linear systems, principles of electronics, circuit models of electronic devices, linear small-signal electronic circuits, nonlinear electronic circuits, and energy conversion. The text is lavishly illustrated.

* * *

"HOW TO SELECT AND INSTALL ANTENNAS" by Len Cantor. Published by *Hayden Book Company, Inc.*, 116 W. 14th Street, New York 10011. 106 pages. Price $3.95 paper.

The emphasis in this book is on practicality. Written for the man who will actually install various antennas for black-and-white or color-TV and FM, the author has drawn on his own years of experience as well as that of his friends and acquaintances in the antenna industry.

Information on all the latest advances in antenna technology is followed by step-by-step instructions and illustrations showing how to install antennas for u.h.f., v.h.f., FM, or complete master systems. The book includes complete information on selecting the correct components, shows how to mount and stack antennas, covers the type of lead-in wire and preamplifier to be used, and discusses the special reception problems of local, fringe, and near-fringe areas.

* * *

"DC-AC LABORATORY MANUAL" by Thomas C. Power. Published by *Prentice-Hall, Inc.*, Englewood Cliffs, N.J. 150 pages. Price $7.95 paper bound.

This workbook is designed to be used in connection with lectures in a course for tyro electronics technicians. It deals with such basics as the color codes, meters and their uses, Ohm's Law, series and parallel circuits, ammeters, voltmeters, ohmmeters, thermistors, Wheatstone bridges, capacitors, the oscilloscope, sine waves, inductive reactance, *RLC* circuits, resonances, *LC* filters, transformer impedance matching, Lissajous figures, diode action, triode characteristics, semiconductors, and filter circuits.

Each of the experiments includes a statement of purpose, a list of equipment, an introductory paragraph, procedure, and instructions for preparing the observation sheet. The requisite forms for preparing data sheets and graphs are included.

* * *

"ELECTRONIC CONNECTION TECHNIQUES AND EQUIPMENT 1968-69" edited by G.W.A. Dummer and J. Mackenzie Robertson. Published by *Pergamon Press Inc.*, 44-01 21st Street, Long Island City, New York 11101. 552 pages. Price $32.00

This volume in the publisher's Data Series features a compilation of techniques and equipment as used in the specialized field of electronic connections. There are descriptions of all current connection methods, including automated systems and microelectronic interconnections, system selection parameters and application techniques, as well as information on reliability. A comprehensive bibliography is included.

Techniques and equipment used in the UK and U.S. are covered along with information on soldering, welding, bonding, wrapping, crimping, pressure, wire and cable strippers, and ancillary items. The text material is lavishly illustrated. The products and procedures are about evenly divided between the two sides of the Atlantic.

* * *

"ELECTRONICS REFERENCE DATEBOOK" by Norman H. Crowhurst. Published by *Tab Books*, Blue Ridge Summit, Pa. 17214. 227 pages. Price $7.95 hard cover, $4.95 paper.

Mr. Crowhurst has developed a new approach to supplying data—he explains how it is to be applied rather than merely listing page after page of pertinent material.

Problems at virtually every level of interest—from electronics theory to measurements, tests, and circuit design work—are covered. The text itself is divided into ten chapters covering units, basic electronics, applications of "J" operator, exponential and other tables, attenuators and equalizers, filter design, practical component design and use, semiconductors and tubes, feedback, and transmission lines. The 46 tables are indexed separately for quick reference. ▲

Communications Satellites

(*Continued from page 48*)

of the bandwidth-limited satellite to 20-24 channels. Since most programs originate at either Los Angeles or New York, the problem is how to transmit up to 20-24 channels on the single available 500-MHz up-link band. This number of channels is required on fall weekends when the *ABC-CBS-NBC-NET* networks are telecasting different programs in each time zone plus regional football games.

Frequency Allocations and the Future

It is apparent that the above problem is a symptom of insufficient available bandwidth. At the end of next year, the ITU plans to convene a World Administrative Radio Conference (WARC) which will consider, among other things, the allocation of additional frequencies for communications satellite use. Table 3 shows present and proposed frequency assignments. The two 500-MHz bands currently allocated at 4 and 6 GHz are shared with terrestrial microwave links. This has led to specific restrictions on satellite power levels so that they will not interfere with established microwave links. The same situation is true for the military band, but the problem here is not as severe since the traffic needs are considerably less.

In preparation for the WARC, the FCC recently recommended additional assignment of two 20-MHz bands at L-band for mobile aerosat use, and two additional new 1000-MHz bands *exclusively* for communications satellite use. Although the new point-to-point bands would triple the currently available bandwidth, the new frequencies are in the millimeter band where they are severely attenuated by rain. For reliable operation, several widely spaced redundant earth stations might be required at each site so that one would always have favorable propagation. This is expensive and so *Comsat* would like, and has requested, the additional allocation of shared frequencies at X-band on an "as available" basis. *Comsat* has also requested that the v.h.f. aeronautical and marine bands be shared with an aerosat.

Although there exists justifiable economic reluctance to begin development of a millimeter band for communications satellites, the use of this band is inevitable. Communications satellites have become popular candidates for many domestic applications and the pressure for exclusive frequencies for advanced domestic applications is great. Only in the millimeter region is exclusive allocation possible.

Not only has this portion of the spectrum room for a fantastic amount of communications, it also offers the hope of extremely inexpensive world-wide communications. By the turn of the century it is quite likely that most industries and many homes will have direct millimeter-wave access to communications satellites. This will not only allow almost instant global connections, but will also allow the centralization of facilities that are now too expensive to duplicate at several locations. It will start the era of centralized world libraries with computer-aided searching and abstracting, global facsimile transmission, automated medical diagnosis using centralized case storages, home teleshopping with individual televiewers and banking units that debit our account when we place an order, as well as direct communications between computers to form fantastic control systems. Also operating will be huge broadcast satellites that can transmit radio and TV programs directly into the home. Considering what communications satellites have achieved in the past ten years, the only real question is whether it will take as long as 30 years for this next revolution to happen.

The author would like to thank the *Communications Satellite Corporation*, NASA, and the U.S. Air Force for their kind help in preparing these articles. ▲

An Electronic Mail Service

(Continued from page 32)

present special delivery, a letter could be mailed, opened, and put on the *WU* facsimile service for instant transmission to the post office nearest to the addressee, sealed again, and delivered by the existing special delivery service. For long distances, now covered by airmail, a day or two may be saved.

Combined with *WU's* multiple-address service, such a scheme might be very attractive to business organizations who want to send out price lists, catalogue-change pages, or other information to dispersed offices. While this service might cut into airmail revenues somewhat, it would reduce the sorting and mail handling problem immediately, since intermediate post office stops could be eliminated.

In February of this year *General Electric*, in a special filing before the FCC, described its proposed "Telemail" service which could transmit a 600-word letter anywhere in the U.S. for 33 cents by 1975. Using a large domestic satellite system with ground stations connected to computer-controlled switching centers, a whole range of communications services was proposed. While *G-E* is not in the point-to-point communications business, its concept of MADS (Multiple Access Digital System) could tie into *WU's* network.

Future Benefits

Thus far we have only considered presently existing communications facilities, but two new services are due to emerge in the near future which will benefit any *WU*-P.O. combination. One of these is some kind of domestic satellite which will add many more channels to the wide-band capacity of *WU's* microwave system. While such satellites will be used for telephone, picture phone, TV, and various data services, they will also provide sufficient additional channels for record communications. The second, already emerging, service is cable-TV.

There are many services which cable-TV provides the individual set owner, but its application to record or message communications deserves special consideration. *RCA* has already developed an inexpensive printer which, when connected to the TV set, decodes information transmitted during the vertical synchronizing period of a TV signal and then is able to print such information as stock-market reports, news, and advertisements. When a cable, rather than the individual antenna, brings TV into the home, this multiplexed approach is not necessary since a separate frequency can be used for the additional data service. In place of an alphanumeric printer, an inexpensive facsimile machine could be used and that would permit not only text but pictures to be printed. *Xerox* already offers a very compact device which can reproduce a facsimile from narrow-band (4-kHz) data.

Now we can combine all of the communications features into a system of the future and, as shown in Fig. 3, we can see how the prophecy of "mailing a letter in your living room" can become a reality. The coaxial cable connecting our TV set with the local cable-TV system will actually connect us to many other local services, and, through the *WU*-P.O. combination, to all parts of the country and, eventually, the world. In all likelihood we will have the option of either a printer and keyboard or a facsimile machine in our home. Either will contain a slot for inserting our credit identification card so that, instead of buying stamps, we can charge the cost of sending letters. The same device will let us charge the cost of seeing special programs over pay-TV, get stock quotations, order groceries, or pay the monthly cable-TV bill.

We will be able to get our mail wherever we happen to be, by simply notifying the computer-controlled switching center. Within a particular city we will only have to insert our identification card into the nearest terminal and push the "Reserve Request" button.

Thus far we have thought mainly of private, individual communications, but it is easy to see how such a system will benefit every type of business and government activity. Sales orders, and their confirmation, will be handled rapidly. Medical prescriptions, important records of all sorts, and information in all of its forms will be automatically transmitted between any two terminals, and terminals will be located wherever a TV set or a telephone is installed.

There are, of course, many problems associated with this dream of the future, and some of them might even turn out to be nightmares. Right now we are besieged by a flood of advertising mail. What if this flood now comes direct to us *via* the printer or facsimile machine? Of course, we can shut off the machine, but then we might miss some really important message. Could we persuade the system to send us only mail addressed in our private code? Would this lead to "private code mailing lists" for sale? How about servicing the equipment? Would *WU* or a local dealer be involved? Would the facsimile machine or printer be leased or owned? What about the legal problems? How about the profitability of such a system? Clearly many questions remain and much development work is needed, not only in the purely technical but also in the economic, legal, and political fields. ▲

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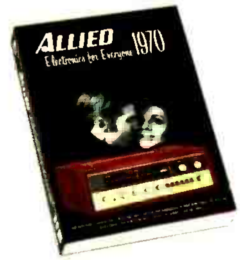

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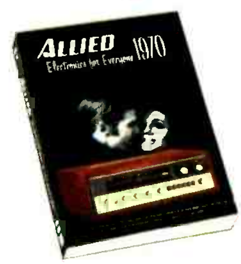

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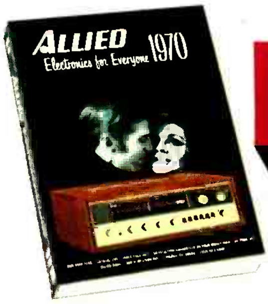

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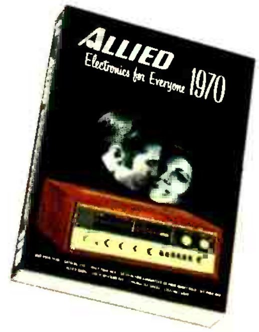

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Japanese Trade-Name Directory

A listing of the most popular Japanese transistor radios and hi-fi equipment, along with the addresses of U.S. representatives offering sales and servicing.*

BRAND NAME	COMPANY
AGS	Sterling Hi Fi Inc., 22-20 40th Ave., Long Island City, N. Y.
AKAI	Camart Products, 1845 Broadway, New York, N. Y.
AIRCASTLE	Spiegel Inc., 1061 W. 35th St., Chicago, Ill.
AIRLINE	Montgomery Ward, 619 W. Chicago Ave., Chicago, Ill.
AIWA	Rand Assoc., 1270 Broadway, New York, N. Y.
AIWA	Selectron International, 4215 W. 45th, Chicago 60632
AMBASSADOR	Allied Stores Purchasing, 401 Fifth Ave., New York, N. Y.
AMD	World Mark Electronics, 663 Dowd Ave., Elizabeth, N. J.
ASTROTONE	Lafayette Radio Electronics, 111 Jericho Turnpike, Syosset, N. Y. 11791
AUTOSONIC	Martel Electronic Sales, 2339 S. Cotner Ave., Los Angeles, Cal. 90064
AZTEC	Aztec Sound Corp., 2140 S. Lipon, Denver, Colo. 80228
BRADFORD	W. T. Grant Co., 1441 Broadway, New York, N. Y.
BRENELL	Fen-Tone International, 106 Fifth Ave., New York, N. Y.
CIPHER	Metric TV Parts, 65 Lexington Ave., Passaic, N. J.
CORONET	Arrow Trading Co., 5 West 26th St., New York, N. Y.
CRAIG	Cardinal Elect., 5069 Broadway, New York, N. Y.
CRAIG	Craig Corporation, 2302 E. 15th St., Los Angeles, Cal.
CROWN	Industrial Suppliers, 755 Folsom St., San Francisco, Cal. 94107
DELMONICO	Delmonico International, 50-35 56th Rd., Maspeth, N. Y. 11378
DEMPA[1]	Delta International, Ltd., Box 1946, Grand Junction, Colorado
DENON	Nippon Columbia (Corp. of America), 501 Fifth Ave., New York, N. Y. 10017
EBNER	Fen-Tone International, 106 Fifth Ave., New York, N. Y.
ELECTRA	Electra Radio Corp., 30 W. 23rd St., New York, N. Y. 10010
ELECTROPHONIC	Electrophonic Corp., 92-00 Atlantic Ave., Ozone Park, N. Y. 11416
ESSEX	Lloyd's Electronics Corp., 59 N. Fifth St., Saddle Brook, N. J. 07662
EVERPLAY	Gulton Industries, 212 Durham Ave., Metuchen, N. J.
FLEETWOOD	Transworld Industrial Corp., 5204 Hudson Ave., West New York, N. J.
GLOBE	GC Electronics Co., 400 S. Wyman St., Rockford, Ill.
GRANADA	Fried Trading Co., 423 Bedford Ave., Brooklyn, N. Y.
HIGHWAVE	Marvel International, 30 E. 42nd St., New York, N. Y. 10017
HITACHI	Hitachi Sales Corp., 48-50 34th St., Long Island City, N. Y. 11101
JADE, REALTONE	Realtone Electronics, 34 Exchange Place, Jersey City, N. J.
JVC	JVC America Inc., 50-35 56th Rd., Maspeth, N. Y. 11378
KENWOOD	Kenwood Electronics Inc., 3700 S. Broadway Place, Los Angeles, Cal. 90007; 69-41 Calamus Ave., Woodside, N. Y. 11377
LLOYDS	Lloyd's Electronics Corp., 59 N. Fifth St., Saddle Brook, N. J. 07662
MASTERWORK	Masterwork Audio Products, 51 W. 52nd St., New York, N. Y. 10019
MAYFAIR	Artic Import Corp., 666 W. Kinzie, Chicago, Ill. 60610
MERCURY	Mercury Record Corp, 35 E. Wacker Dr., Chicago, Ill. 60601
MIDLAND	Midland International Corp., 1909 Vernon St., North Kansas City, Missouri 64116
MIRANDETTE	Allied Impex Corp., 300 Park Ave. S., New York, N. Y.
MITSUBISHI	Mitsubishi International, 277 Park Ave., New York, N. Y.
NATIONAL	Panasonic, 200 Park Ave., New York, N. Y. 10010
NIVICO	Delmonico International, 50-35 56th Rd., Maspeth, N. Y. 11378
ORION	Orion Electric Co., 1199 Broadway, New York, N. Y. 10001
PANASONIC	Panasonic Parts & Repair, 43-30 24th St., Long Island City, N. Y.
PENNCREST	J. C. Penny, 1301 Ave. of the Americas, New York, N. Y.
PIONEER	Pioneer Electronics USA Corp., 140 Smith St., Farmingdale, N. Y. 11735
PLAYTAPE	Playtape Inc., 1115 Broadway, N. Y. 10010
RANGER	Tenna Corp., 19201 Cranwood Pkwy., Cleveland, Ohio
REALISTIC	Radio Shack Corp., 730 Commonwealth Ave., Boston, Mass.
REMBRANDT	All Channel Products, 47-39 49th St., Woodside, N. Y.
RHAPSODY	B & B Import-Export, 15755 Wyoming Ave., Detroit, Mich. 48238
ROBERTS	Roberts Electronics, 5922 Bowcroft St., Los Angeles, Cal. 90016
ROSS	Ross Electronics Corp., 589 E. Illinois St., Chicago, Ill. 60611
SANSUI	Sansui Corp., 34-43 56th, Woodside, N. Y. 11377
SANYO	Sanyo Electric Co., 350 Fifth Ave., New York, N. Y.
SATELLITE	Best of Tokyo, 11 W. 42nd St., New York, N. Y.
SHARP	Sharp Electronics Corp., 178 Commerce Rd., Carlstadt, N. J. 07072
SONY	Sony Corp. of America, 47-47 Van Dam St., Long Island City, N. Y.
STANDARD	Standard Radio Corp., 36-09 39th Ave., Woodside, N. Y. 11377
SUPEREX	Superex Electronics, 4 Radford Pl., Yonkers, N. Y. 10701
SUPERSONIC	Spiegel Inc., 1061 W. 35th St., Chicago, Ill.
TEAC	Teac Repair Center, 404 Jericho Turnpike, Syosset, N. Y.
TECHNICORDER	Oki Electric Industry Co., 202 E. 44th St., New York, N. Y.
TELMAR	Martel Electronic Sales, 2339 S. Cotner Ave., Los Angeles, Cal. 90064
TOSHIBA	Toshiba America, 477 Madison Ave., New York, N. Y. 10002
TRUETONE	Western Auto Supply, 2107 Grand Ave., Kansas City, Mo.
UNICORD	American Geloso, 251 Park Ave. S., New York, N. Y.
VISCOUNT	Consolidated Merchandise Corp., 520 W. 34th St., New York, N. Y. 10001
VISTA	Craig Corp., 2302 E. 15th St., Los Angeles, Cal. 90021
WILCO	Sanyo Electric Co., 350 Fifth Ave., New York, N. Y.

*For a more complete list of Japanese consumer electronic products, write Electronics Div., Japan Light Machinery Information Centre, 437 Fifth Ave., New York 10016.

[1] Publishers of Japanese television schematic diagrams.

Radiation Detector Sounds Off

Fig. 1. Compact monitor can be carried easily in a shirt pocket.

By EUGENE WALTERS

Unknowingly, people can be exposed to high level radiation. This monitor helps prevent such accidents.

PEOPLE who work with nuclear radiation must carry some kind of personal detector or monitor for their protection. These units come in a variety of forms, most of which are checked visually, or by developing in a photographic darkroom long after the radiation may have exceeded safe limits. Many devices, especially capacitive type monitors, require daily recharging. These methods are cumbersome, costly, and time-consuming—and can even be dangerous, especially if radiation levels are subject to sudden changes.

The ideal personal monitor should be small enough for a shirt or jacket pocket and provide a loud audible warning when radiation levels increase above a preset limit. Few devices manufactured today—to our knowledge—fulfill all of these requirements.

The most sensitive and practical basic radiation detector is still the Geiger-Mueller tube. In addition, this halogen-quenched tube is particularly useful because of its resistance to environmental conditions. The monitor described here uses a special ultraminiature G-M detector, the *Amperex* 18509. Although there are some roughly equivalent types available, none of them has performed as well as this one. Cost of the tube is relatively low; the single quantity price is $25.

Battery-Powered

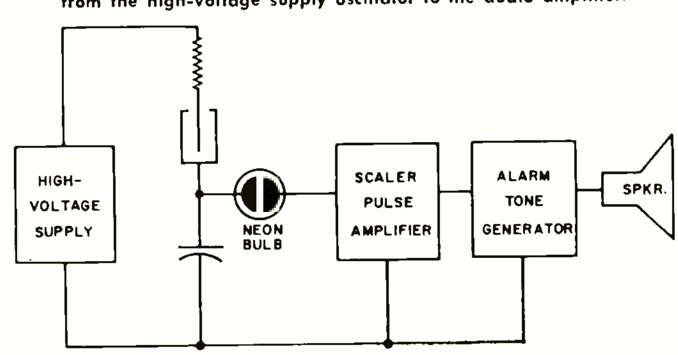
Surprisingly, perhaps, the operation of the personal radiation monitor (Fig. 1) is relatively uncomplicated. The circuit diagram is shown in Fig. 3. Note transistor Q1's circuit forms a blocking oscillator to switch the 4-volt input supply (through a voltage quadrupler) up to the 520 V needed for the G-M tube.

Q1's rate of oscillation can be adjusted by changing the effective resistance between its base and the plus side of the battery. In the circuit, this is the parallel combination of R8 and the scaler pulse amplifier system—composed of Q2 and Q3. Ordinarily this oscillator works at a very low repetition rate—about 50 pulses per second—just enough to maintain suitable voltage at the detector tube in low-radiation fields.

While this oscillator is generating the 520 volts needed for the G-M tube, it also sends a signal to audio amplifier Q4 and to the speaker through capacitors C7 and C8. Because the audio amplifier is almost turned off at this point, the speaker produces only a faint ticking sound, which is not audible to the wearer in normal use. Battery drain is very low, approximately 0.5 mA in low radiation fields, allowing a battery life of about 2000 hours or three months of continuous operation.

When higher radiation levels are encountered, pulses from the G-M tube build up a charge on C5, which then fires the neon lamp (PL1), sending a pulse of current to Q2 and Q3. The amplified and lengthened pulse (about 0.5 second) is then fed to audio amplifier Q4. At the same time, the pulse changes the blocking oscillator's rate from 50

Fig. 2. Simplified block diagram of the personal radiation monitor. The "alarm tone generator" is activated by a signal from the high-voltage supply oscillator to the audio amplifier.



to about 3000 pulses per second. The oscillator rate then decays back to its idling rate. The decay time is determined by the value of capacitor C6. This action produces a characteristic "chirping" sound through the speaker—the monitor's way of warning the user that radiation is present.

Frequency vs Voltage

Accelerating the oscillator frequency in response to the scaler pulse has another important function. It generates the higher voltage needed to compensate for the increased current through the G-M detector tube. Although zener diode regulation of the high-voltage pulse amplitude in the transformer secondary would best control the high-voltage output, suitable high-voltage zeners are expensive and difficult to obtain. Much the same regulatory effect is possible with the low-voltage zener and a blocking capacitor (shown by the dashed lines between "A" and "B"). Regulation is not as good as with the other methods but the difference is not noticeable and, of course, it is a lot easier and less expensive.

Since a personal monitor must have a wide operating temperature range, silicon transistors are used except for oscillator Q1, a germanium type 2N1304.

Silicon devices are inherently more reliable, even in high radiation fields. If the monitor is going to be used in continuous high-temperature environments where freezing temperatures are never encountered, extra reliability is possible with circuit modifications. Reduce R8 to 100,000 ohms and R4 to 15,000 ohms, and move the ungrounded side of R4 to base of Q4 for added quieting.

Variable Sensitivity

Sensitivity can be changed by altering C5 within the limits of 0.001 to 0.05 μF. The 0.005-μF value used in this model provides a sensitivity of one "chirp" every 5 seconds for a radiation level of 5 milliroentgens/hour (mR/h). At one chirp every half-second, radiation intensity is 50 mR/h, calibrated with a radium-226 standard. If short-term high sensitivity is needed, a momentary-contact push-button switch which throws a larger capacitor in parallel with the smaller C5 will accomplish this.

Neutrons are as big a hazard in radiation laboratories as *beta* particles and *gamma* rays. Therefore, a certain amount of neutron sensitivity is built into the monitor. A small piece of 5-mil thick silver foil wrapped around one-half of the G-M tube does the job.

What happens is this: thermal neutrons hit the silver atoms and knock off an electron which, in turn, is counted by the detector. Carried in the pocket, the detector is still sensitive to fast neutrons. Incidentally, leaving half the detector tube uncovered retains the instrument's *beta* particle and low-energy *gamma* ray sensitivity.

(The basic circuit can be modified to operate with larger, more sensitive halogen-quenched G-M tubes of the type commonly used in portable radiation survey instruments. This tube requires a much higher operating voltage—about a kilovolt. Thus extra stages must be added to the multiplier network.—Editor) ▲

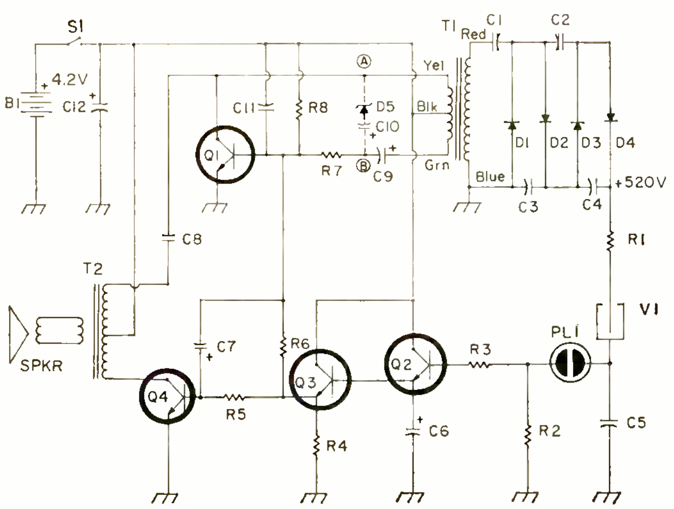


Fig. 3. Circuit diagram of the personal radiation detector.

R1—2 megohm, ¼ W res.
R2, R4—100,000 ohm, ¼ W res.
R3, R5, R6—5100 ohm, ¼ W res.
R7—1500 ohm, ¼ W res.
R8—470,000 ohm, ¼ W res.
C1, C2, C3, C4, C8, C11—0.0022 μF, 600V ceramic capacitor
C5—0.005 μF, 200 V Mylar capacitor
C6, C7, C9, C10—1 μF, 10 V tantalum or ceramic capacitor
C12—56 μF, 6 V tantalum capacitor
PL1—1/25 W neon lamp, Type A1B or NE-2
T1—Miniature trans. (Microtran M-8073)
T2—Output trans. (Microtran UM-27F)
S1—S.p.s.t. miniature slide sw.
Spkr—8-ohm speaker
D1, D2, D3—1N3255 or equiv.
D5—1N963B, 12 V, 400 mW zener diode (see text)
V1—Geiger-Mueller tube (Amperex 18509)
Q1—2N1304 germanium transistor
Q2, Q3, Q4—2N697, 2N2714, 2N2380A silicon transistor
B1—4.2 V battery (Eveready EI 33 or equiv.)

Relay Circuits

(*Continued from page 36*)

upper/switch contacts are closed, the relay is energized by current flowing from the transformer, through the switch, diodes *D*1 and *D*3, the relay coil, diode *D*6, the normally closed contact circuit of the relay, and back to the transformer. The relay latches through the normally open control contacts and resistor *R*4. Toggling one of the switches down sends a pulse through the control circuit which is of opposite polarity to the signal from the relay's holding or latching circuit. This immediately releases the relay and opens the latching and power circuit. Capacitor *C*3 filters the half-wave-rectified current as it is applied to the relay coil. With the relay de-energized, toggling the switch down, closing the lower contacts, finds diodes *D*2 and *D*6 in opposition, which blocks the flow of control current and the relay will not pull in.

This circuit is discussed in U.S. Patent 2,892,132. Component values are included in Fig. 3 for a typical 24-28 volt d.p.d.t. relay, with silicon rectifying diodes, operating from 24 volts a.c.

Remote pilot-light indication of the attitude of the control relay is possible without using additional control wires. The addition of lamps *PL*1 and *PL*2 and diode *D*5 (shown in dotted lines) in Fig. 3 accomplishes this. The lamp glows when the relay is not energized as a small current will flow through the lamp, *D*1 and *D*3, the relay coil, diode *D*6, and the normally closed relay contacts. If diode *D*5 were not in the circuit, the lamp would glow continuously.

With the relay latched in, diodes *D*1, *D*3, and *D*5 are in opposition and blocking so no current flows through lamps *PL*1 and *PL*2. A low-current lamp must be used because the current flowing through the relay must be less than that required to pull it in. For the pilot light to indicate that the power circuit is "on" would require the use of the normally closed power contacts with the circuit as shown in Fig. 3. This type of operation is not desirable in many cases as the relay will automatically revert to its de-energized condition and turn the power circuit "on" should the control-circuit a.c. supply fail or if it should be interrupted for any reason.

The circuit of Fig. 4 provides a true pilot-light indication of the power circuit's "on" condition by using a relay with three "Form A" or normally open contacts. In the relay's unenergized position, diodes *D*2, *D*4 and *D*5 block flow of lamp current. When one of the switches is toggled up, polarized a.c. current flows through *D*1 or *D*3, *D*5, and the relay coil. The relay latches through the lower and middle "Form A" contacts, diode *D*6, and resistor *R*4. Simultaneously, diode *D*5 is shunted by resistor *R*5 and the closed middle "Form A" contacts, which permits lamp current to flow in the reverse direction through the relay coil, resistor *R*5, diodes *D*2 and *D*4, and lamps *PL*1 and *PL*2. The forward current flowing through the relay coil is enough larger than the reverse lamp current to keep the relay latched in. Because of the reverse lamp current, capacitor *C*3 must be somewhat larger in this circuit than in other circuits in order to hold in the relay. Toggling down any of the switches shorts *PL*1 and *PL*2 and applies a reverse-polarity pulse to the relay. This opens the relay and immediately removes the shunt resistor (*R*5) from diode *D*5. With the switch still closed, diode *D*5 blocks the flow of any additional current.

Three-pole, normally open relays are not readily available as stock items, so the component values of Fig. 4 apply when using a general-purpose, three-pole, double-throw, 24-volt d.c. relay operating from 24 volts a.c. and using a single 1819 pilot light. If two or more 1819 pilot lights are used, the value of resistor *R*4 will have to be reduced to insure that the relay remains latched in.

This circuit is well suited for use with reed-switch relays since the basic reed switch is normally open. ▲

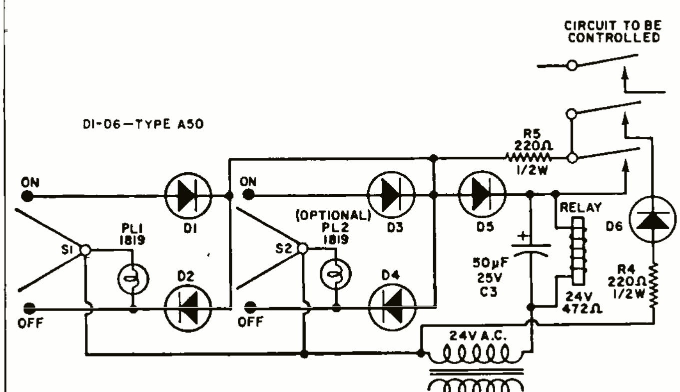


Fig. 4. This circuit is used to indicate a true "on" status. When "off," diodes D2, D4, and D5 prevent current from flowing in the lamp.

NEW PRODUCTS & LITERATURE

For additional information on items identified by a code number, simply fill in coupon on Reader Service Card. In those cases where code numbers are not given, may we suggest you write direct to the manufacturer.

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

HOME MATV DISTRIBUTION SYSTEM

A home entertainment distribution wiring system is now available as a package to permit wiring any home for all-channel TV and stereo FM. Each package includes everything required to install a four-set system: amplifier, all transmission line, wall plate outlets, and u.h.f./v.h.f. signal splitters for each set.

Two models are currently being offered. Model HWK-75 is a 75-ohm kit which uses interference-shielding coax cable, and the Model HWK-300 which uses a foam-type 300-ohm twin-lead transmission line for an economy installation where interference is not likely to be a problem.

A brochure giving details on both systems will be supplied on request. Finney

Circle No. 1 on Reader Service Card

ELECTROSTATIC HEADPHONES

The Model ESP-7 electrostatic headphone is powered by a separate, small energizer and is considerably lighter than the predecessor ESP-6. The energizer connects directly to a good-quality amplifier or receiver.

According to the company, the ESP-7 gives smooth, peak-free response from 35-13,000 Hz ±6 dB. The new push-pull electrostatic design

automatically cancels all second-harmonic distortion.

Other features include fluid-filled ear cushions for high ambient noise isolation, sponge-foam-lined wide headband for maximum comfort, and a dynamic level indicator light (on the energizer box) to pinpoint average listening level.

The Model ESP-9, with a frequency response 15-15,000 Hz ±2 dB, is also available. Its separate energizer unit contains larger transformers and a switch for the choice of energizing through an a.c. power line or self-energizing from the bias supply.

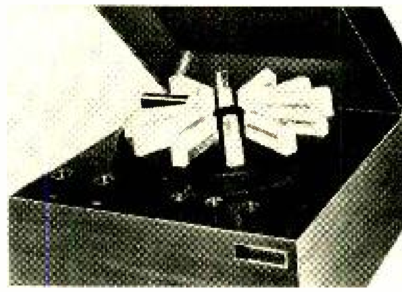
The ESP-9 has been designed to be lighter than the earlier ESP-6 for the comfort of studio engineers who must wear headsets over extended periods of time.

Complete details on either or both of these headphones are available on request. Koss

Circle No. 2 on Reader Service Card

8-TRACK STEREO CHANGER

An automatic 8-track stereo tape changer has just been introduced as the Model 48. Designed for either home or car, the unit accepts twelve tapes and will play them in three distinct sequences, all at the option and control of the lis-



tener. In addition, individual tapes can be dialed in manually and cartridges can be rejected or repeated at any time.

The unit is designed around a circular magazine, similar in principle to that used in many modern slide projectors. The magazine is removable and additional magazines can be purchased to store large tape collections.

Used as a playback deck, the Model 48H may be integrated into an existing home stereo system by connecting its preamp outputs to the high-level inputs on a stereo amplifier. It is also available with matching speakers to become a self-contained home music system with 24 watts of peak audio power. Frequency response is 50-15,000 Hz ±3 dB; total harmonic distortion (at 5 W) is less than 1%; and signal-to-noise ratio is 50 dB. Controls are provided for tape selector, programming mode, volume, tone, stereo balance, and magazine release.

The auto version is designed to be mounted inside the car trunk thus eliminating the possibility of theft, tape damage, and tape wear. Qatron Corp.

Circle No. 3 on Reader Service Card

HOME MATV DISTRIBUTION KITS

Four "Program Center" kits, each containing wall outlets and other accessories for all TV channels and all mono and stereo FM transmissions, are now available.

The Model HS41-300 is designed for city and suburban areas and works with 300-ohm systems, while the Model HS41-75 is for 75-ohm installations. The other two kits are designed for fringe and poor-reception areas and are designated Models HS42-300 (300 ohms) and HS42-75 (75 ohms).

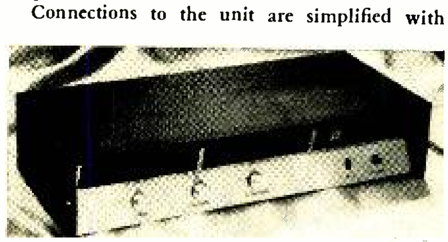
A colorful 8-page brochure describing the line and various available accessories will be forwarded on request. JFD

Circle No. 4 on Reader Service Card

REVERB UNIT

A new reverberator which is designed to be used with any stereo or mono sound system is now available. It features a ten-watt amplifier specifically designed for reverb and uses solid-state components throughout. Distortion is less than 3% at 1000 Hz and both input and output impedances are 8 ohms.

Connections to the unit are simplified with



handy terminals on the rear panel for stereo or mono amplifier leads and an auxiliary reverb speaker. Controls on the front panel permit full tone control and amount of reverb. It is also possible to run the music source without turning on the reverb unit or disconnecting any amplifier or speaker leads.

The unit is housed in an attractive furniture-style cabinet designed to blend in with any decor. Gibbs

Circle No. 5 on Reader Service Card

CONNECTOR LAB KIT

A boxed assortment of 25 selected Type N field serviceable connectors in eight popular physical configurations is now available in a "Lab Kit" for laboratory use and prototype manufacture.

The connectors included in the kit are manufactured in accordance with MIL-C-39012 and represent the latest in coaxial connector design to insure performance within the limits stipulated by the specification.

More information on this kit and the connectors included will be supplied on request. Amphenol RF Div.

Circle No. 6 on Reader Service Card

23-CHANNEL CB UNIT

The all solid-state "Messenger 123" features a high-performance, high-reliability circuit design with full 23-channel operation.

The unit is equipped with a special compression circuit that puts maximum voice intelligence into the radiated signal. Power input to the final amplifier is the maximum allowable 5 watts. It has a super-sensitive receiver with 0.4-μV sensi-

tivity with sharp filtered 7-kHz selectivity to pull in distant stations while rejecting interference from adjacent-channel users. A high-efficiency noise limiter reduces ignition and other forms of radiated noise interference. The solid-state circuitry has low current drain and is fully temperature compensated to operate from −22° to +140° F.

Only 2½" high x 6⁹⁄₁₆" wide x 8¾" deep, the unit can be installed in the smallest underdash space. Weight is 5 pounds. E.F. Johnson

Circle No. 7 on Reader Service Card

STEREO RECEIVER

The KR-77 is a budget-priced, solid-state AM-FM-stereo receiver which features two FET's and two IC's in the FM i.f. stages. Sensitivity is 1.9 μV, selectivity 45 dB alternate channel, and the capture ratio is 2.5 dB.

The receiver permits great amplifier flexibility with left- and right-channel preamplifier outputs and corresponding power amplifier inputs to allow separate operation of any amplifier and make possible connection of a multi-channel system. The center-panel keyboard switches offer control of interstation muting, low and high filter circuits, and loudness. Front panel jacks provide easy access for dubbing/tape record and stereo headphone.

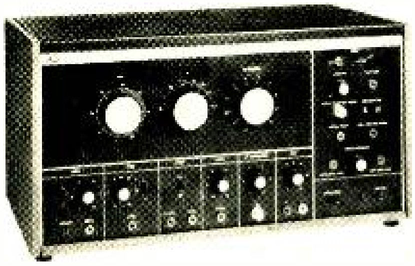
The receiver comes complete with a simulated walnut cabinet. Full technical specifications are available on request. Kenwood

Circle No. 8 on Reader Service Card

TV DIAGNOSTIC INSTRUMENT

The Model 1077 television analyst is designed for troubleshooting all types of TV receivers, including u.h.f. and transistorized types and color sets.

The instrument uses a flying-spot scanner system and signal-substitution techniques. TV sig-



nals can be injected at any time, at any point in the circuit, and used to track down the source of intermittents or general TV troubles. The procedure is designed to reduce troubleshooting time.

The new instrument is housed in an attractive, modern cabinet and comes with an illustrated 108-page instruction manual. Additional information is included in Catalogue AP24-B which will be forwarded on request. B&K

Circle No. 9 on Reader Service Card

COMPACT MUSIC SYSTEM

The Model 35-106 compact stereo music system features 60 watts music power, an AM-FM-stereo receiver, an integrated Garrard automatic record changer with magnetic cartridge, and two acoustic-suspension speaker systems with a front-loaded 8" woofer and 3½" tweeter with electrical crossover. The system comes complete with oiled walnut decorator cabinets. The speakers measure 11¼" x 17¼" x 8¼" deep.

Specifications include frequency response 20-25,000 Hz with 40-dB separation; loudness

a.f.c., stereo/mono, and tape-monitor controls; and provisions for adding remote speakers with a front-panel selection switch. The tuner section features a stereo indicator light and tuning meter; better than 3-μV sensitivity with over 30-dB stereo separation; 300-ohm FM antenna; and a built-in ferrite loop for AM. Claricon

Circle No. 10 on Reader Service Card

V.H.F. CRYSTAL OSCILLATOR

The new CO-221 series crystal oscillators provide a stable fixed frequency output in the 25-125 MHz range and are suitable for use either directly at the oscillator output frequency or for multiplication to u.h.f and microwave frequencies.

Use of a precision "Koldweld" overtone crystal results in a low aging rate, while a high-gain integrated-circuit proportional oven control system results in a stability better than $\pm 5 \times 10^{-8}$ over 0-50° C with −55° C to +75° C operation optional.

The output level of this 2" x 2" x 4" package exceeds 10 mW into 50 ohms. Voltage frequency control is optionally available. Complete specifications will be forwarded on request. Vectron

Circle No. 11 on Reader Service Card

ELECTRONIC RHYTHM KIT

The new "Combo Sideman", which plugs into a music amplifier, will reproduce, electronically, the sounds of bass drum, snare drum, and cymbals. The sounds are generated and mixed in various combinations and timing, controlled by the operator, to produce six precise, perfectly timed rhythms.

The kit is easy to assemble as there are only a few wires to be connected. An assembled PC board contains the solid-state timing circuits. Operation is from a single 9-volt battery. Jacks are provided for remote control of start/stop and solo functions. The assembled unit fits into a small case which measures 7½" x 7" x 2".

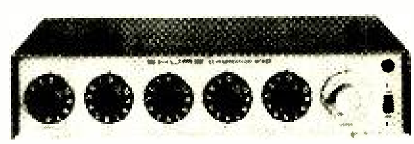
The kit, Model KG-392, comes complete with battery, footswitch, and output cable. Full details are available on request. Allied Radio

Circle No. 12 on Reader Service Card

FOUR-CHANNEL MIKE MIXER

A new microphone mixer with adjustable, built-in reverberation, suitable for the full range of multi-microphone applications in commercial p.a. and paging systems is now available as the Model M68RM.

The unit is fully transistorized and features four microphone input channels, each with an individual volume control and an individual slide switch to select high or low impedance. One of these channels also doubles as an aux-



iliary high-level input that accepts tape recorder, tuner, and accessory signals for maximum flexibility.

With its adjustable reverberation capability, the new unit can simulate the acoustics of a large concert hall to provide "mellow" sound output. A master volume control governs the volume of all four inputs simultaneously. Shure Brothers

Circle No. 13 on Reader Service Card

WEATHER RECEIVER

A 12-transistor, single-frequency weather receiver, set on the ESSA-U.S. Weather Bureau's continuous broadcast frequency of 162.55 MHz, has been introduced as the "Weathercaster."

This compact 5" x 3" x 1½" deep receiver operates from a single 9-volt battery. There are two tuned r.f. stages, three i.f. stages, and a limiter for greater sensitivity and more rejection. Reception is a minimum of 40 miles from the transmitter, more in some areas. There are nineteen cities where such broadcasts emanate: New York, Chicago, Los Angeles, San Francisco, Honolulu, Kansas City, Washington, D.C., Boston, New Orleans, Lake Charles, Baton Rouge, Corpus Christi, Galveston, Charleston, S.C.,

Norfolk, Atlantic City, Jacksonville, Tampa-Clearwater, and Miami.

The instrument is designed for a wide variety of applications wherever accurate, up-to-the-minute weather information is of importance. Radio Communications

Circle No. 14 on Reader Service Card

ADHESIVES KIT

A new kit for various electrostatic/electromagnetic shielding and adhesive applications (or tests) includes four different silver conductive paint formulations and two epoxy-based adhesives.

The adhesives are two-component formula-

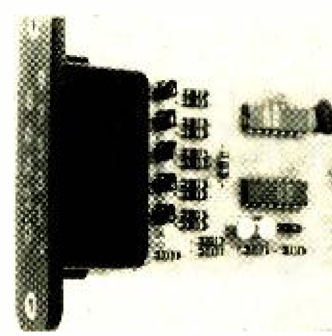
tions: one for fast setting at room temperature and the other with rapid low-temperature cure of class-B electrical and physical properties. The paints include a silver-filled single-component lacquer for elevated temperatures; a silver-filled vinyl-based coating for a high degree of flexibility; silver-filled paint which accepts conventional tin-lead solder; and acrylic-based silver conductive for general-purpose shielding.

The kit comes in a reusable styrofoam pack, with complete technical information and stainless steel mixing spatula. Epoxy Products

Circle No. 15 on Reader Service Card

DECADE COUNTER KIT

A new decade counter kit for the electronics experimenter is now available as the Model DC10-1. The counter module uses Signetics' "Utilogic" IC's for high noise immunity and a guaranteed 10-MHz clock rate. Eleven neon



lamps illuminate the ten digits and a decimal point on the readout face.

The modules include a fully drilled G-10 fiber glass PC board. An assembled and tested version of the counter is also available. A data sheet on this new kit will be forwarded on request. Display Electronics

Circle No. 16 on Reader Service Card

150-WATT SOUND CENTER

The Model 6000 150-watt AM-FM-stereo sound center is designed to permit any of several popular automatic turntables to be mounted on the precut walnut cabinet of the receiver. Besides accommodating any of the current Dual or Garrard SL65 or SL55 automatic turntables, a phono sensitivity switch is provided to accommodate any recent stereo magnetic phono cartridges.

Music power output, which is rated 150 watts ±1 dB at 4 ohms, is adequate for use with any quality component speaker system and is designed to handle multiple speaker systems as well as a mono center-channel or remote-extension speaker.

There are front-panel tape dubbing and stereo headphone jacks and an FET FM tuner. The six front-panel push-buttons control main and remote speakers, loudness contour, stereo/mono selection, tape monitoring, and high filter. A front-panel tape jack provides for stereo tape playback and recording of reel-to-reel or cassette tapes. Additional rear-panel stereo tape jacks permit dubbing from one recorder to another or simultaneous stereo recording using two tape recorders. Sherwood

Circle No. 17 on Reader Service Card

NEW TURNTABLE

A new Perpetuum-Ebner turntable, the PE-2018, is a three speed (78, 45, 33 r/min) unit which incorporates all of the essential features of the earlier PE-2020.

The turntable features a 15° vertical tracking angle adjustment, gentle lowering action of the tonearm, stylus protection as the tonearm will not lower on the turntable unless a record is on

the platter, and automatic selection of record size.

Also included is anti-skating, pitch control, and automatic cueing. The tonearm and motor are the same as those used in the PE-2020. Elpa Marketing

Circle No. 18 on Reader Service Card

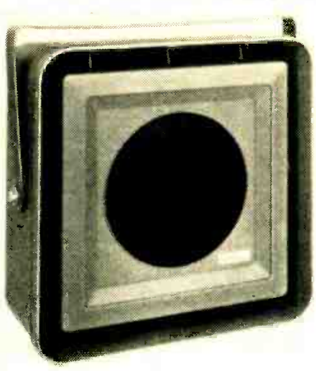
CLAMP-ON V.O.A.

A 4¾" x 2½" x 1⅜" five-range, clamp-on volt-ohm-ammeter is now available as the Model YTO525/100. It has two voltage ranges (0-150/600 V a.c.), two current ranges (0-25/100 A a.c.), and a 25-ohm midscale ohmmeter range. A second version, without the ohmmeter range, is also available. Accuracy is ±3% full-scale. Voltage test leads are supplied. A fused ohmmeter battery attachment is also included. Amprobe

Circle No. 19 on Reader Service Card

OUTDOOR SPEAKER

A new series of portable indoor/outdoor speaker systems has been introduced with a number of new features. The new "Musicasters" retain the bass-reflex-type enclosures and forward-facing wide-range speakers of the earlier models, but a ¼-inch Acoustifoam barrier, sandwiched



between the silicone-treated speaker and the front grille, provides improved waterproofing. The enclosure itself is of glass-filled polyester for appearance, durable finish, and light weight. The speaker is a 12-inch unit.

Nominal impedance of both units is 8 ohms. Frequency response of the "Musicaster I" is 80-10,000 Hz while the "Musicaster IIA" extends high frequencies to 16,000 Hz. Power handling capacity is 30 watts program material and 60 watts peak. Electro-Voice

Circle No. 20 on Reader Service Card

MANUFACTURERS' LITERATURE

SHORT-FORM CATALOGUE

A condensed short-form catalogue which provides useful information on an extensive line of jacks, plugs, switches, connectors, indicating devices, and audio accessories is now available for distribution.

The 28-page publication pictures and describes products which the company markets through industrial distributors. For those requiring engineering specifications on any of the products, the company provides a prepaid post card to facilitate such requests. Switchcraft

Circle No. 21 on Reader Service Card

ELECTRONIC TEST ACCESSORIES

A 52-page general catalogue of electronic test accessories is now available. The new publication lists 375 products, 78 of which are new in the line. Featured new products include a series of shielded "black boxes" slotted to accept circuit boards, a new series of coaxial adapters, a new series of push-on coaxial cables, an a.c. high-voltage probe with built-in voltmeter, and a line of standard and miniature unmounted banana plugs and jack hardware.

Complete engineering information as well as photographs of the products, dimensional drawings, schematics, specifications, features, and operating ranges are included. Pomona Electronics

Circle No. 22 on Reader Service Card

POWER SUPPLIES

A 12-page catalogue (No. 68) covering power supplies, precision voltage references, laboratory instrument accessories, and potentiometer voltage supplies is now available for distribution.

Specifications are presented in tabular form along with construction details, optional features available, and package outlines. Ordering information and delivery schedules are also included. Dynage

Circle No. 23 on Reader Service Card

COMPONENT SELECTOR

A 36-page "Component Selector" catalogue has been issued as No. 300. Complete information on an extensive line of resistors, rheostat/potentiometers, potentiometers, trimmers, tap switches, variable transformers, capacitors, relays, power controls, light dimmers, r.f. chokes, meter savers, and design aids is provided.

Specifications are tabularized and application data is provided for each product, along with photographs and pertinent mechanical details. Ohmite

Circle No. 24 on Reader Service Card

ELECTRONIC SWITCHES

Alco Electronic Products, Inc., P.O. Box 1348, Lawrence, Mass. 01842 has issued a new 20-page "Alcoswitch" catalogue featuring an expanded line of miniature electronic switches and keyboard assemblies.

There are five complete lines of toggle switches including the 5-amp standard and 6-amp series, waterproof series, 15/32" bushing series, and locking toggle series. S.p.d.t., d.p.d.t., 3-pole d.t., and 4-pole d.t. configurations are available in each group.

An illuminated push-button switch features easy lamp removal without use of tools. The reed-actuated keyboard assemblies are available in four standard stock models. Push-button module sections are also listed for the engineering designer.

Write direct to the company at the above address on your business letterhead for a copy of this catalogue.

ELECTRONIC COMPONENTS

All electronic components stocked by the company's distributors are covered in a new 32-page catalogue just issued by Erie Technological Products, Inc, 644 West Twelfth Street, Erie, Pa. 16512.

Contents include ceramic, mica, electrolytic fixed capacitors; air ceramic, glass, quartz, and plastic variable capacitors; EMI filters; resistors; and semiconductor devices. Illustrated with photos, diagrams, and charts, the catalogue provides a quick-reference guide for selecting the correct component.

Business letterhead requests to the above address will be honored.

CERAMIC CAPACITORS

Maida Development Company of Hampton, Virginia 23369 has just issued a new 32-page catalogue describing its line of ceramic capacitors and multilayer monolithic chips. The publication contains graphs, performance curves, and dimensions charts. Four pages are devoted to test specifications for capacitors.

Also outlined in the publication are high-voltage disc, 75-V ceramic disc, 500-V disc, and leads for disc capacitors, ceramic feedthroughs, leadless disc ceramic capacitors, power insulators, 500-V tubular ceramics, axial lead tubular ceramics, spark gaps, and ceramic trimmers.

A request on your business letterhead will bring a copy of this catalogue.

COILS AND TOROIDS

A new 16-page catalogue covering the complete line of products manufactured by Automatic Coil Co., Mineola, New York 11501 is now available for distribution.

The catalogue describes in detail the wide variety of standard coils, toroids, and transformers available from the company. Special assemblies including discriminators and filters; r.f. high-voltage transformers; variable pitch coils; variable inductor and capacitor assemblies; and many other types are shown.

Write the company on your business letterhead for a copy of this catalogue.

MATV SPECIFICATION GUIDE

For architects and engineers who plan master antenna television systems, copies of a new guide, Specification No. 5319-102, are available.

Including recommended minimum specifications for equipment and signal levels at all points of MATV systems, the guide is applicable to all such systems, whether in apartments, hotels, motels, schools, commercial or industrial buildings.

The 37-page guide includes the step-by-step procedures that should be followed in balancing an MATV system and in proving its satisfactory performance. The booklet also lists minimum specs for each component of a system. Jerrold

Circle No. 25 on Reader Service Card

VTR DATA SHEETS

Two four-color data sheets on new video equipment are now available for distribution.

One of the publications details the latest addition to the company's EV Series, the EV-310 "Videocorder" video tape recorder, and includes complete specs, call-outs of all controls, and a brief description of the optional accessories. The other data sheet describes in detail one of these options, the CLP-1B video color pack, which provides a unique and economical method of recording and playing back color tapes on the EV-310 and PV-120 Videocorders. Sony Corp.

Circle No. 26 on Reader Service Card

SMALL-SIGNAL/POWER TRANSISTORS

A 52-page condensed catalogue, featuring the company's line of silicon and germanium small-signal and power transistors for military, industrial, and commercial applications, is now available for distribution.

The publication also lists many new devices introduced by the company during the past twelve months, including r.f. power and "p-n-p" power transistors, and special products such as hybrids, die and wafers, and multiples.

Each family of transistors is presented in a separate section and includes typical h_{FE}, $V_{BE(SAT)}$, and $V_{CE(SAT)}$ curves, along with specification charts, outline dimension drawings, and actual size photos of the standard cases. Brief suggested applications are included throughout the catalogue. Solitron Devices

Circle No. 27 on Reader Service Card

PRECISION TEMPERATURE SENSING

Texas Instruments Incorporated has issued a comprehensive application report showing how to use "Sensistor" precision temperature-sensitive resistors. This 20-page booklet (Bulletin CA-125) contains a section on compensating drift of transistor bias, because of temperature changes, through use of Sensistor resistors.

A second section describes eleven sensing or control applications of the resistors. A typical circuit is given for each application. Applications include a d.c. voltage regulator, a fire alarm, an electric thermometer, and a temperature threshold detector. A third section provides help in designing circuits using the resistors.

Write to the Inquiry Answering Service, MS 308, Box 5012, Dallas, Texas 75222 on your company letterhead for a copy of the bulletin.

STEREO CONSOLE BROCHURE

A colorful 20-page brochure covering the company's entire line of stereo consoles has been announced. Each of the models is shown in a handsome decorator setting with details regarding the cabinetry listed. Technical specifications on the various models are listed in a special section at the back of the booklet. Tabular specs are included for making buying comparisons. H.H. Scott

Circle No. 28 on Reader Service Card

CCTV PRODUCT DATA

New literature is now available on an extensive line of black-and-white CCTV products. The literature includes general descriptions, features, specifications, and photos of the Models 2961 and 2962 cameras and the Model 2943 monitor.

The Model 2961 camera comes with 25-mm lens, standard "C" lens mount, and automatic light control. The Model 2962 has a 5" electronic viewfinder and a 5 to 1 zoom lens. The Model 2943 is a 9" monitor which weighs just 13 pounds. Bell & Howell

Circle No. 29 on Reader Service Card

MANUAL SWITCHES

Catalogue 51a, the first revision of the firm's manual-switch listings, has been announced by Micro Switch, 11 W. Spring St., Freeport, Ill. 61032.

The 56-page catalogue reviews eleven categories of lighted and unlighted push-buttons, indicators, matrix-mounted switches, and toggle switches. This publication contains over 500 photographs, diagrams, and cutaway drawings of these manual switches. In addition to information on electrical ratings, terminals, and colors, the catalogue also discusses hand- and tool-revamping techniques, special circuitry, hermetic sealing, locking configurations for toggles, button options, lamps, screens, and decorative hardware.

For a copy of Catalogue 51a, write on your business letterhead direct to the company.

BATTERY REPLACEMENTS

RCA Electronic Components, Harrison, New Jersey 07029 has just issued a comprehensive Battery Replacement Guide which includes information on batteries used in radios, tape recorders, phonographs, TV sets, and CB receivers made by over 300 manufacturers.

The material is presented alphabetically by manufacturer and model numbers and then the suitable RCA battery replacement number is listed.

Copies of this publication, BAT-137, are 25 cents each. Send your order and payment direct to the company at the above address. ▲

EW Lab Tested

(*Continued from page* 13)

as a logical choice for a second system, in a den or boy's room, since many of its special features are less likely to appeal to the lady of the house.

The *Hallicrafters* CR-3000, complete with a walnut-grained metal cabinet, sells for $230. ▲

Miracord 620 and 630 Automatic Turntables

For copy of manufacturer's brochure, circle No. 31 on Reader Service Card.

THE *Miracord* 620 and 630 automatic turntables offer many of the features and most of the performance of the highly regarded Model 50H, but at substantially lower prices. The 620 and 630 are basically the same machine, with few obvious differences.

The trim of the more expensive 630 is more attractive, with chrome details and chrome push-button operating controls, compared to the flat black used on the 620. The arm is the same on both, but there is a small difference in the plug-in cartridge slide. On the 620, the cartridge stylus must be aligned with two white dots on the plastic slide during installation, to provide the correct stylus overhang for minimum tracking-angle error. The 630, on the other hand, has a screw on the end of the slide which moves the cartridge within the slide after installation, and a retractable post on the motorboard which serves as an index for setting the stylus overhang. In both models, the cartridge slide removes easily and installation of the cartridge is exceptionally convenient.

The arm counterweight, isolated in rubber, screws on easily and is adjusted by a simple rotation for arm balance. The tracking-force dial, on top of the pivot housing, is calibrated in intervals of ¼ gram up to 6 grams, and is accurate to within less than 0.25 gram once the arm has been correctly balanced. We found that the optimum balance point was with the arm a few degrees above horizontal, and we suggest the use of an accurate external stylus gage when making the initial installation.

A ring around the base of the arm pivot housing adjusts the anti-skating correction force. It is calibrated to

match the tracking force, and is supposed to be set to the force in use. As with many record players we have tested, we found the optimum anti-skating setting to be about 2 grams higher than the tracking force in use, but this is not critical and one can obtain most of its benefits by following the manufacturer's instructions. The measured tracking error of the arm was less than 0.6 degree per inch of record radius, which is good, and there was no significant resonance in the audio range.

The push-button controls used on all *Miracord* turntables are noteworthy for their smoothness, positive action, and low operating force. The 620 and 630 are no exceptions to the high standards set by their predecessors. Three buttons are marked 7, 10, and 12, for the three record sizes. Pushing any of them puts the player into operation, indexing the arm to play the selected size. If the automatic changer spindle is inserted in the center hole of the turntable, records drop and play automatically, and the machine shuts off after the last one is played. By simply removing the automatic spindle and inserting the short manual-play spindle, a single record may be played, with automatic arm indexing still effective. Alternatively, the arm may be picked up and set down manually, and the motor starts as soon as the arm is lifted off its rest.

If the short manual-play spindle is inserted upside down, the record on the turntable will be played repeatedly until the player is stopped by pushing the Stop button, or by picking up the arm and placing it on its rest. The Stop button may be used during automatic play, in which case the arm returns to the rest and the motor shuts off. If it is pressed again later, the record on the turntable is replayed, while pressing one of the three Start buttons drops the next record and initiates a new play cycle. At any time, either in manual or automatic play, the Cue lever can be used to lift the pickup from the record, and lower it smoothly to the same groove. It is hard to think of any form of record playing which is not available in these units.

Both models are four-speed players, using the same four-pole induction motor. The operating speeds were essentially correct and did not change significantly over a line-voltage range from 90 to 135 volts.

The major functional difference between the two units lies in their rotating turntable platters. The 620 has a drawn aluminum platter weighing about 2.5 pounds. The 630 platter is a balanced casting which weighs about 4.5 pounds. The measured rumble levels of both units were nearly the same. Combined vertical and lateral rumble was −30 dB, by NAB standards (unweighted). Canceling out the vertical rumble by paralleling the cartridge outputs had no effect in the 620, but lowered the 630 to −32 dB. These figures, while not as low as the top-priced Model 50H, are good and rumble is not audible in use.

The major measured difference in performance was in the wow and flutter, which one would expect to be affected by turntable mass. The lighter 620 had a wow figure of 0.25% at 16⅔ r/min, 0.15% at 33⅓, and 0.09% at both higher speeds (45 and 78). Its flutter was 0.15% at 16⅔ r/min, 0.08% at 33⅓, and 0.05% at the higher speeds. These are, of course, quite low figures and are negligible from a listening standpoint.

The 630 with its heavy cast platter had a measured wow of 0.07% at 16⅔ r/min, 0.05% at 33⅓, 0.04% at 45, and only 0.025% at 78 r/min. The latter is essentially the residual level of our test record and instruments. Flutter was 0.03% at all speeds, which is also near the limit of our measuring ability. These are as low as we have measured on any turntable.

The *Miracord* 620 sells for $99.50 and the 630 for $119.50. Apart from styling considerations, there is little practical difference between them. The extremely low wow and flutter of the 630 should appeal to the audio purist, although we could not at any time hear any difference between them. Both are well made, very flexible, and as easy to use as any record player we have seen. ▲

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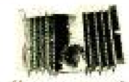

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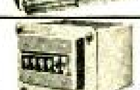

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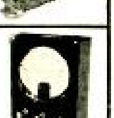

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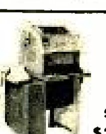

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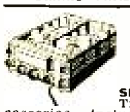

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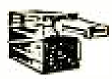

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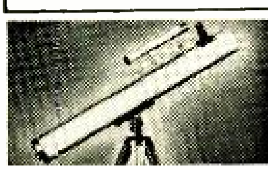

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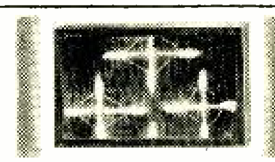

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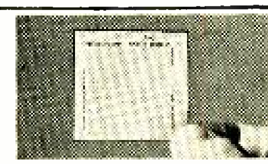

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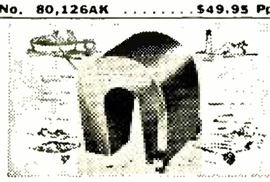

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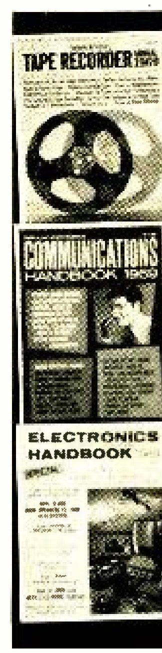

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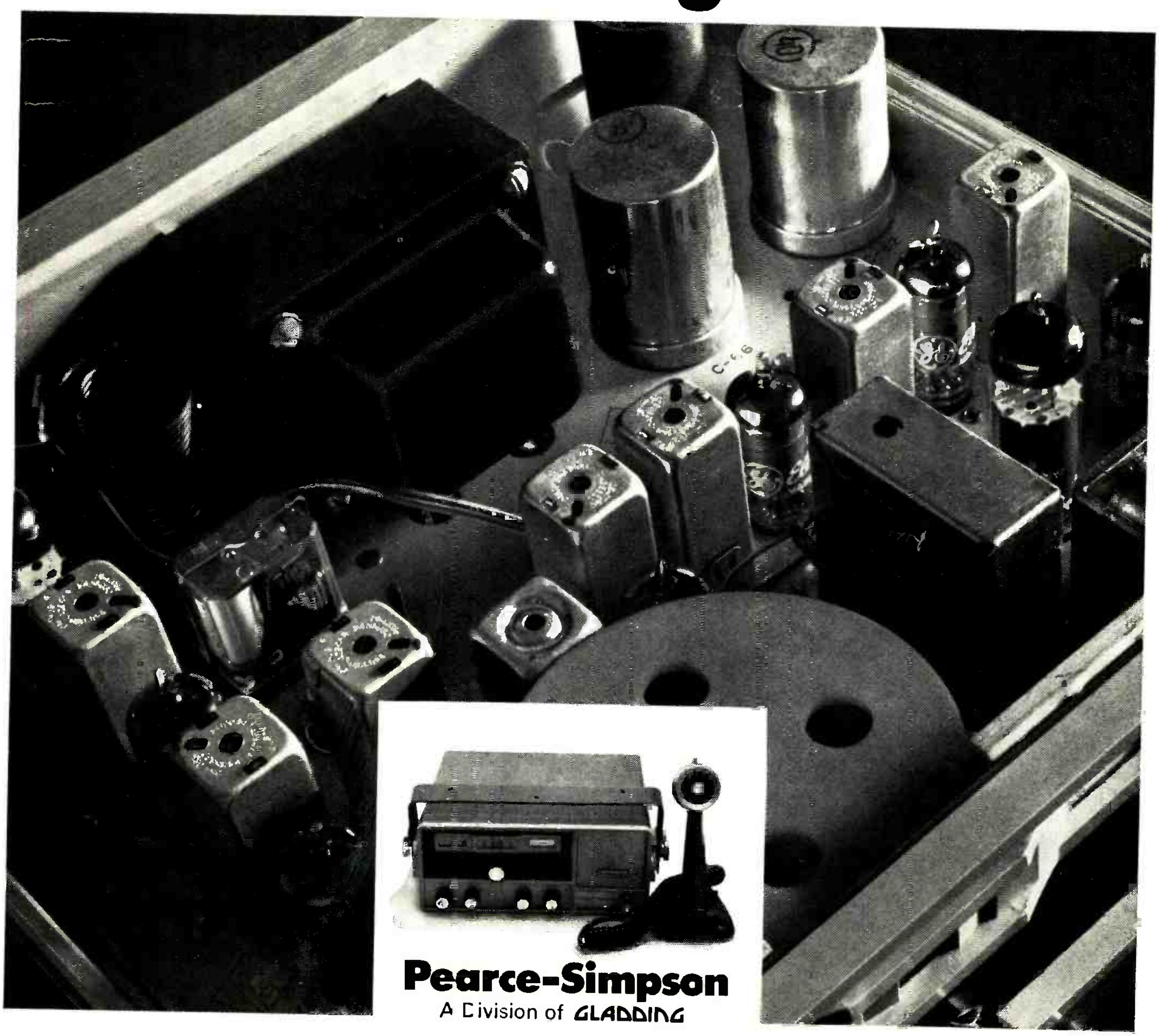
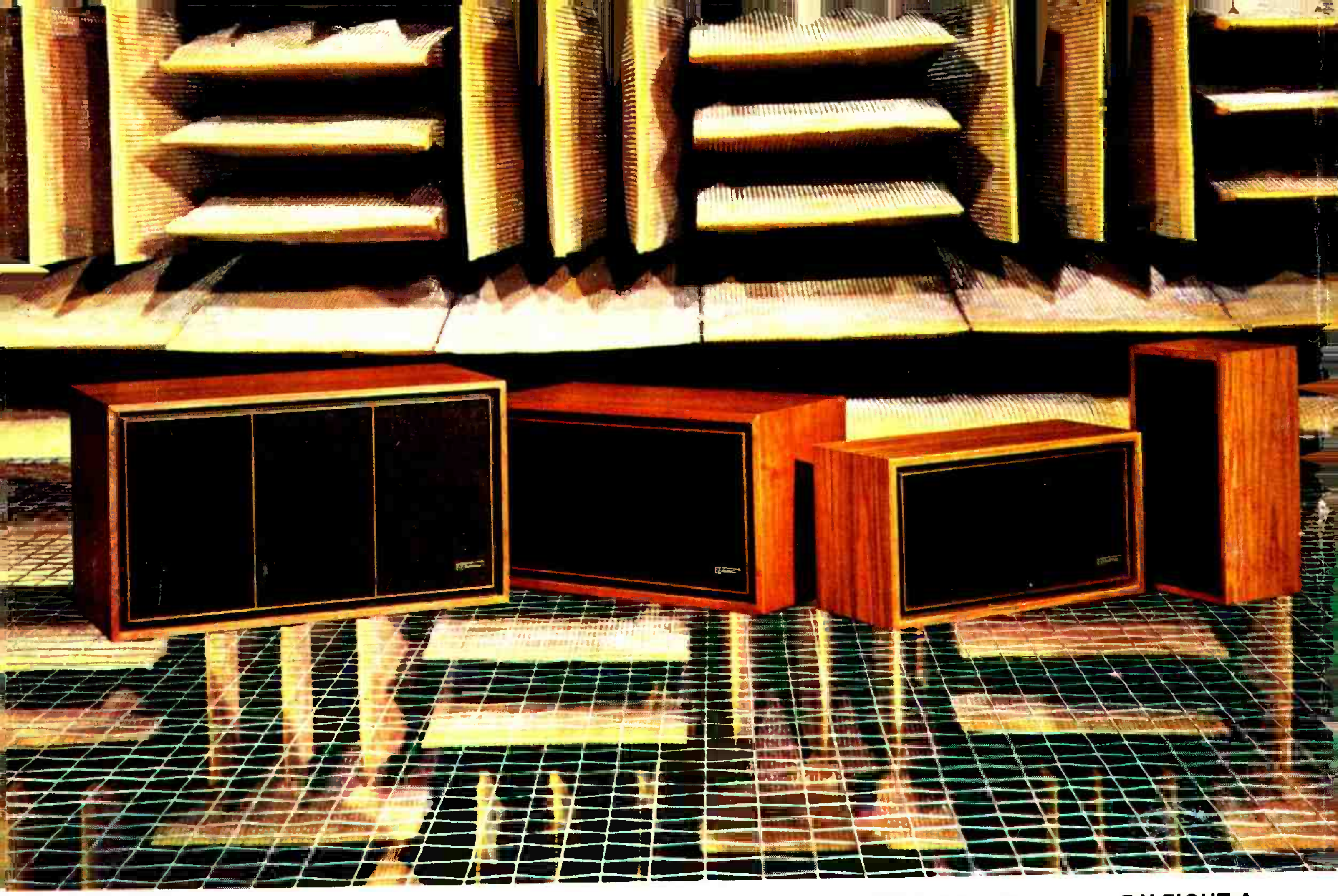


CIRCLE NO. 149 ON READER SERVICE CARD



E-V FOUR·A
12″ 3-way $199.95

E-V FIVE·C
10″ 2-way $99.95

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8″ 2-way $66.50

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Any similarity between these four Electro-Voice bookshelf speaker systems is strictly scientific!

These four speaker systems share a surface beauty. But don't be misled. Underneath — where it counts — there are scores of important differences. There have to be.

Because what's right for a small system may be all wrong for a big one. And what works well in a 2-way system may be poison for a 3-way. (Even a little change, like just 1″ more cabinet, can upset the design of every component inside.)

Of course not everybody can afford to design every speaker in their line from scratch, the way Electro-Voice does. But then, not everybody has a scientific computer that pre-tests hundreds of ideas on paper to find the few good enough to build.

And not everybody has a huge anechoic chamber (like the one above) to prove the superiority of each design. Nor the staggering array of test equipment that goes with the chamber. Or — most important — the engineering talent and musical sensitivity to take full advantage of these unique laboratory facilities.

When you select an E-V speaker system — regardless of size or price — you can be certain it truly represents the state of the art . . . and good value to boot.

Anything less would be a cop-out.

But don't take our word for it. Listen. Compare. The difference you see and hear is what high fidelity is all about.

ELECTRO-VOICE, INC., Dept. 894N,
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For name of nearest dealer, call TOLL-FREE: (800) 243-0355 ANY HOUR, ANY DAY.
In Connecticut call collect: 853-3600

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PA Speakers/Accessories
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Musician's speakers/microphones
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