Electronics World

MARCH, 1970
60 CENTS

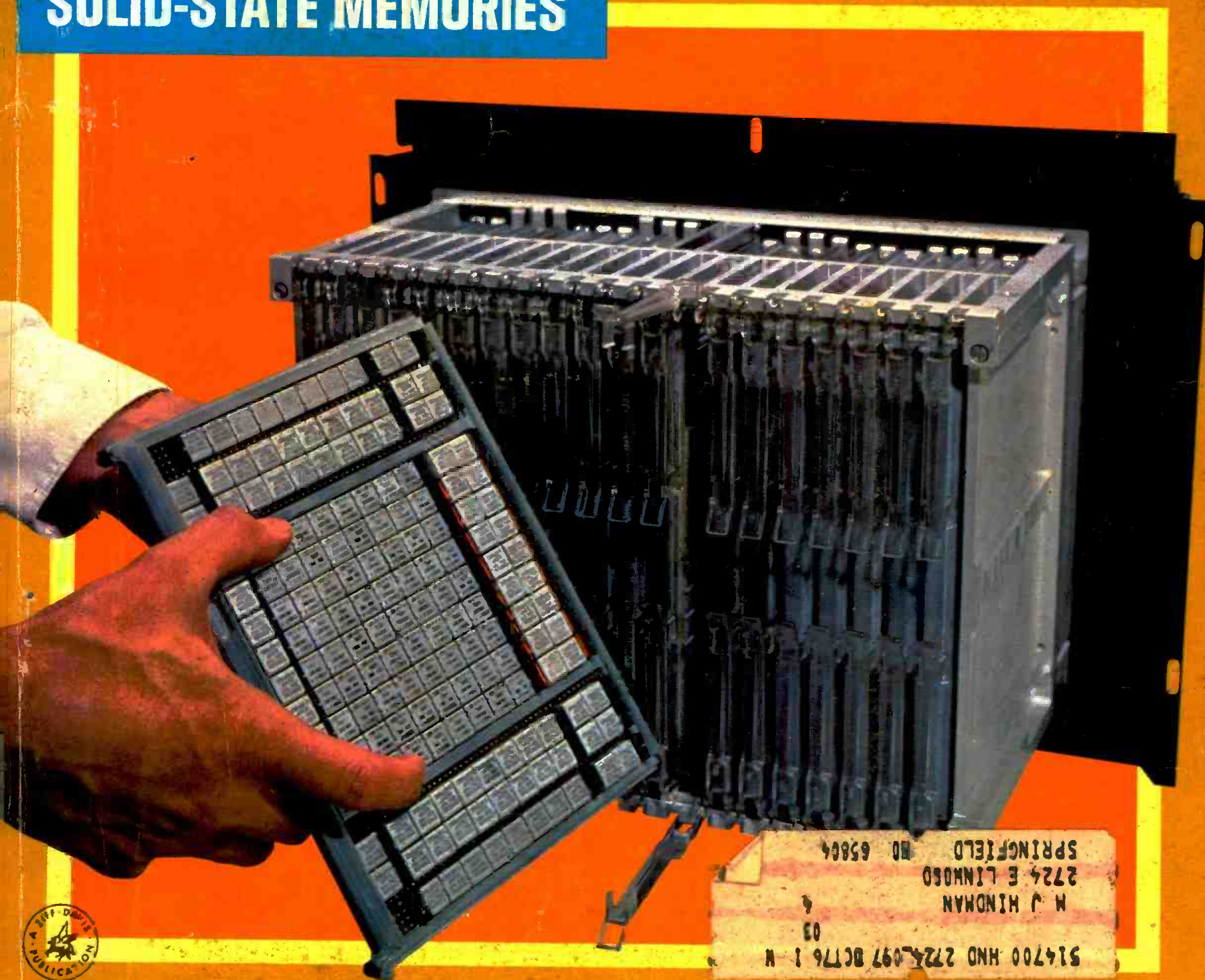
More on FOUR-CHANNEL STEREO

1937—A HISTORIC DEMONSTRATION OF RADAR

How to Use TV'S BUILT-IN TEST SIGNALS

COMPUTER TIME SHARING—Do You Want Your Own Computer?

SOLID-STATE MEMORIES



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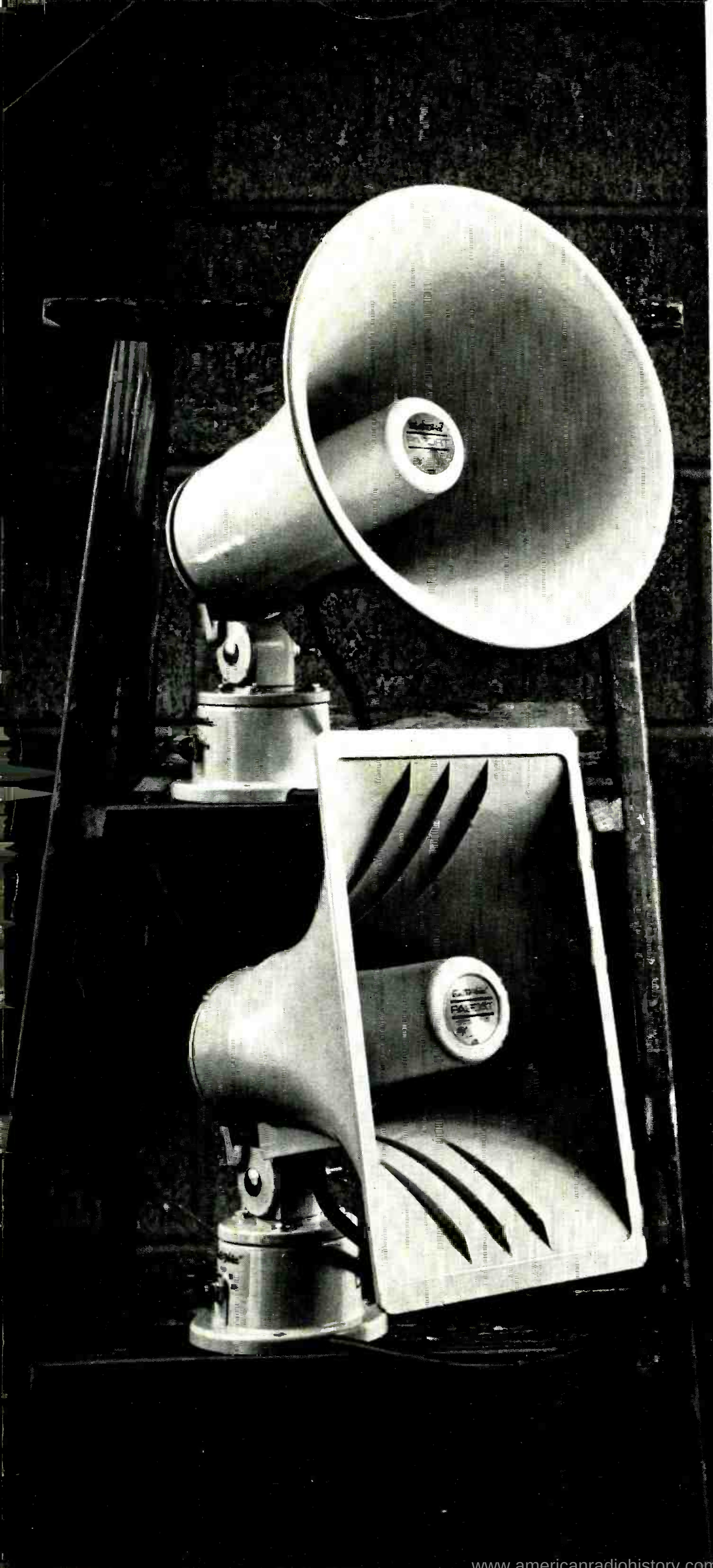

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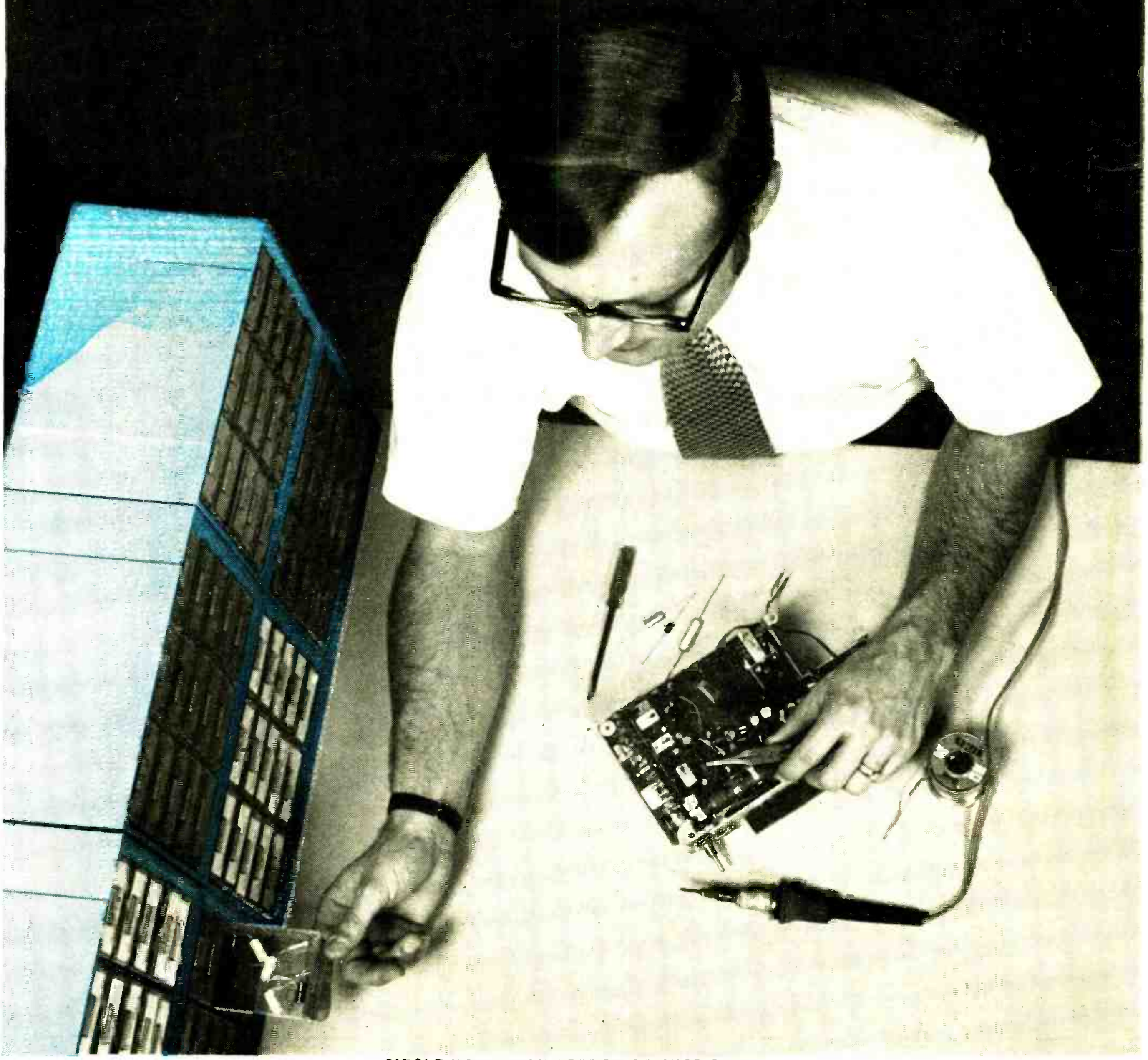

THIS MONTH'S COVER shows a high-speed three-dimensional IC memory unit, two of which form the complete one-quarter million bit buffer memory of IBM's System/360 Model 85. Access time is 40 nanoseconds, faster than previous computer memories used by the company. Seventy-two monolithic memory modules, together with drive and sense circuit modules, are packaged on 7 x 9 inch multilayered pluggable card at left. Sixteen storage cards and four logic and terminating cards make up the basic storage unit (right), which can hold 2048 72-bit words. The illustration ties in with a two-part article beginning in this issue on the topic of "IC Memories—Growth and Future" . . . Cover photograph courtesy of IBM.

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Coming Next Month

Special Issue

VARIABLE CAPACITORS

Don't miss this special section which offers a wealth of information on all types of variables—from glass piston trimmers to air plate, air tubulars, ceramic disc, to LC tuned circuits. The issue will also include up-to-date information on Teflon trimmers, polystyrene tubular and vacuum high-voltage capacitors, along with an LC reactance chart. Experts from JFD. E.F. Johnson, Erie Technological, Johanson, Centralab, and Jennings will serve as your guides to this interesting and important subject. Be sure to get your copy of this timely and authoritative Special Issue.

ELECTRONICS & PARAPSYCHOLOGY

Does man possess latent psi-sensitivities that have been stifled by modern communications systems? Parapsychology, an aspiring science using modern electronic methods, has been working to unleash this "natural" ability in man. L. George Lawrence gives you details on the experiments and the equipment being used to conduct them.

SEEING THROUGH WEATHER CLUTTER

Howard L. McFann of the FAA's National Aviation Facilities Experimental Center explains the operation of a new weather outline device which will enable air traffic controllers to guide planes safely around all types of hazardous weather conditions.

IC MEMORIES— GROWTH & FUTURE

In his second, and concluding, article, Dale Mrazek of National Semiconductor, explains how the new assembly methods and anticipated technological advances point to a bright future for IC memories—especially bipolar types.

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

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Editorial and Executive Offices
One Park Avenue
New York, New York 10016
212 679-7200

NEW YORK OFFICE
212 679-7200
Joseph E. Halloran, Adv. Mgr.
Michael E. Kelman

MIDWESTERN OFFICE
307 North Michigan Avenue
Chicago, Illinois 60601 312 726-0892
George B. Mannion, Jr.

WESTERN OFFICE
9025 Wilshire Boulevard
Beverly Hills, California 90211
213 CRestview 4-0265; BRadshaw 2-1161
Western Advertising Manager, Bud Dean

JAPAN: James Yagi, Ishikawa Mansion,
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Radio & Television news

By FOREST H. BELT/Contributing Editor

Quasar II: More Modules

Motorola has said goodby to tube-type TV sets. Its new Quasar II color chassis has only four tubes; the rest is solid-state. The new TS-934 replaces tube chassis in the $400-$600 line. It is modular, and looks unusually serviceable—more so, even, than the first Quasars with their pull-out drawer and plug-in modules. The regular Quasars stay in the over-$600 line.

The Quasar II chassis have six modular panels, but not all solid-state. The sweep panel has two tubes, and two other tubes are mounted on the chassis pan. The pull-out drawer is smaller than in Quasar models.

Disappointingly, none of the Quasar II panels is interchangeable with those from Quasar models. Now, a *Motorola* panel caddy, to be complete, needs sixteen spare boards. With fewer panels, there are more circuits on each. That raises the specter of higher exchange prices, but—at least for now—that isn't a problem. The most expensive panel in the Quasar II is the one that contains chroma, video, and color driver and output stages; exchange price to the customer is $18. That's only slightly more than for the Quasar horizontal sweep board, which exchanges for $14.

Two integrated circuits are included. One is a color demodulator. The other contains almost all the sound-section circuitry. Both are 14-pin in-line IC's instead of the spider-like 11-pin TO-5 type.

A new *Motorola* monochrome chassis also has modules. Actually, it isn't broken down into small modules like the color chassis. This one has just two large panels, called "mini-circuits." They do snap out for easy access, and replacements will likely be available.

Of course, this isn't the only modular TV. *Zenith* has a monochrome solid-state chassis with four color-coded "dura-modules" that plug in along the rear of the chassis. They carry the a.g.c./sync, vertical sweep, video/sound, and horizontal sweep stages. The printed boards for all dura-modules are the same. The difference is in the wiring and components. A dura-module in the Titan-90 color chassis contains the final color amp and an IC demodulator. In Zenith sets for 1971, to be shown in May, additional dura-modules are expected (and there's a hint of another modular approach that's even more sophisticated).

New Picture Tube Numbers

The Electronic Industries Association has a new way to type-number picture tubes. The old numbers began with the outside diagonal dimension of the tube face. Numbers in the new system begin with the viewable inches by diagonal measurement, followed by a "V" to indicate it is the new system. (Old numbers will not be changed.) That's followed by the usual three-letter type assignment and the final number that indicates phosphor (4 is a monochrome TV phosphor and 22 is the standard tricolor).

Of Cheap Cassettes

Something of a phenomenon may soon plague the cassette field. The market has grown by leaps and bounds. Even so, marketers have pushed for ever lower prices on playback machines. And they're getting them. At $34.95 and $29.95, prices keep dropping lower. At least one is down to $19.95, which discounters have been plumping for.

But what now? As prices have lowered, a dark cloud has begun to materialize. The stigma of cheapness may close down many markets for cassettes. Problem is not that the more-expensive cassette recorders won't have quality; they can and they will. But if the public comes to believe that most cassette players are merely toys—and that idea is already prevalent—it'll be hard to push the notion aside with ordinary logic. Too-cheap cassette players may drive customers interested in quality back to 8-track equipment. (And some executives say there's no hi-fi market there, either.) A price/quality tradeoff anytime soon may turn mildly disastrous.

Return of AM Hi-Fi

Stereo receivers for a long while omitted the AM broadcast band. Theoretically, the stations couldn't put out a hi-fi signal, anyway; that was a gross misconception. Another theory was that listeners would settle for no less than stereo, available only by FM multiplex. Wrong again.

Most new stereo receivers have AM back in. Recent examples are the *Electro-Voice* 1282, the *H. H.*

Scott 3800, and the *Heathkit* AR-19. All include AM, FM, and stereo FM tuner sections, feeding powerful amplifiers. The *Scott* and *Heathkit* have field-effect transistors and integrated circuits.

How come the turnaround? Actually, the frequency limitation of most AM listening is two-fold: (a) the telephone-company line from studio to transmitter commonly has only an 8-kHz top-end response; and (b) the receiver i.f. strip is narrow and selective. In an AM receiver for hi-fi listening, new crystal and other special i.f. filters make it easy to widen i.f. response and keep selectivity—although a sharp 10-kHz whistle filter may be needed in the hinterlands (to block adjacent-carrier beat).

Where a studio and transmitter are together or connected by radio link, audio-channel response to 15 kHz is common. Practically all AM transmitters nowadays handle frequencies out to 15 kHz nicely. So, any station limitation is usually self-imposed (or unintentional). No FCC Rule prohibits amplitude-modulation sidebands that wide with ordinary program material unless they cause interference.

The variety of music today is the widest in history. Individuals have broad-ranging tastes. Stations tend to specialize. This means some kinds of music can be heard only on AM, other kinds only on FM. An eclectic listener needs both, and it looks like he'll be getting it. And don't you be surprised at the quality of sound you hear from a good AM receiver. The old limits don't apply any more.

Franchised TV Leasing

Not unexpectedly, leasing color-TV sets may catch on. It has with *Teletronics Industries, Inc.* of Dallas. And the firm is looking for other operators to do the same, in a franchise arrangement. Cost for the franchise is nil (at this writing). The franchisee buys color receivers from *Teletronics* and leases them to customers of his own. The parent company collects the lease payments and sends the franchisee's portion to him. *Teletronics* builds its own color sets (an 18-inch and a 23-inch) in Mexico. One interesting innovation concerns service. An analyzer used for production-line testing has been adapted to servicing. The analyzer connects to test points wired in the chassis. That may save a lot of repair pennies; the sets are leased with maintenance included.

Quadrasonics? . . . Maybe

Four-channel sound is having severe growing pains. There's no resolution of standards yet. Three different disc systems are proposed, at least two FM-radio systems, and one AM/FM simulcast system. The simplest way still seems to be with tape. Nearly a dozen manufacturers have amplifiers or tape decks to fit the new medium. One manufacturer *(Electrohome)* simulates the effect by adding reverberation to two-channel stereo programs; two behind-the-listener speakers are fed from an amp with a 2-second delay.

Many scoff that quadrasonic music is a fad that won't catch on; some said the same thing about two-channel stereo a few years ago. If a standard is set that is compatible with two-channel stereo and retains the same quality, four-channel sound will probably attract a wide following.

New Society for Technicians

During a meeting at Peoria, Illinois early in February, a group of Certified Electronic Technicians (CET) from all around the U. S. formed the first international professional society for service technicians. Only CET's qualify for membership. The CET exam is administered through National Electronic Associations, 12 So. New Jersey Street, Indianapolis, Ind. 46204. Exams are held in all 50 states and in more than a dozen foreign countries. Worldwide, there are already more than 1500 CET's. The new society has offices at the NEA address.

Small Stuff More Popular?

If you're a trend-watcher, give this some thought. Toward the end of last year, sales of console stereo and TV dwindled. Sales of TV portables and compact stereos rose a bit, leveling the over-all sales picture. At Christmas, hopes were that console sales would bounce back. They didn't. Anyone who is interested in keeping realistic set inventories should be alert to the possibility that smaller sets are where the market is really going to be this year.

Flashes in the Big Picture

Color-TV sales are holding about steady; sometime this month, over 40% of TV households will have color. . . . Nearly 300,000 1970-model cars, about half of them *Fords*, are expected to have tape-cartridge players. . . . Replacement color picture tubes from *Admiral* carry the same 3-year warranty as do the company's new-set color picture tubes. ▲

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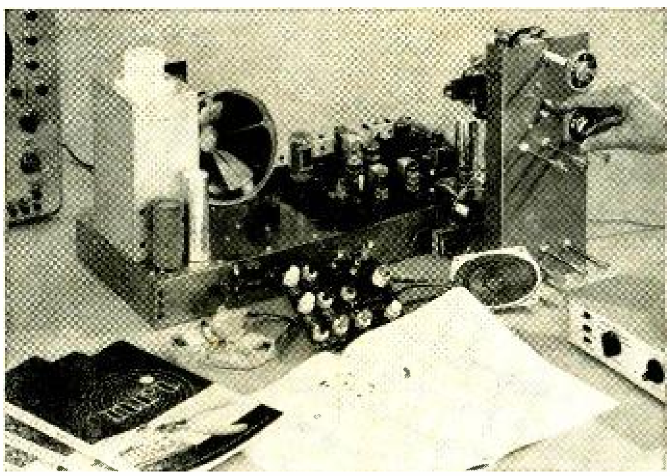
Some NRI firsts in training equipment



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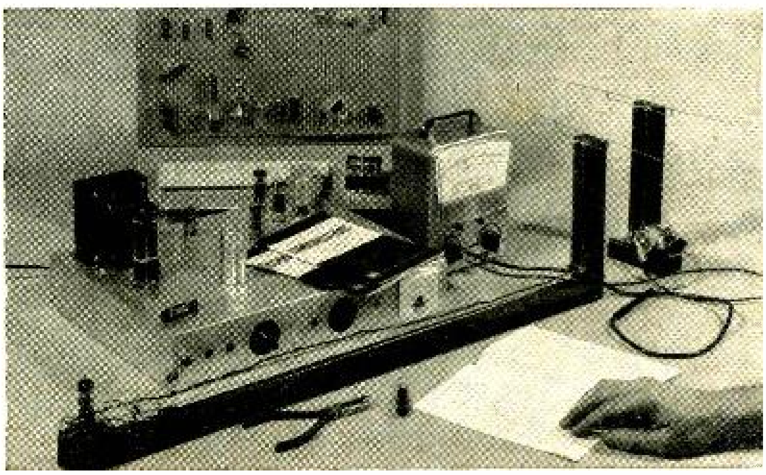

first to give you transmission lines and antenna systems that include experiments not otherwise attempted outside of college physics laboratories. The experience gained with this kind of Communications training equipment is matched only by months — sometimes years — of on-the-job experience.

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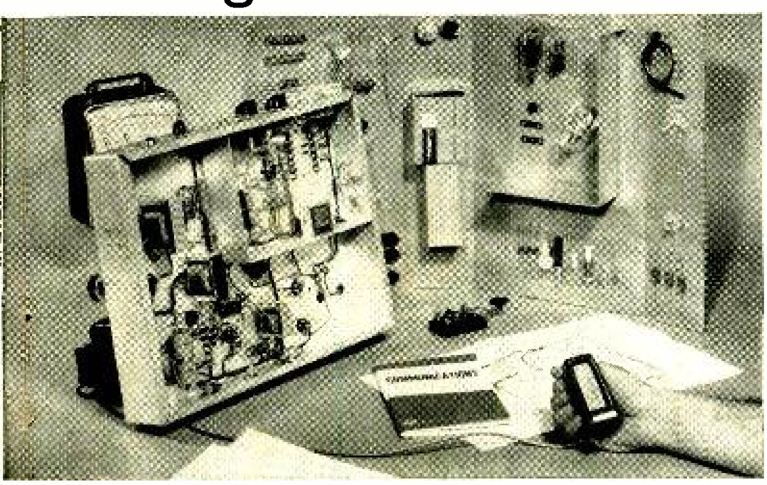

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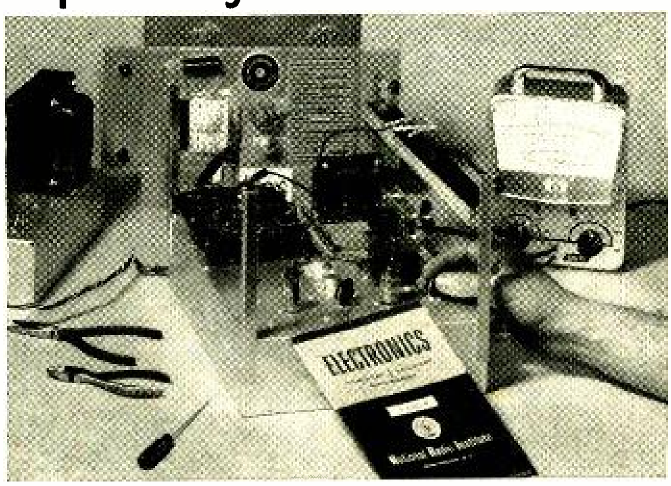

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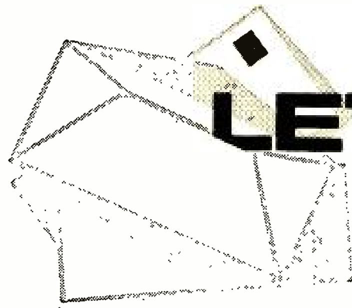


LETTERS

CLOSED-BOX SPEAKERS

To the Editors:

As a builder of my own speaker systems for over 20 years, I was very much interested in Hugh C. Morgan's "Closed-Box Speaker System" in the November issue.

I find that I must take issue with Mr. Morgan on some points:

1. Mr. Morgan recommends that a speaker with a heavy cone be used and, if necessary, to add a small weight to the center to afford greater mass. This is in line with the practice of several manufacturers of closed-box systems: they add a rubber or a metal ring about half-way down the slope of the cone for the same purpose. The net effect of the heavy, weighted cone is an increase in inertia. Accordingly, the system does not respond to the bass frequencies for several microseconds and does not stop for several microseconds after the signal has stopped. It is the same as the result that is sought by adding weight to the turntable plate—steady, continuous motion, and not the sharp response to the variations of the signal.

There are other ways of obtaining a lowering of the free-air resonance of the speaker, such as constricted front openings and front loading.

2. Mr. Morgan recommends that, because the walls of the speaker system are "flexed by changes in enclosed air pressure and absorb more energy than (they) transmit to the outside air," wall flexure should be minimized. This conclusion does not follow. If the walls of the speaker cabinet are suitably padded with absorbent material, much of the energy from the cone will not reach the walls. The small amount of energy that is then transmitted by the walls has the effect of increasing the radiating area of the cone in the bass region and affords a superior bass quality. I have built speaker systems with ⅜" walls and several thin layers of absorbent material tacked to the *entire* inside. These systems have a clean sound as well as good bass.

NATHAN GROSSMAN
Brooklyn, N. Y.

Here are Author Morgan's comments on the points raised above.—Editors

To the Editors:

Mr. Grossman's point on transient response is very interesting. However, such response depends upon many factors. Motional energy from the voice coil is most efficiently transferred to the cone when the interface bond is optimized and the coil-mass to cone-mass-plus-air-load ratio equals unity. As to cone mass *per se*, the old-fashioned, hard, thin woofer cones tended to peak and distort and were heavier than some of the newer, thicker, low-density woofer cones which can produce equal efficiency and at the same time smoother, less distorted response with controlled range.

Cone profile, spider, surround, and other elements also contribute to smoothing of response. And as Villchur, Jordan, and others have shown, smoothness (or *flatness*, if you prefer) equates with excellence of transient response. Also, as *Bose* advises, we are periled with buying or engineering waste; that is, no bass musical instrument produces vertical wavefronts in the low partials of its low tones, the high-rise effect being produced by the upper partials of the tone (all musical tones being formed of many partials). Hence, the real-world speaker is not required to produce vertical wavefronts in its extreme low end but must be well-damped so as to avoid overhang. Also, please note I did *not* advise a "heavy" cone. (How many grams is "heavy," and for what size cone?)

As to front-loading, this presently appears to be a dead end. The *R-J*, and other forms of box-within-a-box, front-slot-loading, and the like, have largely left the market. This is not because they are expensive but because they do horrible things to the response. The front-loader which really works is the horn, but it must be impracticably large if it is to reach down to the low bass easily within the grasp of a modest-sized, closed-box system.

Mr. Grossman's second point is also an interesting one. Except for panel resonance, flexing cabinet walls indeed act as extensions of the cone (down to f_{oc}). But these extensions raise the system resonance and the bass cutoff just as if the speaker *had* grown in size, and this adds to reactance mass and raises Q_t. But worse yet, whence comes the energy to move those walls? Again, from the cone. Now if we had a reinforced concrete, thick-walled enclosure with no wall movement, what would happen?

The box would *not* appear to shrink relative to cone size which, in turn, would not appear to expand; hence the cone would travel farther. Since the cone can move more easily than can the wall, more acoustical energy would be developed and more air would be moved. The internal resistance of the plywood panel is very high—so high that it will absorb more energy than it radiates—a very inefficient radiator. This is true except at panel resonance, which is not our concern here, and can be treated *per* the article.

As to *eliminating* panel movement by absorptive lining or filling, this is not in sight. We may *reduce* Q_t and f_{oc} by absorption or box enlargement. But the value of absorption or enlargement required to reduce f_{oc} output to *zero* is indeed out of sight. Hence in the real world, f_{oc} energy is always present, internal air compression-decompression is always present, and the panels always move.

Sorry, but that's the way the wall bounces!

HUGH MORGAN
Bethany, Okla.

* * *

TRIGGERED SWEEP FOR SCOPE

To the Editors:

Some readers have complained about a possible error either in the circuit of my article "Triggered Sweep for Any Scope" (Nov. issue) or in the PC board supplied by *PrinTrac.*

There is no error in the schematic published in the article. However, the PC board has a mistake and the layout drawing has a capacitor polarity marked the wrong way. The following corrections would be appropriate:

(1) *Error on PC board.* The 500-μF, 15-V capacitor's positive side is connected to the emitter of Q13. To connect it to the base where it belongs: (a) drill small hole below the original one; (b) mount capacitor; (c) cut lead short and make small eyelet by bending it back; and (d) run 1⅜"-long insulated wire to base of Q13.

(2) *Error on PC board layout drawing furnished with the board.* The 10-μF, 12-V capacitor near point (A) is shown in reversed polarity.

(3) *The 220k-ohm resistor on base of Q5 is missing on PC board.* If proper blanking pulse can't be obtained, add the resistor.

Also, the 6.2-V zener diodes specified in the diagram will work, although 1N4735 or 1N5234A are preferred.

IMRE GORGENYI
Scottsdale, Ariz.

A number of readers have pointed out the discrepancies between the circuit shown in the article and the printed-circuit board supplied. Our thanks to Author Gorgenyi for setting the record straight.—Editors ▲

HI-FI PRODUCT REPORT

EW LAB TESTED

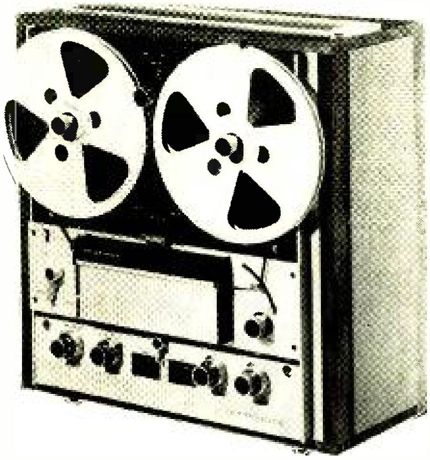
by Hirsch-Houck Labs

Ferrograph 724A/P Tape Recorder
Empire 7000 Speaker System

Ferrograph 724A/P Tape Recorder

For copy of manufacturer's brochure, circle No. 1 on Reader Service Card.

THE new *Ferrograph* Series 7 stereo recorder, imported from Great Britain by *Elpa Marketing*, is available with a variety of head configurations, tape speeds, and installation formats. We tested the Model 724A/P, a three-head, four-track stereo machine with speeds of 1⅞, 3¾, and 7½ in/s. The 724A/P has a pair of 4- × 7-inch monitor speakers and 10-watt amplifiers built into a portable case. It also has many unconventional design features and a careful study of the comprehensive 75-page hard-cover operating manual is necessary before attempting to use the recorder—or even trying to open it up.



The deck seems conventional enough, but much is hidden from view. The take-up reel is clamped firmly in place on the hub by means of a small lever that protrudes from the hub. For good measure, a pair of screw-on reel locks are supplied. The machine, incidentally, will take 8¼-in reels.

The tape path appears to be a straight line, but nevertheless the process of threading takes a bit of fussing. A couple of what appear to be fixed guides on the deck are not identified in the manual, and it is not clear on which side of one of them the tape should go. We tried both sides of the guide with no apparent difference.

A trim strip along the bottom of the deck can be pushed down to reveal an impressive array of controls. Most are duplicated for the two channels. Screwdriver adjustments set playback levels and recording-bias currents. A switch connects the two multipurpose recording-level meters to read record-bias current. A three-position switch connects the output of either playback amplifier to the other recording line input for the purpose of making sound-on-sound recording.

The three-motor transport is controlled by a single switch operating through solenoids. There is an accessory connector for remote control of the transport switch. In the "Fast" position, a separate knob smoothly varies the tape speed from maximum wind to maximum rewind (the tape stops in the middle of the knob's rotation). This permits smooth tape handling and precise cueing. The lack of tape lifters facilitates fast and accurate zeroing-in of the desired spot on the tape by listening. The transport starts up quickly, thereby eliminating slurring.

To move the transport switch past "Stop" to the "Pause" or "Run" positions, a separate release button must be operated together with the control knob. The 724A/P has an unusually elaborate system of interlocking to prevent improper operation, and a number of conditions must be met in order for the tape to move. The tape speed (set by a small knob and dial) must agree with the setting of the equalization control. Otherwise, a red "Reset" indicator lights and the transport will not operate. Once running, if either the tape speed or the equalization control is changed, the tape stops and the "Reset" light goes on. Similarly, tape stoppage because of loss of tension or the contacting of an auto-stop foil attached to the tape actuates the reset system.

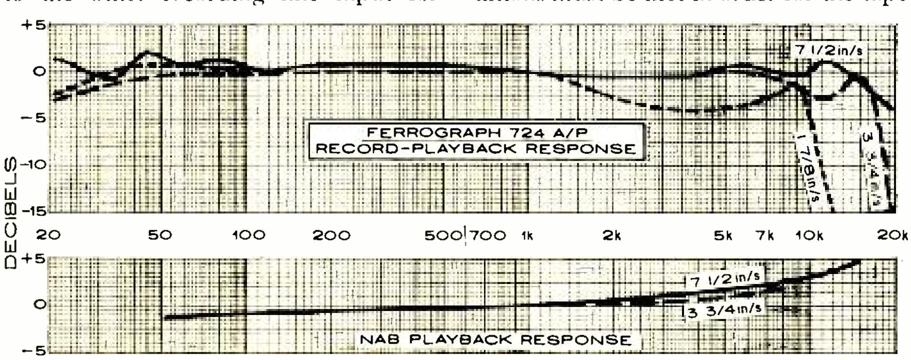
On the deck are individual screwdriver adjustments for setting reel spacing from the deck to center the tape in reels of slightly different dimensions. This is a very useful feature and it enables the *Ferrograph* to operate in dead silence, without the scraping heard on so many recorders.

One precaution should be observed in using the recorder. The red "Record" button can be pressed—and it will remain engaged—at any time while in "Pause" or "Play" mode. There is no protection against accidental erasure of tape if someone should accidentally touch this button while playing a tape. Incidentally, there are no annoying clicks or pops due to bias transients when recording new information on the tape.

How well does the 724A/P perform? Very well indeed, we are happy to say. Using *3M* Type 202 tape, we found the over-all record-playback frequency response to be within ±2 dB from 20 to 18,000 Hz at 7½ in/s. At 3¾ in/s, the response was ±2 dB from 20 to 17,000 Hz, almost identical to the 7½-in/s performance. At 1⅞ in/s, it was within ±5 dB from 20 to 10,000 Hz, which compares with the best cassette machines at that speed (and with better signal-to-noise ratio and speed constancy). Needless to say, these particular frequency response figures are outstandingly fine.

The playback response with *Ampex* test tapes was +4.5 dB, −1.5 dB from 50 to 15,000 Hz at 7½ in/s and +1.5 dB from 50 to 7500 Hz at 3¾ in/s. The distortion was only 1.2 percent at "0 vu" recording level, increasing to 3 percent at +8 dB. The signal-to-noise ratio was good, but not outstanding, at 43 and 45 dB for all tape speeds. The background was, however, very quiet on listening tests.

The transport worked very smoothly with 0.03-percent wow at all speeds and



flutter of 0.07 percent at 7½ in/s and 0.13 percent at 3¾ in/s. Both figures are well within the recorder's specification limits. The machine handled tapes in fast speeds far more rapidly than most machines, taking 42 to 45 seconds to handle 1200 feet of tape. The operating speeds were exact.

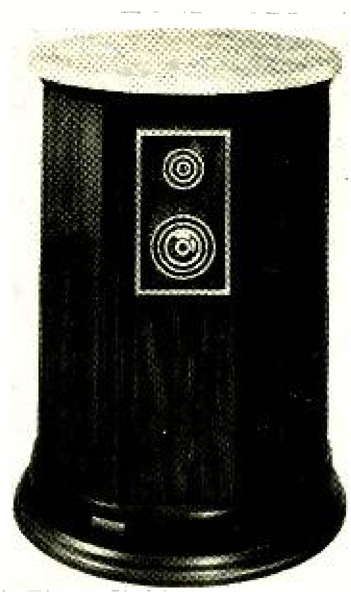
A unique feature of the recorder is the highly accessible brake controls. These are simple screw adjustments that can be made easily without dismantling the unit.

To summarize our impressions of the *Ferrograph* 724A/P: it is made exceedingly well, handsomely styled, very flexible in use, and sounds as good as anyone could desire. Although we did not measure their performance, the built-in amplifiers and speakers sounded very pleasant and external speakers of moderate efficiency can be driven directly by the machine to provide first-class stereo playback performance. The *Ferrograph* 724A/P tape recorder sells for $699.00. ▲

Empire 7000 Speaker System

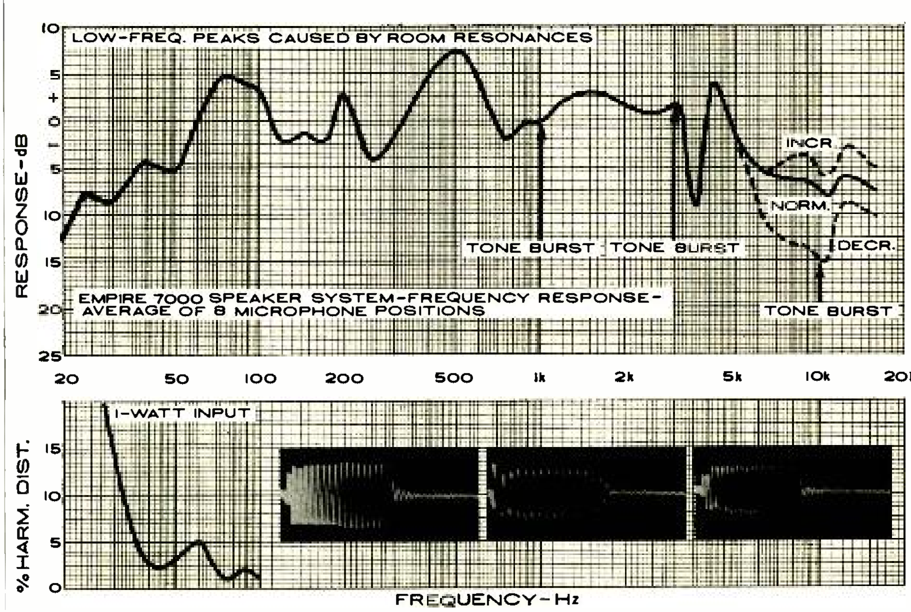
For copy of manufacturer's brochure, circle No. 2 on Reader Service Card.

IN its new Model 7000 Grenadier speaker system, *Empire* has, in our estimation, hit the proper balance between lows and highs. The 7000, like the other Grenadiers, is cylindrical, measuring 19 inches in diameter and 26½ inches high. It is finished in walnut and is available with either a walnut top or a handsome and practical marble top.



The Model 7000 has a 12-inch woofer that faces downward and radiates through a slot around the base. The mid-range speaker and tweeter are mounted in a separate structure near the top of the column, and they radiate through acoustic lenses designed to improve their polar dispersion. Under the base of the speaker, where the input terminals are located, is a three-position slide switch for normal, increased, or decreased tweeter level.

For our frequency-response measurements we averaged the output of eight microphones placed in various locations in the listening room to obtain a single composite frequency-response curve. Tone-burst and low-frequency harmonic-distortion measurements were made with a single microphone close to the high-frequency speakers and on their centered axis. The measured frequency response of the speaker system was quite uniform from about 50 to 15,000 Hz. Above about 5000 Hz, with the tweeter control set at "Normal," there was a shelf in the response that resulted in an average high-frequency output about 5 dB lower than the average level at lower



frequencies. The tweeter-level switch in its boost and cut positions produced about a 3-dB increase or a 5- to 7-dB decrease in output (from the "Normal" position) above 6000 Hz. However, the high-frequency response was exceptionally flat and smooth—within ±1.5 dB from 5000 to 15,000 Hz.

Two broad peaks of 5- or 6-dB amplitude were observed at about 75 Hz and 500 Hz. We believe them to be a property of the speaker rather than of the room, since we listened to the speaker in other rooms and noticed effects which seemed to confirm this. Of course, all speakers show such irregularities in response and their frequencies and magnitudes have much to do with the differences in sound quality.

The Model 7000 has what the manufacturer terms a "Dynamic Reflex Stop System" that enables the user to adjust the bass response below about 100 Hz. Each "stop" is said to boost the bass response by 1 dB. The system arrived at our lab with all four stops removed, and that is the way we tested it. It could be that the 75-Hz peak we measured would have been somewhat reduced by installation of the stops.

At 3500 Hz there was a sharp notch or dip of about 10 dB in the response. This showed up in all our tests, and was undoubtedly due to some crossover-frequency cancellation effects. Because of its narrow bandwidth, it is not likely to be heard in normal listening.

Tone-burst response was generally excellent. Only at 300 Hz and below did it depart significantly from ideal characteristics and at these frequencies we can no longer separate the characteristics of the listening room from those of the loud-speaker.

Listening tests are the ultimate verification of a speaker's performance. The highs (as our curves suggest) were delightfully smooth and well dispersed. In fact, we would rate the middle- and high-frequency sound and dispersion among the best of the current loudspeakers.

Because of its smooth, peak-free performance in the region between 100 and 200 Hz (where so many speakers add coloration to men's voices) the bass was completely free of boom, but definitely "all there." The useful output of the system extends down to below 35 Hz with low (under 5%) distortion. The 500-Hz peak mentioned earlier added a slight trace of boxiness to the sound, which could be detected on white noise and on certain program material but never became objectionable. The speaker had a "live" quality and less coloration than most speakers at or above its price; it is thoroughly listenable. In the case of the Model 7000, there are no qualifications; we like it. The *Empire* 7000 sells for $209.95 with either walnut or marble top (7000M). ▲

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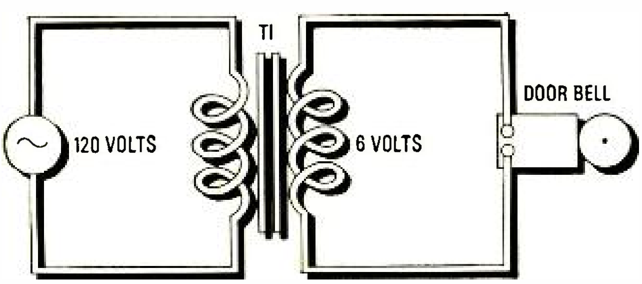

In this door bell circuit, which kind of transformer is T_1—step-up or step-down?

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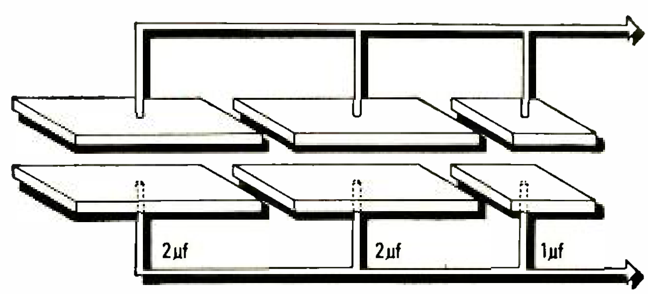

What is the total capacitance in the above circuit?

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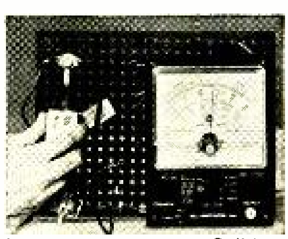

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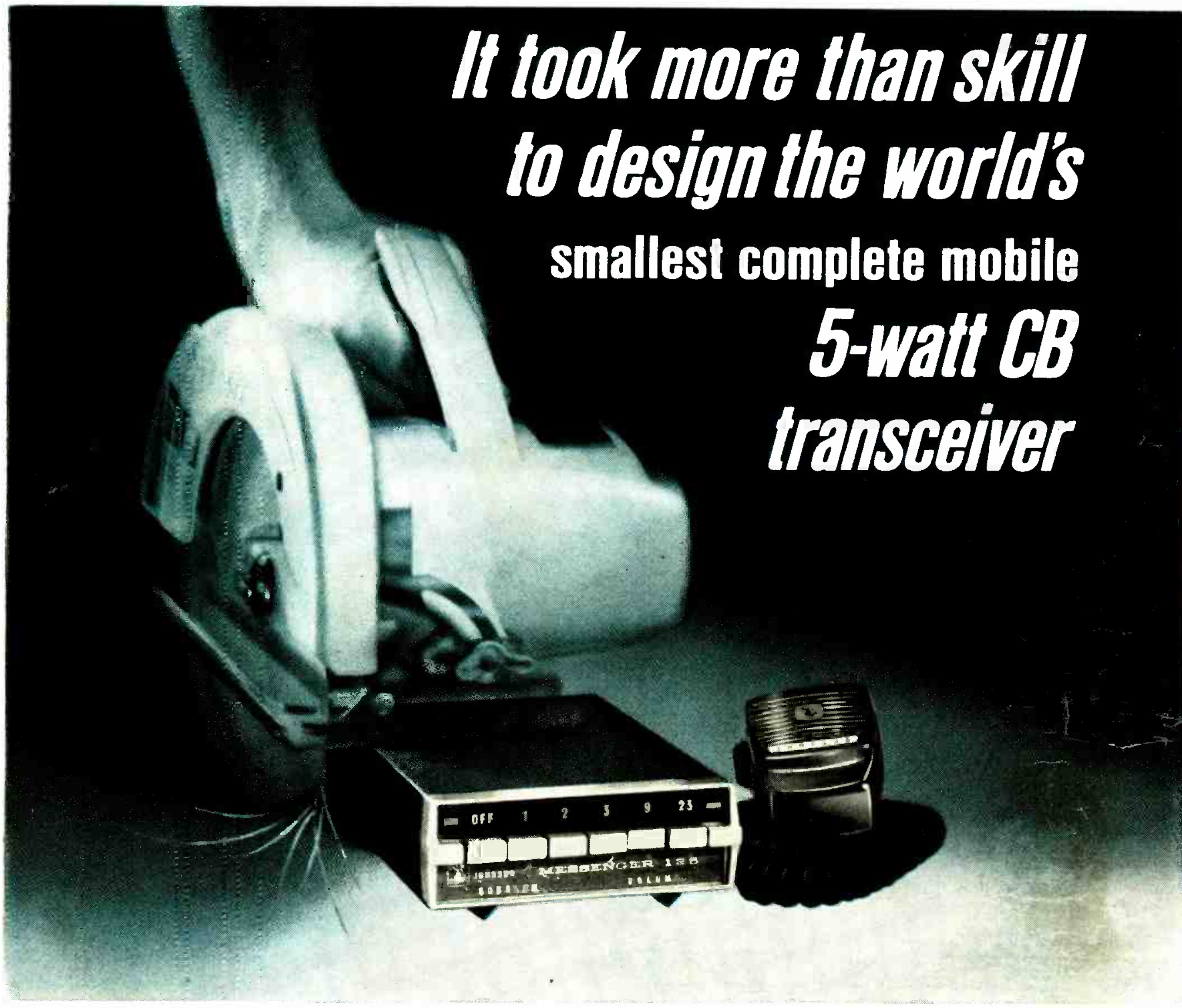

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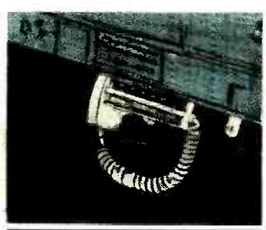

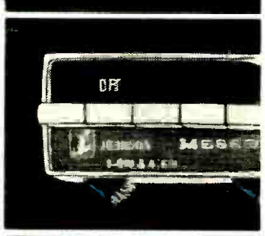

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NEWS HIGHLIGHTS

Pollution Engineers Carry Ball

John G. Hoad, first chairman of National Engineers Commission on Air Resources (NECAR), a newly formed commission of the Engineers Joint Council (EJC), started calling signals for what could very well be man's last "down" in his drive to rid "modern" world of one of its greatest scourges—air pollution. NECAR, representing almost half a million engineers, will attempt to educate, advise, and work actively with the public; federal agencies; regional, state, and local governments; industry; and other professions. Let us all root for a touchdown . . . and while we're on the subject, late last year we were invited by The Copper Development Association, the trade group of the copper industry, to see its contribution to anti-pollution battle—an electric, pollution-free car powered by a 1700-pound set of lead-cobalt batteries produced by *Electric Fuel Propulsion* of Detroit. Model was quite maneuverable and had rapid acceleration. Has range of 150 miles at 40 mi/h before batteries require recharge. Mass-produced price between $3500 and $4000 and operating costs about 2¢ per mile. . . . Automobile giants please note that at recent International Electric Vehicle Symposium sponsored by arm of the Edison Electric Institute, an association of investor-owned utilities, a great deal of excitement was generated over new electric vehicle that has great potential for use as delivery vans. Post Office trucks, in-plant transportation, and as second car for two-car families.

Sighted Shrimp, Shocked Same

If economic law of "supply and demand" holds true, shrimp prices should buck "inflation" tide and start dropping when electronic shrimping system, developed by *The Rochester Corp.*, a subsidiary of *Pauley Petroleum Inc.*, is put to full-time use. The electronic shrimping system, by using an electro-mechanical cable to create a pulsating electrical field in front of a standard trawler, will literally shock shrimp from normal daytime burrows to be caught by trailing net. Shrimping, normally nighttime operation, can now be extended round-the-clock, thereby helping shrimp industry increase its catch by approximately 25 percent.

Time-Sharing Tax Returns

The *Information Services Div. (ISD)* of *Honeywell* has designed a new computer service that reduces income tax computation time from one week (batch-process method) to 20 minutes (time-sharing method). New service uses remote teletypewriter terminal to feed tax information directly to *Honeywell* 1648 time-sharing computer through standard telephone lines from tax consultant's office and receive computed tax back in office on a multiple-copied 1040 form ready to be signed by client and sent to government within 20 minutes. Ideal for tax consultants who handle hundreds of individual returns annually.

Laser Communications Due Soon?

Let's not make *light* of this, but perhaps 25 years or so from now man may be projecting his voice thousands of miles across the country over beams of light. Racing towards what appears to be saturation point of supplying frequency channels to accommodate increasing communications demand, *Bell Laboratories*' scientists are investigating the practicability of using laser light beams for transmission of voice, data, and television signals. Before this can become a reality, communications system devices that amplify, guide, and receive laser-transmitted information must first be developed . . . meanwhile back at *CBS Laboratories*, Dr. Peter C. Goldmark, President and Director of Research of the labs, announced development of system using laser-beam scanning and satellite communications that can transmit military reconnaissance pictures directly from an air strip in Saigon to President Nixon's office in approximately 15 minutes. Air Force officials claim that pictures produced by the *CBS* Image Scanning and Recording System contain highest resolution ever reported in transmission of aerial reconnaissance photographs.

Seeing Electronically

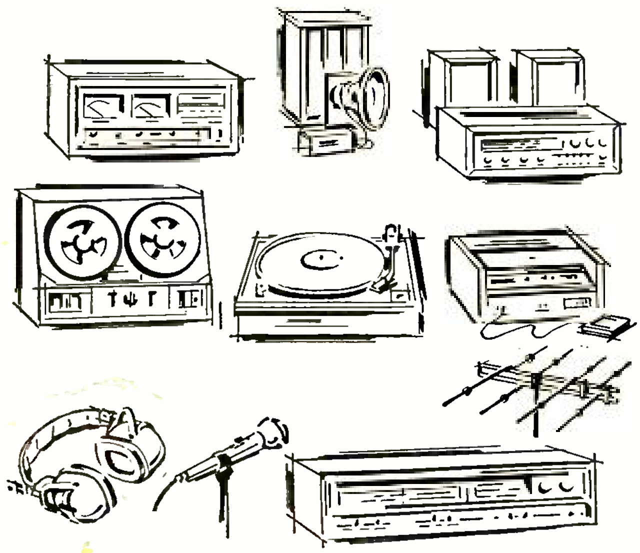
Thanks to research being conducted at San Francisco Pacific Medical Center, those eternally cloaked in darkness may soon be able to "see" through sense of touch. Doctors at center have developed a system that converts image of an object picked up by TV camera into a tactile image, formed by the vibrations of a planar array of stimulators, placed against subject's back. Using this system, blind person can be taught to recognize simple objects in 10 hours or less. Big problem that remains is to refine present system to make it portable and battery powered. Similar system, that permits blind to read ordinary printed material, was described in our November 1969 issue ("Reading Aid for the Blind").

People in the News

Dr. John V. N. Granger, Chairman of the Board of *Granger Associates*, Palo Alto, Calif., succeeded Dr. F. Karl Willenbrock as president of IEEE for 1970. . . . Hugh Robertson, honorary board chairman of *Zenith Radio Corp.*, was recently honored at a luncheon for his 45 years of service to the company and the electronics industry. Starting as office manager for *Zenith* in 1924, he became company treasurer in 1926, executive vice-president in 1934, president in 1958, chairman of the board in 1959, and was elevated to his present post in 1965 . . . and another radio oldtimer, the venerable Haskel A. Blair, president of *University Sound*, a Div. of *LTV Ling Altec, Inc.*, announced his retirement on January 4. Reluctant to leave electronics scene completely, he will be available in an advisory capacity as a consultant to his successor, William Garmon.

What's New Around?

For habitués of the deep who would like to extend underwater vision, *Burnett Electronics Lab, Inc. offers* completely transistorized, flashlight-battery-powered, basketball-size sonar system. Unit, called "Diver Held Sonar," operates on continuous transmission frequency-modulated principle and can "locate," by audio tones, wrecks of ships, planes, other divers, etc. up to range of 120 yards at depths of 0-200 feet. Extra set of headphones is included to maintain scuba diving "buddy" system . . . and for those in management who would like to see what subordinates are doing without leaving desk, *Concord Communication Systems* has the AVC-10 desk-top audio-video communicator. Operator can communicate visually and verbally with persons at as many as five locations simultaneously making it ideal for supervisory situations, hospitals, and as a security or theft-deterrent device. ▲



Next time you're in the market for audio equipment, consult the all-new, 1970 STEREO/HI-FI DIRECTORY first.

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PLUS . . . Julian Hirsch (of famous Hirsch Houck labs) on how to decide upon—and what to pay for—your hi-fi equipment. ■ Tips on how to coordinate components, whether you're upgrading your present system or starting from scratch. ■ Fascinating articles to increase your understanding of audio engineering, and the technical advances that mean better listening for you.

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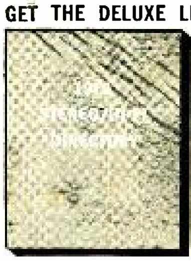

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(Editor's Note: Part 1 of this article covers the read-write and read-only (ROM) random-access and sequential-access IC memories being produced today in an attempt to capture the computer memory market. The potential of bipolar, MOS, and bipolar/MOS memories and their advantages, as compared with ferrite-core memories, in capacity, speed, and cost, are discussed. Part 2 will cover some of the current applications for IC memories and their future, based on the research and development that is now under way.)

IC Memories —Growth and Future

PART 1

By DALE MRAZEK
National Semiconductor Corp.

Part 1 of an article that describes recent advances being made in the IC memory field. Emphasis is placed on the application of bipolar and MOS processes to produce read-write and read-only IC memories that are compatible with logic IC's, thus facilitating logic/memory design.

INTEGRATED-circuit developments indicate a trend toward a merger of logic and storage functions pertinent to digital systems. Memory and logic IC's are being made with the same basic transistors so that they are compatible in electrical characteristics, speed, power, and packaging. The monolithic chip containing the storage cells frequently contains the decoding, sense, and drive circuitry as well. Often, in fact, the dividing line between logic and memory cannot be clearly drawn.

Generally, the system designer uses memory IC's as "building blocks" rather than purchasing preassembled memory systems. Economically, it made sense to handle magnetic memories as preassembled subsystems because they do not have the same sense, drive, and power-supply requirements as logic IC's. Now, the reverse is generally true—it costs little, or nothing, to interface logic and memory IC's, giving the designer freedom to organize subsystems without having to accommodate conflicting component characteristics.

As a result, the range of memory IC applications is becoming very broad, running the gamut from computers to visual displays. Memory IC's are being used not only for conventional memory functions, but as replacements for analog devices, components such as delay lines, and even logic IC assemblies, as well.

IC's are not yet cost-competitive with large-core memories, although this is the main goal of LSI (large-scale integration) development efforts. At present, the principal large-computer applications of memory IC's are high-speed scratchpad, buffer, and control memories. However, IC's are rapidly becoming the dominant memory form in minicomputers and electronic calculators and could conceivably become the leading small-computer memory technology soon, judging from the number of small computers being developed with semiconductor main memories.

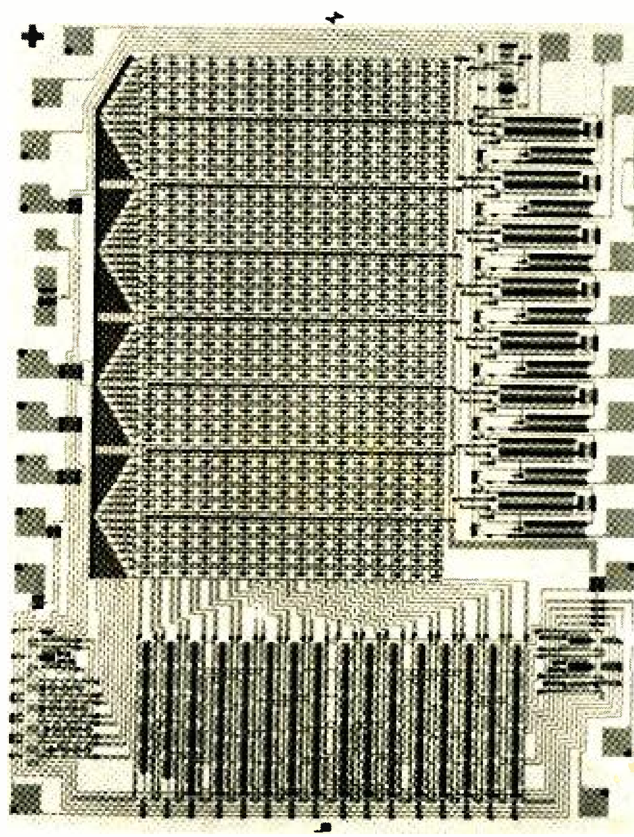
Semiconductor Memory Families

Both random-access and sequential-access types of memory IC's are being produced as "standard" building blocks—devices made for off-the-shelf use, as opposed to custom or in-house designs. Memory IC's can also be used to assemble associative, or content-addressable memories, with additional external logic IC's. Associative memory IC's are being developed with the required logic on the chip.

Both read-write and read-only types of memories are found in the two families. The read-write, random-access types are typically organized as an X-Y array, similar to the two-D core plane, while the read-write sequential-access circuit is generally based on the shift-register design. The basic read-write storage cell is a simple flip-flop or latching circuit while in a read-only memory (ROM) IC, the storage cell is usually a single transistor. Usually, transistors representing binary "0" bits are made inoperable during circuit processing, so that only operable transistors produce a "1" bit when selected. The transistors are arranged in an X-Y array that may be accessed randomly through decoding logic or sequentially through counting registers and decoding logic.

Read-write types of semiconductor memories usually read out nondestructively, but are volatile. The flip-flop cell assumes the state of the binary input bit, which can then be sensed in random-access arrays or shifted out of serial arrays. Storage is volatile because the flip-flops will quickly assume a random state if the power supplies providing biasing volt-

Photomicrograph of National Semiconductor 1024-bit ROM.



TECHNOLOGY	CELL AREA (sq mils/bit)	CYCLE TIME	POWER DISS. (per bit)	COST (per bit)	IC CAPACITY (in bits)
Ferrite core	1000 to 2000	600 ns-2 μs	About 20 mW	1½-8¢	--
Bipolar IC	100 to 250	100 ns (typical)	10 to 35 mW	50¢-$5	4, 8, or 16
P-MOS serial and read-write	50-100	250-500 ns/bit	1 μW to 1½ mW	2½-10¢	32 to 512
P-MOS ROM	10 (typical)	350 ns-2 μs	¼ to ½ mW	1-5¢	256 to 2048

NOTE: This data applies to memory IC's in mass production for general use.

Table 1. Physical, cost, and performance comparison of ferrite core and IC memories.

ages should fail. Although this is not a serious problem, particularly if only small amounts of data are stored temporarily, the loss can be prevented by incorporating a small emergency battery supply.

Read-only semiconductor memories are as non-volatile as other "wired" types of memories, for example core-rope memories, and readout is considered nondestructive. However, some types of ROM's exhibit a form of destructive readout whereby bit selection is controlled by "dynamic" circuits that must be clocked continuously while processing the addresses. If the clock is stopped, the address is lost and the output will go to zero and be restored only when the clock is resumed. Static-type ROM select circuits, which need not be clocked continuously, avoid this problem.

MOS and Bipolar Elements

Virtually all standard memory IC's are produced either by the bipolar or MOS *p*-channel processes. Bipolar refers to the familiar planar silicon process used to make *n-p-n* and *p-n-p* transistors and most linear and logic IC's. Bipolar memory IC's, as a rule, contain *n-p-n* transistors as switching, sense, and drive elements, and diffused resistors as load elements. MOS, for metal-oxide semiconductor, produces the insulated-gate, field-effect transistors known as MOSFET's. MOS memory IC's customarily employ MOSFET's as load elements, as well as using them as switching, sense, and drive elements.

The bipolar technology is used primarily for small, high-speed random-access read-write circuits and small shift-register types of memories. MOS is the processing method generally used for medium-speed random-access read-write IC's and for almost all large read-only and sequential memories.

Table 1 lists the reasons for these splits in the semiconductor-memory family tree. Bipolar circuits are extremely fast but costly because of their small capacity and relatively high power dissipation. They are chiefly used in computer main-frame scratchpads and in other applications where speed is the paramount selection factor. MOS, on the other hand, features high capacity per chip, low cost, low power dissipation, and medium speed (250 ns). While not as fast as bipolar, it is considerably faster than most core memories. Therefore, when a semiconductor memory is desired, MOS is generally chosen today for all functions that can be performed at medium to low speeds.

Basic differences in the production processes are responsible for the applications trade-offs. One slice of silicon crystal has enough space for several hundred IC's about 0.10 square inch in area. Each bipolar IC requires approximately 150 process steps to produce about 100 *n-p-n* transistors and their associated diffused load resistors, while about 25 process steps will produce 1000 or more MOSFET's in the MOS integrated circuit. MOSFET's are small, single-diffused devices; *n-p-n* transistors are relatively large, double-diffused devices.

Bit-storage capacities of read-write production IC's are typically 4, 8, and 16 bits for bipolar IC's and 32 to 512 bits in MOS IC's. Bipolar ROM's are presently at about the 64-bit level, although *Motorola* reports developing an array containing 128 emitter-follower transistors and 8 buffers. MOS ROM's with 256 to 2048 bits are in mass production. Design engineers are aware that the next plateau for standard MOS ROM's, 4096 bits, should be reached before long.

The cost figures in Table 1 are ballpark estimates which vary with memory size. It is difficult to make valid comparisons of magnetic and semiconductor memories today because core technology is oriented toward large main memories while semiconductor production emphasizes small-storage functions. IC prices vary widely with the total of bits-per-chip and the number of circuits ordered. Operating characteristics also have different meanings; for instance, the user of bipolar IC's will usually try to utilize the full speed of bipolar, while the MOS user will frequently use a speed less than maximum and reduce power dissipation.

Capacities per chip may seem small to engineers accustomed to specifying core memories. Memory IC's are usually assembled to build up words of the desired length. Unpackaged chips may be interconnected on a small ceramic substrate, as hybrid IC's, although assembly of packaged circuits is the most common practice. The packages are the same as those used for comparable logic IC's—hermetically sealed metal packages for MOS and hermetically sealed metal and ceramic or molded packages for bipolar. About ten IC packages take up a cubic inch in an assembly. The volumetric efficiency of high-density core planes is reached in a 16-pin dual in-line package IC with a capacity of 256 bits—a point that MOS has already surpassed.

Memory IC's generally meet the same electrical and environmental specifications as logic IC's. According to a recent NASA report, the reliability of bipolar and MOS circuits is 0.016 percent per 1000 hours at the 60 percent confidence level. No direct comparisons between failure rates of magnetic cores and IC storage cells can be made, but life tests of MOS shift registers made at *National Semiconductor* ("MOS Integrated Circuits Reliability Report", November 1969) indicate that the failure rate of flip-flop type cells is 0.00011 percent per 1000 hours at 60 percent confidence. Like logic IC's, memory IC's can operate at temperatures to 125° C, a capability that is expensive to achieve in magnetic memories.

IC Operating Characteristics

Most bipolar memory IC's are practically identical in op-
capability that is expensive to achieve in magnetic memories.

IC's. This means that they operate at a V_{cc} of +5 volts referenced to ground, sense a signal near ground as logic "0", and one at 2 volts or higher as logic "1." Ordinarily, TTL gates operate at rates of 20 MHz or higher, but since memory IC's are considerably more complex than simple logic IC's, read-write cycle time is typically 100 ns rather than 50 ns. Fanout is typically 10.

High-threshold MOS logic circuits sense a signal near ground (which may be arbitrary) as a logic "0" and sense the more negative signals as logic "1". A change of about —24 volts in the MOSFET's gate-control voltage is usually required to switch the device. Operating frequency of high-threshold MOS logic is typically limited to 1 or 2 MHz. MOS is a high-impedance technology and long *RC* time constants cannot be avoided (although they can be compensated for in special designs).

During the past two years, a type of MOS that is compatible with bipolar logic (DTL, or diode-transistor logic, as well as TTL) has been produced. It is now the preferred technology for MOS memory IC's. Low-voltage MOS can sense signals at bipolar levels and eliminate the former requirements for interface circuits (voltage translators). These circuits can switch with a gate-voltage swing of only 14 to 18 volts. Bias or clock voltages can be obtained or derived from standard +5- and ±12-volt power supplies. MOS logic IC's compatible with these MOS memory IC's have been developed.

There is no absolute limit on the fanout of MOS circuits into MOS circuits. Fanout depends upon the repetition rate. Fanout of MOS into bipolar logic is generally better than 1.

Conventional high-voltage MOS is still being used for storage in some custom designs for all-MOS systems. However, the majority of new systems are a combination of bipolar logic and MOS memory, giving low-voltage MOS a considerable competitive advantage over and above a number of performance advantages. Functions such as clock formatting, data multiplexing, and serializing of parallel memory outputs can be done at several times the normal MOS maximum rate to minimize cycle times. Only bipolar logic has the necessary speed for these control functions. In addition, the faster the MOS memory can run, the more efficiently associated data-processing circuits, which are usually bipolar, can operate.

Merely coupling the MOS input and output stages to bipolar gates significantly improves MOS performance, mainly because bipolar gates can detect lower voltages. Low-impedance signal sources and receivers are substituted for high-impedance ones, and the reduction in signal-voltage transitions permits reductions in bias and clock voltages. MOS circuits that operate at 1 or 2 MHz in all-MOS systems can usually be speeded up to 2 to 4 MHz in bipolar/MOS systems. In some special designs, optimized for a given application, rates as high as 10 MHz have been achieved.

The TTL/MOS/TTL interfaces for building-block circuits are shown in Fig. 1. The shift register or serial-memory type of interface (Figs. 1A and 1B) permits coupling of MOS devices within the serial string, while the ROM type of interface (Fig. 1C) provides high-speed operation of paralleled ROM's when ±12-volt supplies are used. The input pull-ups, accomplished with 2-cent resistors, assure that input signals rapidly make the transitions between the TTL "0" and "1" levels, while the resistors at the outputs sink the —1.6-mA current from the TTL receiving gates.

Pulling the input to +10 or +12 volts instead of only to V_{cc} (+5 volts) in large ROM's doubles the shift register's frequency and reduces the access time to between 0.5 and 1 μs. Some devices designed to be used singly between TTL gates will operate at low frequency without the resistors, but in such cases performance will generally be marginal.

Most engineers are familiar with the operation of *n-p-n* transistors, but further information on MOSFET characteristics may be useful. MOSFET's are switched by a gate-control voltage (the clock in shift registers) that biases the

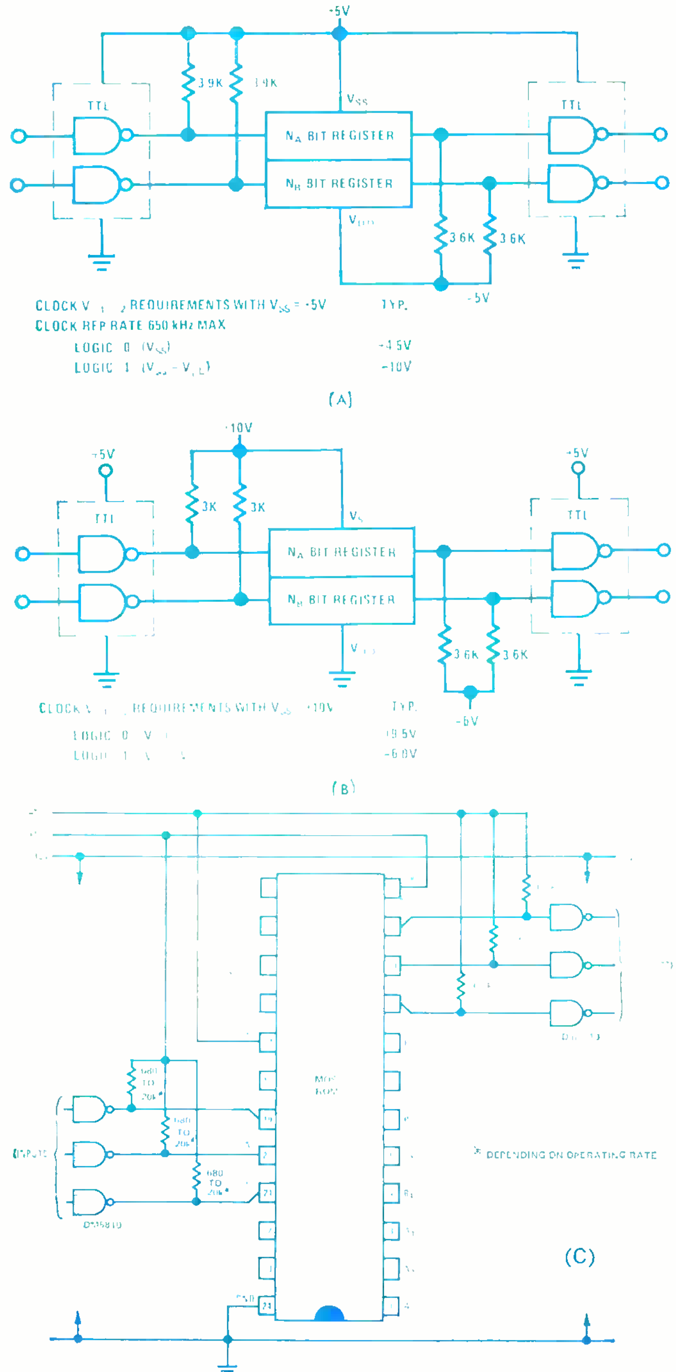
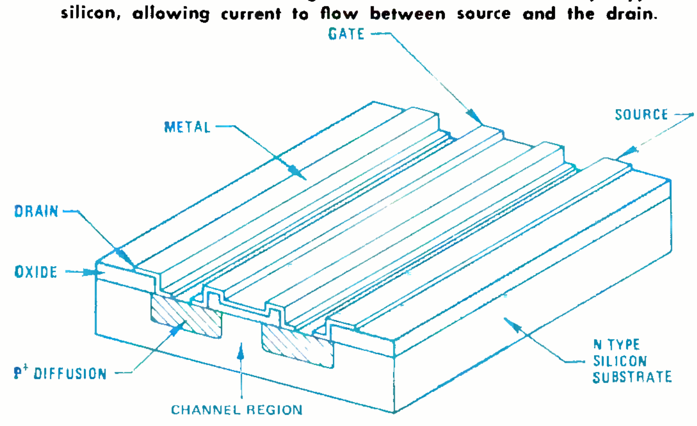
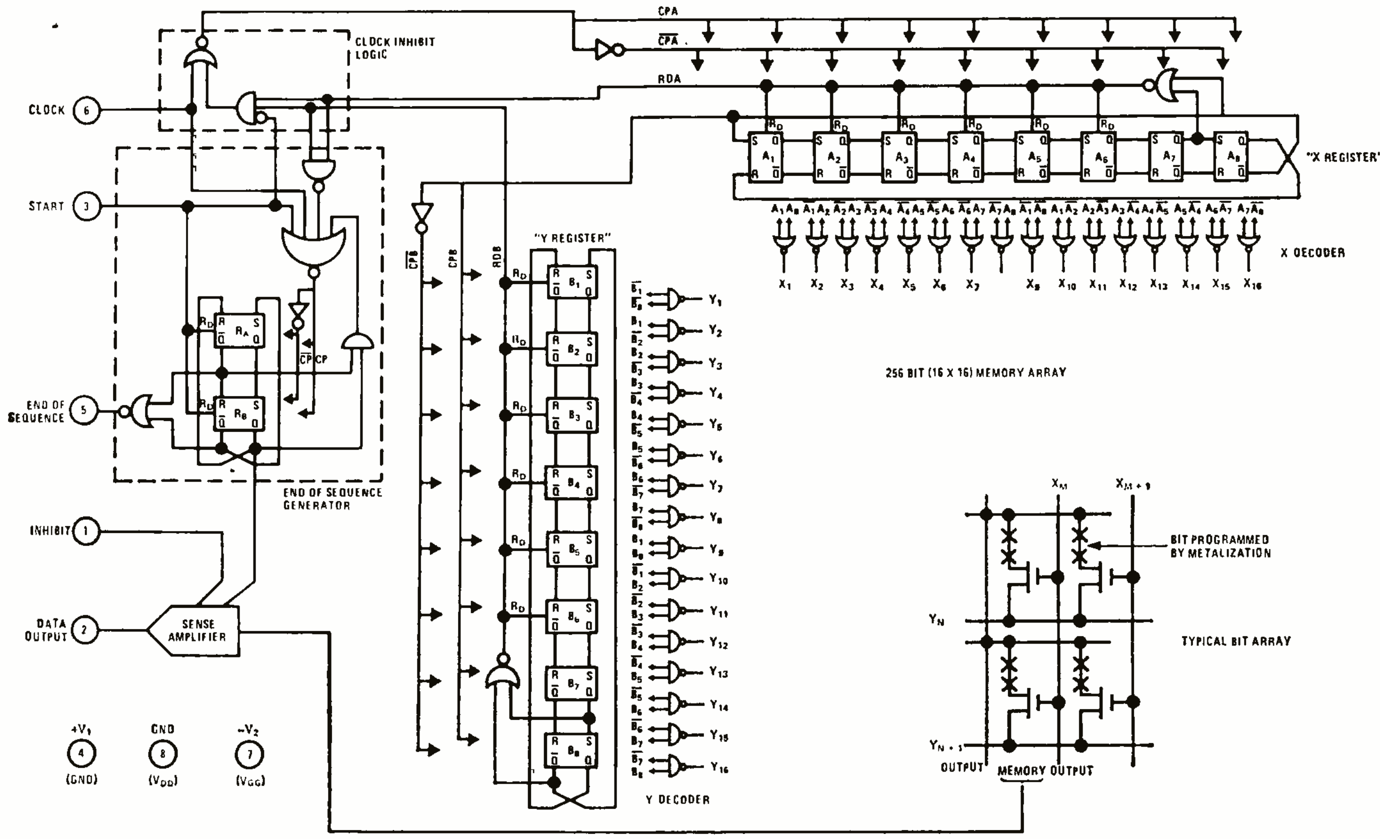
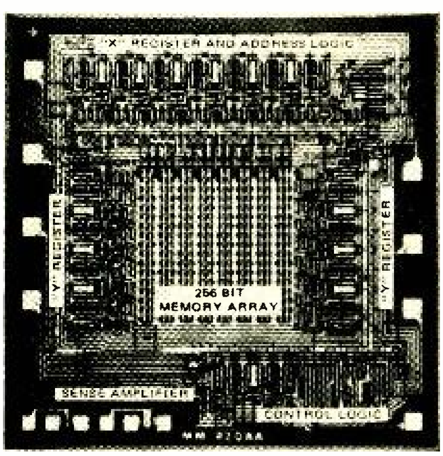


Fig. 1. TTL/MOS/TTL interfaces for low-voltage MOS memory IC's. (A) Low-speed and (B) high-speed interfaces for serial memories, and (C) high-speed interface for random-access ROM's.

Fig. 2. Application of negative voltage to gate electrode of the MOSFET causes channel region to invert from "n"- to "p"-type silicon, allowing current to flow between source and the drain.







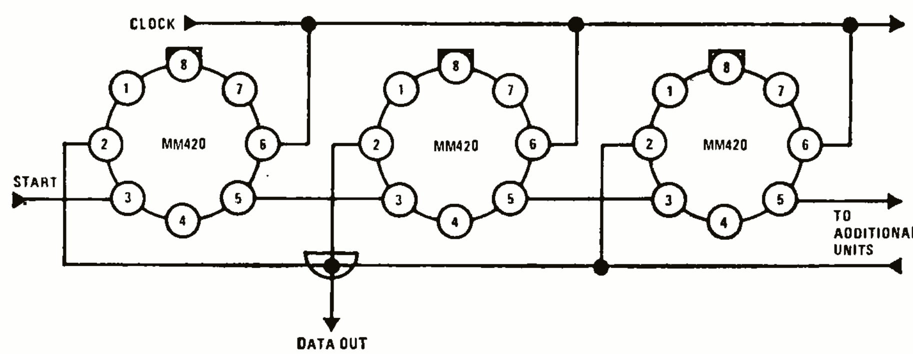


Fig. 3. Sequential access 256-bit MOS ROM. (Top) Layout of circuits making up (left) the chip and (right) the cascade arrangement when a word series longer than the standard 256-bit capacity is required.

gate electrode negative. This electrode, the gate insulation, and the silicon substrate form a capacitor, which must be charged to a threshold voltage to switch the transistor "on." At this threshold—2 volts in low-voltage devices under zero-bias conditions—the silicon in the channel region "inverts" from the normal n-type to p-type semiconductor. Current can therefore flow through the p-channel that is formed between the p-type source and drain diffusions, shown in Fig. 2.

The MOSFET's in memory IC's are small, very-high-impedance devices with the exception of output buffers. Their R_{on} is about 50k-ohms, R_{off} about 10^{18} ohms, and input capacitance only about 0.04 pF. Consequently, internal *RC* time constants are short, about 2 ns. Operating rates are therefore limited by the output MOSFET's, which have high capacitance because they are made large to reduce R_{on}. A low R_{on} is essential in interface devices to reduce *RC* time constants. Output time constants in a MOS/MOS couple are typically 500 ns to 1 μs. This can be reduced to as little as 250 ns in a MOS/TTL couple because the *RC* values are smaller.

As a trade-off, the MOSFET's are much smaller than n-p-n transistors and have lower average power dissipation, that is, the R term in the general power equation, $P = E^2/R$ is much larger. Power dissipation in a typical MOS read-write memory is well under 1 mW per bit, while in a typical bipolar memory it is greater than 10 mW per bit. The average power dissipation is much less in a MOS ROM because most of the cells are inactive at any given time. In addition, bipolar IC's have a higher proportion of buffers to storage cells because of their smaller capacities. The average power dissipation/bit ranges for p-channel, low-voltage MOS and bipolar are given in Table 1.

Read-Only Memories

Bipolar and MOS ROM's have applications similar to core-rope and transformer read-only memories. MOS ROM's predominate at present because of cost factors. Bipolar ROM's are used now only in applications where speed is the paramount consideration, such as microprogramming in large computers. The majority of bipolar ROM's produced have been diode arrays storing about 100 bits, rather than n-p-n transistor arrays.

MOS ROM's are made in 256-, 512-, 1024-, and 2048-bit capacities, as standard sizes. Some 4096-bit MOS ROM's, as well as a variety of odd sizes for special applications, are being produced. MOS ROM's larger than 2048 bits are not difficult to design, but are costly because of small pro-

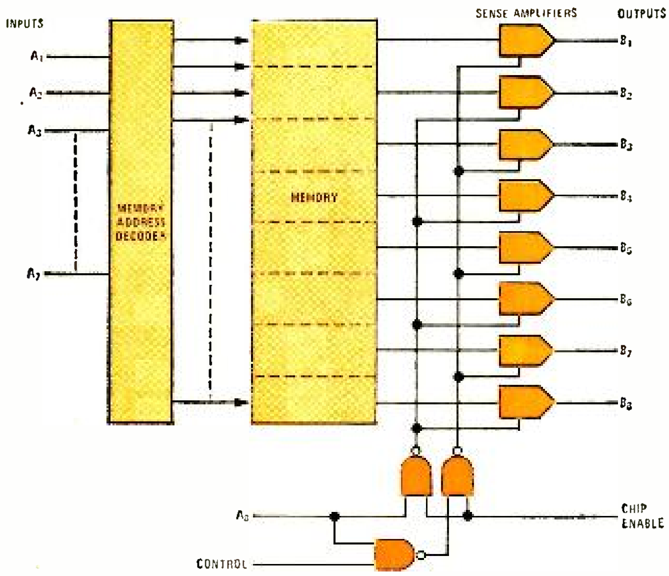


Fig. 4. Organization of the parallel-address, parallel-output MOS ROM where the memory array is accessed randomly.

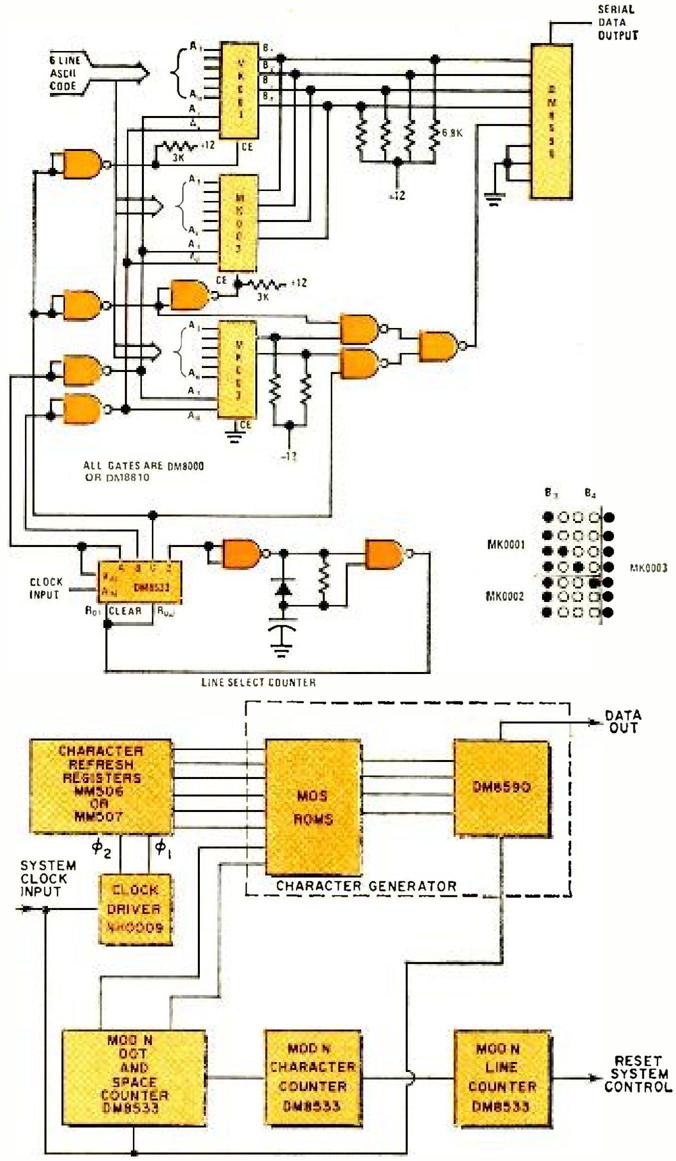


Fig. 5. (A) Television raster-scan character-generator used in (B) character-generating line display and refresh system.

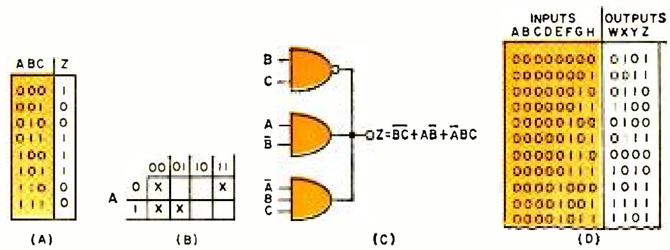


Fig. 6. Implementation of logic functions with read-only memories. (A) Truth table function reduces to the (B) function $Z = \overline{BC} + A\overline{B} + \overline{A}BC$ and can be implemented with 8 bits in ROM or with (C) three logic gates. Today much more complex (D) functions are being accommodated by read-only memories.

duction yields and it is usually cheaper to make the memory with smaller ROM's. Standard MOS ROM's appear to be settling down to 4-bit and 8-bit word organizations. Since capacities higher than 256 bits are readily obtainable the 256-bit sizes generally are more complex. In any size, though, decoding logic is usually located in the chip.

Each bit of storage in the larger arrays requires about 1⅓ MOSFET's—one transistor to store a bit and the other ⅓ in the common control logic and sense circuitry. Bipolar ROM's are generally decoded off the chip to allow for diffusion of the maximum number of storage cells on the chip. However, in future large-scale bipolar arrays, decoding will probably be done on the chip.

Generally, the ROM is programmed to order; the system designer supplying a truth table or other notation of input/output functions needed for his application. The table is a guide as to which transistors in the array should produce a logic "1" output when selected by the address input, and which should be prevented from switching, producing a "0" output.

Some bipolar arrays can be programmed by the user with the fusing-link technique. This technique is not used on MOS ROM's and is suitable only for devices that have no control or sense circuits, or those with only a few such circuits that can be bypassed. All the transistors are connected with thin-film wiring to make them operable as fabricated, but the wiring to each cell is narrowed down at some convenient location on the chip, such as in the emitter lead. A high current pulse is then applied to the "0" bit lines, melting the fusing link.

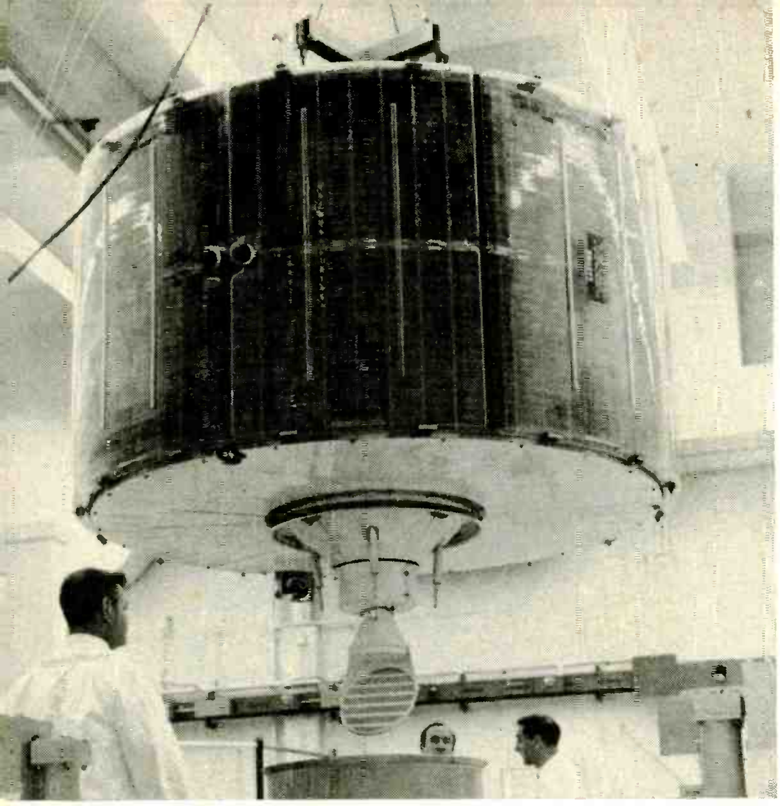
The fusing-link technique is not popular with MOS manufacturers because control and sense circuitry would have to be made very large to provide the fusing surges; and it is laborious compared with the masking methods used for mass production. Furthermore, most of the chip surface is already occupied by fine-line wiring and broadening the lines would seriously reduce ROM capacity. One exception is used by *Autonetics*, which has a method of cutting selected lines with a laser beam, to program one or a few ROM's.

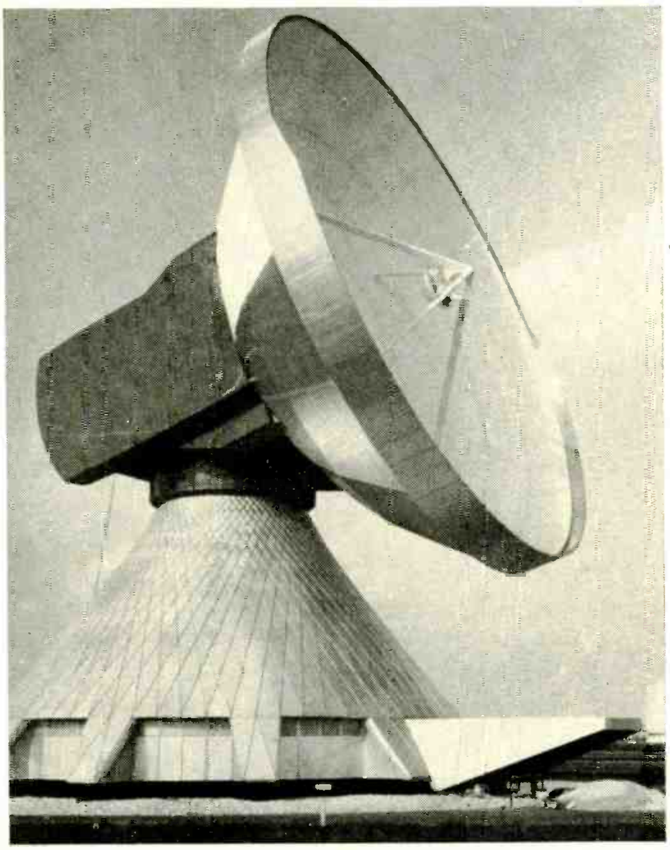
In most cases, the manufacturer alters the etching mask that controls the thin-film electronic pattern or the mask that controls thickness of the MOSFET gate oxide. Mask-preparation costs per bit are insignificant over a production run. However, if fewer than 100 ROM's are to be made, a tooling charge of $500 to $1000 is incurred by the customer. This charge may be avoided by buying one of the preprogrammed, standard-function ROM's that are just starting to come on the market. *National Semiconductor*, for instance, makes several preprogrammed ROM's for table lookup of standard math functions and for display-character generation.

The oxide-programmed method, whereby the gate oxide is left too thick, alters the switching threshold of the "0" bit MOSFET's so that they will not turn on. The alternative is to either etch away the gate electrode metal, etch open the wire to the gate, or open some other connection to the cell. Fig. 3, top illustrates the situation where the drain connection is etched open.

MOS ROM Applications

Although the MOS ROM of Fig. (*Continued on page* 64)





RECENT DEVELOPMENTS IN ELECTRONICS

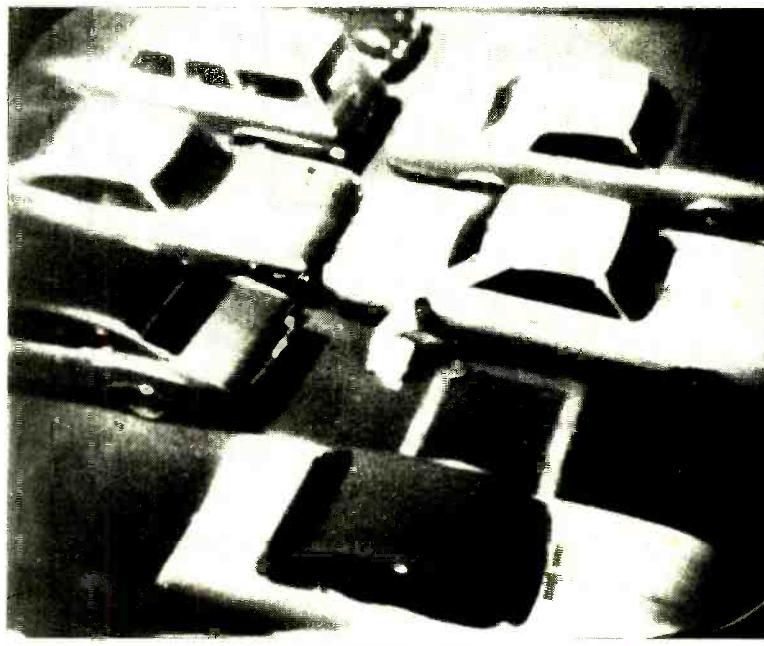
British Defense Communications Satellite. (Top left) This satellite carries the flags of two nations, the U.S. and Great Britain. Designed and built for the United Kingdom by Philco-Ford under a U.S. Air Force contract, it is the first of two such satellites that will provide communications for the British Skynet defense system. The satellite was launched by NASA. Once in orbit it was handed over to Britain's Royal Air Force. The satellite will be positioned in a 19,324-nautical-mile-high synchronous equatorial orbit, over the Indian Ocean off the east coast of Africa. This will provide Great Britain with a highly secure communications link between points as far apart as England and Singapore. The Skynet satellite is compatible with the U.S. Initial Defense Satellite Communications Systems which became operational in mid-1967. Twenty-six satellites are now in orbit as part of the U.S. IDSCS system, which is the world's first global military communications satellite network.

German Satellite Ground Station. (Center) The West-German Post Office now has its second "ear" directed towards space. The second antenna of the earth station at Raisting near Munich has been officially opened. The Post Office is now able to establish simultaneous connections with communications satellite ground stations in the U.S. and in East Asia. While the previous antenna was driven by means of hydraulic motors, the new antenna uses thyristor-controlled electric motors. In conjunction with the automatic tracking system, the antenna can be tracked to an accuracy within a few hundredths of a degree. Parametric amplifiers are used to handle the extremely weak signal powers received from the Intelsat communications satellites. These amplifiers have a gain of 10,000 with a 500-MHz bandwidth; they operate below 20 degrees K in liquid helium. A third installation of this type has been planned as a standby installation and for a number of special applications. Probably a fourth installation will be made in the future to operate in conjunction with the Franco-German communications satellite Symphonie. Contractor for installation was Siemens.

Lower-Cost Instant-Replay TV Disc Recorder. (Below left) The instant-replay feature that is widely used in television sports broadcasts is made possible by means of a magnetic disc recorder. This recorder is able to store and play back up to 30 seconds of action in full color. Stop motion and slow motion can also be used when desired to show details of any event. The same manufacturer of this equipment, Ampex, now has a lower cost version of this device for black-and-white TV pictures. This disc-recording system is intended for use in closed-circuit TV applications in education, industry, medicine, research, and sports, or wherever slow or stop motion is required for close study of recorded TV pictures. Price of the new unit starts at \$8000. (The commercial color-TV version has a price around \$100,000.) Up to 2400 black-and-white TV pictures are available for detailed and lengthy analysis, so that the unit can be used as a random-access slide projector by broadcast TV stations. The device continuously records information from a TV camera, with the last 7½ to 80 seconds always available for replay. Pictures are viewed on a TV receiver. As new information is recorded, the old signals are erased.

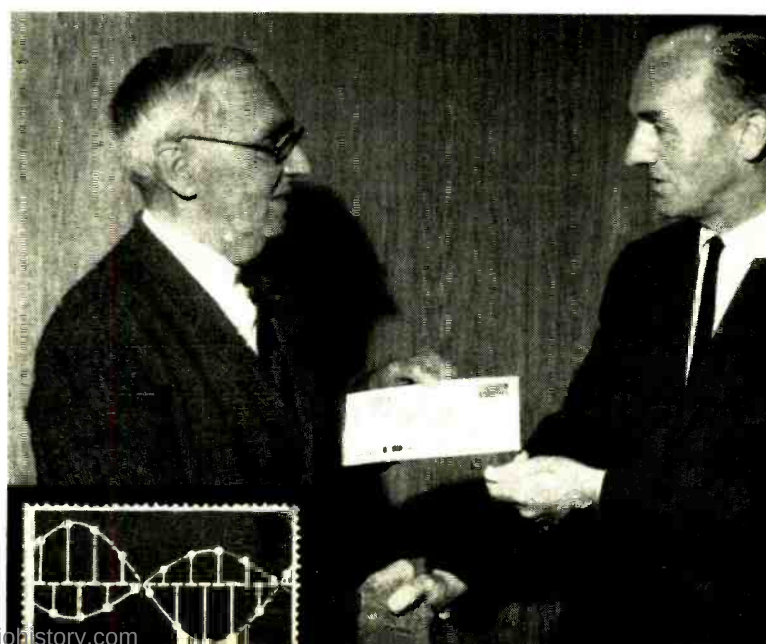
Giant Accelerator for Cancer Treatment. (Top right) A huge accelerator built for radiotherapy of cancer is shown here undergoing final testing at the manufacturer's plant. This high-energy device produces an accelerated electron beam with energies up to 32 million electron volts and x-rays with energies of 25 million electron volts. The accelerator is being built for the University of Texas' M. D. Anderson Hospital and Tumor Institute. Manufacturer of the giant cancer fighter is Raytheon.

Day-Night Surveillance TV. (Center) This picture, photographed directly off the screen of a TV monitor, was made at 9:30 in the evening with only moonlight as illumination. It demonstrates the night-seeing capability of the new Westinghouse round-the-clock TV surveillance system that needs no adjustments throughout its 24-hour vigil. Some versions of this system use the highly sensitive secondary electron conduction TV pickup tube. This was the tube that was supposed to have provided color-TV coverage of the recent Apollo-12 walk on the moon. Perhaps the tube's sensitivity was its own undoing as it was reported that camera failure resulted when sensitive TV camera was inadvertently pointed at sun or at sun's reflection.



New Credit Card Uses Imbedded Magnetic Lines. (Below left) Look closely at your next new credit card. It may have on the reverse side a thin strip less than 1/16 inch high by less than 3/4 inch long containing a pattern of closely spaced lines made of imbedded iron-type material. When this card is inserted into the low-cost (about $100) reader as shown in the photo, the lines are magnetized and read off directly into a computer. The individual owning the card is then immediately identified and his account can be billed automatically for a purchase. Unlike punched holes, which obliterate some of the printed matter on the card, or unique numbers, which must be read by expensive optical scanners, this system has neither of these drawbacks. Because the lines are indented into the plastic, the card, developed by Synergistics, Inc., will take considerable abuse.

Pulse Code Modulation Stamp. (Below right) The British stamp shown in the lower left-hand corner of the photo has been issued to honor the invention of pulse code modulation. One of the most important uses of PCM is to transmit many audio channels simultaneously over a single circuit. It is also widely used in our space program for voice and data transmission and telemetry. Alec Reeves (left), inventor of the technique and a leading electronics engineer with ITT laboratories for more than 25 years, is receiving a first-day cover with the stamp from Stanley B. Marsh, managing director of Standard Telecommunication Laboratories, in Harlow, England, a British unit of ITT.



An Instructor Looks at—
The TV-Technician Shortage

By L. GYARMATHY / Associate Professor
Electronics Dept., Los Angeles Trade-Technical College

Highlights from speech delivered to national service managers of radio-TV manufacturers at a recent EIA (Electronic Industries Assn.) conference. Here are suggestions on how to bring more men into the service industry.

WHY is there a shortage of competent TV technicians? Why are there so many Better Business Bureau complaints and lawsuits against TV repair shops? Why is there a stigma attached to the TV technician in some localities?

The shortage of good technicians explains the many complaints and troubles; and the troubles in the field may explain the shortage. But why does this have to be at a time when there is so much TV viewing and so much hi-fi listening? Why shouldn't there be a pleasant, lucrative, and satisfying supply-and-demand situation?

From my vantage-point as a close ally of the service industry, for the past thirteen years on the education-training end of it, I will list as many factors as I can and try to suggest possible avenues of improvement and remedies.

The Bright Young Men

In my experience, two main types of young men go into radio-TV servicing. Let us refer to them here as Group A and Group B.

The Group-A man looks forward to having his own shop and dealing with customers. He hopes and tries to prepare himself for a growing, prospering business. He has energy, enthusiasm, and determination. He knows that after his training he will probably have to work for somebody else for a while—to save up some money and gain technical experience at the same time—but he would not give up his dream of striking out and being his own boss some day soon.

This fellow could be the backbone of the service industry because, if he succeeds in having his own business, there is a good chance that he can and will do well. However, if finances won't permit him to establish his own business, he will find himself having to work, permanently, for a service organization, or a smaller outfit—and that's where disillusionment sets in.

He will now see that the pay is not commensurate with his training and not comparable to what he can make in industrial electronics. His chances for advancement are poor compared to work in industry with its frequently better working conditions, guaranteed raises, and other opportunities for promotion.

Well, this bright young man, who should be the backbone of the TV service industry, will move over into industrial electronics very soon. Hourly rates of $2.20 to $3.20 just can't compete against $3.20 to $4, plus the other advantages.

The Other Group

Let us now consider Group B. In this group we find the young man with a comfortable sort of self-defeatist attitude. He feels he could not master the theory and mathematics needed for other work so he "just" wants to do radio-TV work. He doesn't have the drive of the Group-A fellow; he would hardly dare dream of having his own shop.

How will this young man fare? He doesn't really anticipate that being proficient today in "radio-TV work" requires quite advanced electronics. Some of these men become "late bloomers" and discover they can learn the circuits and testing techniques. As a rule, they do a good job. Others will find that they cannot stand the complexity of color-TV circuitry and will run from it. This is the more fortunate case, because if a man stays with it by just muddling through the circuits without understanding them, he becomes a dangerous, notorious tinkerer.

I have described two main, characteristic groups. Of course, there are in-between cases. There are, fortunately, also loyal and highly skilled adherents to the service industry, but there are not enough of these. That's why we have a shortage of TV service technicians. And this picture is getting worse at a time when more and more color-TV sets are being sold.

What Are the Remedies?

In what way can this situation be remedied? Here are a few ideas.

Scholarships at the high-school level, funded by the manufacturers, could attract more and better students to the field of radio-TV service. This investment would reap rich rewards, since we know that one scholarship can motivate many dozens of youngsters each year.

A committee with members selected from the ranks of the manufacturers and local vocational school educators should approach Boards of Education with cogent arguments regarding community needs and request more vocational radio-TV training at high schools and junior colleges, or wherever facilities are available. Vocational instructors rather than industrial arts teachers should be used in such programs.

By providing such programs in public schools, we can reach a large number of prospective radio-TV technicians, including those from the lower income groups.

At Los Angeles Trade-Technical College we are in a fortunate position: our instructors must have had at least seven years of industrial background and have achieved some eminence in their line of work. Our always over-enrolled color-TV courses produced *Zenith's* local chief technician, *Magnavox's* chief technician, and *RCA Service Company's* (Hollywood branch) lead technician who recently became supervisor. Three of our students were hired right out of the classroom for *NBC*'s (Burbank) Color Studio maintenance. Graduates such as these recruit hundreds of new students for us.

What can be done for instructors who are to train radio-TV technicians? Workshops can be established by the TV-set manufacturers in the summer time, with pay. In return, the instructors in the workshop could develop course outlines and shop experiments for the new sets and these, organized and edited, could be disseminated throughout the training and service fields. Schools providing vocational training should be given different brands of current sets. School finances just do not permit purchasing all the representative new models.

Once the scholarships begin moving new blood from the high schools to radio-TV training, and adequate numbers of vocational courses are made available, the radio-TV industry should advertise these courses.

I can envision troubleshooting and/or alignment contests set up by the industry for students, with attractive prizes for the winners. And for the young man just starting out in his own business, technical help, financial incentives, even counseling in business management could be furnished—perhaps through the above-suggested committee.

Remember Gelett Burgess' famous four-liner about never having seen a purple cow? Well that was before color TV, because now too many customers are complaining to repair people that they're seeing impossibilities like that on their TV screens. I hope that some of the suggestions made here can help the situation to the point where the customer would be seeing red only when it is actually being transmitted. ▲

Four-Channel Stereo

—Problems and Solutions

Here are the problems to be solved and possible solutions leading to transmission and reproduction of four channels of stereo information.

By DANIEL von RECKLINGHAUSEN / Technical Director, H.H. Scott, Inc.

WITHIN the past few months, popular attention has turned to a new 4-channel sound. Broadcasts in 4-channel sound have been made in Boston and New York, and are planned for the West Coast. These programs show an increased spatial perspective over 2-channel stereo sound and the listener has a substantially increased listening area over which good multichannel stereophonic sound can be heard. A number of manufacturers have made 4-channel tape recordings and 4-channel amplifiers and tape recorders are beginning to appear.

The usual designation of the four channels are left-front, right-front, left-rear, and right-rear. Generally, in classical recording, the two front channels are located closer to the orchestra and the two rear channels therefore receive more reverberant information. In popular music, this is not always the case, and performers may be assigned to any one of the channels. The listener would have the feeling of being right in the middle of the performers.

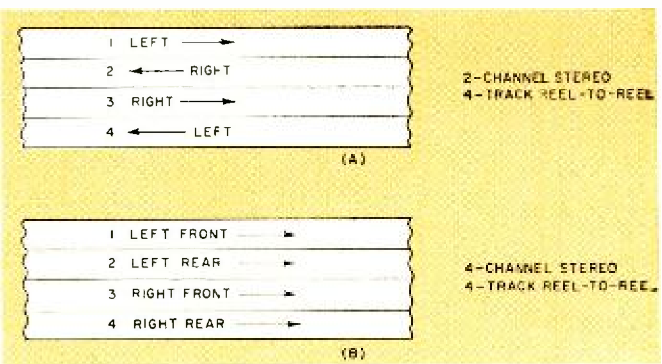
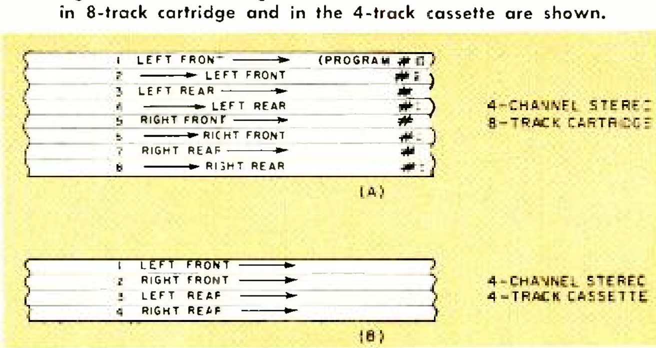


Fig. 1. The use of 4-track tape for 2- and 4-channel stereo.

Fig. 2. Possible arrangement of tracks for 4-channel stereo in 8-track cartridge and in the 4-track cassette are shown.



At the time of this writing, recording engineers have concluded that since usage of the four channels cannot be predicted, it is best to have all four channels of equal transmission characteristics. Hence, frequency response, noise, and distortion of all four channels should be equal. Another group feels that the channels located behind the listener need not have the same high quality as the front two channels.

This difference of opinion points up the need for determining what is a just noticeable degradation of performance in any one of the channels. Tests would also have to be made to determine what separation is necessary between the four channels. Another test might determine whether certain channels can tolerate more distortion or noise than others.

The present 2-channel stereo system was subjected to the same arguments ten years ago. Listening tests resulted in the requirement that the two channels should be of equal quality. The separation for just noticeable audible degradation should be at least 24 dB at mid-audio frequency and at least 20-dB separation should be maintained between 100 and 8000 Hz. The standards adopted by the FCC for 2-channel stereo broadcasting exceed this requirement as does present stereo equipment.

Tape Recording

In tape recording, it has been standard practice to record a number of channels on the same piece of tape. Professional recorders with 16 or more channels are available. For home use various types of multitrack tapes exist. For example, 2-channel, open-reel tapes are available at 7½ in/s in which four tracks are recorded with tracks 1 and 3 carrying the left and right stereo channels in one direction and tracks 4 and 2 the left and right channels in the other direction (Fig. 1). The 4-channel tapes carry the left- and right-front channels on tracks 1 and 3 respectively and the left- and right-rear channels on tracks 2 and 4. Track width, spacing, equaliza-

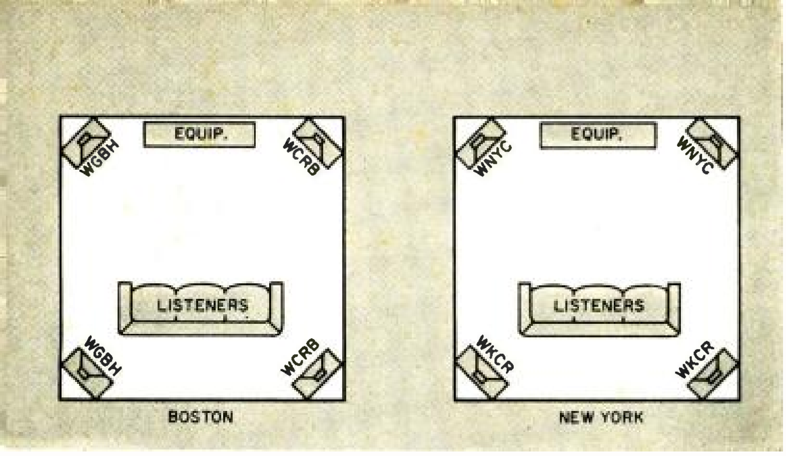


Fig. 3. Two methods that have been used to transmit 4-channel stereo in Boston and New York by means of two FM broadcast stations.

tion, frequency response, and noise are exactly the same as in 4-track, 2-channel stereo tapes.

For playback of the 4-channel tapes, a 4-channel head picks up the recorded magnetic flux and a 4-channel amplifier provides the necessary amplification. The major problem is to find room inside the playback head for four magnetic structures in a space previously occupied by only two. This results in a lower output voltage and perhaps poorer signal-to-noise ratio, placing more demands on the amplifier. Because of closer spacing, cross-talk between the channels is higher than we have been accustomed to in 2-channel recordings.

Other tape formats are also possible for recording 4-channel sound. The 8-track tape cartridge is a likely candidate. Conceivably, tracks 1, 5, 3, and 7 may be used for one program and tracks 2, 6, 4, and 8 for the other program (Fig. 2). This track sequence would correspond to the 1, 3, 2, 4 sequence of reel-to-reel tapes. At the time of writing, playback heads for this purpose have just become available. Similarly, the tape cassette, which normally contains two channels recorded in one direction and two channels recorded in the other direction is adaptable to 4-channel sound. Here, the track sequence might be 1, 2, 3, and 4. However, after each playing of such a cassette or reel-to-reel tape, the tape will have to be rewound before it is played again.

As simple as the 4-channel tape system sounds, there is still room for arguments. The first argument is compatibility: What is heard by the listener who wishes to start a library of 4-channel tapes and play those on his existing stereo equipment? At the present time, he can listen to either the two front channels or the two rear channels, but in each case he will not have full compatibility because he will not get the information from the other two channels. In playing 4-channel stereo tapes, it would be possible to sum the outputs of the left-front and left-rear channels to make a new left channel and, similarly, to sum the outputs of the right-front and right-rear channels to make a new right channel. For this purpose, a 4-channel head would be necessary for playback.

Another possible argument might evolve around the complexity and difficulty of making 4-channel tape playback heads, particularly for the narrow track widths. Consequently, one might propose to use two heads spaced, say 1 in from each other, where one head reproduces the front information and the other one the rear information. This is the staggered-head approach which was used in the early days of 2-channel stereo tape recordings. More than likely, however, a single head with all gaps in the same line will be used.

Stereo-FM Broadcasting

Another source of 4-channel program material for the listener is stereo-FM broadcasting. At the present time there are two different methods in use, although these may be changed. In Boston, the two left channels are provided by station WGBH. The other station, WCRB, provides the two right channels. (See Fig. 3.) The four microphones are arranged approximately in a semicircle located near the orchestra and the recommended loudspeaker arrangement for listening is in the form of a square (as it is for other 4-channel playback).

The Boston arrangement has the advantage that two mono receivers can be used to receive 2-channel stereo. Two-channel stereo can also be received by tuning to either one of the two stereo stations. This is the way these two stations solved the compatibility problem. This is not full compatibility as talked about above, and it also suffers the problem of having somewhat different frequency-response characteristics between the two stations as received on two different receivers. Also, the relative phase of the signals from one station with respect to the phase of the signals from the other station is not controlled. Consequently, loudspeaker reversing switches are necessary to take care of this problem. Boston's problems are somewhat simplified since the 4-channel programs of these two stations are live broadcasts of the Boston Symphony Orchestra, which plays mainly classical music.

In New York, the station arrangement is somewhat different. The signals from the front microphones are carried by radio station WNYC-FM and the signals from the rear are carried by radio station WKCR. In this case, compatibility is again a problem because a listener tuned to one station gets only the front information and the listener tuned to the other station gets only the rear information—whether he listens in stereo or mono. The listener with two monophonic receivers will then have one of his channels provide only the rear information and the other one the front information. Here the listener might miss important parts of the program, for example, if it is specially recorded pop music.

At present, the use of two broadcasting stations to transmit 4-channel stereophonic sound is the only way such broadcasts can be made to the public. The reason for this lies in the Rules and Regulations of the Federal Communications Commission, which specifies in detail what types of signals each radio station can put on the air.

At some time in the future, broadcasts will be made using the carrier of a single FM station to transmit all four channels. A new type of multiplex system will have to be adopted by the FCC if sufficient grounds can be shown that 4-channel broadcasting is in the public interest. The first step is the proposal of a multiplex system. At the present time there is one proposal before the FCC (made by William Halstead), but it is possible that a great number of systems will be proposed over the next few years. As many as 17 different systems were proposed for 2-channel stereophonic broadcasting before the FCC adopted a single standard system.

The FCC will probably be operating under the same type of ground rules that were used in 1955 through 1961. The first question to be resolved is "How much interference is caused by a 4-channel stereo broadcast to signals of other broadcast stations located on adjacent or alternate channels?" Since these stations are allocated to adjoining cities, interference components by one local station may make the reception of another distant station more difficult. To minimize such interference and to protect the broadcasts of the various stations, the FCC regulates the signal strengths of all stations on all frequencies. The permissible ratio of these strengths existing within any one service area of a station is known as the *protection ratio*. If 4-channel broadcasts require a wider channel bandwidth than 2-channel or single-channel broadcasts, more interference components may appear in other channels and the protection ratio may be reduced. This may prove to be a stumbling block for certain 4-channel multiplex systems.

The second question to be resolved is that of compatibility. Here compatibility will have to be observed in two directions —up and down. The upward compatibility means that a 4-channel-equipped listener tuned to a mono station will receive the mono signal on all his channels and will receive the left channel of a 2-channel stereo broadcast in his two left channels and the right channel in his two right channels. Downward compatibility means that a 2-channel stereophonic receiver tuned to a 4-channel broadcast obtains a suitable mixture of the two right channels in the right-channel output. Similarly, the single-channel mono listener would have to be able to listen to a mixture of all four channels.

In the past, the FCC has defined "suitable" as an equal proportion of both channels, in the case of 2-channel programming. It may be assumed, therefore, that the monophonic component of a 4-channel broadcast most likely will consist of an equal proportion (or sum) of all four channels. Similarly, the two existing stereophonic channels will contain an equal proportion of the left-front and left-rear channels in the left stereophonic channel and an equal proportion of the right-front and right-rear channels in the right channel.

Compatibility goes even further. There should be minimal degradation in volume to the 2-channel stereophonic listener and to the monophonic listener when tuned to a 4-channel broadcast. From past FCC actions, it will not be satisfactory to have 4-channel broadcasts accompanied by a greatly reduced or even noticeably decreased volume for existing listeners. This requirement presents some rather formidable engineering problems and could be the downfall of many systems that may be proposed in the future.

Other questions that will have to be resolved are problems existing with practical transmitters and receivers. Audible cross-talk and distortion may occur when a transmitter is modulated with a composite signal comprising the four channels and listening tests are made with 2- or single-channel equipment. Such distortion components would have to be minimized.

A further question to be resolved is the amount of separation required between the four channels. This can be answered only by a series of controlled listening tests and then by setting transmitter specifications in excess of those which result in just audible degradation.

The least of these questions is the allowable signal-to-noise ratio within the service area of a station. It has to be determined whether the addition of two more channels to a signal degrades the signal-to-noise ratio to such a point that, within the station's prime service area, there will be marginal listening quality to the four channels.

It is worthwhile to repeat the old truism that one can't get something for nothing. In order to get two channels from a single FM station, signal-to-noise ratio decreases for listening to weak signals and distortion due to multipath and receiver and transmitter deficiencies increase. However, the development of new receivers within the past ten years overcame many of these difficulties. It is possible that a 4-channel multiplex system will result in a lesser additional decrease in signal-to-noise ratio. It may also eliminate the existing background music (SCA) channel.

One of the further questions to be resolved in each proposed 4-channel broadcast system is that of receiver complexity and quality. Most of this complexity will center around the multiplex decoder section. Here, a system which uses relatively simple decoder circuits, capable of high quality, will have a clear advantage over a system requiring more complex circuits.

Phonograph Discs

A difficult problem that engineers will face concerns recording and storing four channels on a phonograph record. This disc has now been developed to a high state of performance capability, but only in two channels. As is well known, the inner-groove wall of a phonograph record carries the left-channel information and the outer-groove wall the right-channel information. Since the two groove walls are perpendicular to each other, two channels can be recorded and played back. But what about four channels?

Experimental stereophonic records of the early 1950's contained two sections on each side. Each one had to be played with a separate monophonic pickup, mounted on a common arm. Excellent stereophonic sound could be obtained, but the

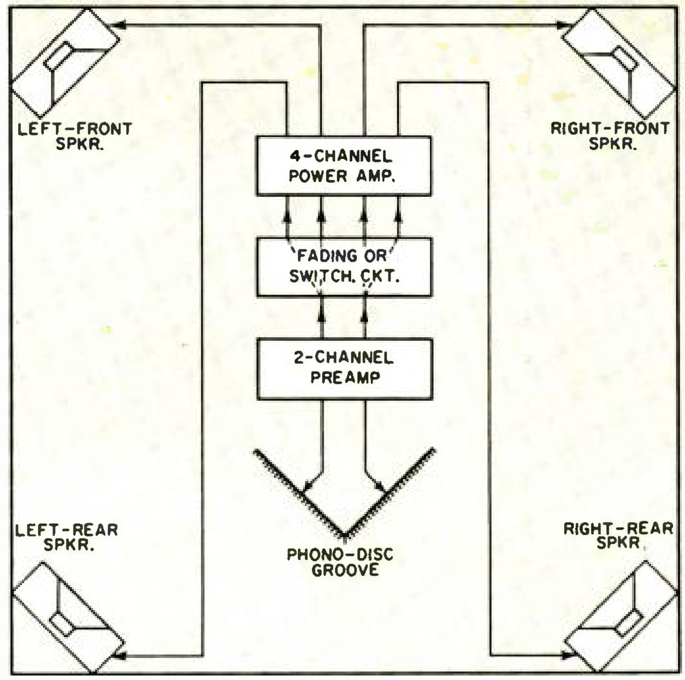


Fig. 4. Possible arrangement for obtaining four channels of information from a 2-channel disc plus special circuitry.

problem of playing these records was rather difficult because the two pickup styli had to start at exactly the same lead-in groove in order to prevent some completely uncorrelated sounds from coming out of the two loudspeakers. If this system were extended to using two stereophonic pickups, 4-channel sound could be recorded and played back on the same record. From past experience, this method does not seem too practical. Similarly, it may be argued that since a record has two sides, one side could be recorded clockwise and the other counterclockwise and the record could be played back with two pickup heads on a common arm, one pickup playing the top of the record and the other playing the bottom. Again, mechanical and practical considerations make acceptance of this system unlikely.

We might record a high-frequency subcarrier signal on a disc. This was attempted a number of years ago. Here the sum channel was recorded along with a difference signal as modulation of an inaudible high-frequency subcarrier. A multiplex decoder then recovered the two separate signals. The problems were increased high-frequency noise and substantial intermodulation between the low-frequency audio channel and the high-frequency sub-channel. Increased problems of dust, dirt, and record wear made such a system impractical. Consequently, recording additional high-frequency information on a record will suffer from the same problems and will probably prove unsatisfactory.

Are Four Channels Necessary?

But are four channels really necessary to give the illusion of 4-channel sound? One might recall some sound movies which were shown shortly after World War II in which there was only one sound track but there were three loudspeaker systems located behind the screen. When the actor spoke from left stage, the left loudspeaker was operating and when he moved to right stage, the right-hand speaker produced the sound. There were problems when there was an orchestra on one side and a soloist on the other side of the stage. In this case, the sound would come from the direction of the louder sound.

This illusion was accomplished by a 25-Hz control signal recorded on the sound track which caused the various speakers to be turned on and off as desired. A similar system, the *EMI*-Percival system, was proposed for stereophonic broadcasting and it even reached the field-testing stage. However, since the reverberant information (*Continued on page 65*)

Expo '70

By MURRAY SUNTAG / Associate Editor

Here is an invitation from Japan to all peoples of the world to join them in attempting to raise hopes of all mankind by fostering good will and understanding among nations.

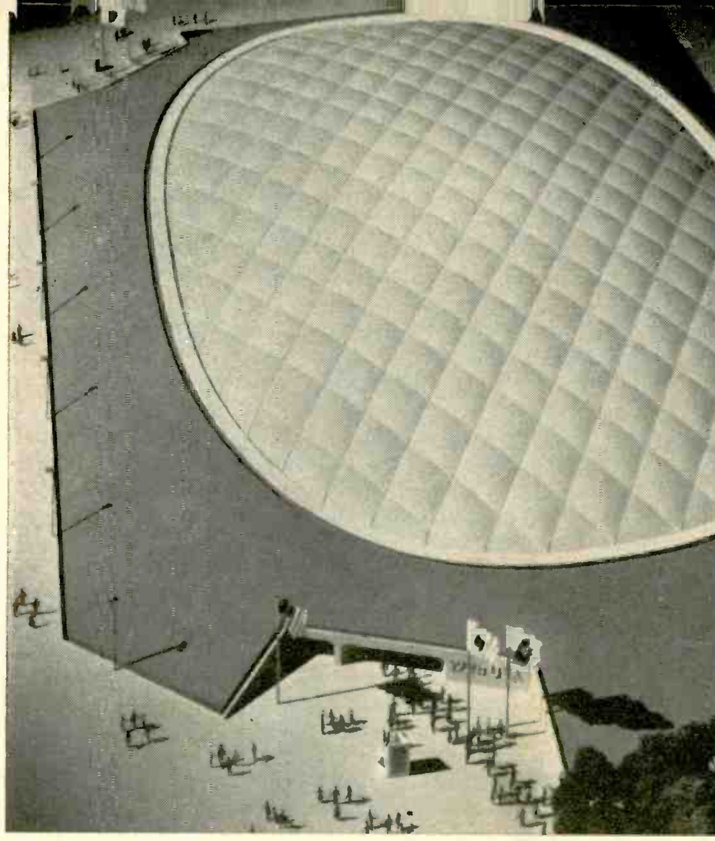
EXPO '70, the first World Exposition to be held in the Orient, will open in Osaka, Japan on March 15 and is scheduled to run until September 13. Osaka, known as the "Chicago of Japan," is the second largest city and the industrial and business center of the nation. Because it is geographically located in the center of Japan and in close proximity to such culturally rich cities as Kyoto and Nara, and is only 45 air minutes or three hours and ten minutes by train from Tokyo, Osaka was considered an ideal location for Expo '70. More than 70 nations, international organizations, and private corporations will participate and, hopefully, contribute more than "lip" service to the theme of the exposition—"Progress and Harmony for Mankind"—which is predicated on the concept of progress in the betterment of human life and harmony or peace among mankind, based on tolerance and understanding.

It is estimated that approximately 45,000,000 visitors (800,000 of these foreign) will have attended Expo '70 before it closes in September. To accommodate these visitors, there will be a number of both Western- and Japanese-style hotels within a one-hour's ride of the exposition site. In addition, some 600 private homes in the immediate vicinity of Expo '70 will provide accommodations for visitors.

Expo '70, constructed on 815 acres of land, is basically composed of three distinct areas: the Symbol area, the Exhibition area, and the Recreational area (Expoland). In addition, a 64-acre Japanese garden has been constructed at the fair which will serve as a quiet place for those visitors who wish to relax and meditate.

The 412 × 2952 foot Symbol area, located in the center of the exposition, contains exhibits that will, by all indications, indelibly impress upon the visitor mankind's relationship to, and effect upon, the past, present, and future of the world and the universe. It is for this reason that the Symbol area—especially the Theme Hall—a feature attraction of this area, should not be missed.

The Theme Hall contains a subterranean exhibition and a 198-ft tall Tower of the Sun (Shown here) flanked by the Towers of Motherhood and Youth. Fairgoers will pass from the subterranean exhibition through a transparent tube directly into the Tower of the Sun. Four escalators will then carry the visitors up through the tower to the horn-like wings that egress directly onto a 4700-ton transparent polyester film roof measuring 958 × 354 × 33 feet, supported above the ground by groups of steel pillars. It is the sharp contrast between the oriental flavor of the three towers and this modern architectural feat that will hold the



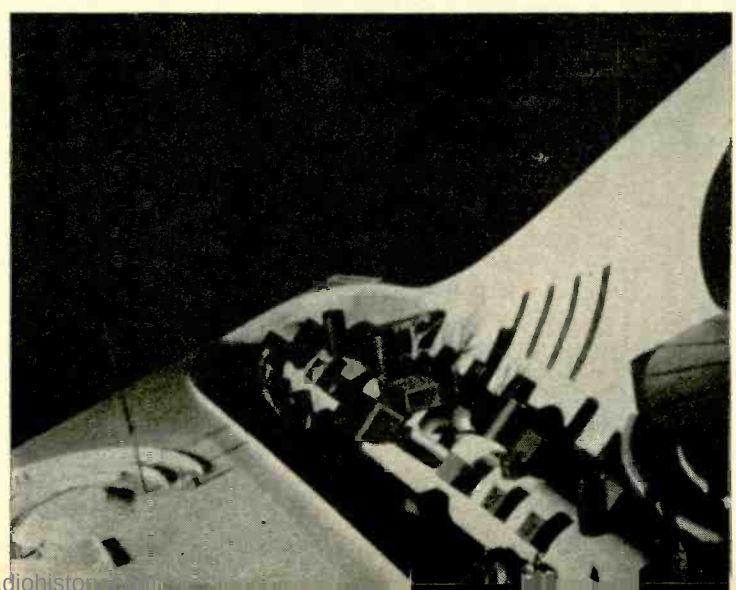
Saucer-like American Pavilion features largest (274 x 465 foot) translucent, air-supported cable roof ever built. Exhibit will illustrate progress in culture, science and technology, as well as phases of American life, past to present. Sample of moon rock will be displayed.

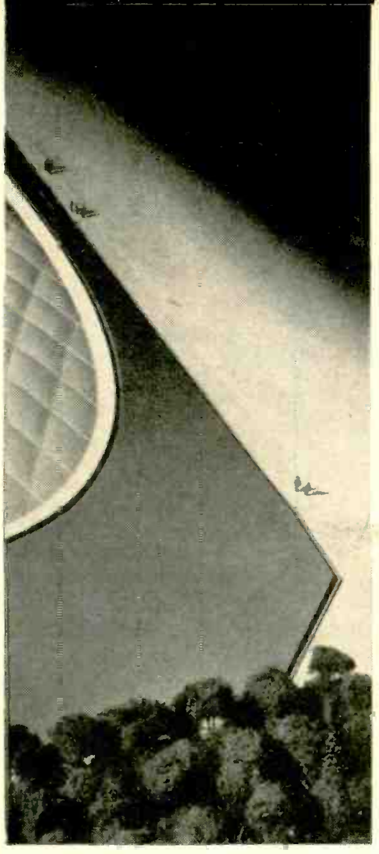
viewer spellbound. The entire trip through the Theme Hall takes about one hour. Once completing this part of the tour, which actually represents an introduction to the theme of Expo '70, the visitor is now prepared for other wonders of the fair.

The Exhibition area will contain the pavilions of the participating nations, international organizations, and foreign and domestic enterprises—each depicting in its own inimitable style its past history, present endeavors, and future plans. In fact, as indicated by the symbol of the exposition—the five petals of a cherry blossom, where each petal represents a continent—every part of the world will be adequately represented. Architecture of pavilions will reflect oriental, occidental, and futuristic tastes.

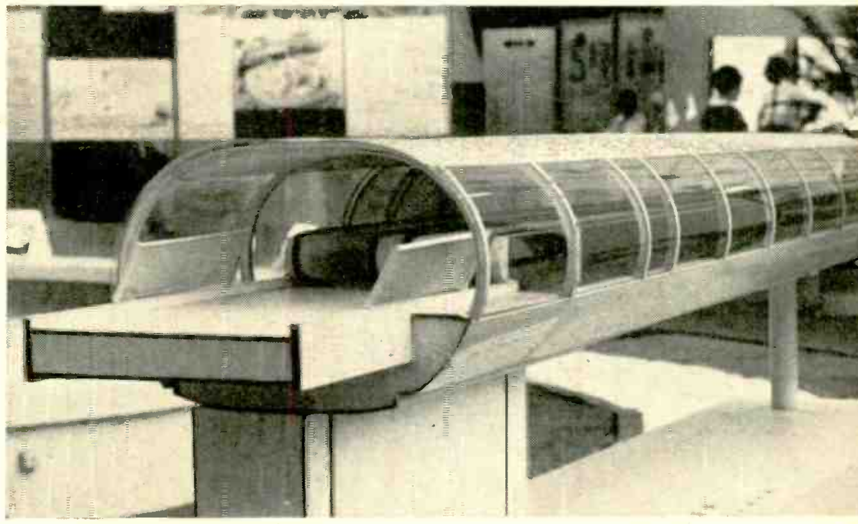
The Japanese electronics industry is well represented at the exposition by such prestigious companies as *Hitachi, Ltd.*, *Matsushita Electric Industrial Co., Ltd.*, and *IBM Japan, Ltd.* In addition, it goes without saying that all of the Japanese electronics firms that do business with the United States, but who are not represented at the exposition, will have their welcome mats out for those who wish to pay them a visit or are looking for information. Some of the American firms represented at Expo are: Ko-

Impressive-looking Australian Pavilion consists of 3 main elements: a cantilever that rises to height of 128 feet to form giant "sky hook" that suspends 159-foot diameter roof; a 250-foot-long, 25-foot diameter underground exhibition space; and display and information hall.





Resembling a space ship, the Hitachi Group Pavilion provides visitors with 30-minute simulated air trip followed by demonstration of latest scientific advances.



Model of very modern-looking moving sidewalk used at Expo to transport visitors to and from gates to Symbol Area. Walks, operated in transparent tubes, carry 9000 persons/hour.

dak, Coca-Cola, Sunkist, Encyclopaedia Britannica, Royal Foods, among others.

Unlike any other exposition ever held, the visitor will be able to obtain up-to-date information about buildings, roads, exhibits, visitors, the weather, etc. which will be continuously fed into five huge electronic computers. Consequently, it will be possible for visitors at the fair, or people anywhere in Japan, to get pertinent information about the exposition just by picking up a phone.

For those who find walking anathema, a monorail, an aerial cableway, battery-powered cars, and moving sidewalks will be available to transport them from one part of the exposition to the other. The monorail will contain six four-coach electronically operated trains that can hold 540 persons and cover the 2.7 miles of monorail in 15 minutes. They will run on a single track at 2-minute, 30-second intervals.

The cableway contains twenty-two 3080-pound ball-shaped gondolas each capable of accommodating 15 persons. The gondolas will be operated at one-minute intervals and can cover its 2871-foot run in $7^1/_2$ minutes, thereby transporting 1800 persons per hour.

The battery-powered cars, designed for comfort and safety, can accommodate six persons including the driver and will move around the fairgrounds at a speed of 5 mi/h. Of the 200 battery-operated cars available, only 70 of them will be used as taxis while the others will be rented to special groups (exhibitors and newspapermen).

The moving sidewalks, operating in transparent tubes, will carry about 9000 persons per hour between the entrance gates of the Exposition and the Symbol area. And for those who arrive at the Exposition site by car, free buses will shuttle between the parking lots and gates, at which point connection can be made with the moving sidewalks.

For those visitors from the Western world, Expo '70 will provide a wonderful opportunity to get to know the Japanese people and something of oriental customs. What better way can people become acquainted than by eating, living (rent a room in a private home), and bathing together (community bath house)? A little understanding among people can go a long way in realizing the theme of this exposition—"Progress and Harmony for Mankind." ▲

One of three types of battery-powered cars used at Expo '70. All are semi-open and travel at 5 mi/h and will accommodate up to six persons, including the driver. Seventy cars will be used as taxis for fairgoers, 120 cars by distributors, and 10 cars for members of press.

TELEVISION'S BUILT-IN TEST SIGNALS

By IVAN MERTES/ Design Engineer, The Heath Company

The vertical-interval test signals transmitted by TV networks can help in evaluating TV receiver and provide quick alignment check or need for repair.

ALL television signals carry a great many built-in means for testing a receiver to pin down a variety of troubles. One set of special testing signals transmitted by three major networks is the *vertical-interval test signals*, or VIT's. These signals will help you decide whether to repair the antenna system, troubleshoot and re-align the r.f. tuner or i.f. amplifier, or troubleshoot and repair the video amplifier. Making use of VIT's may help you avoid the tedious connecting of all your sweep-alignment equipment, only to find the real trouble is elsewhere in the system. VIT signals also fill the void left today by rarely seen test patterns. Evaluation of receiving systems may be accomplished without regard to the quality of the picture content as seen on the set's screen.

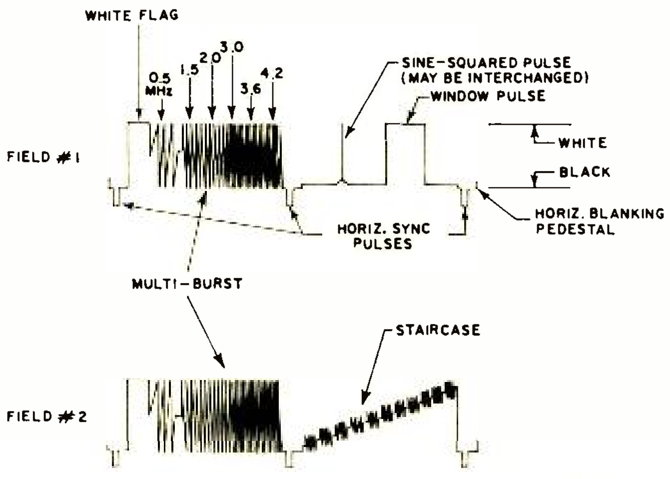
VIT's are primarily intended for evaluation of network transmission equipment. You probably have seen these signals before and wondered in passing, "What are these bright lines here for?" Well, these bright lines can help you. They appear in nearly all network color telecasts and will be found in the vertical-blanking interval.

Contents of VIT's

To make use of these signals we must know what they contain. Fig. 1 shows VIT's as they appear in two consecutive fields of the TV signals. The multi-burst is composed of a white flag and six groups of video frequencies. The white flag extends from black level to maximum white level. This appears on the TV screen near the bottom left side of the vertical blanking pulse as a solid white portion about 2 inches long on a 295-square-inch screen.

When viewing multi-burst on an oscilloscope, the white flag serves as a reference. Immediately to the right of this pulse come sine-wave frequencies in groups at 0.5, 1.5, 2.0, 3.0, 3.6, and 4.2 MHz, respectively, with the 4.2-MHz burst near the right side of the TV screen. Each of these multi-burst frequencies is transmitted at equal strength. Therefore, by comparing the strength of each of these frequencies after the receiver has worked on them, we have the means to measure the frequency response of the receiving system.

Fig. 1. VIT's (vertical-interval test signals) are added to the last two horizontal lines of the vertical blanking.



The other parts of VIT's—the sine-squared pulse, window, and staircase—are not nearly as useful to us in servicing color sets. These signals are useful mainly to engineers with very high-priced equipment. For example, the sine-squared pulse has a particular shape that makes it valuable for checking ringing and such things in video amplifiers. Hopefully, the sets we come across in servicing are designed to keep ringing to an acceptable level. If one shows excessive ringing, we will start looking for broken resistors across peaking coils, coils shorted by solder blobs, etc., rather than looking at a test pulse that only confirms what we see on the screen. The same goes for the window signal—it is fine for checking amplifier tilt, smearing, and response, but its use is quite limited for servicing applications.

The staircase signal consists of ten or eleven equal steps, beginning with the first step at black level and proceeding up to the white level. Each step is modulated an equal amount by 3.58-MHz energy. By comparing the amount of 3.58-MHz signal on each of the steps, a check of the receiver's linearity may be made. Meaningful test results from the staircase require very elaborate equipment beyond the means of service shops.

Fig. 2 shows the horizontal sweep lines during two consecutive vertical-blanking intervals. As shown, there are two horizontal lines of VIT's in each vertical blanking pulse: lines 17 and 18 in field number 1, and lines 279 and 280 in field number 2.

As seen on the screen of a TV receiver, field 1 will be interlaced with field 2 and you will find line 17 followed by line 279, then line 18 and finally line 280, followed by the first line of video at the top of the picture. In other words, near the bottom of the vertical blanking pulse you will see four bright lines among the dark lines of the pulse. The upper bright line will be line 17 carrying the multi-burst, then line 279 also carrying multi-burst. Third comes line 18 carrying the pulse and window, then line 280 carrying the staircase signal. Immediately below these bright lines will come the picture information.

To see the VIT's just described, the set's height and/or vertical linearity controls are adjusted to reduce the picture size vertically. Now carefully adjust the vertical hold control to interlace the two fields of the picture and prevent "pairing" of the horizontal sweep lines. The multi-burst signals will now appear just above the picture as two "beaded" white lines, followed by two more mostly white lines.

On some sets recently manufactured this procedure may not work and you will see nothing but black in the blanking pulse even when VIT's are present. This is because of a very effective vertical blanking signal, produced in the set itself and designed to completely eliminate vertical retrace lines from the picture. To sidestep this, roll the blanking pulse

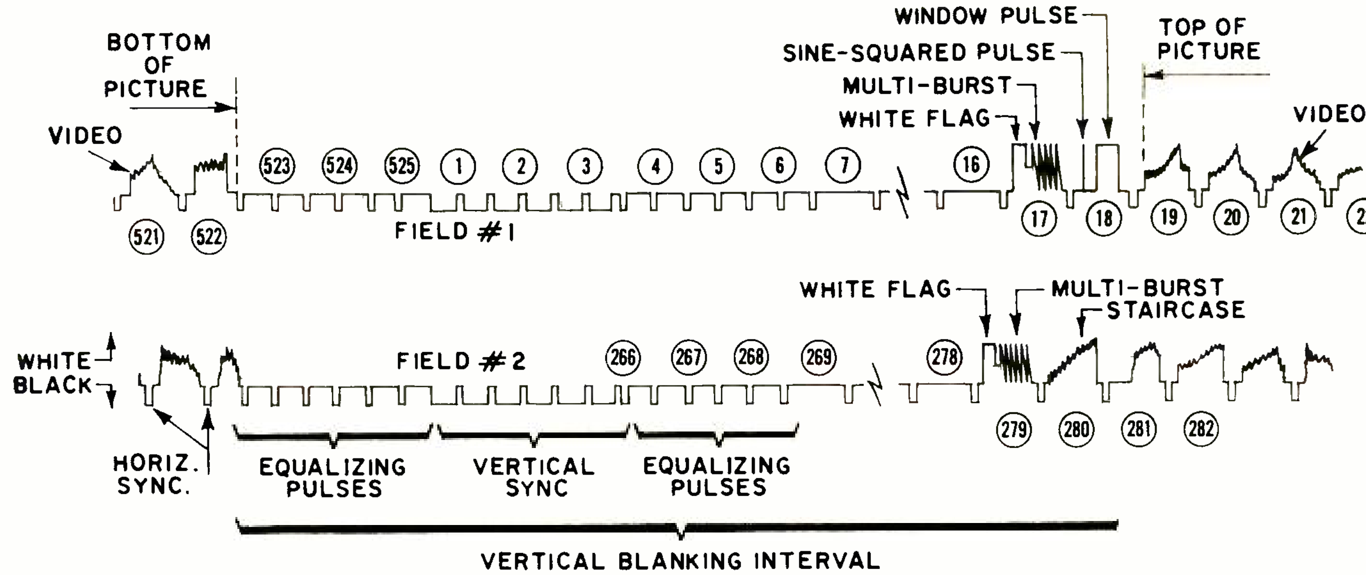


Fig. 2. Horizontal line-by-line illustration of composite TV signal. Circled numbers identify each horizontal line.

into view on the screen with the vertical hold control, "riding" the control to keep things as nearly stationary as possible. Now, however, VIT's will probably show as only two bright lines instead of four, because the set is not interlacing when the vertical-hold control is misadjusted as we have just done. This is no problem, though, because lines 17 and 279 will pair up. Since these lines carry the same multi-burst signal, nothing is lost. The multi-burst signal is the part of the VIT's we are most interested in, and pairing the pulse and window signals and the staircase on the next line will not lose much for us.

Estimating System Response

Now let's see how to measure frequency response with VIT's. Fine-tune the set as accurately as possible. View VIT's by either of the methods just described. If the station being received is transmitting the test signals, you should see them as in Fig. 3. What you see here will represent the frequency response of the entire receiving system from antenna to CRT. In the photograph of Fig. 3, separate white dots are seen resulting from the peak of each multi-burst sine wave reaching an amplitude great enough to make the CRT screen white. Where the amplitude of the multi-burst is lower, each sine-wave peak will be more gray, and with very weak multi-burst the screen will remain nearly black.

The highest frequency response of the set will correspond to the multi-burst frequency group which can just be resolved as separate dots on the screen. In Fig. 3 this is at about 3 MHz, where the dots begin to run together. So we can say the response of this receiver is good to about 3 MHz. (*Note that the actual TV picture shows more detail than the small photo reproduced here.—Editor*)

Of course, the set's high-voltage and focusing circuits must be operating and adjusted properly. Also, some touch-up of brightness may be called for.

Observing VIT's with an Oscilloscope

A more satisfactory way to look at VIT's is with an oscilloscope. The first requirement for the scope is that its frequency response must be good at least up to 4.5 MHz before it rolls off, or it will influence the results. Second, it must have a triggered sweep. What this means is that with no signal into the scope vertical input there will be no sweep generated. When composite video from a TV receiver is fed to the scope, it may be adjusted to start a sweep only each time a vertical or horizontal sync pulse comes along. The advantage of this is that the waveform seen on the scope screen will be very stable and free of jitters or drifting. This is what we require if we are to look at VIT's multi-burst.

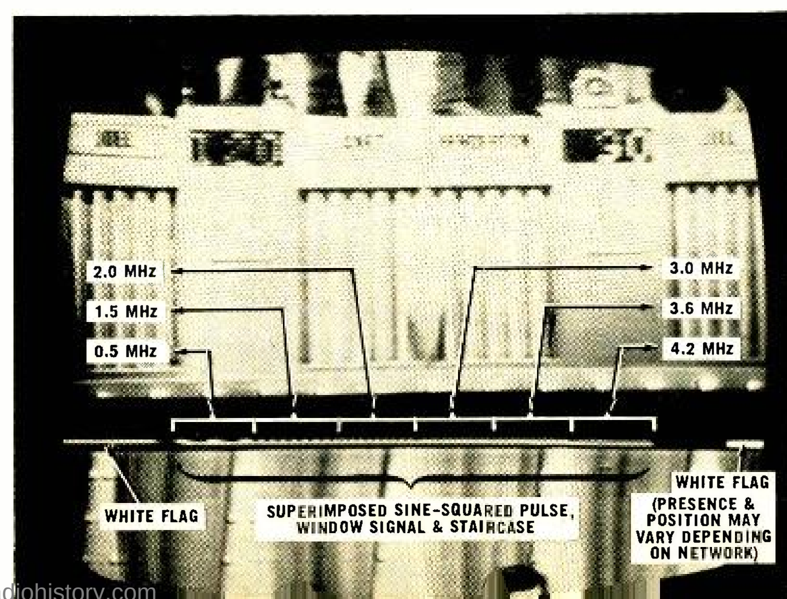
Another important requirement of the scope used is that it have enough gain to allow use of a 10-to-1 isolation probe. The isolation probe lets you hook on to high-impedance points in a circuit without loading the circuit down or detuning it too far. The loss in these probes is usually ten times and this must be made up by the gain in the instrument's vertical amplifier. Minimum sensitivity needed is about 25 millivolts per screen division.

More satisfactory scopes for VIT's viewing have sweep-delay provisions. With these instruments any portion of the displayed waveform may be selected, expanded to fill the trace, and swept at any desired rate. This means you are able to take the VIT's part of a TV signal display on the scope and, in effect, expand this tiny part enough to fill the entire baseline without loss of brightness and the jittering that would be present with simple sweep-expanders.

Measuring Frequency Response with Scope

Using a 10-to-1 probe, clip it on to the color CRT red cathode. Using a scope without delay provisions, adjust the Sweep Stability and Trigger Level controls on the scope to obtain a stable trace with two horizontal lines of the TV signal (two horizontal sync pulses should be visible). Now turn the scope brightness up and very carefully adjust the stability control to either end of the range where the trace brightness drops suddenly. With sufficient patience, the horizontal lines carrying the VIT's will come into view as in Fig. 1. Look first for the staircase pattern, the most easily

Fig. 3. Photo of TV screen with vertical blanking bar rolled to center of screen in order to show the VIT's.



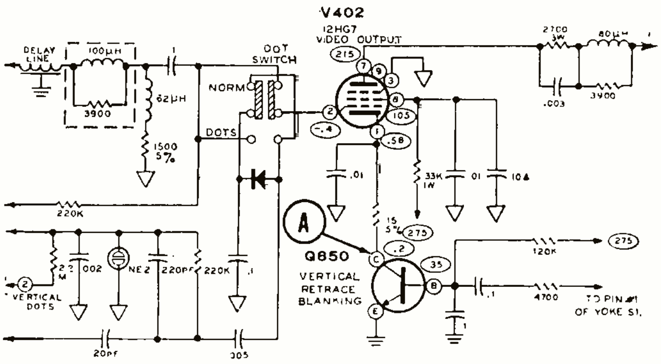


Fig. 4. Partial schematic of video amplifier of Heathkit GR-681. Short "A" to chassis to disable blanking.

identified portion of VIT's. Some varying video information from other parts of the signal will also be visible but a usable multi-burst pattern will appear.

If you are using an instrument with sweep delay, results will come much easier. Follow the manufacturer's instructions for selecting and expanding the desired part of the waveform—in this case the portion showing the VIT's.

One thing that may stop us at this point is vertical blanking in the set. Some recent sets, such as the *Heathkit* GR-681, have a very effective blanking circuit which operates in the video amplifier. This will remove VIT's information, so the blanking will have to be defeated. A partial schematic of the GR-681 video-output stage is shown in Fig. 4. By shorting point A to the chassis with a clip-lead, blanking will be defeated and VIT's will come through to the CRT cathodes.

Now that we have VIT's captured on our scope screen, let's continue. We can expect to see the multi-burst appearing somewhat as shown in Fig. 5. This is a photograph of the multi-burst response at the CRT cathodes of a normally operating color set. The maximum resolution of the set is at the frequency where the multi-burst height is about half that of the lowest frequency multi-burst groups. This response shows 2 MHz to be ½ of that at 0.5 MHz, or 6 dB down. Likewise, 3 MHz is 10.3 dB down, 3.6 MHz is 17.6 dB down, and 4.2 MHz is so far down we can't measure it. This response measured on a scope is from the same set used for the photo in Fig. 3. Response to VIT's shown by our scope connected to the picture detector will appear similar to Fig. 6 with a normal color receiver.

Effect of the I.F. Response

The most often asked question concerning VIT's is, "What sort of response should a normal color set have as measured by the multi-burst?" To answer this, let's do some digging.

The multi-burst is applied to the picture carrier at the transmitter as amplitude modulation. Each group of multi-burst frequencies will form sidebands at the frequency of picture carrier plus and minus multi-burst frequency. Since the TV transmitter uses mainly the upper sideband (carrier plus modulation frequency), we can forget the lower sideband. As the TV signal is passed through the receiver's tuner it is converted to the i.f. frequency range and also flipped over frequency-wise due to the conversion action of the tuner. The picture carrier frequency is now 45.75 MHz regardless of which channel is being received (if the fine-tuning control is adjusted right).

Imagine a TV station transmitting on channel 4. The picture carrier is at 67.25 MHz, the color sub-carrier is at 70.83 MHz, and the sound carrier is at 71.75 MHz. This is upper-sideband transmission because the picture, color, and sound information show up at higher frequencies than the picture carrier. This channel-4 signal is sent to the tuner input from the antenna, where it is amplified and heterodyned with the r.f. oscillator.

The r.f. oscillator is on 113 MHz when receiving channel 4. 113 MHz minus 67.25 MHz, the picture carrier frequency, comes out to 45.75 MHz. This is now the frequency of the channel-4 picture carrier as sent on to the i.f. amplifier. The r.f. oscillator frequency, 113 MHz, minus 70.83 MHz, the color sub-carrier, comes out to 42.17 MHz, the frequency of the color sub-carrier in the i.f. amplifier. Likewise, the sound carrier at 71.75 MHz is converted to 41.25 MHz. If the multi-burst at 2.0 MHz, for example, is being transmitted, it will appear in the i.f. amplifier at 43.75 MHz.

After many decibels of amplification in passing through the i.f. amplifier, our channel-4 signal reaches the picture detector and is converted back to the same form it started with at the studio: video frequencies. Next, the video amplifier amplifies the TV signal in video form sufficiently to drive the picture tube.

The i.f. amplifier of the receiver has a great effect on the over-all frequency response. Fig. 7 is the familiar i.f. response curve of an ideal color-TV receiver. Note that the picture carrier and the color sub-carrier are both down by 6 dB.

Expressed in fractions of the maximum amplification, or in terms of voltage as would be seen on an oscilloscope screen, the curve of Fig. 7 would look something like Fig. 8. The picture carrier and color sub-carrier would be half-way down the curve, but the frequencies around the lower skirts of the curve would be compressed to almost nothing, so that a representation of the trap action would be lost. In effect, putting this curve in decibels instead of percentage amplification shows more of the interesting details. One more point: 6 dB is a factor of two only when talking voltage. When talking power, the magic number is 3 dB to show half or twice power.

Referring again to Fig. 7, we see that the VIT's multi-burst frequencies of 0.5, 1.5, 2.0, 3.0, 3.6 (3.58), and 4.2 MHz will appear at 45.25, 44.25, 43.75, 42.75, 42.17 and 41.55 MHz, respectively.

These multi-burst frequencies will come from the picture detector at full strength at 1.5 and 2.0 MHz, down slightly at 3.0 MHz, down 6 dB at 3.6 MHz, and down 28.5 dB at

Fig. 5. Photo of multi-burst waveform at CRT red cathode.

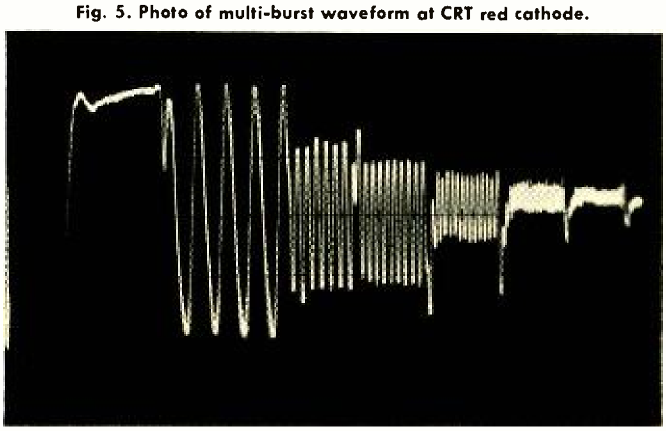
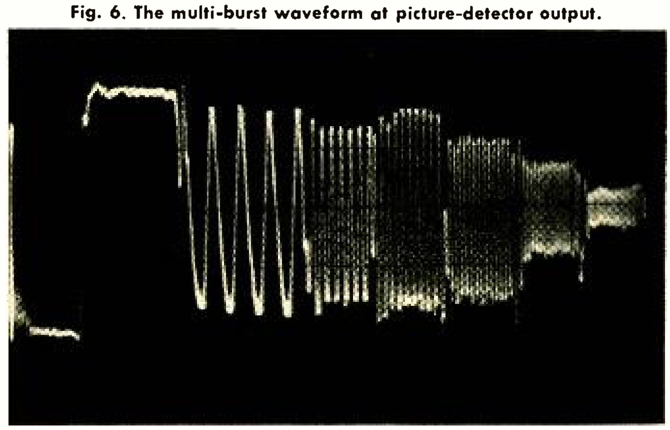


Fig. 6. The multi-burst waveform at picture-detector output.



4.2 MHz. Missed 0.5 MHz, you say? Well, that's a special case. We said earlier that only one sideband is used in our TV system. That is not quite true because a second sideband is transmitted at frequencies near the picture carrier. So these frequencies must receive less amplification in the receiver to prevent these "double-sideband" frequencies from humping up the final response. This works out just right with the picture carrier set at 6 dB down, and 45 MHz at or very near to maximum amplification.

We can sum up by saying that the frequency response of a properly operating and aligned color-TV set at the output of the picture detector will be flat from below 0.5 MHz to about 3 MHz. At 3.6 MHz the response will be down about 6 dB, and at 4.2 MHz the response will be down far enough to allow us to forget it. The r.f. tuner response is supposed to be sufficiently wide and level on each channel so that the response of the rest of the set will not be changed. (*Editor's Note: The video amplifier is between the picture detector and the CRT cathodes; it handles the brightness component of the signal and affects picture resolution. Hence, it should have a fairly wide response. The chroma section also has an effect on the response but only for the color signals applied to the CRT grids. This portion of the receiver need handle only sideband frequencies up to 0.5 MHz, or at the most 1.5 MHz, and need not be discussed when considering picture resolution.*)

This leaves only the video amplifier to further affect results. Ideally, this part of our set will not upset the response either. However, such is not usually the case. In designing color sets for home use, much thought is given to what the majority of customers will consider a "good" picture. With local live telecasts and a strong signal into a viewer's set, full advantage may be taken of the response available. But, with a slightly snowy picture and a movie from 1940 being programmed, there will be a revolting mess. Wide frequency response will bring out every flaw in the whole chain, from dirty and scratched film and noisy preamps at the studio, to snow from an over-aged antenna and lead-in, overshoot and ringing in the receiver, and dozens of other possible problems.

With these responses in mind, most set designers tailor the response of their video amplifier to produce a picture sharp enough to satisfy the average set buyer, but not so sharp that pictures appear grainy. As an added feature, several sets now appear with resolution, or sharpness, controls. This control lets the customer adjust the sharpness (frequency response) of his set to suit himself.

Actual measurements on several sets show over-all responses to be typically down from 1 to 5 dB at 1.5 MHz, 1 to 7 dB down at 2 MHz, 8 to 14 dB down at 3 MHz, and 15 to 29 dB down at 3.6 MHz. These responses are all compared to 0.5 MHz. On paper this kind of drooping response appears terrible, but the sets that were measured were late models, and all had very acceptable pictures.

Use of VIT's in Troubleshooting

The idea for rapid localization of trouble is to observe set response at the picture detector first by use of VIT's. This will localize trouble to a point either before or after the detector. If the multi-burst is not normal at the detector, check VIT's on other channels. If all channels appear about the same, the trouble is in the i.f. amplifier. If some channels look okay, you probably have tuner or antenna-system troubles. Don't overlook the chance of the antenna system causing "holes" or tilted responses on some channels.

Say that we have a set on the bench with a very bleary looking picture. Hooking our scope to the picture detector output shows VIT's to be about normal except that the burst at 2.0 MHz is way down compared to the bursts on either side. This suggests an i.f. trap is detuned into the passband, chopping out frequencies about 2 MHz below the picture carrier frequency. Switch to another channel carrying VIT's. If the same thing is seen, then our reasoning is right, and the i.f. amplifier requires realignment. If the poor response at 2 MHz is not seen on other channels, maybe be an FM trap at the tuner input is misadjusted, causing a bite on only one channel. Other traps at the input of the set could similarly be misadjusted or faulty.

If the VIT's response at the detector output is normal, the trouble will be in the video amplifier. Look for open peaking coils, off-value resistors, solder bridges across foil patterns, etc. ▲

Fig. 7. I.f. amplifier response curve of a modern color-TV receiver showing placement of VIT's multi-burst modulation.

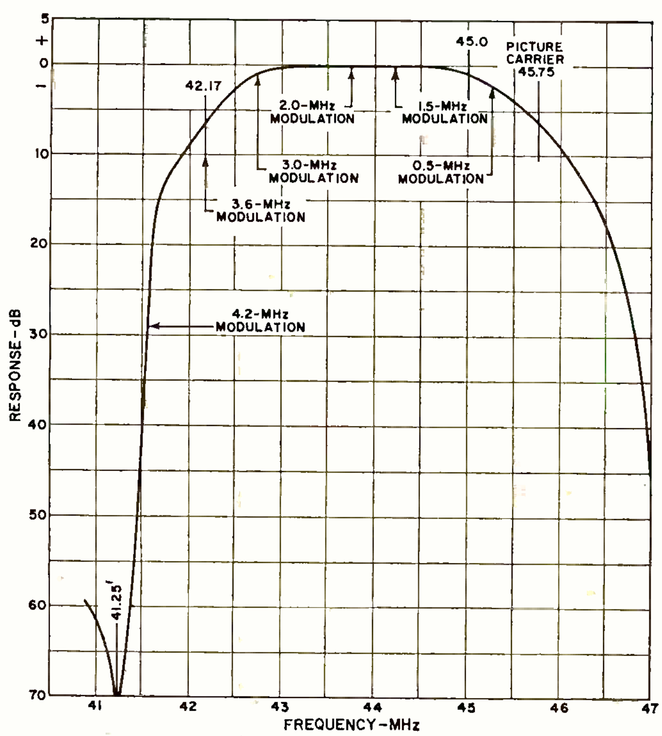
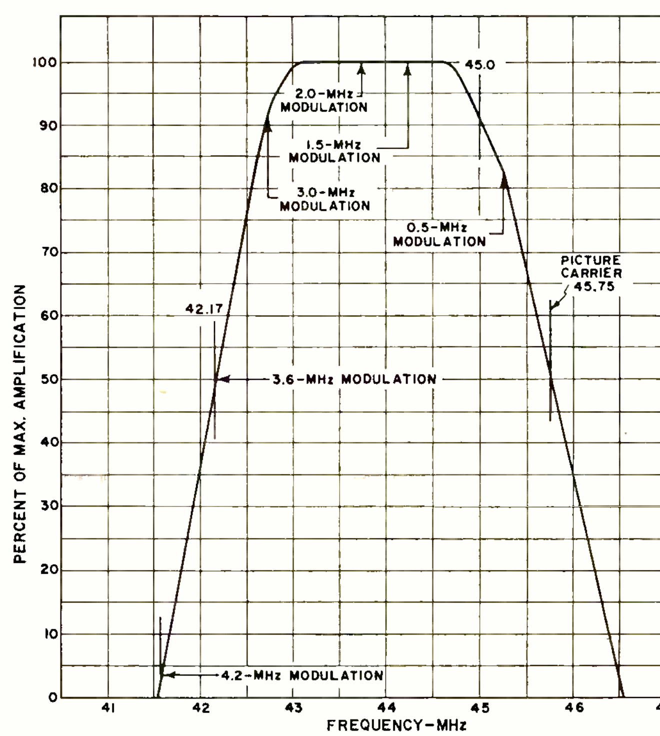


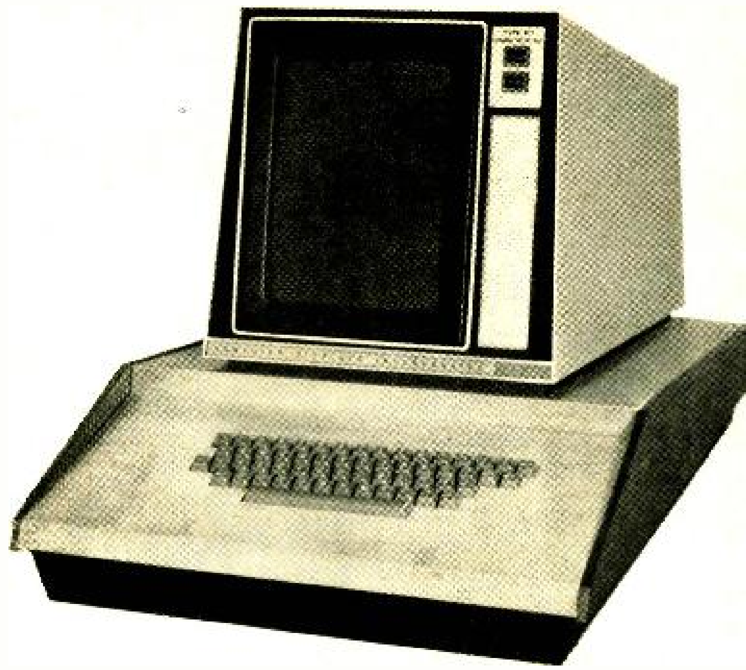
Fig. 8. Same response as in Fig. 7 except expressed as percent rather than in dB. This is how curves appear on scope.



COMPUTER TIME SHARING

By DAVID L. HEISERMAN

Want your own computer? Here are some pertinent facts about time-sharing systems that can make this possible.



CRT display terminal that uses alpha-numeric symbols to show user results of his program much faster than a teletypewriter.

IN their occasional moments of idle fancy, engineers and scientists used to dream of having a private computer system right in their own office or home. Of course, a computer system costs a good share of a million dollars, but it was fun to think about it anyway. Today, that dream has become a reality. In fact, anyone who can spare about $300 a month can have access to a vast general-purpose computer system in the privacy and in the comfort of his own home or office!

A time-sharing computer system makes this possible by, as its name implies, sharing the computer time among a number of users at remote telephone terminals. The system can switch from one user's problem to another's and, since the computer can manipulate a great deal of information in a very short period of time, the users generally aren't aware that they are being switched in and out of the system. As far as the users are concerned, each one of the individual users is working alone with the distant general-purpose computer system.

The basic idea of computer time sharing is not new. In the early 1960's, researchers at Dartmouth and MIT worked on the first time-sharing computer systems. In those days, large industries, businesses, and universities had to lease a complete system if they wanted to make extensive use of a general-purpose computer. The whole point of the first time-sharing research was to find a way to let these large organizations scatter remote-access terminals around their facilities. So the first time-sharing systems were merely optional add-on features for someone leasing an entire computer system.

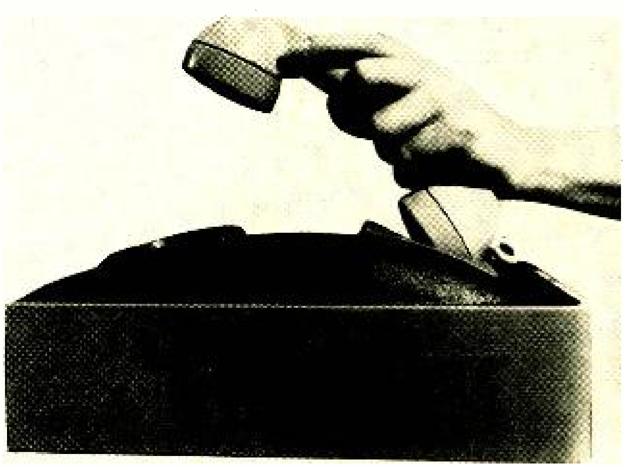
About 1964, computer manufacturers began working on the idea of setting up their own computer facilities, and leasing remote telephone terminals to anyone who wanted them. In 1965, the new commercial computer time-sharing firms did a $10,000,000 business, and by 1967 the income from time-sharing users was close to $30 million, and nearly twice that amount in 1968. Less conservative experts estimate a $5-billion time-sharing business by 1975.

Some of the computer manufacturers entered the time-sharing business by simply extending their present computer operations. *GE* and *Honeywell* are examples of such companies, while other major computer firms, such as *IBM*, established separate subsidiaries to handle time-sharing systems and services. Of course, it was inevitable that a new multimillion-dollar industry would spawn new companies. Today, there are about 200 new firms dealing exclusively in time-sharing services. A fourth source of time-sharing services is the large, non-computer industries that have to lease entire general-purpose computer systems for their own use. Aerospace industries, in particular, reduce their share of computer operating costs by subleasing time-sharing devices to other users.

LARGEST AND MOST VERSATILE TIME-SHARING FIRMS

Computer Sharing, Inc., Bala-Cynwyd, Pa.
Com-Share, Inc., Ann Arbor, Mich.
Datalogics, Inc., Cleveland, Ohio
General Electric Company, Bethesda, Md.
Honeywell, Inc., Minneapolis, Minn.
I-C Computer Corp., Tulsa, Okla.
ITT Data Services, Paramus, N.J.
On-Line Systems, Inc., Pittsburgh, Pa.
Service Bureau Corp., White Plains, N.Y.
Technical Advisors, Inc., Wayne, Mich.
VIP Systems Corp., Washington, D.C.

Fig. 1. Data set that's used in commercial time-sharing communication systems to condition signals from a user's teletypewriter for transmission along ordinary telephone lines and recondition signals coming to the user from the computer center.



The User's Terminal

The only computer hardware the user ever sees is a teletypewriter and a small "black box" called a data set. Whenever he wants to work with the computer, the user dials a certain number on his office telephone, listens for a characteristic 2225-Hz tone, and fixes the telephone handset to the data set (Fig. 1). In an instant, the teletypewriter seems to come to life, and the user is ready to go to work.

The user's teletypewriter resembles an ordinary type of machine with a few added computer-type symbols. The teletypewriter generates 10-bit digital words for every keyboard character the user types on the machine. The teletypewriter also accepts digitized words and commands from the time-sharing computer, and types them out on a long sheet of paper.

Ordinary telephone lines are cluttered with clicks, buzzes, and beep tones; some of them are explainable and others are not. For this reason, the digital "mark" and "space" outputs from both the user's teletypewriter and the computer system must be suitably conditioned before they can pass reliably through the telephone lines. The data-set "black box" does this job.

Whenever a user is sending information to the time-sharing computer, the data set generates a 1270-Hz "mark" signal, and a 1070-Hz "space" tone. When the user's data set receives the same kind of audio signals from the computer, it uses a simple FM-like filter circuit to convert the frequencies to mark and space voltages for the teletypewriter. The mark and space signals from the computer are 2225 Hz and 2025 Hz, respectively.

Time-Sharing Field Offices

Although commercial time-sharing users do not like the idea of having to add long-distance telephone charges to their computer-terminal budget, it would be prohibitive for commercial time-sharing computer firms to place an elaborate general-purpose computer center in the vicinity of every large city in the nation. To solve this problem, time-sharing firms are beginning to establish local field offices to relay all the data from nearby users to a distant computer center. As far as the user is concerned, he dials a local number, and pays the usual local telephone rates for the use of the line.

A local time-sharing field office leases a dozen or so local telephone lines just as most large businesses do. The difference is that the "answering" is automatic, and the incoming lines connect to data sets rather than to a secretary. The time-sharing firm can save multiple long-distance telephone charges by using a single line to the central computer station rather than a line for every data set in its offices. To do this, the outputs from the field-office data sets feed a multiplexer that combines all the local-terminal signals into a single channel (Fig. 2). The field office multiplexer also accepts multiplexed data from the computer center, unscrambles it, runs it through the office data sets, and sends it on to the individual terminals in the area.

Time-Sharing Techniques and Hardware

All the techniques and hardware described so far are concerned with the communication of data between the central computer station and the individual users. The hardware for performing the actual time-sharing operations is at the central computer station along with the central processing unit (CPU). The basic time-sharing subsystems (Fig. 3) are a communications interface unit, the users' I/O buffers, a set of rapid-access memory devices (RAD), and a time-sharing scheduling programmer. Some time-sharing companies consider the I/O buffers part of the CPU, and some think of the scheduling program as CPU software. In any case, all of these subsystems work together with the CPU to give terminal users the impression that they have their own private computer.

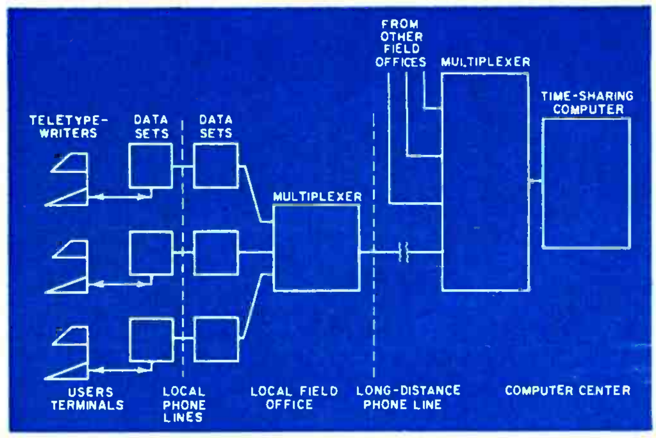


Fig. 2. Layout of typical time-sharing computer system. Local field office between users and computer central eliminates the need for separate long-distance telephone link for each user.

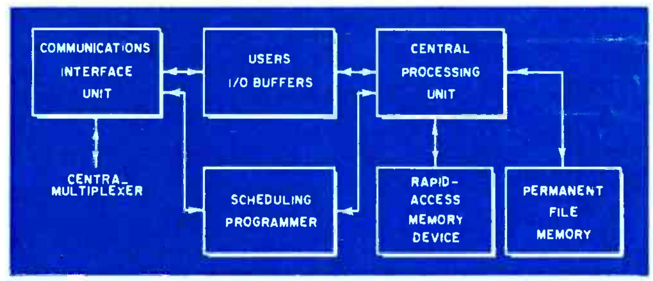


Fig. 3. Block diagram of a basic time-sharing subsystem. The central processing unit switches the users' programs and data into and out of a rapid-access memory device according to the schedule that is set up by the automatic scheduling programmer.

The communications interface unit keeps track of what every user is doing as well as what the computer is doing for every user. Suppose, for example, a user has just dialed into the system; the communications interface senses the incoming call, assigns the new user an I/O buffer and notifies the scheduling programmer that a new user is on the line. As soon as the ongoing schedule permits, the CPU acknowledges the new user, loads the I/O buffer with an opening statement, signals the interface, and quickly switches to another customer. The communications interface then tells the buffer to write out the opening statement—usually a request for a customer code number.

When the user's teletypewriter has printed out the request, the interface waits for the user's code sequence. When it begins to come in, the interface tells the buffer to accept the information, and notifies the scheduling programmer that the new data are in the buffer.

This example describes the activity of the communications interface unit only for a sign-on routine. The interface actu-

CURRENT APPLICATIONS FOR TIME-SHARING

Application Area	Percent of Total Time-Sharing Usage
Engineering Calculations	27
Financial Calculations	13
Computer Program Development	11
Scientific Research Calculations	9
Planning and Business Forecasting	9
Marketing	9
Accounting	7
Manufacturing	7
Management Information	4
Miscellaneous	4
	100

Source: Research Survey, December, 1968. International Data Corp., Newtonville, Mass.

TYPICAL CHARGES FOR A TIME-SHARING TERMINAL

Terminal Connect Time— the time the user is on-line with the computer—	$10.50 per hour
Computer Time— actual time the CPU works on the user's problem—	$3.00 per minute
Storage Charge— for data stored in memory units—	$1.00 per 1000 characters
Rent for Data Set and Teletypewriter— depending upon model and accessories—	$125.00 per month

ally carries on this kind of traffic control throughout the entire time the user is on the line. The communications interface services all users simultaneously.

Taking its cues from the scheduling programmer, the CPU works on a user's program for only a millisecond or two before switching to another user and, if the CPU happens to finish the user's program at that time, it will dump the results into the user's I/O buffer. If the CPU has not completed a program when it is time to switch over to another user's work, it will dump the entire program and all the unfinished results onto a RAD. When the scheduling programmer tells the CPU to work on that program again, the CPU retrieves the data from the RAD, and works on it again for a short time. Chances are that the CPU will switch an average program in and out of the RAD many hundreds of times before it finishes the work.

Actually, there is no point in making a user wait for the CPU to complete his program before beginning to read out some of the results. Compared to the actual computing time and switching rate, the teletypewriter print-out time is infinitely long. So, the CPU can fill a user's I/O buffer with a fragment of the unfinished computations, cycle through hundreds of other bits of work, and return to the original user long before the I/O buffer can unload its data to the teletypewriter.

The CPU switching of scheduling program varies somewhat from one time-sharing firm to another and none of the scheduling programs gives each user a fixed amount of CPU time. The scheduling programmers all have some sort of user-priority logic built into them. The priority schedules give some users larger time segments in the CPU than others, and allow some users to have access to the CPU more frequently.

Priority Rating

A user in active "conversation" with the computer, for example, generally has the highest scheduling priority. The reason is that, during a conversation, the user and CPU exchange small bits of information at a relatively rapid rate. The lowest priority goes to users who have already typed in a program, and are waiting for a long string of data from the CPU. Such users are said to be "core bound," and their teletypewriters seldom stop running even though the CPU may pass them over hundreds of times. Occasionally, a core-bound user will notice a one- or two-second pause during a long print-out sequence if the user traffic is exceptionally heavy, but such pauses do not irritate a core-bound user as much as the user who is waiting for a simple "yes" or "no" answer to a question.

Services Available

At present, the time-sharing firms offer their customers three basic kinds of services: conversational time sharing, remote-batch processing, and a group of miscellaneous special services.

Conversational time sharing was the only time-sharing service described so far in this article. With conversational time sharing, the user is in direct "conversation" with the central computer system—the user asks questions or requests data, and the computer replies as soon as it has a chance.

In the case of remote batch processing, the user calls up the computer system and loads the memory drums with a program or a prepared list of data requests; the computer does not respond to the user's program at that time. When the user finishes loading the memory drums, he hangs up the phone, and leaves the computer to run the program and prepare the readout format at its leisure. Some time later, perhaps the next day, the user calls the central computer station again, and requests a readout of his data; the computer has already performed the routines, and simply types out the data on the user's teletypewriter.

The biggest single advantage of the batch-processing service is that the time-sharing firm saves money invested in high-speed terminal switching hardware. Of course, the time-sharing firm can pass the savings on to the customers who request batch-processing services only. The obvious disadvantage is that the user has to wait at least several hours to get his data or to find that he made some mistakes in the programming.

With both the conversational and remote batch-processing services, the user must write his own programs. Among other things, the special time-sharing services include "packaged" programs prepared by programming experts. These programs are the most frequently used standard programs for engineering, science, and business. The user does not have to know the first thing about computer programming to use a packaged program. All he has to do is call the computer, type in a code designation for a particular program, and feed the computer the data it asks for. Generally, the time-sharing firms offer a file of prepared programs for no extra charge.

Other special services include reports about the time schedules for the computer system, notices of new services or changes in the services, and even some computer games. Sales representatives for time-sharing firms often like to impress potential customers by showing how a user can play nine holes of golf, shoot craps, or talk with a rather impudent and wisecracking electronic conversationalist by means of their time-sharing system. (*Continued on page* 78)

TYPE OF ORGANIZATIONS USING TIME-SHARING SYSTEMS

Organization	Percent of Total T/S Service Use
Education, research, government	13
Chemical, petrochemicals	10
Finance, insurance, real estate	10
Aircraft, ship and vehicle mfg.	9
Construction	9
Business services	9
Transportation, communications	7
Metals, machinery manufacturing	6
Wholesale, retail	6
Mining, oil, gas	5
Hotel, personal services	5
Consumer products	4
All others	7
	100

Source: Research Survey, December, 1968, International Data Corp., Newtonville, Mass.

SEMICONDUCTOR INJECTION LASERS

By RONALD L. CARROLL
R & D Electro-optics Engineer, Texas Instruments

These solid-state diodes, which emit coherent light, are much smaller than the more common gas or pumped ruby-rod lasers. When mounted in arrays, they can produce substantial output power.

An injection laser is a solid-state diode fabricated in such a way that it will emit coherent light. The most common fabrication materials are gallium arsenide and gallium phosphide, although other materials have exhibited lasing properties. These offer a tremendous size advantage over the gas and ruby-rod lasers more commonly used. An individual laser chip can vary in size from 3 mils × 10 mils to 50 mils × 15 mils and, when mounted in arrays, these devices can compete with gas lasers on a power basis. Today, individual laser diodes capable of producing peak powers of 10-15 watts are commercially available for less than $50. And the current demand is for more powerful and less expensive units. Fig. 1 is a typical example of such a device. In order to better dissipate the heat generated, the chip is kept as thin as possible without making it too difficult to fabricate. Thickness is typically 3-6 mils.

Being relatively inexpensive, small, and simple in operation, injection lasers are finding many new uses daily: for communications, terrain illumination, missile tracking, airborne computers, range finders, bomb fusing, "seeing" through fog and underwater debris, intrusion detection, and optical calibration.

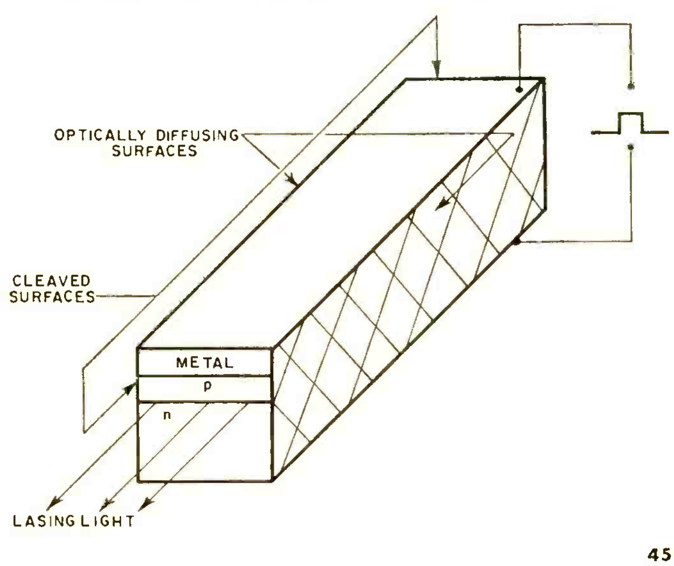
Fig. 2 displays various light spectra. Although we cannot see infrared energy (wavelengths longer than 0.75 micron), we can feel it. These wavelengths penetrate the surface of the skin, generating heat. We call a mercury-vapor lamp "cool" since it has little infrared emission. Most of its radiant energy is in the visible portion of the spectrum, with little of its radiant energy at invisible wavelengths. Lasers emit most of their energy at one wavelength; hence, they are monochromatic. Lasers also have considerably higher efficiencies than tungsten-filament light sources, which radiate a wide range of frequencies.

In Fig. 3 we see in more detail what an actual laser emission peak looks like when detected by a receiver corrected for flat response (insensitive to changes in wavelength for constant-intensity light). The spectral half-width is a figure of merit relating to lasers. It is the width of the spectral peak at half of the peak's amplitude. A good, highly monochromatic laser peak appears more like a line; thus the term "line-width" rather than "half-width" may be used.

The *threshold current density* (in amps/sq cm) is defined as the minimum current required to cause lasing. It is highly temperature-dependent and varies directly as the cube of the temperature.

Another temperature aspect is the *propagation delay* which exists in room-temperature lasers but not in cooled

Fig. 1. Simple diffused semiconductor injection laser diode. Laser light is emitted from ends at the p-n junction of device.



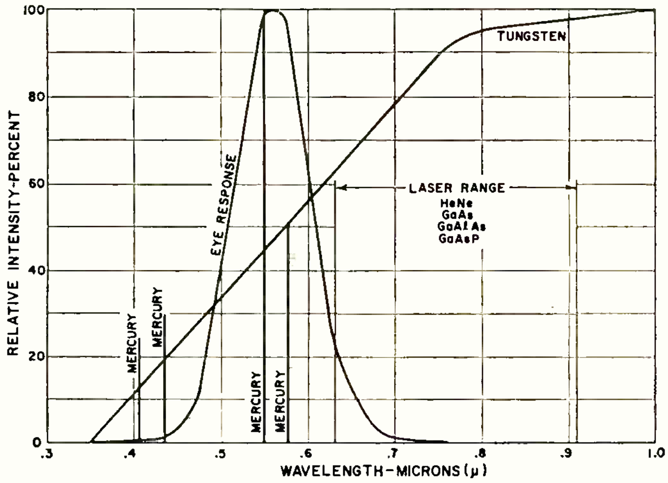


Fig. 2. Spectra of mercury vapor and tungsten lamps compared to laser range, which is mainly in the red and infrared region. Wavelength is given in microns, which are millionths of a meter.

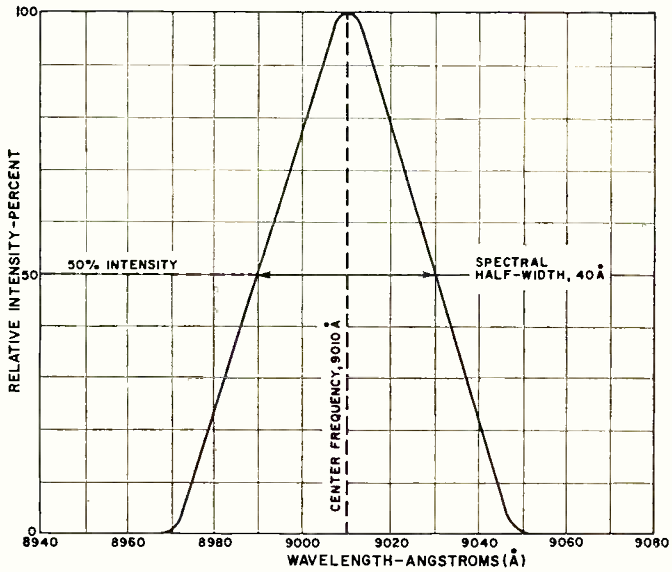
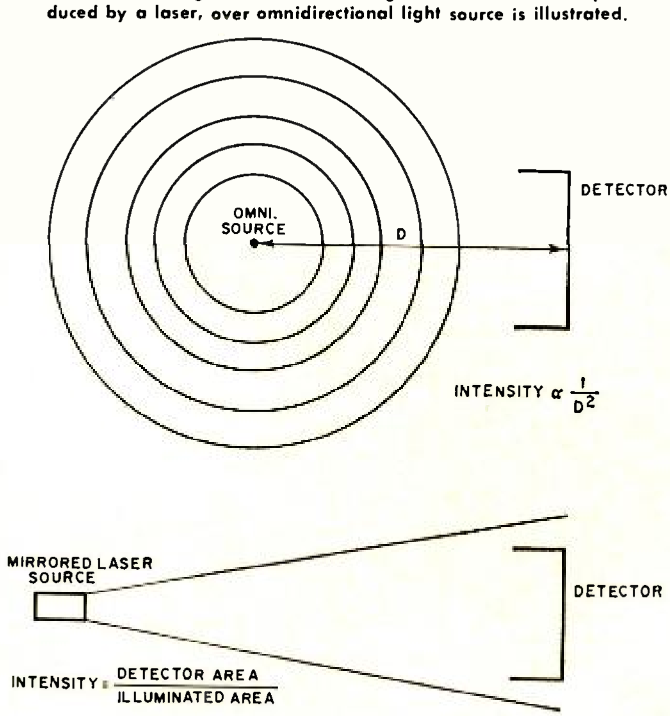


Fig. 3. Spectrum of laser emission in the infrared region. Wavelength is in angstroms. One micron equals 10,000 angstroms.

Fig. 4. Advantage of a directional light source, such as is produced by a laser, over omnidirectional light source is illustrated.



units. At room temperature (300°K) there exists a time lag between the application of the current pulse to the laser and the light pulse emitted. In most cases this varies from 20 to 50 nanoseconds, but in some of the poorer units it can be as great as 250 ns (or 0.25 microsecond). This delay does not exist to any effective extent at the very low temperature of 77°K.

Fig. 4 shows the directivity advantage of lasers over non-lasing semiconductor and filament emitters. With no refinements, a laser will emit equally from both cleaved surfaces. To eliminate back-edge emission and increase front emission by about 60% (optical absorption prevents doubling the preferred front emission), a mirror surface is placed over the back cleaved surface.

The quantum efficiency, which is photon per electron ratio expressed in percent, is 5%-10% for filament sources, and 5%-20% for spontaneous (non-laser) semiconductor light emitters at room temperature. Injection lasers have a quantum efficiency of 10%-30% at room temperature. At 77°K, spontaneous emitters have as much as 30% efficiency while injection lasers can go as high as 40%-50%.

To compare the different sources on a basis of absolute power efficiencies is complex since it would require integrating spectral intensities in the case of filament and spontaneous emitters. However, lasers can be measured directly and yield power efficiencies from 2% to 5% at 300°K, and 20% to 35% at 77°K.

Degradation Effects

There are two types of degradation in performance of an injection laser: these are long term under moderate conditions and irreversible catastrophic. The long-term variety can reduce output 10%-20%, but most of this takes place during the first few hours of operation. Irreversible catastrophic degradation means, as the name implies, that once a certain level of operation has been exceeded the device will begin degrading and continue to do so even if the power level is reduced to within safe levels. In this case the mirror-smooth finish of the emitting cleaved surface in the region of the junction will be destroyed to the point that the device will no longer produce a useful light output.

As a rule-of-thumb, any current less than three times the threshold current is safe. However, above this point, there are three factors to consider: temperature, lasing junction uniformity, and area of the lasing junction. At 300°K, devices cannot be operated safely at more than 4 to 7 times threshold current, while at 77°K, this factor increases to 6 to 10. However, in actual tests some devices have degraded at 2.5 times threshold current and others have operated safely at 8 times the threshold current at room temperature.

Lasing junction uniformity and junction area are closely related to degradation. The maximum permissible photon density is about 1.5-2 watts/mil of emitting junction.

This means that a 5-mil wide junction can be expected to produce 7.5-10 watts for long periods of time. This presupposes that there may be some "dead" or non-emitting regions of the junction. Low-efficiency regions of the junction cause degradation to begin at lower levels than expected.

Electrical Considerations

Laser fabrication is mainly a problem of heat dissipation. Present materials dictate the current densities necessary to initiate lasing within a junction, thus the chips cannot be too large or the required current will exceed the ability to produce the necessary currents. It is not practical to generate these powers within a junction using d.c. as we would not be able to carry away the heat produced; therefore, when we speak of laser current and power requirements, we are considering only peak powers involved with the pulses that are actually used.

Electrical requirements of the pulsers differ according to the ambient temperature at which the laser is to be operated.

Cooled devices operate in the 77°-150°K range, while a room-temperature device generally means one operated at 300°K.

By cooling the device we can obtain the following advantages: higher quantum efficiency, much lower currents required, ability to use pulsers of poorer quality (slower rise and fall times, such as 100-300 ns).

Cooled laser pulsers can be made using conventional switching transistor techniques and inexpensive, commercially available power devices. A typical cooled laser having an area of 200-250 square mils and producing 7-10 W peak output power will require 20-25 amps peak and can tolerate pulse widths up to several microseconds at frequencies over 10 kHz. Room-temperature operation is considerably more demanding.

If the current rise time is too long, the device will heat more rapidly than the current builds up, and lasing action may not occur. Even with a typical satisfactory pulser having a rise time of 1-10 ns, the device will heat after the current peak is reached and, hence, stop lasing despite the presence of adequate current initially. This effect is known as "self-quenching" and is common among all room-temperature devices. Using longer pulse widths than the individual device's quench time, plus whatever propagation delay time it may exhibit, is a waste of efficiency.

Although the fall time is not too important, it does have some effect. A long fall time has the same effect as excessive pulse width. It represents efficiency loss and contributes to a reduction in peak power output by increasing the average temperature of the chip.

The pulsers for room-temperature lasers cannot employ conventional transistors due to the fast rise time and high currents required. To date avalanche transistors and special SCR's have been used. The avalanche transistors appear to have a better pulse match since their current pulse more closely resembles the laser's optical output pulse. However, their avalanche operating voltage is fairly critical, permitting little adjustment in current. Typically one will produce a peak current of 50 amps when biased to 100 V and 60 amps at 120 V, and will not operate above or below these values. SCR's permit a wide range of current adjustment but have a poor fall time—up to 250 ns as compared to an avalanche fall time of 40 ns. In either case, these fast high-current pulsers require etched circuit boards and strip-line layout, whereas the cooler pulsers may be chassis-built with conventional coaxial connections.

A typical room-temperature laser having an active area of 50-80 square mils will produce an 8-W peak power output with 200 ns half-power points when driven by a 60 amp peak 250-ns (half-power points) current pulse at frequencies up to 5 kHz.

Recent Developments

Fig. 5 depicts the latest technique in laser fabrication. The junction is grown in layers with a heavily doped p-plus region over it. The device is merely sawed to the desired width according to the desired output requirements. The emitting faces are formed by the usual cleaving method of placing a sharp-edged instrument against the edge of the material and applying adequate pressure to cause it to break along its predetermined grain-structure line. These devices have been called "close-confinement" or "heterostructure" lasers.

They generally yield lower current densities and higher quantum efficiencies since the p-plus region confines more of the radiated light to the active emission region. However, growth techniques lack refinement and presently require thicker chips with the junctions generally being formed about in the middle of a 5-6 mil thick chip. This creates more heat-transfer problems as well as increasing the devices already lossy series resistance. Manufacturers claim higher power efficiencies but actual tests yield lower efficiencies than diffused units of comparable quality. If the series resistance problem can be solved, this technique will supersede former diffusion methods.

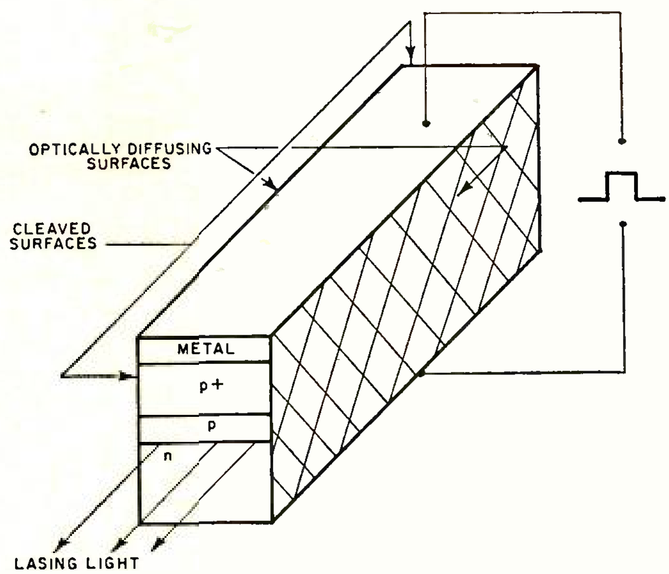


Fig. 5. The close-confinement or heterostructure laser.

Quarter-wavelength anti-reflection coatings are now being applied to the emitting surfaces to increase output. One manufacturer eliminates the back-surface mirror and permits emission from both cleaved faces as shown in Fig. 6. The light is reflected in parallel rays to an optics system, consisting of an angle mirror. This increases source size considerably and introduces alignment problems.

Precautions to be Observed

Injection lasers can be dangerous to eyesight. Although medical science has yet to come up with a reliable number for the safe power level the eye can tolerate, all efforts are being made to do so. The key to safety is average power output and one should use the numbers below as a guideline to eye protection. Below 1 milliwatt average power output is safe. From 1 to 10 milliwatts is that region where eye damage can occur if the energy is focused on the retina; laser goggles should be worn. About 10 milliwatts average is dangerous, and adequate proper-wavelength goggles must be worn. ▲

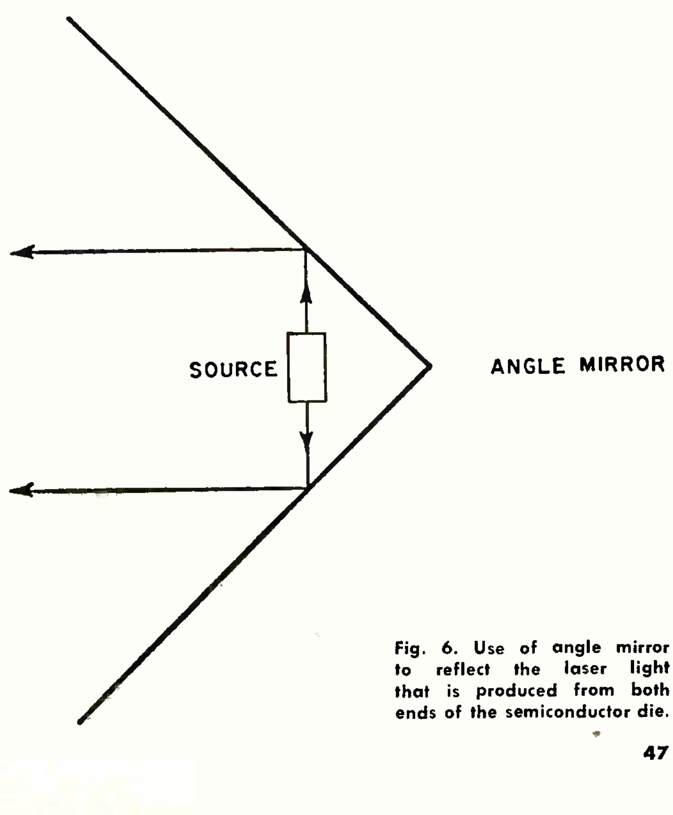
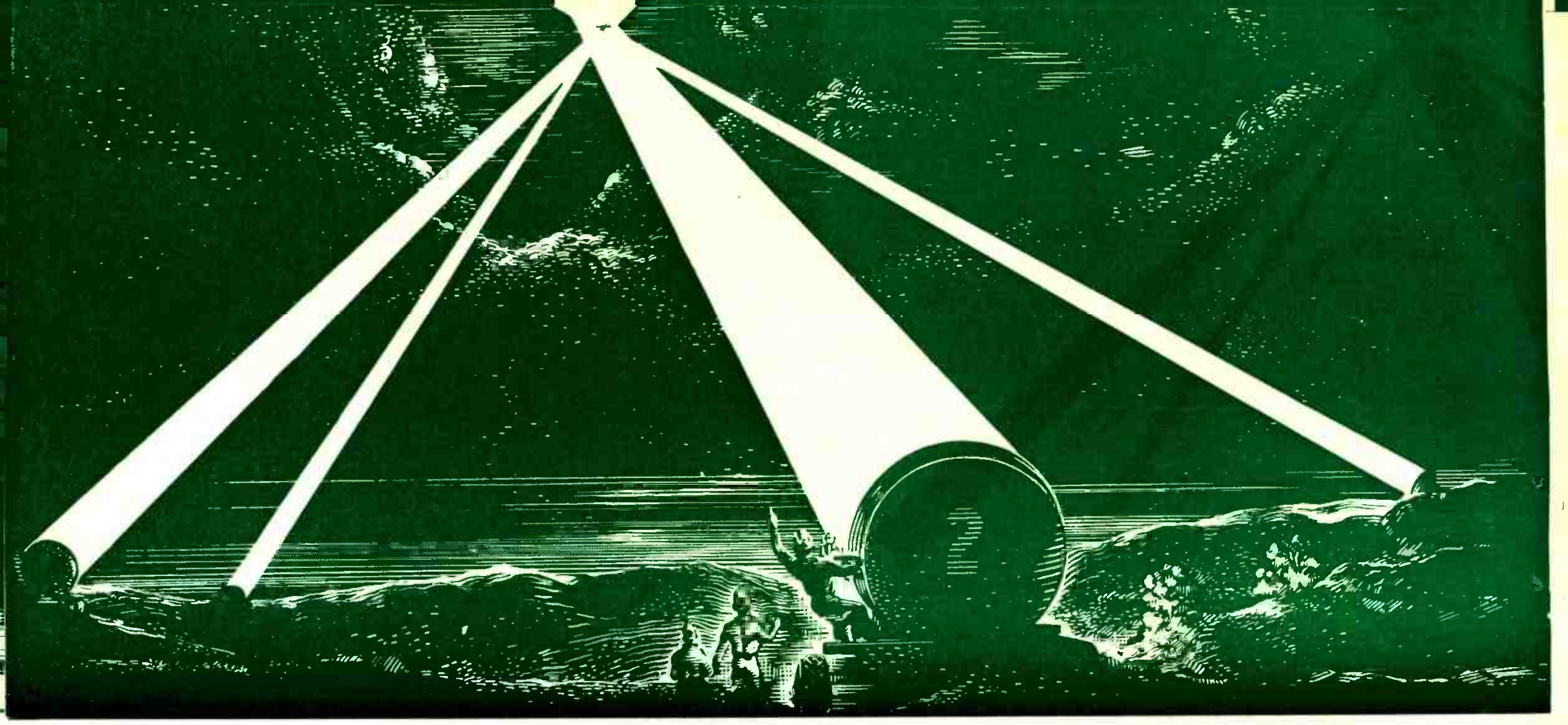


Fig. 6. Use of angle mirror to reflect the laser light that is produced from both ends of the semiconductor die.



Early drawing showing the detected test plane caught in the intersecting beams of the aerial searchlights.

1937

—A New Device to Detect Aircraft

By HAROLD A. ZAHL

Description of a historic demonstration of early radar and heat detector from one who was there on the night of May 26, 1937.

IT was the night of May 26th, 1937. From the several small huddles of military and civilian observers, an air of expectancy could be sensed, as if they had been chosen to be a part of a great moment in history. The group of some 25 observers had distributed themselves around four huge, varied, and complex pieces of electronic equipment—the combination of which, the Signal Corps said, could detect airplanes. The almost fantastic claims for the new device had brought out the "brass" in both quantity and quality.

Military personnel at the Fort Monmouth, N.J., site included the Secretary of War Harry H. Woodring, Chief of Staff Malin Craig with some of his top generals—Chiefs of the Signal Corps, Coast Artillery, and Air Corps—the latter corps having already had a glimpse of the new equipment a few weeks earlier through an officer by the name of "Hap" Arnold.

But the show was not so much for the military, for the guest list included members of Congress who made up the all-important Military Affairs Committee of both the Senate and the House of Representatives. What was at stake was whether the Congress would allow the Signal Corps some emergency funding to push forward more rapidly the development of a new aircraft detection device. With Goering's Luftwaffe now blackening the skies of Europe, the need for such a device in our military arsenal was most urgent.

For the first time, a demonstration was scheduled, the claims for which were that the *exact* position of an airplane could be determined by reflected radio waves traveling through space at 186,000 miles per second—as compared to the then current military practice of listening to the airplane sound traveling earthward at only about 1100 feet per second. Besides being very limited in range, the sound locator could only tell where the airplane had been—and detection was not quick enough for aiming a gun.

The equipment around which the visitors had spread themselves included: a radio transmitter which would beam out powerful pulses of energy, hoping to intercept the target in the sky; two sensitive receivers with antennas to collect the reflected energy, one to tell the elevation (altitude) angle of reflection, the other to give an azimuth (or bearing). Then also, by measuring the time required for the pulse to travel to the airplane and be bounced back to Earth—and

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ABOUT THE AUTHOR: *Until his recent retirement, the author was Director of Research at the Army's Fort Monmouth Laboratories, joining those laboratories in 1931, after receiving his Ph.D. degree from the University of Iowa. While the author of some 100 technical articles and a physics textbook, in recent years some of his interest has shifted to writing about things which happened "behind the scenes" in electronic events of great historical importance. Dr. Zahl is also author of a recent book, "Electrons Away . . . or, Tales of a Government Scientist" (Vantage Press, New York, N. Y.).*

this would be in millionths of a second—the range or distance could be determined and the exact position of the airplane could be computed almost instantly.

Besides the three huge radio antennas, there was a control-center to which all the radar data were transmitted. This center included a 60-inch diameter mirror having a heat-sensing device at its focus. When fed approximate position data from the radio system, the thermal device, on picking up the heat radiated by the engine of the airplane, could give an even sharper direction. An 8-degree accuracy from the radar would become less than one degree for the system, if the infrared detector could find the target. To simplify this operation, one huge 800,000,000 candlepower searchlight was "slaved" to the thermal pointer so it always pointed precisely in the same direction. As further back-up, three other identical supporting searchlights, separated by a mile or so, would be illuminated to track the target. Picked up by any searchlight, the other three would join in support and hopefully escort the bomber over its theoretical target. Thus brilliantly pointed out, the aircraft would become an easy target for anti-aircraft fire.

The Test Begins

With Fort Monmouth as the "target," the attacking plane was to be a B-10 bomber, flying out of nearby Mitchell Field, and without running lights. The pilot was to circle to the north some 30 miles from the Fort, a range well beyond the capability of this first fire-control radar. On command by radio, he was to approach Fort Monmouth at any altitude of his own choosing. If we put a searchlight on him a few miles before his "bombs-away" point, it was one for the Signal Corps; if we couldn't illuminate him at all, or in time for our guns to be effective, that was one for the Air Corps.

As "contest-time" approached, everyone grew silent, since the sound of the airplane's engines, without radio-thermal detection, meant a successful sneak raid for the Air Corps. Little did anyone at the site dream that only a few years later, the same situation would occur a thousand times in a night, but then with death-dealing bombs being dropped, and with anti-aircraft fire thundering over all England.

My responsibilities in the test were to operate the control-center and to keep my eyes glued on the output of the thermal device—being particularly familiar with this part of the equipment, since it was my invention. Accordingly, it was to be my word when the pilot searchlight was to be turned on.

It was now dark, and by radio, Lt. Col. Roger B. Colton gave the bomber pilot the "come-in" signal. Our guests watched and listened intently—the game had started. The only sounds came from our partially muffled power generators some distance away. Twenty long minutes of tense anticipation passed.

Suddenly the stillness of the night was broken, as first one operator and then another cried out "Target," the signal showing as a flickering line on TV-like oscilloscopes. The radar pickup had been made at about 15 miles.

As the radar track continued, I searched for that source of heat which would be an airplane coming toward us at 140 miles per hour. Now it was up to me, and soon my heart jumped a bit as the signs of a target appeared on my indicator. I knew we were close to having him dead on center. We waited now only for him to come within searchlight range. He was flying at about 10,000 feet.

When my radar range-meter showed 12,000 yards, I gave a hand-signal to Sergeant Harry Belot, and he bellowed: "In action!" Immediately the light equal to 800,000,000 candles bored a pencil-beam through space, followed seconds later by the three supporting light beams. The razzle-dazzling about the tip of my light was a brilliant spectacle, and people for miles around wondered just what the Army was up to now.

"There he is!" cried one of the searchlight crew—and soon all four lights were on the bomber as he dove and twisted, trying to find some place to hide and escape. Had it been war, and were he carrying bombs, the pilot would probably have torn the wings from his plane, so desperate were his escape maneuvers. Even had there been a friendly cloud at his altitude and nearby, clouds were transparent to radar. The closest cloud was miles away, so it was searchlights all the way.

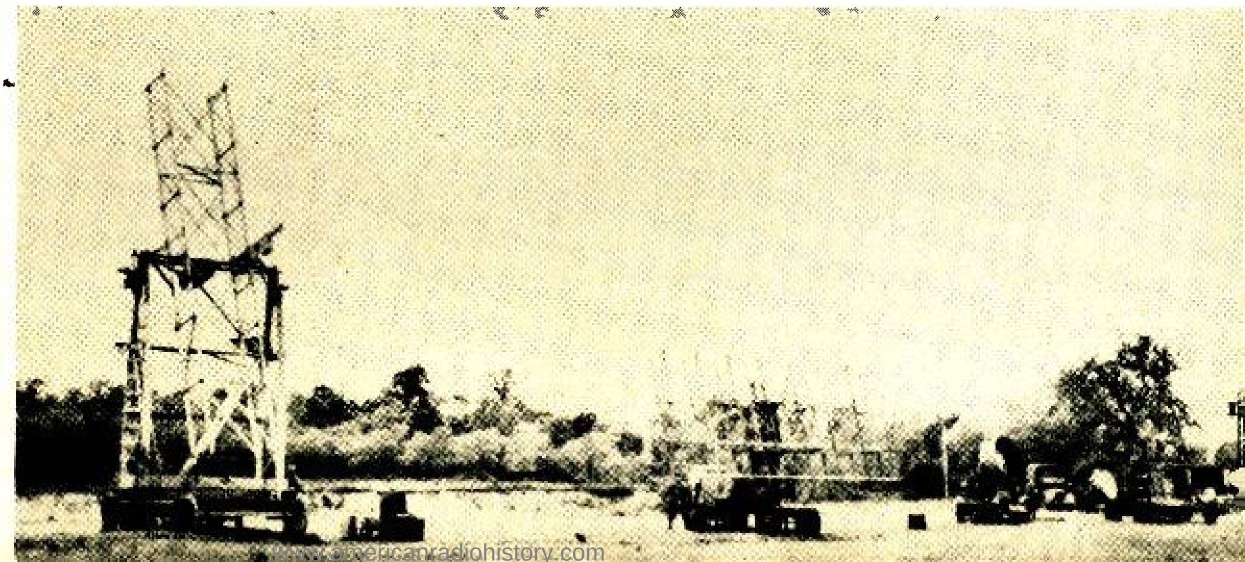
Spectacularly, the first round went to the Signal Corps!

During the next two hours, time and again success attended the men on the ground. Each time the Air Corps was thwarted in trying to reach the target area undetected. Radar had indeed stepped out of the incubator; for on that Spring night in 1937, a new weapon of war had proven itself.

Congratulations All Around

The guests were enthusiastic and returned to Washington highly elated, everyone congratulated Chief Signal Officer James B. Allison, Lab Colonels Blair and Colton, and key civilian engineers. A few days later the Secretary of War wrote formally to General Allison; "It [the demonstration] gave tangible evidence of the amazing scientific advances made by the Signal Corps in the development of technical equipment." It was now a sure thing that Congress would provide emergency money to accelerate the development of our new invention. I seem to recall that the initial allotment was around $40,000—a fantastic sum for that day.

After the distinguished guests had departed, technical and military personnel responsible for the research and development leading to the new equipment met for a short critique, combining a few beers with backslapping and handshaking. Lady Luck had certainly been kind, for the results were about twice as good as even the most optimistic expected. "Strange, though," said John Hessel, one of the engineers, "that most of the initial pick-ups were made by No. 2 light down by the coal pile." (*Continued on page 79*)



This early photo is of the first radar equipment in which azimuth, elevation and range were obtained from a single system. Three radio antennas, operating at 110 MHz, were employed along with a heat-sensing detector.

COLOR TV for 1970

By FOREST H. BELT
Contributing Editor

Part 2. Here is a rundown on circuit innovations and serviceability in the new color-TV receivers in 1970 lines.

IN last month's installment of this two-part article, we gave an over-all picture of the present color-TV market. We also showed how the new sets were beginning to use more and more transistors and that a number of IC's were starting to find their way into the new models. Now, we will tell you about some of the circuits that make operation automatic. We will also cover some of the new remote-control units, and then conclude with a discussion of serviceability of the new receivers.

Lots of Automatic Features

One problem among set owners is that they don't know how to operate a color set. If fine tuning, brightness, contrast, color, or hue is set wrong, the picture doesn't look right.

The answer is to have the set make all those adjustments for itself. And so, 1970 color chassis are loaded with automatic circuits and stages to take the effort out of color-TV watching. These include automatic brightness limiter (a.b.l.), automatic fine tuning (a.f.t.), automatic chroma control (a.c.c.), and automatic degaussing circuits (a.d.c.).

And last, but far from least, is an automatic tint control (a.t.c.) pioneered last year by *Magnavox*. It senses phase of chroma signals that cause flesh tones on the picture tube. If demodulator phase drifts a few degrees one way or the other, the a.t.c. corrects the error. It does this even if the error is in the chroma when the signal arrives at the set. (See "Automatic Tint Control for Color-TV," Sept., 1969 issue.)

Top billing among all brands goes to automatic fine tuning or a.f.t. The basics are the same as ever. The a.f.t. gets a 45.75-MHz signal from the third video i.f. A tuned 45.75-MHz amplifier feeds a discriminator centered at that frequency. The discriminator senses any frequency drift from precisely 45.75 MHz, and produces a d.c. error voltage. That's fed back to the tuner, where it works on a varactor diode, part of the oscillator tuning circuit. The oscillator is kept exactly 45.75 MHz from the station picture carrier.

The a.f.t. in the *Packard-Bell* 98C21 has an unusual error-sensing circuit. Instead of a standard discriminator, this one has a ring phase detector—called "ring" for the way the diodes are wired. The circuit is shown in Fig. 8.

A transistor amplifies the 45.75-MHz signal. The ring input transformer is a simple two-winding type. Its output is applied to the diode ring at two opposite corners. A matched pair of 47-pF capacitors form a divider across the transformer. Signal from the top of the transformer primary is fed to the center tap of the capacitive divider, which gives it a quadrature (90-degree) phase shift with respect to the secondary signal. In effect, there is a quadrature signal fed in parallel to both sides of the ring phase detector at the same time a push-pull signal is being applied at the input "corners."

The ring circuit is balanced when the frequency of the signal is exactly at 45.75 MHz, because both diodes conduct the same. Any shift in signal frequency upsets the balance. The signal entering the center tap of the capacitance divider is phased differently at the ends, compared to the secondary signal. One diode conducts more than the other. The normally zero voltage at the output "corner" of the ring detector shifts either positive or negative, depending on direction of the frequency shift. The amount of d.c. output voltage depends on how far the frequency shifts. Output filter network *C3-R3-C4* smooths the resulting d.c. correction voltage and keeps i.f. signal from the tuner a.f.t. lines.

Automatic fine tuning is popular. At least 18 manufacturers have it, for over 40 chassis. Some that don't have it offer an alternative, such as a meter or an "eye" to help the viewer know when fine tuning is set properly.

Automatic color control is old hat, although its importance is often overlooked. Its job is to level out any variations in chroma sideband signal. The demodulators need a fairly steady chroma sideband signal. A.c.c. senses the amplitude of the color sync burst and develops a gain-controlling d.c. voltage which it applies to a bandpass or chroma amplifier stage.

Automatic degaussing circuits (a.d.c.) aren't new, either. But there are a couple of unfamiliar ones in 1970 chassis.

One degaussing circuit, in the *Hitachi* CWA-200, operates as the set is turned off. Special degaussing contacts on the power switch close when the set is turned off. They apply a.c. power to the degaussing coil through a thermistor. At first, current—and demagnetizing action—is large. But the current heats up the thermistor and reduces current through the series circuit; demagnetizing dwindles. Equilibrium current is very low.

Automatic degaussing in late runs of the *Admiral* 4K10 chassis is based on the use of a special negative-temperature-coefficient thermistor. As you can see in Fig. 9, part of the circuit is an ordinary thermistor, with positive temperature coefficient. The dual unit, with the negative coefficient, is actually two thermistors in a single case. As power-supply current flows through *R1A*, it heats up *R1B*, connected across the degaussing coils. *R1B* gets lower and lower in resistance, finally so low it bypasses all current around the coils. Meanwhile, the positive-coefficient thermistor resistance is increasing—enough to keep the coils from being a low impedance across the power line.

Then there's the automatic brightness limiter (a.b.l.). It keeps beam current in the color picture tube from becoming so high it saturates the phosphor and causes blooming.

Motorola has had an a.b.l. in its transistor chassis since it was introduced. High beam current loads down the horizontal sweep circuit, through its relationship to CRT high voltage. The a.b.l. stage senses the change and converts it to a d.c. bias. The correction voltage goes to the brightness-control transistor, then to the video drivers and outputs, and finally to the CRT cathodes. Beam current is reduced enough to keep the picture from blooming. The secret is to set the a.b.l. adjustment for no blooming with highest video (white picture content).

In the *Hitachi* CWA-200 transistor chassis, an a.b.l. stage protects the horizontal-output transistor from too much loading. A diode at the grids of the CRT (all three G1's are tied together) conducts if beam current goes beyond a certain value. The slight current thus generated is passed through a large-value resistor. The voltage across the resistor is applied to the output transistor and damper circuit stage and opposes conduction there enough to avoid overload.

The automatic tint control (a.t.c.) employed by *Magnavox* has already been mentioned.

The Armchair Viewer

Remote controls have been around too long to really be news. Even that solid-state "wonder," *Motorola's* Memory Module remote system without motors on the controls, is more than a year old but still in the line this year.

One new remote-control idea is the search tuner. It sweeps the u.h.f. and v.h.f. spectrum, stopping only when it finds an active channel.

An example is the *Magnavox* Instant Automatic Remote Control. The heart of it is one little printed board with circuits that drive the motor of v.h.f. or u.h.f. tuner on and on, stopping only on a station signal. If there's no station on the air, an automatic shut-off stops the whole operation. The board is called the *search and auto-off* board.

For v.h.f., a 40-kHz remote signal trips a relay that applies power to the tuner motor. A latching system, part of which is a search relay with contacts normally closed, keeps power applied and the motor turning. When the tuner reaches a station, circuits on the board open the search relay contacts, stopping the motor.

For u.h.f., a 43-kHz signal actuates an up-relay. It applies power to the up winding of a bidirectional motor. The tuner dial moves up-frequency. When the motor reaches the top limit, a reversing switch shifts power to the down winding. Direction reverses again at the bottom limit. A 41.5-kHz

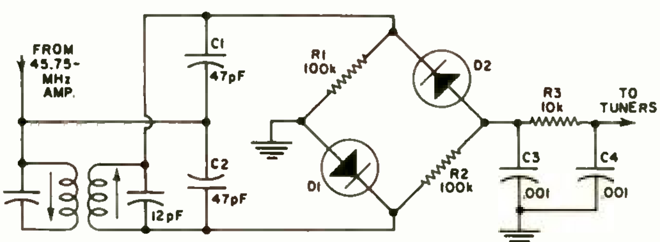


Fig. 8. Ring phase detector used in the Packard-Bell 98C21.

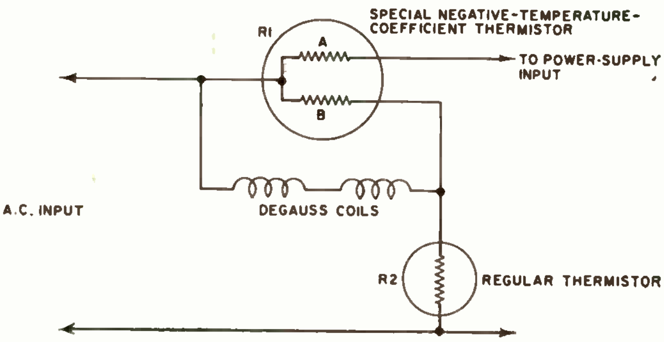


Fig. 9. Late runs of the Admiral 4K10 chassis employ negative-temperature-coefficient thermistor for degaussing

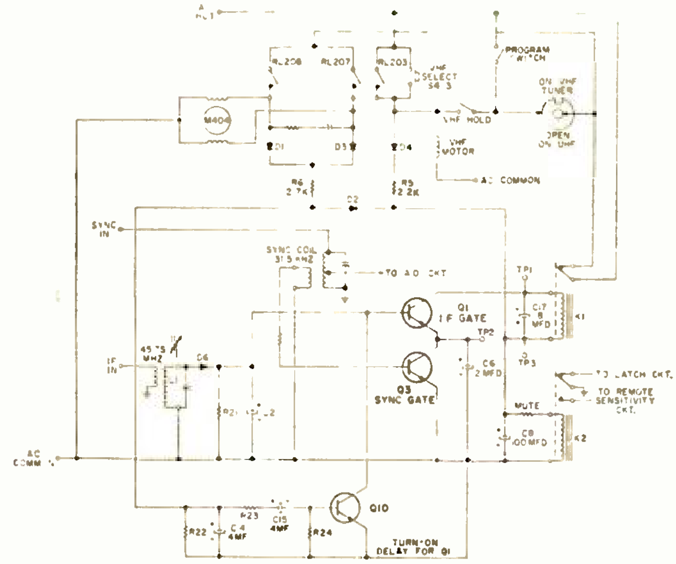


Fig. 10. The Magnavox automatic search circuitry.

signal from the remote transmitter operates the down relay, making the initial movement down-frequency.

You can trace the main functions of the search and auto-off board in Figs. 10 and 11. When a TV station signal is picked up by whichever tuner is operating, the 45.75-MHz i.f. picture carrier is coupled to the search and auto-off board. A tuned transformer applies the signal to a diode and filter. The resultant d.c. goes to the base of *Q*1, the i.f. gate. If the u.h.f. tuner is searching, a delay voltage from *Q*10 keeps transistor *Q*1 cut off when there is no signal; that voltage must be overcome by the rectified voltage from the diode when a signal is picked up.

Meanwhile, sync signals are applied to the search and auto-off board too. A tuned transformer doubles their frequency and couples the 31.5-kHz signal to *Q*3. Since *Q*3 is in series with *Q*1, both transistors have to be active to operate search relay *K*1. Thus, both sync and i.f. signal have to be present to pull the contacts of *K*1 open.

The power contacts at the top of Fig. 10 belong to function relays in the remote-control receiver. Depending on which relay closes, a.c. is applied to one motor winding. Either *D*1, *D*3, or *D*4 rectifies the voltage, and applies it to *C*8 and *K*2; the capacitor smooths it out to about 28 volts d.c. If *D*4 is rectifying, because the v.h.f. motor is active, *D*2 blocks the d.c. from the u.h.f. side of the system. Relay *K*2 is a muting relay and part of a u.h.f. latching circuit (not shown) that works with the reversing switches.

With a motor turning its tuner, the first station signal encountered applies both i.f. and sync on the board inputs. *Q*1 and *Q*3 operate *K*1 and remove power. The tuner stops on-station, and the receiver's a.f.t. system fine-tunes the signal precisely.

The automatic-off operation is diagrammed in Fig. 11. A tap on the 31.5-kHz transformer (Fig. 10) feeds the auto-off section. The regulator on-off system operates from a 38.5-kHz remote signal. The signal fires *Q*208 and steps *RL*204. *RL*204 is a multiple-step relay, and if the set is on, it keeps cycling until the off position is reached.

Silicon controlled switch (SCS) *Q*2 is wired to operate *RL*204 when the SCS turns on. The SCS gate remains at 15 volts as long as the SCS is quiescent. Large-value capacitor *C*11 charges slowly from the 200-volt line through *R*1 and *R*3. Left alone, the charging time is about 80 seconds.

Transistor *Q*4 amplifies incoming sync pulses when a station is present. Diode *D*5 lets the amplified negative-going pulses through to buck the normally positive voltage at the anode of the SCS. The SCS can't fire as long as this keeps up, because the charge on *C*11 never gets high enough; it is regularly discharged by the negative pulses.

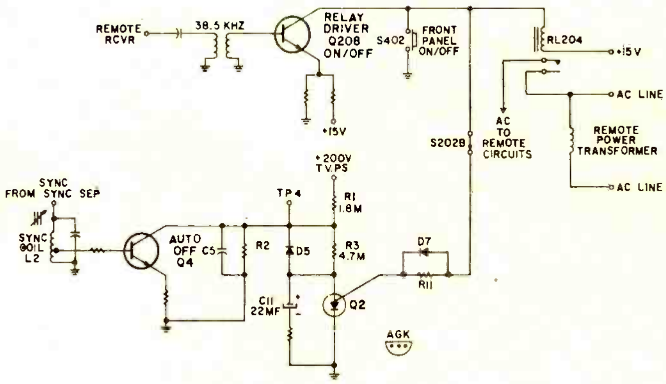


Fig. 11. Automatic-off operation of the Magnavox circuit.

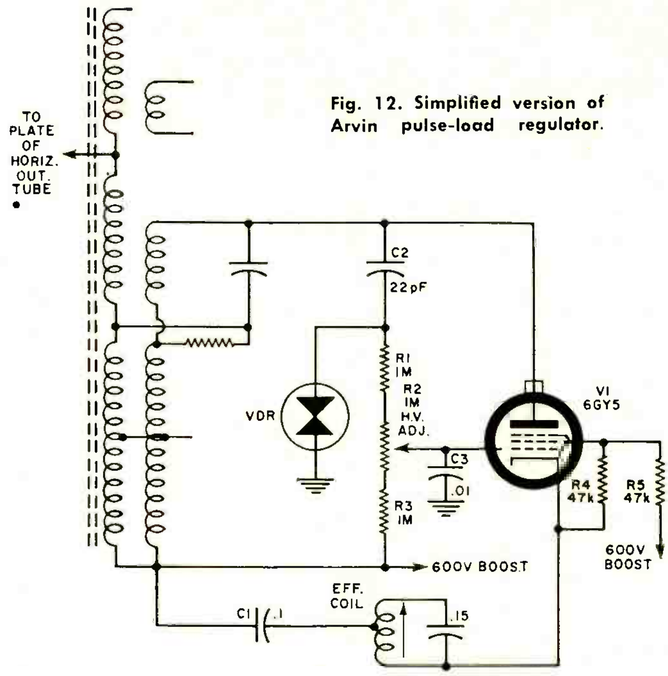


Fig. 12. Simplified version of Arvin pulse-load regulator.

Without sync, *C*11 continues charging undisturbed. So, if no signal is found by the tuner, voltage on *C*11 finally builds up to the 15-volt firing potential of the silicon controlled switch. (An SCS fires when its gate and anode are at the same potential.) *Q*2 fires, the gate goes to ground potential or nearly so, and *RL*204 operates, turning the receiver off (or steps once each time the SCS fires, until it reaches off position).

Magnavox has no corner on u.h.f. search systems. Several other set-makers have them. Another that stands out is in a limited-run *RCA* chassis, the CTC 47. When the v.h.f. selector is in its channel-1 position, a motor drives the u.h.f. tuner up and down the band until a signal is encountered. A group of circuits in the special remote-control system utilize sync, a.g.c., and a.f.t. to sense when a signal is tuned in, and stop the motor. The a.f.t. does the final precise tuning.

This is part of an *RCA* remote system that has similarities to *Motorola's* non-mechanical one. Memory modules supply voltages to the main chassis to control color gain, hue phase, and volume. The memory modules are controlled by signals from a 10-function remote-control transmitter.

Unique to this *RCA* chassis is a switchless v.h.f. tuner. It and its remote switching are too complex to cover in detail, but here are the highlights. Selecting a channel is a matter of applying 16 volts to one of the 13 channel-activating input terminals of the tuner. Inside the tuner, a voltage forward-biases a group of switching diodes that connect inductors and capacitors (not varactors) for the channel chosen. On the remote control boards, logic switching carries out an electronic search operation that stops on the v.h.f. station that has been dialed by the viewer. This search is finished in a fraction of a second, so tuning appears instant.

High-Voltage Regulation

With the cry of x-radiation ringing loudly in their ears, engineers have just about wiped out the main possible source: shunt-type high-voltage regulators. Of the approximately 100 chassis, only 22 have shunt regulators (last year about half did). And some of those have hold-down circuits that prevent high voltage from becoming too high even if the shunt regulator fails.

Most sets today use pulse-type high-voltage regulation. Anything which controls the amplitude of flyback pulses in the deflection yoke also controls high voltage. A feedback pulse from the flyback transformer is rectified and the negative d.c. applied to a potentiometer. The pot applies just the right amount to the horizontal output grid to control its gain. The pot can thus set the desired high voltage (which usually depends on CRT size).

If high voltage goes up for any reason, more pulse reaches the pulse rectifier (sometimes a voltage-dependent resistor, instead). Bias on the output tube goes higher, reducing gain and cutting the flyback-pulse amplitude back down. High voltage is lowered. If h.v. goes down, opposite reactions raise it. This pulse-feedback system works well, and it eliminates the shunt regulator.

There's another type of pulse regulator. Forms of it were used occasionally last year, by *RCA* and *Zenith* in particular. Several are using it this year. It can be described as a pulse-load regulator. There's an example in Fig. 12, in simplified form.

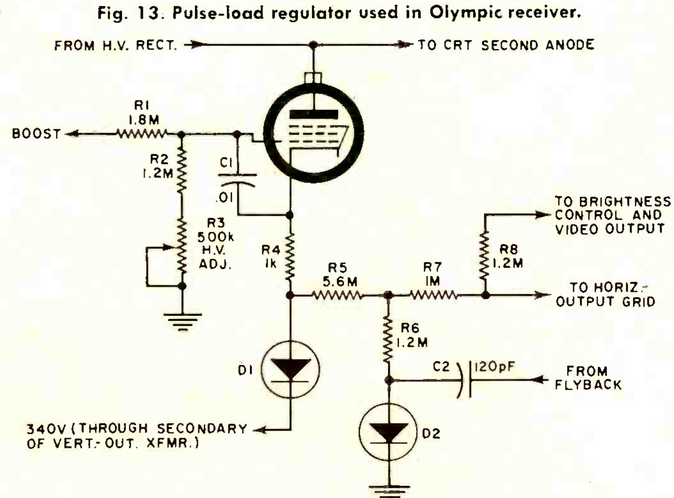
This is in an *Arvin* 60K34 chassis. The plate connection is direct to the flyback winding; the cathode connection is through the efficiency coil and *C*1. The tube plate impedance loads down the flyback transformer. Plate impedance is determined by bias on the control grid.

Bias depends on how much pulse voltage reaches the voltage-dependent resistor (VDR). Pulses are applied from the flyback winding by *C*2. The VDR is part of a divider—comprising *R*3, *R*2, *R*1, and the VDR—between the 600-volt boost line and ground. *R*2 applies part of the voltage to the grid of the 6GY5 pulse-load regulator tube.

Imagine the high voltage going down. The flyback pulse amplitude goes lower, reducing VDR resistance. That develops less positive voltage at all points in the divider, because there is less resistance to ground. So the voltage at the slider of *R*2 is lower. With the control grid of *V*1 less positive, the tube will consequently load the flyback winding less.

If the high voltage goes higher, the VDR resistance increases because of the higher flyback pulse. More positive grid bias lets *V*1 conduct (*Continued on page* 94)

Fig. 13. Pulse-load regulator used in Olympic receiver.



JOHN FRYE

Trying to look like a professional is not enough; the public must be made to realize the TV service technician IS a professional.

INSIDE THE TV TECHNICIAN'S HEAD

TWO days of unseasonably balmy March weather had ended abruptly in the night, and Barney had to drive through snow squalls all the way to the Center City airport to pick up Mac, his employer, who had flown in with his wife from a two-week vacation in Florida.

"I suppose this weather is pretty hard for you two snow-dodgers to take," Barney offered as he headed the car for home.

"It *is* quite a change," Mrs. McGregor said from the back seat, "but I'll let you in on a secret: Mac has been itching to get back to work for the past week. I think he flew at least a hundred feet out in front of the plane all the way home."

"Aw it wasn't that bad!" Mac protested. "I enjoyed the sunshine and the fishing, and I especially enjoyed hearing that blowhard put down in the restaurant last Saturday night."

"Barney, that was the high point of Mac's whole vacation," Mrs. McGregor said with a reminiscent giggle, "and I've the feeling you would have enjoyed it, too."

"Her brother lives in a big trailer community in Bradenton," Mac explained, "and every week several of the couples have dinner together in a good restaurant. My brother-in-law and his wife took us along as their guests last Saturday. While we were waiting on dessert, this character started entertaining the whole table with an account of how a TV technician recently charged him twelve dollars for putting 'a little resistor that couldn't have cost more than a dime' in his color receiver, how it had taken 'the dummy' a whole hour and a half to find the defective resistor 'that actually hadn't burned out at all but simply had changed some in value,' and how it was no wonder it took him so long because all he brought with him were a few instruments and tubes and hand tools he carried in a 'metal suitcase.' He concluded with the insinuation that all TV technicians tried to make comparatively simple work look tough and used a smattering of technical knowledge as a license to steal."

"My brother was getting redder by the minute," Mrs. McGregor said, "and several of the others who knew Mac was a service technician were squirming in their chairs; but Mac looked at my brother and shook his head as a sign to keep still. Suddenly a nice looking gray-haired man down at the end of the table looked up and asked: 'What did that TV technician have in his head?' "

" 'What do you mean? How do I know what he had in his head?' the complainer said."

" 'You seem to think the fellow didn't deserve his twelve dollars because he didn't have a lot of equipment in his tube caddy, and I was just thinking you might say the same thing of a doctor who brings only his little black bag on a house-call. Yet you are willing to pay the physician's fee because you know you are paying for what he carries in his head, not for what he carries in that little black bag. Maybe the TV technician should be accorded the same consideration. You say you don't know what he carries in his head. It just happens I do.' "

"My sister-in-law whispered to me that the nice-looking man had recently retired from NASA where he held an important job in something electronic," Mrs. McGregor interrupted her husband's story.

" 'We are tremendously impressed,' the man continued, 'with the ability of our space people to maneuver a space capsule through a small window in space and bring it to a landing on a comparatively restricted area of the earth or moon. But that TV technician must be able to make three separate beams of electrons originating at three different points in the back of the picture tube pass simultaneously through some tiny holes less than one-thousandths of an inch in diameter in a metal plate at the front of the tube and then spread apart to land precisely on three adjacent but separate landing spots on the face of that tube. In order to do this he must shape the beams, bend them, apply individual mid-course correction to them, and correct for many factors tending to divert them from their pinpointed ultimate destinations. And he performs this triple coordinated landing over and over again, each time sending the beams through different holes in the metal plate and each time causing them to find three different landing spots until they have touched down on every square millimeter of the tube face. The harnessed troika of beams is directed through more than 400,000 separate holes every thirtieth of a second, with the intensity of each beam being individually and continuously controlled.' "

" 'Oh come now!' the other man said. 'You're confusing the engineering of a TV set with the repair of it. Maybe the fellow who invented color TV or who designed my set had to know all that stuff, but I'm talking about the jerk who fixes it when it breaks down.' "

" 'Let me ask you a question,' the man from NASA replied. 'Can anyone repair or maintain *anything* unless he knows how it works? I believe not. That's why medical students spend long and weary months studying anatomy and the functioning of the human body before they take up the treatment of disease. How far would a garage mechanic get if he didn't understand thoroughly how an internal combustion engine works? Before you can tell what is wrong you must know what is right. For a TV technician to converge a color set properly, he must understand well the operation of the tri-color TV tube I was describing.

'But that only scratches the surface of what he must know. He must understand how the eye sees color to grasp why certain hues on the face of the tube must be present in small detail while other hues are only necessary in grosser areas for natural color rendition. Only through knowledge of the strengths and weaknesses of human color vision can he understand the *why* behind the design and adjustment of many of the circuits on which he works.

'Let's think about the TV technician and precise timing. You know how important time is to space flight: how a clock in the capsule must be synchronized with the clock in the control center at Houston, and how the length of a retrograde burn during re-entry must be of just the right duration down to the second. But the TV technician must measure time in millionths of a second. Every color set has a very precise crystal-controlled clock built into it that "ticks" 3,579,545 times a second, with a required accuracy of .0003% and a drift held to less than 1/10 of a tick per second. To keep the receiver clock precisely synchronized with the master clock of the TV station, every receiver clock is automatically reset—if it needs it—15,734 times a second. And this synchronization must be maintained by the TV technician if color rendition is to be true.

'Not long ago I had an electrician install a patio light for me. The installation consisted of attaching a simple fixture to the side of the trailer, running two wires carrying 120 volts, 60-hertz a.c. current to it, and inserting a simple s.p.s.t. switch in one of the wires. This job is typical of the work done by most electricians called to the home: they work with a single-frequency sinusoidal current and usually with only 120 or 240 volts. The charge for the job, incidentally, was $45.

'Compare this with the problems confronting the TV technician. He must contend with currents that vary all the way from direct current to currents that alternate back and forth hundreds of millions of times a second. He works with voltages measured from fractions of a volt to 25,000 volts or more. In addition to the simple sine wave of the electrician, the TV technician works with square waves, sawtoothed waves, narrow square-topped pulses, and with a host of complex waves made up of combinations of these basic forms. Not only must the technician know what shape wave to expect in any part of a TV receiver when he sees it displayed on his oscilloscope, but he must know how much deviation from the ideal shape can be tolerated in each instance.

'I could go on detailing the esoteric knowledge a TV technician must have,' the man from NASA said, 'but it would be belaboring the point. The sad truth is the things a TV technician must know are so complex, so far removed from universal knowledge, that the public simply cannot comprehend them. People have at least a hazy notion of how their telephone, automobile, refrigerator, and washing machine work; but they have no conception at all of what goes on behind the face of that color picture tube. Even the rash set owner hesitates to take the back off the color set when it quits because he does not have any idea of where to start looking for trouble in that array of tubes, transistors, capacitors, transformers, and resistors—most of which he doesn't recognize for what they are. Yet the TV technician seems to be able to locate the trouble and repair it with disarming ease. Like all work done by an expert, it looks easy.

'The upshot is the public wants to pay the TV technician just for what they see him *do*—which usually consists of taking a few measurements and then cutting out a defective component and soldering in a new one. Since they cannot see what takes place "in the little gray cells" as Hercule Poirot called them, while the technician is deciding which component is bad, they are not willing to pay him for what he knows or for being the true professional he is. And never doubt for a minute but that he is a true professional according to the definition: "One who is in an occupation requiring a high level of training and proficiency."

'This rejection quite understandably bewilders and disturbs the technician. He sees others who obviously know far less being paid much better—without too great a protest—for the work they do. For example, a plumbers' union last summer demanded $11.48 an hour, including fringe benefits, for an annual wage of $21,500. This makes the technician wonder if his rather pitiful attempt to win acceptance as a professional by dressing the part—wearing neatly pressed clothes and a white shirt—isn't a waste of time. Anyone who has seen a working plumber knows that certainly that wasn't the way he got *his* start!

'Seriously, it's always a good idea for a man to be neat and clean, but he is not going to be recognized as a professional simply because he tries to look like one. Actually it's a good thing for the true professionals it's not that easy. The Spanish have a proverb: A monkey dressed in silk still remains a monkey. The only way the TV technician is ever going to be accorded the respect and pay he deserves is for the public to be made aware of the complexity of the work he does—a public relations job that should be undertaken by the whole industry.

'Thinking people had an opportunity to grasp the difficulty of electronic maintenance when the color camera of Apollo 12 failed to function because it was pointed directly into the sun. Think of all the electronic brainpower that went into the design of the camera and into the instructions for its use. Yet for the lack of a 50¢ lens cap properly used, the camera became a piece of expensive junk; and not all the king's horses nor all the king's men could make it work again. Remember that the next time you hear someone saying TV service is such a snap.' "

"That broke up the party," Mac concluded, "but it really warmed the cockles of my heart to hear such a knowledgeable and sympathetic defense of TV technicians by a man who had nothing to gain by standing up for us. And I am with him: let's not fawn on the public and beg them to accept us as professionals; let's demand recognition and payment in accordance with the time and effort it took—and continues to take—for us to know our work. Lots of people only value a thing according to the price tag!" ▲

Cross-modulation and Intermodulation in Receiver R.F. Amplifiers

By JOHN KNEPLER / Design Engineer, Heath Co., Benton Harbor, Mich.

Performance comparisons of JFET, MOSFET, bi-polar transistor, emitter-coupled transistor, and cascode IC front ends of high-quality communications receivers.

MODERN high-quality communications receivers make use of sophisticated and expensive crystal or mechanical filters to achieve a high degree of selectivity. However, no amount of i.f. selectivity can compensate for a front end which has not been designed to minimize the effects of cross-modulation and intermodulation distortion. The purpose of the following study is to compare the relative inherent CM and IM susceptibility of some common r.f. amplifiers.

Cross-modulation

Cross-modulation is the transfer of the amplitude modulation on an interfering carrier to a desired carrier. To state it in another way (which seems more applicable to single sideband), cross-modulation distortion occurs when the amplitude of a desired signal varies in accordance with the amplitude of an interfering signal.

As an example, consider the following situation: A receiver is tuned to an SSB signal at 3.85 MHz. Assume there are no other signals on the band except for one strong SSB signal at 3.95 MHz. The "interfering" signal is then at 3.95 MHz, a full 100 kHz away from the "desired" signal at 3.85 MHz. This is, of course, well outside the normal 2- or 2.5-kHz passband of the i.f. filtering. Nevertheless, if the r.f. amplifier is prone to cross-modulation, the 3.85-MHz signal will be distorted by the 3.95-MHz signal.

The preceding example is based on the premise that there is only one interfering signal in the band. This is seldom, if ever, the actual case. Today's amateur bands are crowded with numerous signals, all of which can cause cross-modulation distortion *simultaneously* in varying degrees. In fact very strong signals far outside the ham bands, such as local broadcast stations, can add to the problem if front-end selectivity prior to the r.f. amplifier is below par. The result of all this multiple CM sounds like unintelligible background "clutter" and noise. So, even if a receiver has an admirable signal-to-noise ratio as measured in the laboratory with a signal generator, but has poor resistance to CM, its "on the air" signal-to-noise ratio (the one that really counts) is considerably poorer.

Also it is apparent that the effective receiver selectivity is not nearly as good as 2 or 2.5 kHz. Furthermore, it is obvious that this degradation of selectivity is a direct result of inferior resistance to CM by the r.f. amplifier.

A mathematical analysis of the causes of cross-modulation reveals some interesting points:

1. CM is caused by third- and higher-order nonlinearities in the transfer characteristic of the r.f. amplifying device.
2. The percentage of modulation transferred to the desired signal is proportional to the *square* of the amplitude of the interfering signal.
3. The percentage of modulation transferred to the desired signal is *independent* of the amplitude of the desired signal.
4. There need be no relationship between desired and interfering signal frequencies for CM to occur.

Intermodulation

When the two signals mix and produce a third frequency, which appears at the same frequency as a desired signal, intermodulation distortion occurs.

Consider the following example: A city has two AM broadcast stations, one operating at 1.5 MHz and one at 0.9 MHz. If third-order IM occurs in a receiver's r.f. amplifier, there will be a signal generated at 3.9 MHz, that is,

$$(2 \times 1.5) + (0.9) = 3.9 \text{ MHz}.$$

If the receiver is tuned to an amateur signal at 3.9 MHz, the listener will hear the desired signal plus an interfering signal caused by the IM described above.

As in the case of cross-modulation, no amount of i.f. filtering can remove the distortion because it is caused by a signal of the same frequency as the desired signal. It should be noted that the 3.9-MHz IM product is not the only one; there are others at

$$(2 \times 1.5) - (0.9) = 2.1 \text{ MHz},$$
$$(2 \times 0.9) + (1.5) = 3.3 \text{ MHz},$$
$$(2 \times 0.9) - (1.5) = 0.3 \text{ MHz},$$
$$(3 \times 1.5) = 4.5 \text{ MHz, and}$$
$$(3 \times 0.9) = 2.7 \text{ MHz}.$$

To fully appreciate the damage poor IM performance can do, one should also be aware that the products listed above are caused only by the third-order nonlinearity in the r.f. amplifying device. Unwanted products are also generated by second-, fourth-, fifth-, and higher-order nonlinearities.

Again, as in the case of CM, the effective receiver selectivity and signal-to-noise ratio are adversely affected by poor IM performance in the front end.

A mathematical analysis of the causes of intermodulation reveals the following:

1. IM is caused by second- and higher-order nonlinearities in the transfer characteristic of the r.f. amplifying device.
2. The amplitude of the undesired product, produced by

the third-order IM described in the example, is proportional to the square of the 1.5-MHz signal amplitude and directly proportional to the amplitude of the 0.9-MHz signal.

3. To produce an IM product at a given frequency there must be a definite relationship between the two frequencies from which the product is generated.

Test Circuits

Fig. 1 shows some of the more common r.f.-amplifier circuits that were tested to determine their relative resistance to cross-modulation and intermodulation. All the test circuits use identical tuned circuits in the output and untuned 51-ohm input circuits. The output transformer secondary is at a 50-ohm impedance level.

Both the emitter-coupled amplifier and the integrated circuit (connected in a cascode configuration) require parasitic suppression in the output circuits. A 100-ohm resistor is used in the emitter-coupled amplifier and a parasitic choke in the cascode circuit.

CM Testing

The test arrangement for cross-modulation is shown in

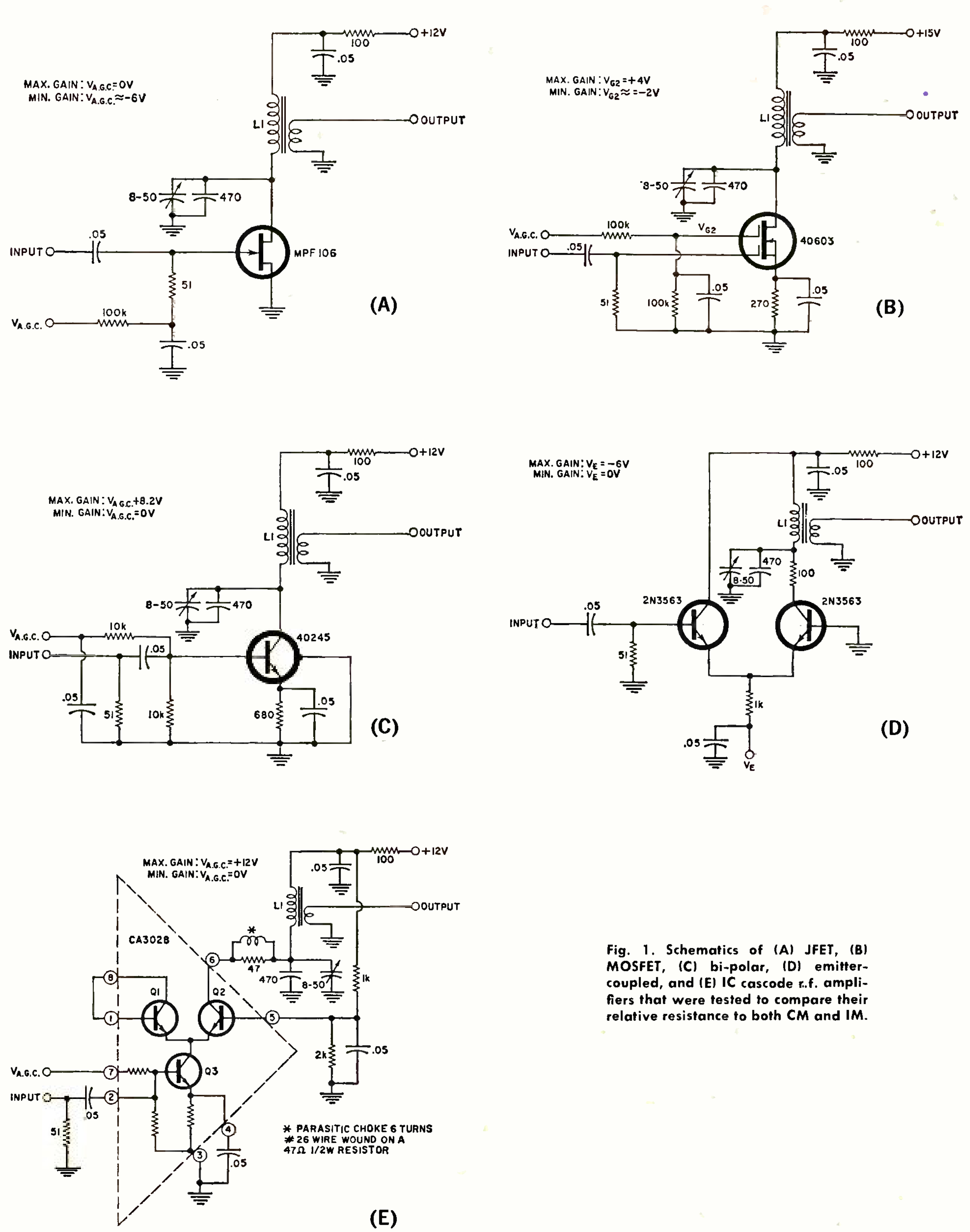


Fig. 1. Schematics of (A) JFET, (B) MOSFET, (C) bi-polar, (D) emitter-coupled, and (E) IC cascode r.f. amplifiers that were tested to compare their relative resistance to both CM and IM.

Fig. 2. Looking back from the test circuit, the three 16-ohm resistors present approximately a 50-ohm impedance. Both signal generators have built in modulators which are set to 30 percent, 1000 Hz.

For this test a desired signal frequency of 3.55 MHz is produced by generator number 1. The interfering signal of 1.55 MHz is produced by signal generator number 2. The test circuit is inserted and adjusted for maximum gain (0-dB gain reduction). The variable attenuator reduces the output of the test circuit to a level easily handled by the receiver. The receiver audio output is measured by a wave analyzer that is used here simply as a tunable audio v.t.v.m. tuned to the 1000-Hz modulation frequency.

The object of the test is to measure the r.m.s. amplitude of modulated interfering signal necessary to cause 5 percent CM of the desired signal and is made at different levels of gain reduction.

Initially the interfering signal is set to zero and modulation is applied to a 5-millivolt r.m.s. desired signal. This desired signal is tuned in on the receiver and the receiver's audio output is adjusted for a reading of 100 on the wave analyzer. Then the modulation is removed from the desired signal and the modulated interfering signal is increased until a reading of 5 is obtained on the wave analyzer. At this point 5/100 or 5 percent CM exists. The interfering signal level is then recorded and the interfering signal generator output is reduced to zero.

Now the gain of the test circuit is reduced by 5 dB and the variable attenuator is reduced by 5 dB, thus maintaining the same resultant level to the receiver. Again the interfering signal is increased for 5 percent CM and the result recorded. The procedure is repeated for each 5 dB of gain reduction until the full available a.g.c. range is covered.

The CM test results for all of the r.f.-amplifier test circuits are shown in Fig. 3. Of the circuits plotted, the dual-gate MOSFET shows the best over-all CM performance, although at certain degrees of gain reduction it is second to one of the other two circuits.

One of the most interesting characteristics of CM curves is best exhibited by the curve for the bi-polar transistor amplifier. Note that the interfering signal required to produce 5 percent CM at 10-dB gain reduction is 20 millivolts. As the gain is adjusted to 15-dB reduction, the interfering signal increases to 105 millivolts. Further reduction of the gain to −25 dB results in an interfering signal of 20 millivolts to produce 5 percent CM. This sharp peak in resistance to CM is a result of varying the operating point of the transistor so that the third-order (and higher) nonlinearities in the device transfer curve are minimized. All the curves depict this characteristic in varying amounts. If perfect test equipment were available (i.e., noiseless receiver, zero-bandwidth wave analyzer, etc.), it would probably be discovered that these peaks are much sharper than the curves show them to be and have a much larger "peak-to-valley" ratio.

IM Testing

The test arrangement for intermodulation distortion is shown in Fig. 4. Note that a variable attenuator has been added between the signal generators and the test circuit. In this test no modulation is used. The received b.f.o. and product detector is used to detect a single c.w. signal produced by intermodulation in the test circuit. The generator frequencies are 1.55 MHz and 1.0 MHz. The generated IM product to which the receiver is tuned is

$$(2 \times 1.0) + 1.55 = 3.55 \text{ MHz}.$$

Notice that this is a *third-order* IM product and should act as a check of the previously completed CM tests, because CM is produced mainly by third-order nonlinearities.

The object is to determine the amplitude of two equal signals at 1.55 MHz and 1.0 MHz necessary to produce 250 microvolts (5 percent of 5 millivolts) at 3.55 MHz.

To begin with, a 3.55-MHz, 250-microvolt signal is inserted to obtain a reference reading on the v.t.v.m. Then the two signal generators are adjusted for equal outputs at 1.55 MHz and 1.0 MHz and the variable attenuator immediately following the generator is set for maximum attenuation. The attenuation is then decreased until the 250-microvolt IM product is obtained. The amplitude of the two interfering signals is recorded and the test circuit gain reduced by 5 dB. The attenuator following the test circuit is reduced 5 dB to maintain a constant level to the receiver. The procedure is repeated for all values of gain reduction in 5-dB increments.

The resulting curves are shown in Fig. 5. Theoretically, the IM curves should be parallel to the CM curves for corresponding circuits. This seems to be generally the case except for the sharp peak described previously for the bi-polar transistor. This discrepancy is probably the effect of one or both of the following:

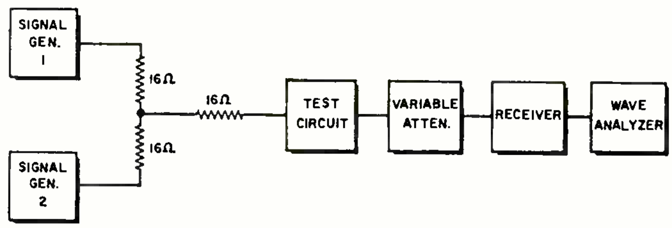


Fig. 2. Test setup for measuring the r.m.s. amplitude of the modulated interfering signal necessary to cause 5 percent CM of the desired signal for each of the test r.f. amplifiers.

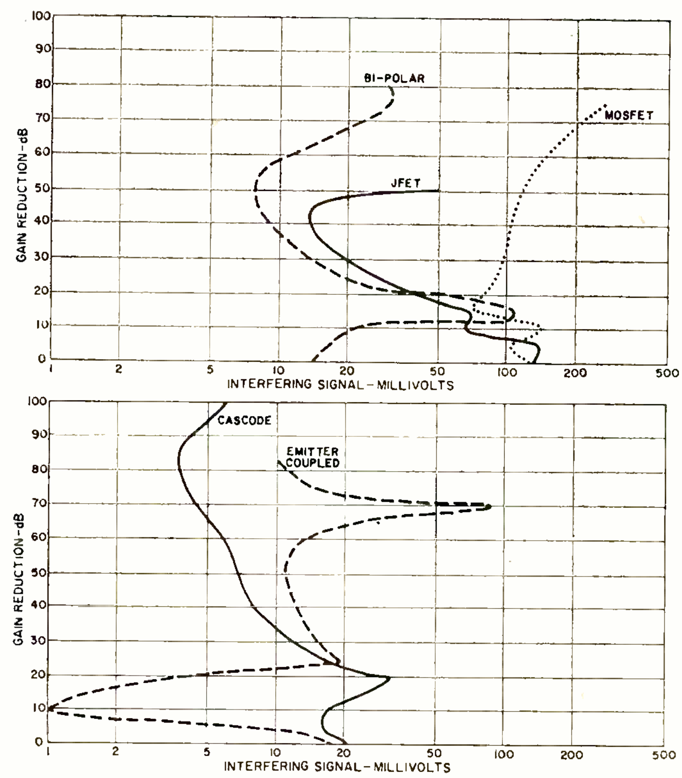
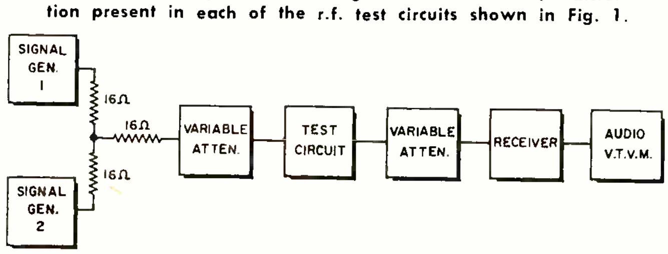


Fig. 3. (Top) Characteristic curves showing the results of the cross-modulation tests performed on the test circuits (A), (B), and (C), and (bottom) (D) and (E) of Fig. 1. The dual-gate MOSFET r.f. amplifier shows the best over-all CM performance.

Fig. 4. Test setup for measuring the intermodulation distortion present in each of the r.f. test circuits shown in Fig. 1.



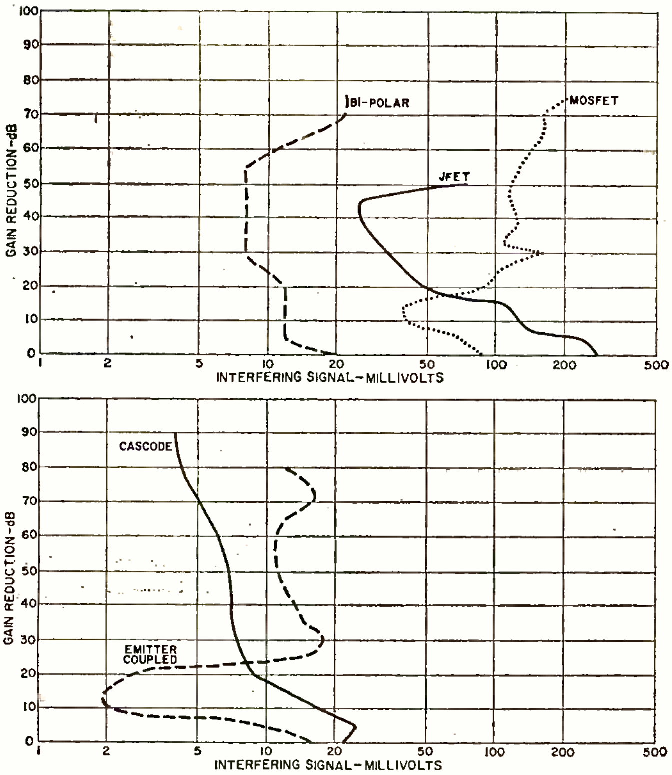


Fig. 5. (Top) Characteristic curves showing the results of the intermodulation tests performed on the r.f. test circuits (A), (B), and (C) and (bottom) (D) and (E) shown in Fig. 1.

CIRCUIT	POWER GAIN	SOURCE IMPEDANCE FOR 15-dB GAIN	DEGRADATION OF CM PERFORMANCE
JFET	3 dB	395 Ω	24 dB
MOSFET	7 dB	158 Ω	16 dB
Bi-polar	30 dB	—	—
Emitter-coupled	17 dB	—	—
Cascode	31 dB	—	—

Table 1. Power gain at 0-dB gain reduction for each test circuit shown in Fig. 1 is listed. Note that FET circuits, although showing best CM and IM performance, have lowest gain. The third column lists the source impedance that each FET circuit should have to raise the gain to a more useful level of 15-dB.

1. Some intermodulation distortion occurs in the output circuits of the two signal generators.
2. The peak is so sharp that it falls between the 5-dB steps used in the measurements.

Measurement Error

The system of measurement used in these tests is by no means error-free. First of all, the devices on which measurements were made are typical only in the sense that they were chosen at random from a group of 25 to 50. The CA3028 (Fig. 1E) was chosen from a group of six. The curves shown are not the average of data taken on several dozen of each device. Other sources of error include:

1. CM or IM in the receiver.
2. Test-equipment calibration error.

Nevertheless, the real object of the tests was not to obtain absolute values, but to compare the circuits on a relative basis. All circuits were tested on equal terms and usable results were obtained.

The data gathered indicates that the dual-gate MOSFET is the least susceptible (throughout the a.g.c. range) to CM and IM of all the circuits tested. Each circuit, though, has its own desirable characteristics which may be considered more important than CM or IM performance by some circuit designers. For example, the cascode circuit has high gain, wide a.g.c. range, and low noise figure. If a method of a.g.c. were employed which permitted the JFET to operate at 0-dB gain reduction, it would obviously be the best choice for an r.f. amplifier.

Power Gain

Table 1 lists the power gain of each circuit at 0-dB gain reduction. Notice that the two circuits with best CM and IM performance have the lowest gain. The reason is the JFET and MOSFET are high input-impedance devices and the source impedance from which they are fed is only 25 ohms (the 51-ohm termination in parallel with the 50-ohm output impedance of the generator arrangements). This mismatching of impedance causes the low gain. The third column in Table 1 shows the source impedance from which the two devices should be fed in order to raise the gain to a more useful level of 15 dB. This would normally be accomplished by using a tapped tuned circuit at the input to the device.

The tuned-circuit "*Q*" should be made as high as possible for the following reason: If an interfering signal is within the bandpass of the tuned circuit, it will be stepped up in amplitude the same as the desired signal. Remember that the percentage of CM caused by the interfering signal is proportional to the *square* of its amplitude. It is no help that the desired signal is increased because the CM is *independent* of the desired signal amplitude. Thus, a step-up of 12 dB in the input circuit results in a 24-dB decrease in the interfering signal voltage required at the antenna to produce an equal amount of CM. This applies to signals within the passband of the input-tuned circuit. Interfering signals falling far outside the passband will not be stepped up and consequently will not present as great a problem.

Hence, to make maximum use of the field-effect devices, they should be driven from as low an impedance as practicable and preceded by a highly selective tuned circuit. The loss in gain should be made up by using devices with higher forward transconductance whenever possible.

The use of a low-source impedance causes some degradation of circuit-noise figure. This may be objectionable at v.h.f., but at frequencies below 50 MHz antenna noise overcomes circuit noise by an amount such that considerable noise figure degradation is not noticeable. Interfering signals are usually farther removed at v.h.f. and CM performance is not as seriously affected by choosing a source impedance for best noise figure.

Conclusion

Obviously, not all the possible r.f. amplifiers were tested. The low-source impedance requirement suggests that common-gate FET configurations may offer improved CM and IM characteristics. Also, an unbypassed emitter resistor in the bi-polar transistor circuits would probably improve their performance. However, the circuits tested are representative of the most commonly used, and the results yield an insight into their relative resistance to cross-modulation and intermodulation. ▲

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C.E.T. Test, Section #2

TV Signals

By DICK GLASS*

What is your electronics servicing I.Q.? You must get 75% on entire exam to pass.

This is the second in a series of 12 test sections to be published monthly, which are representative of the Certified Electronic Technician (C.E.T.) examinations given by NEA, a national association for radio and television service technicians.

(Answers will appear next month.)
Answers to last month's quiz appear on page 89

1. **The portion of the composite video signal usually called the "blacker-than-black" portion is:**
   (a) *the sync pulses* (c) *zero reference level*
   (b) *blanking pulses* (d) *vertical interval test signals*

2. **Which of the following statements is *untrue* concerning the composite video waveform?**
   (a) *sync pulses take up at least 25% of the total amplitude*
   (b) *blanking pulses are at approximately 75% of the total amplitude*
   (c) *picture information may take up to 75% of the total amplitude*
   (d) *the FM sound modulation takes up to 75% of the total amplitude*

3. **When viewing the vertical-blanking bar on a TV screen, which statement is *true*?**
   (a) *the white dots or dashes near the bottom of the bar are the vertical serrations*
   (b) *the square dark "hammerhead" in the center is made up of vertical sync pulses*
   (c) *the square dark "hammerhead" is made up of equalizing pulses used to improve vertical interlace*
   (d) *the dark bar extending across the vertical blanking bar, from left to right, is the horizontal sync pulse*

4. **Peak transmitter power occurs during:**
   (a) *blanking* (c) *maximum black areas*
   (b) *maximum white areas* (d) *sync tips*

5. **The sound carrier and color subcarrier are located at what frequencies in a 40-MHz TV i.f. section?**
   (a) *41.25 and 42.17 MHz* (c) *42.17 and 45.75 MHz*
   (b) *41.25 and 45.75 MHz* (d) *40.00 and 43.58 MHz*

6. **The TV intercarrier, 4.5-MHz, sound i.f. frequency is usually derived in:**
   (a) *the sound discriminator* (c) *the video detector*
   (b) *the TV tuner* (d) *the video i.f. amplifier*

7. **Which statement is *incorrect*?**
   (a) *the color burst is approximately 8 cycles in duration*
   (b) *the color burst synchronizes the receiver's color oscillator*
   (c) *the color burst is located on the "front porch" of the horizontal sync pulse*
   (d) *the color burst is present only during color broadcasts*

8. **Which statement is correct?**
   (a) *the horizontal scanning frequency is 262 1/2 times the vertical scanning frequency*
   (b) *the color burst is 3.68 MHz*
   (c) *the video signal is FM*
   (d) *the vertical blanking pulse is 75% of the horizontal blanking pulse height*

9. **What is the standard FM radio i.f. frequency?**
   (a) *88 MHz to 108 MHz* (c) *21 MHz*
   (b) *262 kHz* (d) *10.7 MHz*

10. **Vertical interlace scanning is controlled in the receiver by:**
    (a) *the vertical sync pulse* (c) *the vertical blanking pulses*
    (b) *the equalizing pulses* (d) *ringing in the vertical oscillator*

*Executive V.P., NEA, 12 South New Jersey St., Indianapolis, Ind. 46204, assisted by Lew Edwards, chairman of Test Make-up Subcomm.

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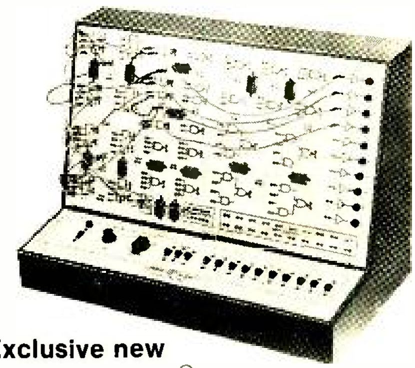

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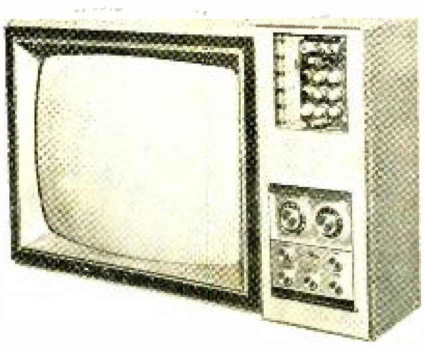

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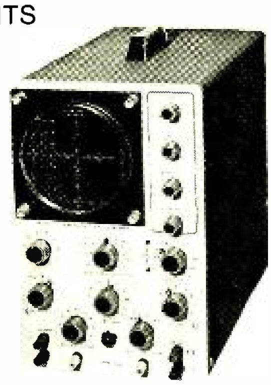

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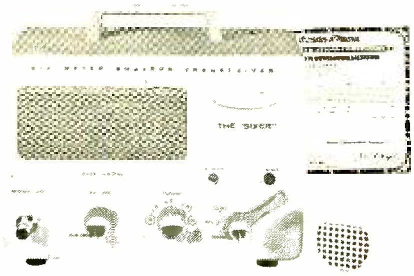

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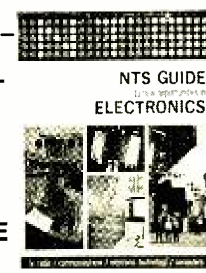

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IC Memories

(*Continued from page 29*)

3 is a building block, its internal organization is unusual in that static shift registers have been added to the usual decode and sense circuitry. It illustrates the complexity achievable with MOS technology—all of the circuitry shown in Fig. 3, top, is physically located on the chip (Fig. 3, left). This ROM will generate words or word series of any length for functions such as programming, control instructions, digital generation of characters or graphic displays, etc. ROM's can be cascaded to produce word series longer than the single-circuit capacity of 256 bits (Fig. 3, right) with all stored bits clocked out after a single start command.

A sequential-output ROM like that shown in Fig. 3, right may also be used as a sequential-select memory. Sequential select is controlled by a time-address method such as counting clock pulses until the desired word appears at the output. A high-speed clock can be used during the search mode. In effect, this ROM is a non-volatile form of shift register.

More typical are the larger, random-access ROM's, which will read out any word in 1 μs or less. This type of ROM is useful in any lookup-table application—storage of constants or programs, code conversion, character generation, random-logic synthesis, etc. They can be parallelled for word lengths wider than 8 bits or cascaded when instruction branching, multi-stage lookups, or complicated conversions are required. The chip shown in the lead figure is outlined in Fig. 4 and is an interesting example because it can be programmed to generate either 128 eight-bit functions or 256 four-bit functions.

MOS-Bipolar Compatibility

The importance of bipolar compatibility is illustrated by the character-generating system shown in Fig. 5. The three 1024-bit ROM's (Fig. 5A) are programmed to convert the ASCII code into 35-bit (5 × 7) outputs that can be used to control display devices. For example, the "1" bits would be seen as bright dots and the "0" bits as unlit spaces in alphanumeric symbols displayed on the raster-scan television screen. However, the parallel outputs of the ROM's must first be converted to a serial-bit stream that controls gating of the CRT electron beam. If the ROM's are to operate at full speed, 1 MHz, the parallel-to-serial converter and the control counter must be several times as fast. These devices and the gates are TTL.

Generating 64 standard alphanumeric characters requires 2240 bits of storage, which can be supplied economically with three 1024-bit ROM's. The counter and gates toggle the system so that the top ROM forms the 4 × 4 upper-left portion of each 5 × 7 pattern, the center ROM generates the 3 × 4 lower-left portion, and the lower ROM produces the 7 bits in the right-hand column. The counter outputs cause the ROM's to be selected in the correct sequence and insert spacing "0" bits between symbols on the display. The additional circuitry in the display-system diagram (Fig. 5B) allows a line of symbols to be generated and refreshed on the display. Each input channel contains a shift register or accumulator operating as a buffer memory and recirculating delay line.

ROM's Instead of Logic

It is possible to build a computer entirely of memory and memory control circuits. In a small way, this is done when a ROM is programmed to replace logic functions. The substitution has been made experimentally in small computers, but designers have shied away from replacing logic with ROM's in large computers because it is necessary to cover all programming contingencies in the ROM designs. Debugging the software of a large, general-purpose computer is a formidable task that can take several years.

However, for selected tasks, such as software emulation, machine-language translations, and replacements for known-function logic, ROM's can be used without difficulty. An estimated 90 percent of all logic functions can be replaced by ROM's. If MOS ROM's are used, the replacement would cost half or less than half as much as conventional logic IC's. One MOS ROM can replace more than 100 logic gates.

As a simple example, consider the truth table shown in Fig. 6A for the function $Z = ABC + ABC + ABC + ABC$. This function reduces to the function $Z = BC + AB + ABC$ (Fig. 6B) and can be implemented directly with 8 bits in an ROM or with three logic gates (Fig. 6C). Much more complex functions like the one shown in Fig. 6D, are actually being obtained with ROM's today.

ROM's used in this fashion are a boon to the designers of special-purpose controls and similar systems. To build equivalent functions with conventional IC logic takes large logic assemblies, with their attendant path delays, logic "race," crosstalk, and other problems. No expertise in logic operation or debugging is needed to prepare a truth table used to program an ROM.

(Concluded Next Month)

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Four-Channel Stereo

(Continued from page 35)

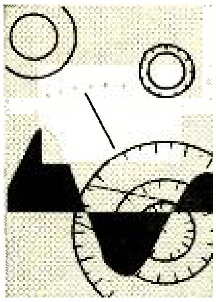
existing between the two channels was not supplied, this system was not adopted. Here an ultrasonic frequency was the control signal.

Since phonograph records are lifted to two full-frequency channels, a similar type of fading system could be used, with the left channel fading between the front-left and rear-left speakers and the right-channel signal between the front-right and rear-right loudspeakers (Fig. 4). For this purpose two fading-control signals would have to be recorded on the disc; they could be just above or below the audible frequency range. Since the record is capable of handling two channels, the control signals could be the same frequency but located separately in the left and right channels. As an alternative, a single control signal could be used to handle simultaneous fading from front to rear. These types of records would be compatible with existing stereophonic equipment but would require some rather complex "4-channel" playback equipment to accomplish this fading.

As a refinement, the separate fading signal might conceivably be omitted by realizing that the human ear is not very sensitive to full separation at very low frequencies. Consequently, the proportion of bass in the left and right channels could be used to actuate the fading-control circuits in the playback equipment. This would increase the circuit complexity but would eliminate the need for additional control signals. There would be no separation of bass in such a system, because all the bass signals would be summed into one signal. The common bass would then be recorded in some varying proportion in the two channels to act as the fading-control signal. As an alternate, the fading-control signal could be derived from the proportion of the lateral to vertical modulation of the record.

(Editor's Note: The recently demonstrated Schreiber-Mowrey 4-channel disc uses two channels on the disc to carry 4-channel information. Although there are still no technical details available, we believe that some sort of fading or switching technique is used depending on the separation or other characteristic of the two channels. A complex encoder-decoder circuit must be included both in the record and playback systems.)

The coming years will bring solutions to the many problems posed in recording, reproducing, transmitting, and receiving 4-channel stereo sound. There will be rapid improvements and new developments that will eventually lead to a 4-channel system that everyone can enjoy. ▲



TEST EQUIPMENT

Product Report

Weston Model 1240 Digital V.O.M.

For copy of manufacturer's brochure, circle No. 3 on Reader Service Card.

Last month we described a low-cost digital v.o.m. that should really begin to compete with pointer-type analog meters where the accuracy and reading simplicity of a digital instrument are desired. That instrument was *Honeywell's* Digitest 500, priced at $250. Another meter for this same market is the new *Weston* Model 1240, shown here.

This meter has 26 ranges for measuring a.c. and d.c. voltage, a.c. and d.c. current, and resistance. The circuit uses a high-impedance bipolar analog-digital converter operating on a *Weston*-patented dual-slope principle. The basic range is 200 millivolts to which all other ranges and functions are converted. A.c. is converted to d.c. by an average-sensing r.m.s.-calibrated converter assembly. Current is measured by the voltage drop it establishes across a precision ring shunt network. Resistance is measured by passing a scaled constant current through the unknown and measuring the d.c. voltage across it.

The highest d.c. range is 1000 volts at an input impedance of 10 megohms with an accuracy of 0.1 percent of the reading ±1 digit. A.c. voltages up to 500 volts can be measured at an input impedance of 1 megohm with an accuracy of 0.5 percent of the reading, ±1 digit. Both a.c. and d.c. current up to 2 amps can be read, and there are six resistance ranges (up to 20 megohms).

The Model 1240 has a tilt stand for using the meter on the bench; the stand can be used as a carrying handle for portability. By removing the handle, the unit can be rack-mounted in a standard 3½-in panel. The compact size of the instrument (7 in by 3 in by 8 in deep) allows it to be carried conveniently in a standard attaché case. All the controls are recessed and can be operated with one hand.

All circuits are protected from overloads either through a resistor-diode network, or through fuses, which are replaceable from outside the case. Fuse-removal tools are on the ends of the carrying handle locking knobs.

The digital meter can be operated from either a 120- or 240-volt a.c. power line. An optional battery pack is also available for field operation in remote locations.

Price of the *Weston* Model 1240 is $379.50. A less expensive Model 1241 is also available for d.c. voltage and resistance measurements only. ▲

Hewlett-Packard Model 198A Oscilloscope Camera

For copy of manufacturer's brochure, circle No. 4 on Reader Service Card.

For the engineer or technician who uses an oscilloscope on the job, the need often arises to make a permanent record of some of the scope traces he observes while developing a circuit or testing some equipment. A special scope camera that mounts directly onto the scope fills this need. Previous scope cameras from *Hewlett-Packard* and other such manufacturers have been fairly expensive, selling for around $425 to $550. This new Model 198A is priced at $350. The price reduction has been made possible by eliminating some seldom-used features like a movable film back. The new camera uses a *Polaroid* back and standard flat-pack self-processing film.

In addition to recording scope traces, a camera extends the capabilities of the

scope. For example, at very low sweep rates where the trace appears simply as a wiggling dot, a photographic time exposure in effect gives long persistence to the CRT phosphor. At high speeds, the scope camera can freeze a fast-moving display that appears as a blurred trace to the eye, or it can capture fast, single-shot events that occur just once. Also by taking a number of multiple exposures with the camera, it is possible to compare waveforms that occur at different times.

A special focus arrangement is used on this camera to eliminate troublesome focus plates. A pair of mirrors reflect twin curtains of light onto the scope screen. The mirror system is interlocked with lens focal distance and the mechanical focusing system. When the curtains of light just meet, the CRT graticule is evenly illuminated and the camera is properly focused.

The Model 198A is easily mounted directly on any 5-in *H-P* oscilloscope by means of an adjustable clamp. Bezel adapters are available for most other scopes. A synchronized contact closure is provided to trigger external circuits or to synchronize other equipment when the camera's shutter-release cable is operated. The fastest shutter speed is 1/60th second and the largest lens opening is *f*/3.5. ▲

Sencore TC154 Tube Tester

For copy of manufacturer's brochure, circle No. 5 on Reader Service Card.

THE test equipment manufacturers are still coming out with new and improved tube testers since there are still plenty of tubes in use in old as well as new TV receivers and other equipment. *Sencore's* popular Mighty Mite Six tube tester has now been updated with this new Mighty Mite Six, Model TC154.

What is unique about this tester is that instead of the usual 12AU7 tube operating in a v.t.v.m. circuit to check grid leakage, solid-state circuitry is used. A selected field-effect transistor and a zener diode form a balanced bridge high-impedance voltmeter circuit. Hence, the tester is ready to go the instant the switch is turned on; there is no need to wait for the checker to warm up and stabilize before accurate testing can begin. Just like an instant-on TV set, this tube tester is also instant-on. Furthermore, there is no chance for the tester's v.t.v.m. tube to develop leakage which might affect the leakage readings of tubes that are being checked.

Another new feature is the use of four push-buttons on the front panel to take the place of the usual function switch. With so many of the new kitchen appliances going to push-buttons these days, the TC154 is right in style.

The tester checks tubes for cathode emission, grid leakage, and shorts. It is extremely simple to use and quick to set up. An additional socket has been provided to check some of the later tubes and tubes that were seldom used in the past but have recently become popular.

Checking a large number of tubes, such as those used in a color-TV receiver, for example, can be done very quickly. The operating controls are located in a straight line and are set up in logical ABCD order. The line cord can be stored in a compartment located at the bottom of the compact instrument.

The TC154 is housed in a two-toned brushed steel and vinyl-clad case with a convenient carrying handle and front cover. Price of the tester is $89.50. ▲

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Harry Remmert decided he needed more electronics training to get ahead. He carefully "shopped around" for the best training he could find. His detailed report on why he chose CIE and how it worked out makes a better "ad" than anything we could tell you. Here's his story, as he wrote it to us in his own words.

Harry Remmert on the job. An Electronics Technician with a promising future, he tells his own story on these pages.

By Harry Remmert

AFTER SEVEN YEARS in my present position, I was made painfully aware of the fact that I had gotten just about all the on-the-job training available. When I asked my supervisor for an increase in pay, he said, "In what way are you a more valuable employee now than when you received your last raise?" Fortunately, I did receive the raise that time, but I realized that my pay was approaching the maximum for a person with my limited training.

Education was the obvious answer, but I had enrolled in three different night school courses over the years and had not completed any of them. I'd be tired, or want to do something else on class night, and would miss so many classes that I'd fall behind, lose interest, and drop out.

The Advantages of Home Study

Therefore, it was easy to decide that home study was the answer for someone like me, who doesn't want to be tied down. With home study there is no schedule. I am the boss, and I set the pace. There is no cramming for exams because I decide when I am ready, and only then do I take the exam. I never miss a point in the lecture because it is right there in print for as many re-readings as I find necessary. If I feel tired, stay late at work, or just feel lazy, I can skip school for a night or two and never fall behind. The total absence of all pressure helps me to learn more than I'd be able to grasp if I were just cramming it in to meet an exam deadline schedule. For me, these points give home study courses an overwhelming advantage over scheduled classroom instruction.

Having decided on home study, why did I choose CIE? I had catalogs from six different schools offering home study courses. The CIE catalog arrived in less than one week (four days before I received any of the other catalogs). This indicated (correctly) that from CIE I could expect fast service on grades, questions, etc. I eliminated those schools which were slow in sending catalogs.

FCC License Warranty Important

The First Class FCC Warranty* was also an attractive point. I had seen "Q" and "A" manuals for the FCC exams,

*CIE backs its FCC License-preparation courses with this famous Warranty: graduates must be able to pass the applicable FCC License exam or their tuition will be refunded in full.

and the material had always seemed just a little beyond my grasp. Score another point for CIE.

Another thing is that CIE offered a complete package: FCC License and technical school diploma. Completion time was reasonably short, and I could attain something definite without dragging it out over an interminable number of years. Here I eliminated those schools which gave college credits instead of graduation diplomas. I work in the R and D department of a large company and it's been my observation that technical school graduates generally hold better positions than men with a few college credits. A college degree is one thing, but I'm 32 years old, and 10 or 15 years of part-time college just isn't for me. No, I wanted to *graduate* in a year or two, not just *start*.

If a school offers both resident and correspondence training, it's my feeling that the correspondence men are sort of on the outside of things. Because I wanted to be a full-fledged student instead of just a tagalong, CIE's exclusively home study program naturally attracted me.

Then, too, it's the men who know their theory who are moving ahead where I work. They can read schematics and understand circuit operation. I want to be a good theory man.

From the foregoing, you can see I did not select CIE in any haphazard fashion. I knew what I was looking for, and only CIE had all the things I wanted.

Two Pay Raises in Less Than a Year

Only eleven months after I enrolled with CIE, I passed the FCC exams for First Class Radiotelephone License with Radar Endorsement. I had a pay increase even before I got my license and *another* only ten months later. I'm getting to be known as a theory man around work, instead of one of the screwdriver mechanics.

These are the tangible results. But just as important are the things I've learned. I am smarter now than I had ever thought I would be. It feels good to know that I know what I know now. Schematics that used to confuse me completely are now easy for me to read and interpret. Yes, it is nice to be smarter, and that's probably the most satisfying result of my CIE experience.

Praise for Student Service

In closing, I'd like to get in a compliment for Mr. Chet Martin, who has faithfully seen to it that my supervisor knows I'm studying. I think Mr. Martin's monthly reports to my supervisor and generally flattering commentary have been in large part responsible for my pay increases. Mr. Martin has given me much more student service than "the contract calls for," and I certainly owe him a sincere debt of gratitude.

And finally, there is Mr. Tom Duffy, my instructor. I don't believe I've ever had the individual attention in any classroom that I've received from Mr. Duffy. He is clear, authoritative, and spared no time or effort to answer my every question. In Mr. Duffy, I've received everything I could have expected from a full-time private tutor.

I'm very, very satisfied with the whole CIE experience. Every penny I spent for my course was returned many times over, both in increased wages and in personal satisfaction.

Perhaps you too, like Harry Remmert, have realized that to get ahead in Electronics today, you need to know much more than the "screwdriver mechanics." They're limited to "thinking with their hands"...learning by taking things apart and putting them back together...soldering connections, testing circuits, and replacing components. Understandably, their pay is limited—and their future, too.

But for men like Harry Remmert, who have gotten the training they need in the fundamentals of Electronics, there are no such limitations. As "theory men," they think with their heads, not their hands. For trained technicians like this, the future is bright. Thousands of men are urgently needed in virtually every field of Electronics, from two-way mobile radio to computer testing and trouble-shooting. And with this demand, salaries have skyrocketed. Many technicians earn $8,000, $10,000, $12,000 or more a year.

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CIRCLE NO. 145 ON READER SERVICE CARD

The ELECTRONIC STROBOTUNER

By FRED MAYNARD
Motorola Semiconductor Products Inc.

Design information and operating procedures for an accurate digital music instrument tuner that uses a number of inexpensive IC's and transistors.

A TEDIOUS chore for the owner of an organ or piano is keeping the instrument properly tuned. Many owners do not bother. but any instrument which tends to drift with time or seasonal changes needs periodic tuning.

The low-cost digital tuner described here can be used to tune an instrument very accurately. It has the same inherent accuracy as some of the best and more expensive mechanical stroboscopic instrument tuners available. It is easy to use and can actually pay for itself by reducing or eliminating the periodic visits of an instrument service technician. In addition. it is easy to assemble.

The tuner is all electronic; it consists almost entirely of integrated circuits which are easy to assemble into electronic equipment and are less expensive than equivalent circuits made up of discrete parts. The MC790P or HEP572, a dual J-K flip-flop designed for binary counting functions. is one type of IC used in the tuner that results in worthwhile savings. This IC sells in small quantities for only two dollars, whereas the parts for two equivalent binary counters using discrete components would be at least three dollars or more.

The Musical Scale

An explanation of the relationship between the notes in the equal-tempered musical scale used in organs and pianos is necessary in order to understand the operation of the tuner. The notes on a piano or organ are divided into eight or nine octaves. The frequency of the first note in any octave (an A) is twice the frequency of the A one octave lower, and half the frequency of the A one octave higher. Each octave is divided into twelve segments called semitones, by the notes labeled A to G#. The semitones in the octave ending in concert A (440 Hz) are shown in Table 1. The ratio of one note to the note below is a constant equal to $\sqrt[12]{2}$ (the twelfth root of 2): if you multiply the frequency of one note by $\sqrt[12]{2}$ you get the next higher note. This constant is an irrational number which cannot be expressed as the ratio of any two whole numbers, but can be approximated to six places as 1.05946. The ratio of the two numbers 196 and 185 is also equal to this value to better than six places, and has proven a convenient approximation.

This ratio is very useful because, given any properly tuned note in the instrument. the next lower note has 185/196 the frequency. The popular electro-mechanical stroboscopic tuners use gears with 185 and 196 teeth to get this ratio, while the electronic tuner accomplishes the same object in a slightly different manner. The basic principle behind the electronic tuner is that if any frequency is divided by both 185 and 196, the resulting frequencies will be (almost) exactly one semitone apart.

The tuner is designed for use in the octave shown in Table 1. If this octave is in proper tune in a divider-type organ, such as almost all popular makes are, all the other notes will also be in tune.

FREQUENCY (Hz)	NOTE
220	A
233	A#, B^b
246.9	B
261.6	C
277.2	C#, D^b
293.7	D
311.1	D#, E^b
329.6	E
349.2	F
370	F#, G^b
392	G
415.3	G#, A^b
440	A

Table 1. The 12 semitones that comprise the octave ending in concert A (440 Hz).

Tuner Circuit and Operation

The schematic of the tuner is shown in Fig. 1. The oscillator (Q1 and associated components) has two modes; the crystal-controlled and variable-tuning modes. When switch S1 is in position A, the oscillator is crystal-controlled (this is optional) and generates a frequency of 81.4 kHz, which is divided by 185 in the divider that follows to give an accurate output of 440 Hz. This tone is the standard A to which instruments are tuned. The 81.4-kHz crystal is available for about eight dollars from most crystal companies.

When switch S1 is in position B. variable tuning, the oscillator can be tuned over a range sufficient to give complete coverage of the octave from 220 to 440 Hz when divided by 185 or 196 (more than 40.7 kHz to 86.25 kHz).

When switch S1 is in position B. tuning potentiometers R7 (Coarse Tuning) and R8 (Fine Tuning) can be used to tune the twin-T oscillator (Q1 and associated components) from above 81.4 kHz to below 40.7 kHz. In the tuning procedure, described later, the fine tuning is quite critical. and unless the potentiometers are installed in a metallic shielded box, the exterior metal parts (shaft and case of the potentiometers) should be grounded.

The buffer stages, Q2 and Q3, isolate the oscillator from the divider that follows and also limit and shape the oscillator signal output that is used to drive the divider. Note that the oscillator and Q2 operate from +9 volts, and Q3 and the IC's from +3.5 volts. R13 and C9 provide this voltage dropping and decoupling.

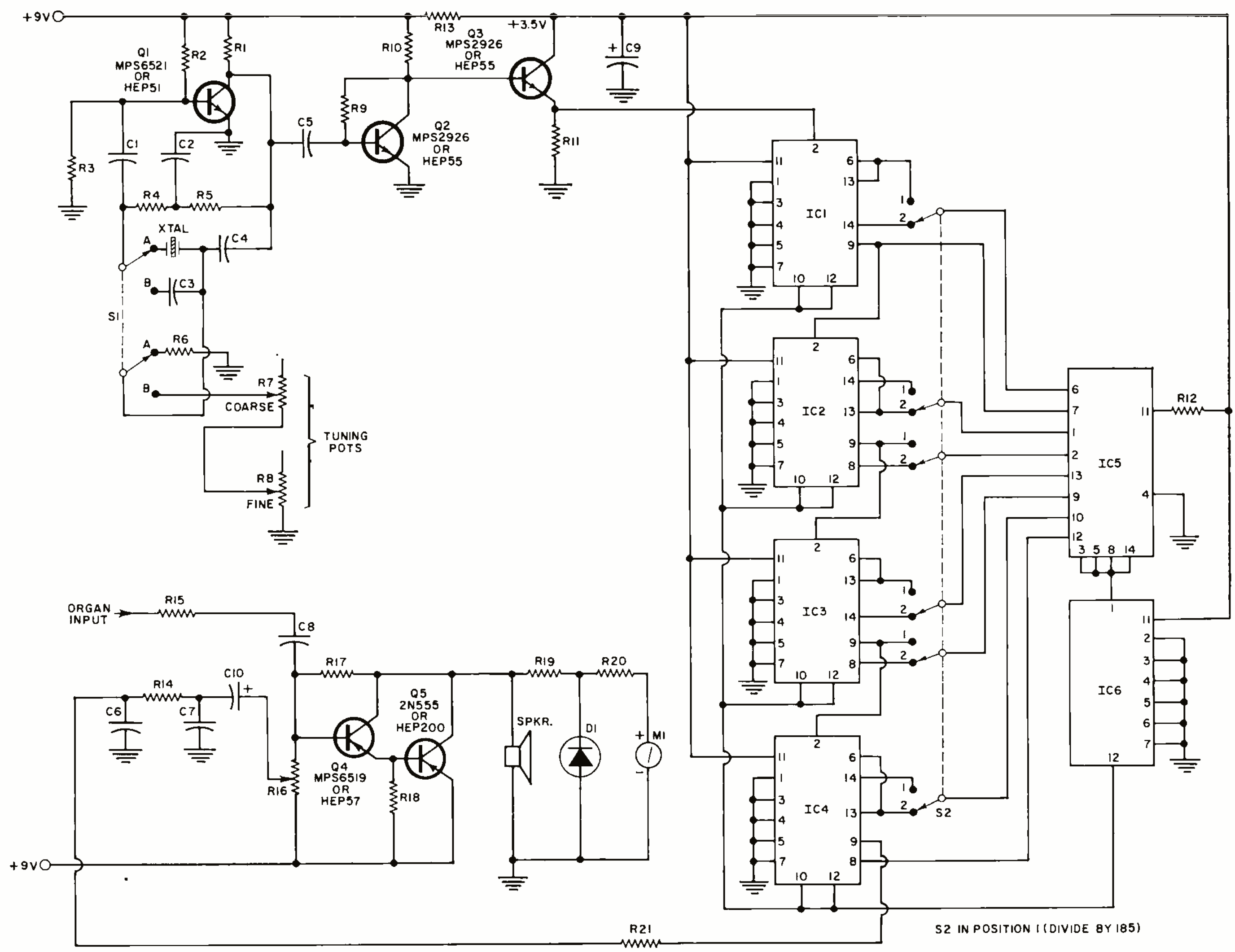
The divider. which consists of four dual J-K flip-flops. a gate, and a buffer can be switched to divide by 185 or by 196 by means of switch S2. The MC790P or HEP572 flip-flops *IC*1 through *IC*4, are cascaded to form a single eight-counter chain capable of accumulating up to 256 counts.

The gate, *IC*5, an MC724P or HEP570 quad two-input gate, is connected as an eight-input *nor* gate and requires an external load resistor (*R*12) when used for this function. Six of the eight gate inputs are connected through switch S2 to the Q and $\bar{Q}$ outputs of the IC flip-flops while the other two inputs (7 and 12) are connected directly to *IC*1 and *IC*4. S2 is a six-pole, double-throw switch. When S2 is in position 1 (divide by 185), gate *IC*5 delivers a signal to the buffer stage, *IC*6, after 185 counts are accumulated. *IC*6, in turn, sends a pulse to all of the counters, which resets them to zero. When switch S2 is in position 2, the same thing happens after 196 counts. Thus, there is one output pulse for each 185 or 196 input pulses; this is equivalent to dividing the input frequency by 185 or 196.

The output from the last counter (*IC*4) is a square wave that is passed through a low-pass filter, made up of *R*21, *C*6, *R*14, and *C*7, to the amplifier and speaker. The filter removes some of the high frequencies in the square wave to produce a more pleasant sound.

Any amplifier could be used with the tuner, but the simple Darlington-type, consisting of *Q*4 and *Q*5, is as good as any. The volume is controlled by potentiometer *R*16. The speaker may have any impedance 8 ohms or over, preferably 40 to 45 ohms, and enables tuning by the zero-beat method to be described later. The use of a meter, *M*1 in Fig. 1, is an optional and additional visual method for tuning and is preferred by many people because of its greater accuracy. This method requires an electrical signal to be inserted at the "Organ Input" terminal at the base of *Q*4. This signal is obtained from an organ by connecting the tuner ground and the Organ Input terminals to the organ's speaker terminals. The difference signals (between the organ and tuner frequencies) are rectified in diode *D*1 and read on the 1-mA meter, *M*1.

Fig. 1. Schematic and parts list of the electronic strobotuner that is discussed in the text. The IC's and switch S2 are used to divide the signal received from the oscillator, via buffer stages Q2 and Q3, by 185 and 196. The difference signal, obtained by mixing the organ input and divider output signals, is monitored for zero beat by either the speaker or meter.



R1, R3, R4, R5, R10—10,000 ohm, ½ W res.
R2—2.7 megohm, ½ W res.
R6—1200 ohm, ½ W res.
R7—5000 ohm pot
R8—100 ohm pot
R9—510,000 ohm, ½ W res.
R11—2400 ohm, ½ W res.
R12—390 ohm, ½ W res.
R13—33 ohm, 2 W res.
R14, R21—15,000 ohm, ½ W res.
R15—100,000 ohm, ½ W res.
R16—50,000 ohm pot
R17—1 megohm, ½ W res.
R18—300 ohm, ½ W res.
R19—620 ohm, ½ W res.
R20—100 ohm, ½ W res.
C1, C5—0.1 μF capacitor
C2—820 pF capacitor
C3, C4—470 pF capacitor
C6, C7—0.02 μF capacitor
C8—1.0 μF capacitor
C9—100 μF, 6 V elec. capacitor
C10—5 μF, 6 V elec. capacitor
D1—Silicon rectifier (1N4001 or HEP154)
IC1, IC2, IC3, IC4—Dual J-K flip-flop IC package (MC790P or HEP572)
IC5—Quad 2-input gate "nand/nor" IC package (MC724P or HEP570)
IC6—Dual 2-input buffer, non-inverting IC package (MC788P or HEP571)
M1—0-1 mA meter
S1—D.p.d.t. switch
S2—6-pole, d.t. switch
Xtal.—81.4-kHz crystal
Spkr.—40-45 ohm speaker
Q1—Silicon "n-p-n" transistor (MPS6521 or HEP51)
Q2, Q3—Silicon "n-p-n" epitaxial, plastic-encapsulated transistor (MPS2926 or HEP55)
Q4—Silicon "p-n-p" transistor (MPS6519 or HEP57)
Q5—Germanium "p-n-p" power transistor (2N555 or HEP200)

For other types of instrument, a pickup can be used. The zero-set screw on the meter can be adjusted to place the meter needle at approximately mid-scale. As the organ is tuned close to the tuner frequency, the meter needle will fluctuate back and forth, with the fluctuations becoming less and less pronounced as the organ is tuned closer to the oscillator frequency. Finally, when the organ frequency equals the oscillator frequency, the needle will remain motionless at mid-scale.

Predetermined Count Function

Before describing how the tuner is used, a further explanation of the counter and *nor* gate function is in order. The counter uses binary numbers rather than decimal numbers in its operations and if you are not familiar with this type of mathematical notation, it would be worthwhile to consult a reference for a simple explanation.

Using the predetermined count function, a frequency may be divided by any whole positive number. The requirements are that enough binary places be provided to produce the largest binary place number that can be subtracted from the desired divisor. The binary place values are: 1, 2, 4, 8, 16, 32, 64, 128, 256, etc.; an infinite series of the powers of 2.

The breakdown of a regular decimal number into its binary equivalent number is straightforward. The general rule is to subtract the largest binary place value from the decimal number and carry any difference to the next lesser place value. Then, subtract where a subtraction can be made, the next binary place value from the difference obtained from the previous subtraction until a difference of 0 is obtained. At every binary place value that a subtraction has been made, put down a 1, where not, a 0.

For the binary conversion of decimal numbers 185 and 196, eight binary places are required, since 128, the eighth place number, is the largest place number that can be subtracted from 185 or 196. The conversion of number 185 to binary notation is accomplished as follows:

2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	Power of 2
185	57 →	57	25	9	1 →	1 →	1	Decimal number
128	64	32	16	8	4	2	1	Binary place number
57		25	9	1			0	Difference
1	0	1	1	1	0	0	1	Binary notation

Thus, decimal number 185 is equal to binary 10111001. To determine the actual wiring connections to be made in a counter, convert the binary number, arrived at by the method described above, to its complement, by changing 1's to 0's and 0's to 1's. Consequently, the binary complements of 185 and 196 would be represented as 01000110 and 00111011, respectively.

Next, wherever a 1 appears in the complement, connect a *nor* gate input to the Q output of that binary, and where there is a 0, connect to the $\bar{Q}$ output of that binary.

Note that in the complements of 185 and 196 shown above, the second and eighth places are the same in both numbers: the Q output on the second counter and the $\bar{Q}$ on the eighth are connected directly to *nor* gate outputs. Since the other six places for the binary complements of 185 and 196 are different, the six-pole, double-throw switch, S2 in Fig. 1, is provided to permit the proper connections to be made to the *nor* gate inputs on *IC5*.

How to Use the Strobotuner

The use of the strobotuner can be explained most easily by an example; in this case the tuning of a divider-type electronic organ. By slightly modifying this procedure other instruments, such as a piano or harp, can be tuned.

Begin tuning an instrument by establishing a standard note in the middle octave range. Concert A with a frequency of 440.0 Hz is usually the standard to which all other notes are referenced. If the 81.4-kHz crystal has been incorporated in the strobotuner, the 185 divider will provide a very accurate concert A. If the crystal has not been included, another source of a standard frequency, such as a pitch pipe, accordion, clarinet, or trumpet, may be used. A very good source of concert A is an electrically driven tuning fork, which can be purchased or made.

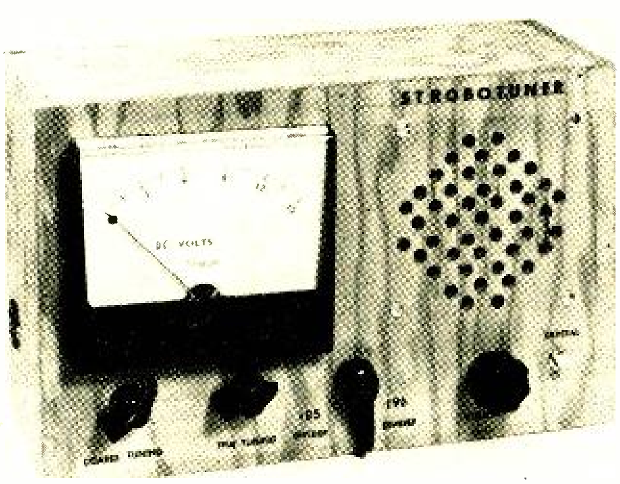
It should be noted that in an instrument like an organ, which is generally a solo instrument, it is not particularly important that the concert A have a frequency of exactly 440 Hz. It can deviate by 5 Hz or even a little more and most people will never notice. It is important, however, that the instrument be in tune with itself.

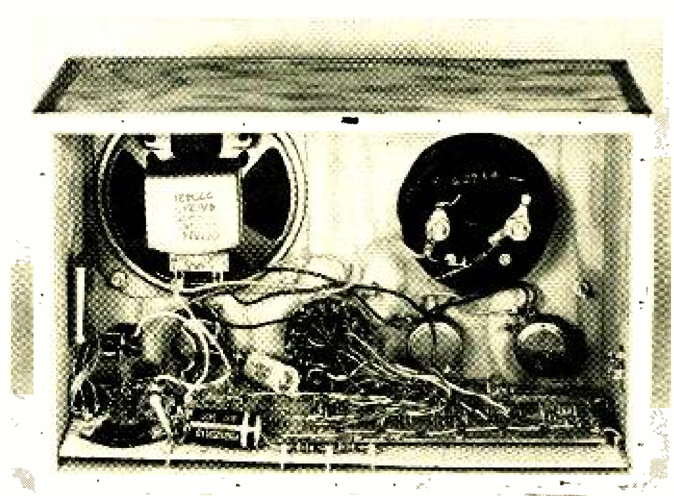
The complete tuning procedure and a check on the tuning to see how well the octave closes are given at the end of this article.

Zero-Beat Tuning

When two tone sources of approximately the same frequency, such as the tuner and organ described, are sounded together, any difference in frequency will be heard as beats. If the frequencies are too far apart, the beats will be rapid, and may not be clearly discernible. As one frequency is adjusted and brought closer to the other, the beats occur more and more slowly, until no beats are heard. This is called zero

Fig. 2. (Left) Front and (right) rear views of inexpensive electronic strobotuner built by the author to tune organs and pianos.





beat. At this point the two frequencies are the same and, if the adjustable frequency is varied further in the same direction, the beats will again increase in frequency.

The trick in zero-beat tuning is to get as close as possible to the null point. This is best done by swinging through the point two or three times to determine the best midpoint.

Actually, an exact zero beat will likely never be reached. There could be, for example, one beat every 10 seconds, or even one beat per day. In practice, however, one beat every two to ten seconds is considered acceptable tuning.

Divider-Organ Tuning Procedure

1. Tune the organ's A oscillator by using the strobotuner as follows:

(*a*) For a strobotuner with a crystal, place S1 in position A and S2 in position 1 to produce a concert A reference frequency (440 Hz). Then tune the organ's A oscillator to this reference frequency by the zero-beat method.

(*b*) For a strobotuner without a crystal, first calibrate for concert A reference frequency by adjusting the "Coarse Tuning" (*R*7) and "Fine Tuning" (*R*8) knobs (Fig. 2, left) until a zero beat is obtained against an alternate source such as an electrically driven tuning fork. Now tune the organ's A oscillator to this reference frequency.

(*c*) In many cases it is safe to assume that the organ's A oscillator is correct, and tune the other intervals to the existing A pitch. This may not place the instrument exactly on the standard musical scale, but it will put it in good tune with itself, which is more important.

2. After having established and tuned the organ's A oscillator, place S1 in position B and S2 in position 2. The strobotuner will produce a G# tone. Tune the organ G# very carefully to this frequency by the zero-beat method.

3. Place S2 in position 1 and re-adjust the strobotuner by varying the "Coarse Tuning" and "Fine Tuning" knobs until zero beat is obtained with the organ G#.

4. Place S2 in position 2. The strobotuner will produce a G tone. Tune organ G to strobotuner G by zero beating.

5. With switch S2 on the indicated position, repeat these sequences:

(*a*) On 1, re-adjust tuner to organ G.
(*b*) On 2, adjust organ to tuner F#.
(*c*) On 1, re-adjust tuner to organ F#.
(*d*) On 2, adjust organ to tuner F.
(*e*) On 1, re-adjust tuner to organ F.
(*f*) On 2, adjust organ to tuner E.
(*g*) On 1, re-adjust tuner to organ E.
(*h*) On 2, adjust organ to tuner D#.
(*i*) On 1, re-adjust tuner to organ D#.
(*j*) On 2, adjust organ to tuner D.
(*k*) On 1, re-adjust tuner to organ D.
(*l*) On 2, adjust organ to tuner C#.
(*m*) On 1, re-adjust tuner to organ C#.
(*n*) On 2, adjust organ to tuner C.
(*o*) On 1, re-adjust tuner to organ C.
(*p*) On 2, adjust organ to tuner B.
(*q*) On 1, re-adjust tuner to organ B.
(*r*) On 2, adjust organ to tuner A#.

6. Steps 1 through 5 should place the divider organ in good tune. However, one final check should be made to test whether the octave has closed. To do this, place S2 on 1 and adjust the tuner to zero beat with the organ A# set in step 5 (*r*). Place S2 on 2. Depending on the accuracy of the previous tuning procedure, the strobotuner will produce an A which is one octave below the A to which the organ was tuned in step 1. If the procedure started with an accurate concert A, the closing A will be 220 Hz. A test of the strobotuner A against organ A will reveal the accuracy of the tuning procedure. If there is less than one beat per second, the tuning job can be considered a good one. More than this indicates a frequency error has accumulated. If this is the case, repeat steps 1 through 6. ▲

Computer Time Sharing

(*Continued from page 44*)

A businessman can use a time-sharing terminal to keep track of inventory, write payroll checks, compute the tax data for all his employes, and even write form letters that look and read like personal letters. Since a businessman or engineer may occasionally have to store confidential data in a memory drum, the question often arises: "Can anyone get into my files if they want to?"

Security Levels

Time-sharing firms offer their customers three levels of security. The user's first line of security is his terminal sign-on code. When the computer asks for the user's identification code, the user must type in a certain sequence of numbers and letters which are known by only the computer and himself. As a further security measure, the user can place certain characters into the identification code that do not print out on the data sheets, thus making it impossible for anyone to discover a complete identification code by looking at a sample of the teletypewriter output that may "accidentally" become available to him.

The second line of security is the identification code the user attaches to every program or data file he stores on the memory drums; again, the user makes up his own file codes, and he can use characters that do not print out on the data sheets.

A third security measure that some time-sharing firms offer as a special service is the data scrambler. With this service, the user can tell the computer to scramble all the data fed into a file. The computer uses a random character generator to scramble the user's data; then it stores the scrambled data in one part of the memory system and the character-decoding information in another. The user attaches confidential file codes to both the decoding program and the scrambled data. Even if someone should manage to find a user's file code, the computer would print out a lot of nonsense that the best cryptographers could not crack. To see the data printed out in their original form, the user has to type in the code that is used to call up the proper unscrambling instructions.

With the new time-sharing concepts, any small business, engineering consultant, or professional office of any kind can have access to a general-purpose computer. As the state of communications technology improves, and the complexity of everyday life becomes greater, we can expect to see some form of the commercial time-sharing idea moving into the lives of us all. ▲

1937—A New Detection Device

(*Continued from page* 49)

Certainly it was strange, we all agreed, if true. But had that been the case? Probability would surely predict that my "slaved" light should have shown the most pick-ups. In the excitement, no one else had kept exact count. Hessel, however, was certain of his observations. Others, thinking back, began to confirm Hessel's point. Members of that particular searchlight crew were certainly to be congratulated for their performance.

Several days later I met the corporal who had been in charge of that particular light. "You boys did real well the other night. Congratulations," I said.

"Thanks, Doc," he grinned, "but it was easy. Remember that white cloud during the night of the tests, the one hanging over Red Bank, quite some distance from where the bomber was flying? Well, with the town lights shining on the cloud, it was possible for me, with my own eyes, to see the dim outline of the plane before you turned on your light. There I was, tracking the guy with my binoculars, right smack on the cross-hairs. Couldn't help but make a direct hit most of the time when you gave the in-action go-ahead."

"But, Corporal," I broke in, crimson-faced, "didn't you know——?"

"On the other hand," the enthusiastic boy continued, "that new secret gadget is all right. Why, every time you fellows turned on the control light, it was pretty close to the target—almost as good as my eyes."

Combining suppressed tears, chagrin and pride, I made a split-second decision. I shook the corporal's hand and said, "Well done, soldier!"

Yes, I knew our equipment was good, and that with more research it would get much better—infinitely better, even, than the corporal's eye. But I knew well too that this was to be the period of a feud between the men on the ground and the men in the air; the men trained with searchlights and sound locaters instinctively following the code of that era—illuminate that airplane as soon as possible; take advantage of every break, lest they get you first! They were soldiers—not scientists—and whoever heard of ethics in a foxhole?

That May night in 1937 was a turning point in military history. Detection of aircraft by reflected radio waves was given its "go-ahead" signal. Our equipment was ready and operating at Pearl Harbor, albeit the system failed because of Man's weakness—not the electronics.

From the efforts of our little group, from a similar group in the U.S. Navy, in England, and later in the Office of Scientific Research and Development, grew the greatest of all electronic military weapons—radar. ▲

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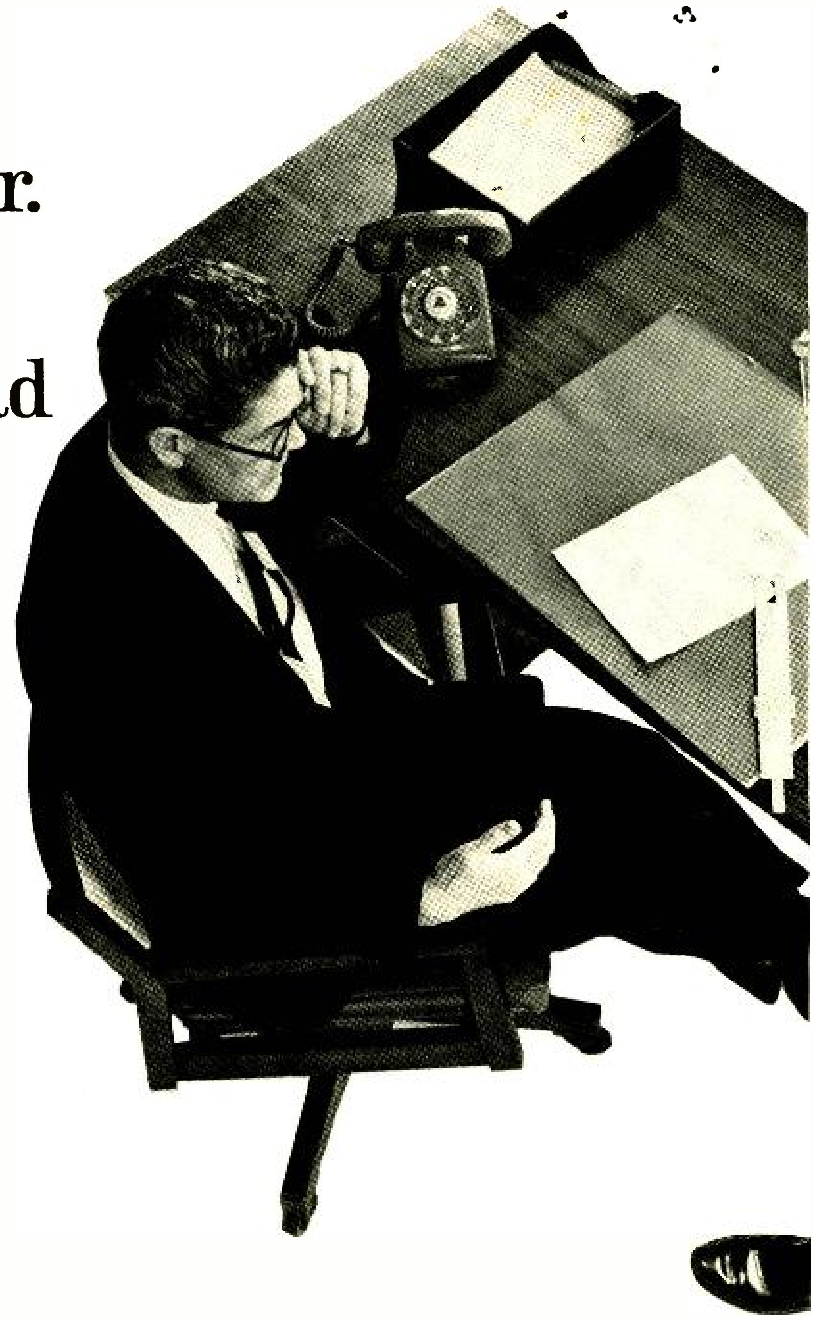
Your subscription to ELECTRONICS WORLD is maintained on one of the world's most modern, efficient computer systems, and if you're like 99% of our subscribers, you'll never have any reason to complain about your subscription service.

We have found that when complaints do arise, the majority of them occur because people have written their names or addresses differently at different times. For example, if your subscription were listed under "William Jones, Cedar Lane, Middletown, Arizona," and you were to renew it as "Bill Jones, Cedar Lane, Middletown, Arizona," our computer would think that two separate subscriptions were involved, and it would start sending you two copies of ELECTRONICS WORLD each month. Other examples of combinations of names that would confuse the computer would include: John Henry Smith and Henry Smith; and Mrs. Joseph Jones and Mary Jones. Minor differences in addresses can also lead to difficulties. For example, to the computer, 100 Second St. is not the same as 100 2nd St.

So, please, when you write us about your subscription, be sure to enclose the mailing label from the cover of the magazine—or else copy your name and address exactly as they appear on the mailing label. This will greatly reduce any chance of error, and we will be able to service your request much more quickly.

"He's a good worker. I'd promote him right now if he had more education in electronics."



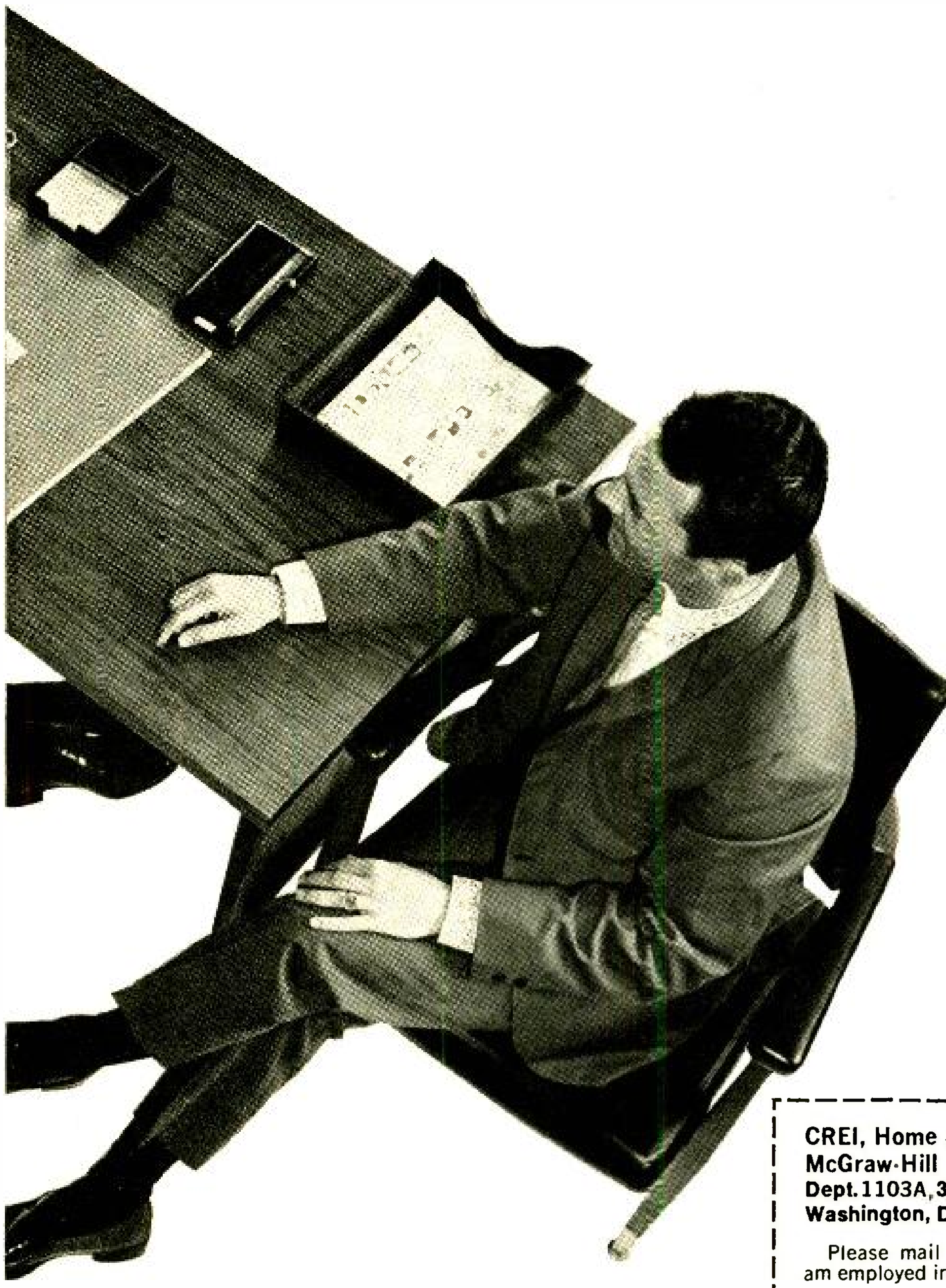
Could they be talking about <u>you</u>?

You'll miss a lot of opportunities if you try to get along in the electronics industry without an advanced education. Many doors will be closed to you, and no amount of hard work will open them.

But you can build a rewarding career if you supplement your experience with specialized knowledge of one of the key areas of electronics. As a specialist, you will enjoy security, excellent pay, and the kind of future you want for yourself and your family.

Going back to school isn't easy for a man with a full-time job and family obligations. But CREI Home Study Programs make it possible for you to get the additional education you need without attending classes. You study at home, at your own pace, on your own schedule. You study with the assurance that what you learn can be applied to the job immediately.

CREI Programs cover all important areas of electronics including communications, radar and sonar, even missile and spacecraft guidance. You're sure to find a program that fits your career objectives.



BOOKS

"SPACE-AGE TECHNOLOGY". Published by *Howard W. Sams & Co., Inc.*, Indianapolis, Ind. Five volumes.

This five-volume set covers synchros and servos, controlled guidance systems, inertial guidance systems, lasers and masers, and microminiature electronics. Each volume has been prepared by a specialist under the over-all supervision of *Training & Retraining, Inc.* This is a programmed learning course and while volumes are available separately ($4.95 each, except $5.95 for the microminiature electronics book), the reader is strongly advised to obtain all five volumes.

The use of everyday analogies, two-color diagrams with special features or salient points highlighted, and an easy, informal presentation—all combine to get the subject matter across clearly and concisely.

As with all programmed courses, this series can be handled by students working on their own. Questions muffed are immediately corrected by referring the student back to the relevant material for additional study.

* * *

"SERVICING THE SOLID-STATE CHASSIS" by Homer L. Davidson. Published by *Tab Books*, Blue Ridge Summit, Pa. 17214. 252 pages. Price $7.95.

This book has been written by a practicing technician for his fellow technicians and is a straightforward, no-nonsense presentation. Well aware of the fact that most technicians are busy men, the author wastes no time on theory, mathematics, and other non-essentials but sticks to the how-to-do-it approach exclusively.

He has divided his material into twelve chapters which start off by checking the transistor, servicing transistorized TV receivers, pocket radio repair, a.c.-d.c. chassis troubleshooting, AM-FM radios, multi-band receivers, auto radios, auto tape players, portable phonos, stereo amplifiers, portable tape recorders, and troubleshooting printed-circuit boards.

There are many illustrations of various types and a generous sampling of case histories to help the technician out with his own "tough dogs."

* * *

"USING YOUR TAPE RECORDER" by Harold D. Weiler & Louis M. Dezettel. Published by *Allied Radio Corporation*, 100 N. Western Ave., Chicago, Ill. 60680. 112 pages. Price 75 cents postpaid.

This revised and updated edition covers in detail the various types of recorders now on the market, including the new cassettes and automatic-reversing units.

Written in simple language and addressed to the non-professional and hobbyist, the text is divided into eleven chapters which deal with sound, the recorder, microphone recording, dubbing from records, off-the-air recording, tape editing, the tape, adding sound effects, adding sound to slides and movies, recorder maintenance, and choosing a recorder. The book is well illustrated and the writing is informal and lucid.

* * *

"SHORTWAVE VOICES OF THE WORLD" by Richard E. Wood. Published by *Gilfer Associates, Inc.*, Park Ridge, N. J. 96 pages. Price $3.95.

This is a unique book in that the author explains the "hows and whys" of the short-wave listening hobby and places less emphasis on schedules and operational details than do many handbooks of this type. In transmitting his enthusiasm for his hobby—which he terms a "window on the world"—the author has provided a guide to this new, fast-changing medium. He explains the significance of international broadcasting, how the frequency bands are allocated, the various broadcasting services, languages used and station identifications, programming, jamming, reception reports and QSL's, propagation, and when to tune in.

The author has written about his hobby with love, enthusiasm, and deep understanding. The text is lavishly illustrated with photographs of station equipment and the personnel who conduct the programs enjoyed by SWL's around the world.

* * *

"MOTOROLA COLOR TV SERVICE MANUAL" by Forest H. Belt. Published by *Tab Books*, Blue Ridge Summit, Pa. 17214. 160 pages plus schematic section. Price $7.95 flexible cover, $4.95 paperbound.

This volume covers all *Motorola* color chassis TS-907 through TS-924 and is designed to speed TV troubleshooting and improve service. The first five chapters deal with setup, alignment, troubleshooting, remote-control systems, etc. as they apply to all models in the line while the next eight chapters deal with specific chassis and servicing procedures. The author has also incorporated factory modifications and service hints to make this volume as self-contained as possible.

Fold-out schematics are provided on the TS-907B, TS-908, TS-912, TS-914, TS-915/919, TS-918, TS-921, and TS-924 chassis. Each of the schematics is cross-referenced to the appropriate chapter where that model is discussed.

A thorough study of the five basic chapters and then reference to the discussions in specific chapters as the set appears on the service bench should provide the technician with sufficient knowledge to handle *Motorola* color-TV repairs with neatness and dispatch.

* * *

"MOST-OFTEN-NEEDED . . ." compiled by M. N. Beitman & Hartford Beitman. Published by *Supreme Publications*, Highland Park, Ill. Price $4.00 each. Soft cover.

Here are two new volumes in this publisher's "Most-Often-Needed" series of servicing information. Volume C-69 covers 1969 color-TV sets while Volume R-27 provides diagrams and servicing information on radio receivers for the years 1967 through 1969.

Both volumes are in the familiar format with photographs, PC board layouts, underchassis views with parts called out, parts lists, service hints, and schematics.

* * *

"INTRODUCTION TO SOLID-STATE TELEVISION SYSTEMS" by Gerald L. Hansen. Published by *Prentice-Hall, Inc.*, Englewood Cliffs, N. J. 07632. 436 pages. Price $15.00.

This book should find a wide audience among educators; medical personnel; utility engineers; owners and operators of stores, banks, warehouses; police and fire department heads, oceanographers—in fact anyone whose job can be made easier and more thorough by the use of TV systems.

The text is divided into six well-illustrated chapters covering applications for such equipment, basic systems, optical principles, camera tubes, scanning systems, video amplification and processing, monochrome sync generators, monochrome TV monitors, operational procedures for black-and-white systems, principles of color TV, the color camera and associated circuits, sync lock circuitry and subcarrier generators, color encoders and associated equipment, color receivers and monitors, video switching systems, and basic principles of video tape recording.

The treatment is non-mathematical and the exposition is lucid yet informal. ▲

Editor's Note: The price of the paperbound edition of the book, "Zenith Color TV Service Manual" by Robert L. Goodman, was incorrectly listed in our January reviews. The correct price is $4.95.

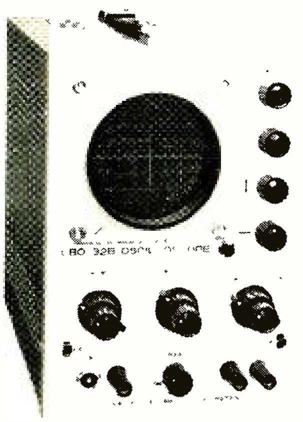
NEW PRODUCTS & LITERATURE

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 on business letterhead.

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

SOLID-STATE SCOPE

The LBO-32B is a wide-band, solid-state oscilloscope with a bandwidth of d.c. to 7 MHz, making it suitable for every phase of color-TV servicing. The 3-inch scope has special input cir-



cuitry which stabilizes the d.c. level so that power-line fluctuations have no effect on the position of the CRT display. This is said to enhance the instrument's input sensitivity of 10 mV/cm. The horizontal and vertical amplifiers are easily balanced so the instrument adapts itself to use as a vectorscope. The sweep circuit has a frequency range of 1 to 200,000 Hz in six steps and automatically locks to the horizontal sweep rate of the TV signal.

The unit measures 9" high x 6¾" wide x 10½" deep and weighs 17.6 pounds. Leader

Circle No. 6 on Reader Service Card

DIGITAL CASSETTE

A precision digital cassette designed specifically for cassette tape drives used as computer peripheral devices has been introduced as the Series PC-800.

The cassette utilizes a new design to provide the greatest reliability and best tape skew and tape pack characteristics, according to the company. The PC-800 employs a precision metal plate, steel-bearing-mounted fixed hubs, and a four-point tape path system. Additional design features include self-aligning precision rollers, new pressure pads, and a new hub construction principle. The cassette uses the Series 870 CATT computer tape. Ampex

Circle No. 7 on Reader Service Card

AM/STEREO-FM RECEIVER

The Model 3800 AM/stereo-FM receiver features a "human-engineered" exterior which includes an upward-angled panel and dial and computer-style keyboard. The tuning knob is weighted and balanced for better "feel" and faster tuning across the dial. The pedestal-based walnut cabinet is integral to the total design and is included.

Indicator lights on the front panel signal reception of stereo broadcasts and also tell when the receiver is tuned for best reception.

Total power is 210 watts ±1 dB at 4 ohms; 85 watts/channel at 4 ohms (IHF), and 53 W/channel continuous power at 4 ohms and 43 W/channel at 8 ohms. Frequency response is 15-30,000 Hz ±1 dB. Usable sensitivity is 1.9 μV and stereo separation is 40 dB. H.H. Scott

Circle No. 8 on Reader Service Card

BASE/MOBILE TRANSCEIVER

A new solid-state, full 5-watt, 23-channel CB base/mobile transceiver has been introduced as the Model SFT-800. Housed in a bright chrome case which measures only 5¾" wide x 6¼" deep x 1⅞" high, the transceiver can be used in any car and may be installed in the glove compartment if desired.

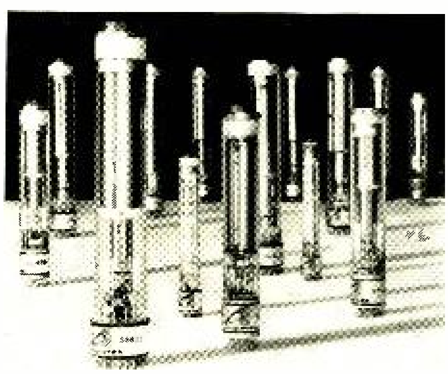
An incoming signal indicator automatically lights up when receiving an S-6 signal or better so the driver can keep his eyes on the road. Ceramic filters are employed to assure best selectivity. An optional accessory, the Model PAC-2 "Priv-A-Call," screens out all noise except for the calls to the station. Left in standby, the unit is completely quiet.

The transceiver comes equipped with crystals for all 23 channels. Fanon

Circle No. 9 on Reader Service Card

TV CAMERA TUBES

An expanded line of Plumbicon TV camera tubes is now available. The line includes new pickup tubes for miniature TV cameras, retrofits



for existing vidicon cameras, and many other new types for specialized functions, including image-intensification, medical, industrial, and educational CCTV applications.

Complete details on this new line will be forwarded on request. Amperex

Circle No. 10 on Reader Service Card

COMPACT SOUND SYSTEM

The C-5600 compact sound system features decor-designed housing, a bi-amplified stereo system with broadcast-quality transcription record player, stereo tuner, and a pair of external matching infinite-baffle speakers.

The AM-FM tuner uses FET circuitry and is equipped with bass and treble tone controls, a loudness contour switch, tape monitor/receiver terminals, and a stereo headset jack. All controls are front-panel mounted beneath the large illuminated dial for easy access.

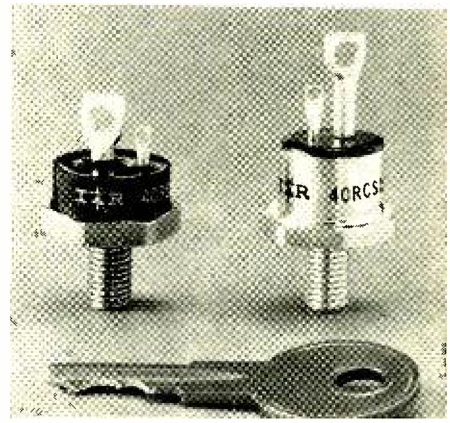
The turntable is operated by a hysteresis synchronous motor for two-speed operation: 33⅓ and 45 r/min. The tonearm is a static balanced tubular type with an arm elevation device. Stylus pressure is 2.5 to 3 grams. A hinged dust cover protects the record player when not in use. Pioneer

Circle No. 11 on Reader Service Card

40-AMP SCR's

An economy line of 40-ampere SCR's offering medium-current-rated units for high-voltage applications of 700 to 1200 volts, is now available.

The 40RCS series is offered in two versions:



epoxy package—up to and including 600-volt rated devices, and glass-to-metal sealed devices rated from 700 through 1200 volts.

The new units are suitable for applications in battery chargers, d.c. motor controls, power supplies, heater controls, and airborne and mobile converters. International Rectifier

Circle No. 12 on Reader Service Card

U.H.F. AMPLIFIERS

Two new solid-state, broadband and single-channel, u.h.f. amplifiers for MATV system applications are now available as the M-174 and M-175.

Both units are designed to serve a MATV system that can accommodate up to 200 TV sets in a building. The M-174 single-channel amplifier offers a 30 ±3 dB gain with a 1-volt output on a single u.h.f. channel, while the M-175 broadband unit provides the same gain with a 1-volt composite output on all u.h.f. channels. Both amplifiers have a 75-ohm single output. Finney

Circle No. 13 on Reader Service Card

DIGITAL PANEL METER

An all-solid-state digital panel meter has just been introduced as the Model 275. The new unit is a full four-digit meter with an accuracy of 0.05% and 100 μV resolution. It is housed in a self-contained package which uses only 2$\frac{1}{16}$" x 4½" panel space.

Input impedance is 100 megohms and the meter features drift canceling, ramp voltage comparator, and crystal-controlled digitizing os-

cillator. Standard features include front-panel error indication and 1-2-4-8 BCD output as an option. The meter displays a full-scale reading of 999.9 millivolts d.c. United Systems

Circle No. 14 on Reader Service Card

8-TRACK/CASSETTE STEREOS

A new line of 8-track and cassette stereo units is now being offered as the Gemini series.

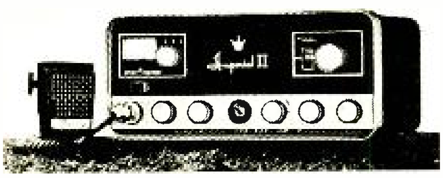
Currently available models include an 8-track stereo player, an 8-track stereo player with AM/FM radio, an 8-track stereo player with AM/FM multiplex, a cassette stereo recorder/player with AM/FM, a cassette stereo recorder/player with AM/FM multiplex, and an 8-track stereo player combined with a cassette recorder/player.

Specifications on the line are included in a compact brochure which is available on request. Soundtech

Circle No. 15 on Reader Service Card

23-CHANNEL TRANSCEIVER

The "Imperial II" CB transceiver is designed to transmit and receive all CB signals. The transmitter section operates on double sideband with suppressed carrier for greater talk power. This



mode can be used when in contact with similarly equipped units, however, a switch of the control knob changes the transmitter to conventional AM operation by producing a double sideband signal with reduced carrier.

The receiver section incorporates a 7:1 vernier controlled v.f.o. control for easy adjustment of sideband reception. The dual-conversion superhet design is complemented with a switch-controlled noise blanker circuit. An r.f. gain control adjusts sensitivity for maximum performance.

The unit comes with two power cords, a built-in 5" speaker, and a four-function "S" meter. The unit operates on 117 V a.c. or 12 V d.c. for either base or mobile applications. Regency

Circle No. 16 on Reader Service Card

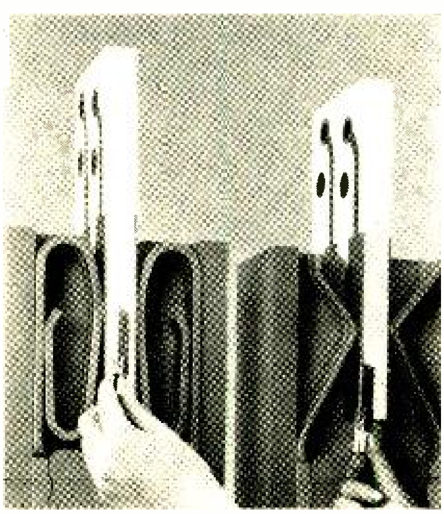
CORDLESS HEADSET FOR TV

Of interest to all those who enjoy watching the Late Show is the new cordless headset, Model 100, that permits the speaker in the TV receiver to be muted yet channels the sound to the wearer and allows complete mobility. Headset frequency response extends to 20,000 Hz. Sharpe

Circle No. 17 on Reader Service Card

NEW CONNECTOR LINE

Sylvania Electric Products Inc., a new entry in the commercial connector field, has introduced a



series of PC board connectors that offers manufacturers 312 different configurations from available tooling, with the same reliability as custom parts, according to the company.

The P101 connectors meet MIL-Specs and are designed to accommodate automatic wire-wrapping machines. For full details on this line, write Parts Div., 12 Second Ave., Warren, Pa. 16365 on your business letterhead.

BASE & DUST COVER

A new base for the Dual 1219 automatic turntable features a unique fitted panel which is designed to hold all of the spindles made for the 1219, plus two mounted cartridges. The base is $14\frac{1}{4}$" x 17", no larger than a conventional base.

The matching dust cover for the WB-19X also has an unusual feature. Its front panel and the front section of the top are hinged so they can be raised and folded back. This provides access to all the operating controls of the turntable without having to remove the cover and its dust protection. The entire cover can also be raised and left in a tilted position, or removed entirely when desired. Made of heavy, smoke-tinted Plexiglass, the cover is listed as the DC-9X. United Audio

Circle No. 18 on Reader Service Card

RESISTANCE STANDARD

General Radio Company, 300 Baker Avenue, West Concord, Mass. 01781 has announced the availability of a new high-reliability, low-temperature-coefficient reference resistance standard, the Type 1444.

Since these 10k-ohm standards are practically unaffected by atmospheric pressure or mechanical and thermal shock, they can be used as portable standards for intercomparison as well as in standard laboratories. The resistor used as a standard consists of two special 5k-ohm resistors hermetically sealed in a stainless-steel container which is shock-mounted in an outer container and then placed in a foam-rubber-lined carrying case.

Two versions of the standard are currently available. The company will supply full details on written request.

BULK CASSETTE ERASER

The new Voice-Master MX-500 "Erase-O-Matic" is designed to erase Memocord; Phillips

Type C30, C60; Norelco 85; Mini-Memo, and other magnetic tape cassettes instantly.

Requiring no electric current, the device may be used anywhere and is suitable for clearing recordings for security reasons or prior to re-use of cassettes. The unit measures $3\frac{3}{4}$" x 4" x 2". Audio Applications

Circle No. 19 on Reader Service Card

BOOKSHELF SPEAKER SYSTEM

The new "Imperial III" is a three-way bookshelf speaker system featuring a 12-inch acoustic-suspension woofer plus separate dome-type, mid-range and high-frequency speakers.

Available in walnut, the system is finished in hand-rubbed French lacquer. Marantz

Circle No. 20 on Reader Service Card

STATIC LOCATOR

The "Staticmaster" is a hand-held instrument which measures static and locates the source. The unit measures 5" wide x 7" high x $2\frac{1}{2}$" deep and weighs 2 pounds. A 36" telescoping antenna permits getting into inaccessible locations.

Operation is simple. A push-button on the left side is held down while the needle on the right

side is brought to zero position by a knob adjustment. Then static may be read either plus or minus up to 100,000 volts. The circuit is solid-state and operates from penlight cells. Kaymaster

Circle No. 21 on Reader Service Card

MASTER PROTECTION SYSTEM

The Model C-7360 master protection system for home or office is battery powered and fail-safe in operation. This user-installed system has a full line of sensors to protect against fire, flood, power failure, smoke, and intrusion. A solid-state circuit accepts all sensors in a single plug-in system. Activation of any sensor in the system sets off a horn with a noise level of about 95 dB. Only a turn-off key at the key-lock switch de-activates the alarm. The master unit measures $5\frac{1}{4}$" x 7" x $2\frac{1}{2}$" and requires two "D" cells. James Electronics

Circle No. 22 on Reader Service Card

QUICK CURE ADHESIVE

Emerson & Cuming, Inc., Canton, Mass. 02021 has introduced Eccobond Kwik, a one-part adhesive which offers new convenience in application because of its rapid cure (10 to 45 seconds). One or more drops are applied directly to one of the surfaces to be bonded, the surfaces are mated, aligned, and held for a few seconds. Clamps are not required.

The adhesive works with almost any combination of materials except polyethylene, polytetrafluoroethylene, and porous materials such as paper and wood.

Full details on Eccobond Kwik will be supplied upon letterhead request.

IC REGULATED POWER SUPPLIES

The "Com-Pak Mark II" LC series of integrated-circuit power supplies is now available in

five package sizes. The series—the first d.c. power components to use an IC to provide the regulation system—is now available in both single- and dual-output models to 150 V d.c. and current ratings to 4.5 amps. Twenty-nine single-output models and seventeen dual-output models are offered.

The power package can be as small as 3 7/32" x 3 9/32" x 1 21/32". The LC series is all-silicon and convection cooled, with no external heat sinks. Regulation is 0.01% +1 mV. Ripple and noise is 250 μV r.m.s.; 1 mV peak-to-peak. The series is multi-current-rated for 40, 50, 60, and 71 degrees C. Input voltage and frequency range is 105-132 volts a.c., 57-63 Hz on this new series. Lambda

Circle No. 23 on Reader Service Card

PROFESSIONAL TAPE DECK

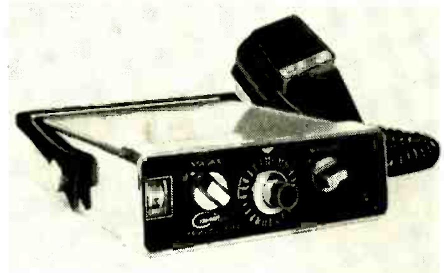
The Model 5050XD stereo tape deck will accept up to 10½-inch reels and offers a full complement of professional features. Included are automatic reverse capabilities which provide 24 hours of broadcast-quality sound in two directions; four separate heads for erase, playback, record, and bias; 3-speed capstan for selection of 7½, 3¾, and 1⅞ in/s via a three-speed electrically switched motor; 3 motors including a 3-speed hysteresis synchronous plus two six-pole eddy-current reel motors for smooth tape takeup, uniform tape tension, long bearing life, faster rewind and fast-forward, and smooth braking.

Complete specifications on this deck are available on request. Roberts

Circle No. 24 on Reader Service Card

SOLID-STATE CB UNIT

The "Traveller II" is a solid-state 23-channel CB radio which measures only 5¾" wide x 6¼" deep x 1⅞" high and weighs 3.5 pounds.



This new mobile model includes automatic i.f. noise blanker to reduce ignition noise; full talk power; instant operation; an exclusive "Safety-Circuit" which guards against antenna mismatch, incorrect polarity, and overload; and an illuminated "S" meter.

The d.c. power consumption is 200 mA on standby and 1 A on transmit. Courier Communications

Circle No. 25 on Reader Service Card

MANUFACTURERS' LITERATURE

POWER COMPONENTS/SYSTEMS

Lambda Electronic Corp., 515 Broad Hollow Road, Melville, New York 11746 has issued a 70-page catalogue covering its line of power instruments, power components, and power systems.

Included in the power components are IC regulated modular d.c. power supplies (both industrial and military models), modular d.c. power supplies, and a.c. power conditioners. LC/LM power-supply assembly systems and power instruments are covered in separate sections of the catalogue.

Write on your business letterhead if you would like a copy of this comprehensive listing.

RFI FILTERS

Components Corporation, 2857 N. Halsted Street, Chicago, Ill. 60657 is offering copies of its new catalogue describing an expanded line of miniature RFI filters covering 50, 100, 150, and 400-volt d.c. types and 115-volt a.c. units.

The catalogue provides complete electrical and mechanical data for easy specifying. It also provides data and charts on minimum attenuation characteristics at various frequencies as well as detailed data and chart on the effect of capacitance over a wide temperature range.

A request on your business letterhead should be sent to the company at the above address.

POWER SEMICONDUCTORS

The Pirgo line of power transistors and triacs is described in detail in a new 28-page short-form catalogue (IND-875).

The publication includes an index by type number, a silicon transistor selection guide, lists of silicon power transistors, an interchangeability chart, triac specifications, and information on packages and physical dimensions. The material is presented in tabular form for quick reference. Sprague Products

Circle No. 26 on Reader Service Card

MODULE LITERATURE

A new catalogue which lists currently available electronic constructor modules in the Sinclair line has been issued. There are over a dozen modules and combinations of modules in the line and each is described in some detail. The line presently offers two complete amplifier systems plus two types of speakers as well as an integrated-circuit amplifier/preamp for varied applications. Audionics

Circle No. 27 on Reader Service Card

RECORDING BIBLIOGRAPHY

A new bibliography of reference works on magnetic recording has been prepared as a service to those interested in developing a technical library on magnetic recording.

Over 40 books and publications are listed, covering such topics as recording theory and practice, circuitry for magnetic recording, video recording, servicing and repair of recorders, and magnetic recording standards.

Copies of Form No. 7288C are available on request. Nortronics

Circle No. 28 on Reader Service Card

TURNTABLE GUIDE

Two colorful booklets describing the automatic turntables in Garrard's two separate 1970 lines have been issued.

The "Component Series," comprising 8 turntables, is described in a 24-page booklet of color photos of all units and precise descriptions of all the features of the turntables. A separate 12-page booklet covers the new "Module Series," with four automatic turntables which are ready to plug into other components and play. British Industries

Circle No. 29 on Reader Service Card

MICROPHONE PRODUCTS

A comprehensive catalogue describing the company's line of microphones, mike mixers, and related products for p.a. and tape-recording applications is now available for distribution.

Included in the catalogue are illustrations and technical specifications, along with an extensive guide to microphone types and microphone selections. Copies of Catalogue No. AL314 are available without charge. Shure

Circle No. 30 on Reader Service Card

SPEAKER SYSTEMS & KITS

A 10-page brochure featuring a line of speaker systems and "instant kits" is now available. Printed in two colors, the illustrated "Sound of Excellence" brochure describes an entire line of speaker systems in both assembled and kit versions. LWE Div.

Circle No. 31 on Reader Service Card

SPEAKERS/SPEAKER SYSTEMS

Two colorful data sheets, one covering hi-fi speaker systems and electronics and the other providing information on component speakers, have been issued as Forms 1262 and 1263, respectively.

The material is presented in concise, easy-to-use form to enable the buyer to decide in advance which models might meet his specific requirements. Electro-Voice

Circle No. 32 on Reader Service Card

NEON LAMP APPLICATIONS

A new 12-page technical brochure which describes application ideas for neon glow lamps as circuit components and voltage regulators is now available from Signalite Inc., 1933 Heck Avenue, Neptune, N.J. 07753.

The brochure lists some 22 circuit applications for neon lamps in vidicons, photomultipliers, power supplies, remote controls, memories, timers, proportional controls, moving signs, suppressors, photochoppers, binary decoding, frequency dividers, flash-tube triggering, and energy-transfer applications.

When writing for your copy, please specify "Applications Ideas."

SMALL COMPUTER HANDBOOK

The 404-page Small Computer Handbook is designed to acquaint readers with Digital Equipment Corporation's PDP-8 family of small computers. The handbook explains both the PDP-8/I and PDP-8/L central processors and how they are interfaced and operated.

The 13 chapters cover standard system operation, basic programming and instructions for the memory and processor, data break, internal operations, input and output equipment instructions and facilities, programmed data transfers and data break transfers, digital logic circuits, interfacing, and system installation and planning.

Write Department P of the company at 146 Main Street, Maynard, Mass. 01756 on your business letterhead for a copy.

ELECTRONIC INSTRUMENTS

Honeywell Test Instrument Division, P.O. Box 5227, Denver, Colorado 80217 has just published a condensed catalogue describing its line of electronic test and measuring instruments.

The 24-page publication covers the complete line of products made by the division as well as instruments distributed under exclusive agreements with other firms.

Products and systems described include oscillographs, X-Y and magnetic tape recorders, signal-conditioning equipment, digital multimeters, transducers, biomedical monitoring and recording instrumentation, and RFI/EMI surveillance and analysis equipment.

Your letters requesting a copy of this catalogue should be addressed to the attention of Kirt Salisbury, the advertising and sales promotion manager, at the above address.

CONNECTOR CATALOGUE

A 48-page catalogue listing a full line of connectors has been published by Dale Electronics, Inc. Included are 18 different connector types within the following categories: printed circuit, rack and panel, side mount, umbilical, and round keyed shell.

Complete dimensional information and ordering details are provided on all models.

Copies may be obtained from the Connector Division of the company, Department 860, P.O. Box 609, Columbus, Nebraska 68601.

SCR CATALOGUE

National Electronics, Inc., Geneva, Illinois 60134 has issued a 16-page catalogue covering its line of SCR's. Included in the publication is a selection guide and technical data in tabular form on all of the company's products.

Copies of this valuable guide are available on letterhead request.

COMPREHENSIVE CATALOGUE

The new, 112-page, 1970 catalogue, #702, which features the latest in hi-fi components, systems, and CB equipment is now ready for distribution.

Included in this comprehensive listing are portable radios, audio lights, TV sets, stereo tape recorders, test meters, cassette and cartridge recorders, hi-fi speaker systems, auto accessories, TV antennas, musical instrument amplifiers, and an extensive line of ham gear.

A copy of this new publication is yours for the asking. Lafayette

Circle No. 33 on Reader Service Card

BOOK LIST

A Winter 1970 catalogue describing over 125 current and forthcoming books is now available. The new 16-page, illustrated catalogue covers schematic/servicing manuals; broadcasting; basic technology; CATV; electric motors; electronic engineering; reference works; TV, radio, and electronics servicing; audio and hi-fi; hobby and experiment; test instruments; and transistors.

Copies of this handy reference list will be forwarded promptly. Tab Books

Circle No. 34 on Reader Service Card

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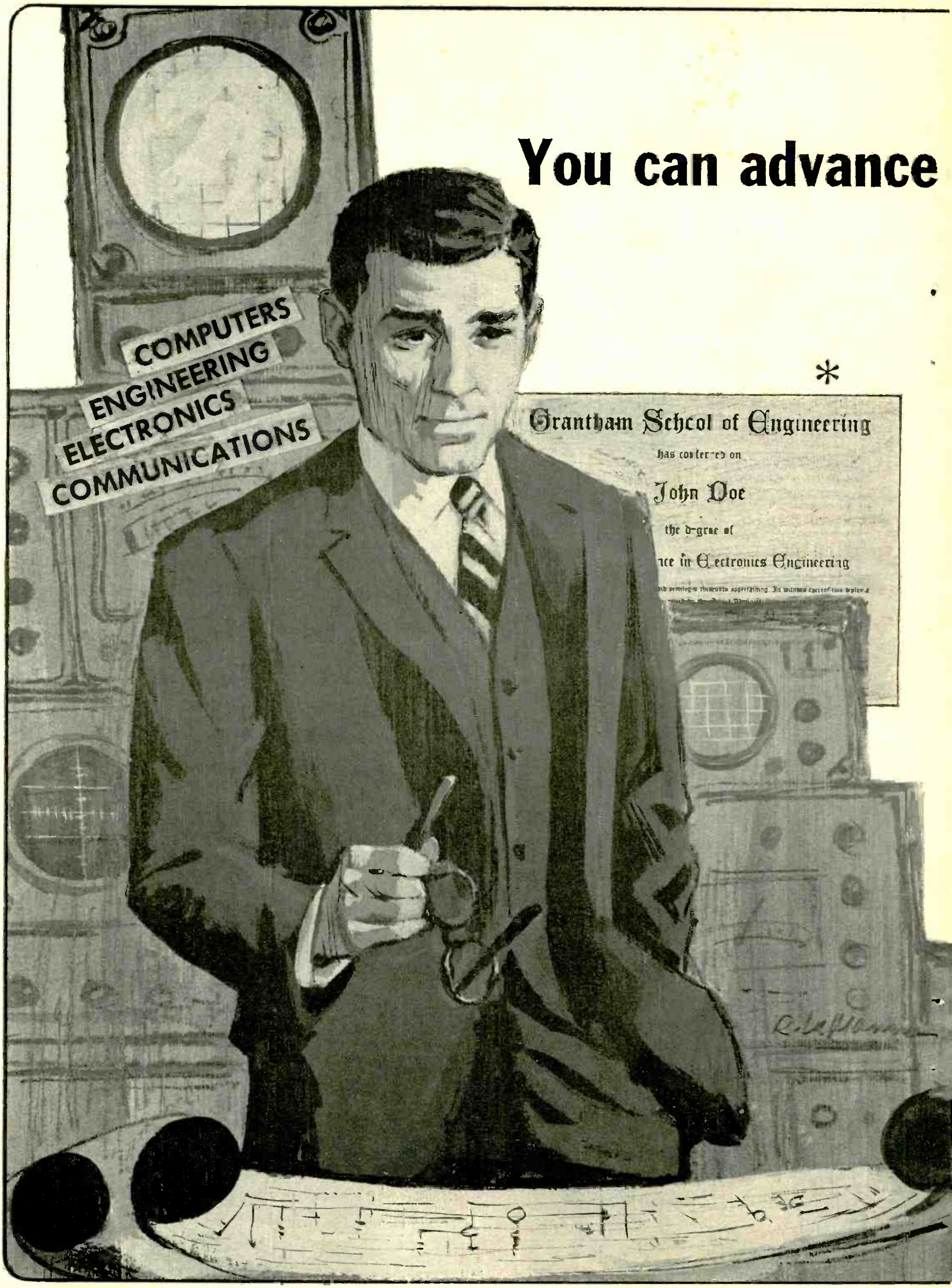
69 (bottom)	Sencore

Answers to C.E.T. Test, Section #1

Published in Last Month's Issue:

1. (d) RG-59U coax will have more loss on channel 13 when the lead-ins are dry.
2. (d) Standing waves are signals reflected back into the transmission line, caused by impedance mismatch.
3. (c) 0 dBm means 1000 microvolts of signal. This was the original standard amount of minimum signal from which TV receivers were designed to operate.
4. (b) A simple dipole has 2 elements separated by an insulator and, therefore, infinite resistance. It also has an impedance of 72 ohms at resonance. A *folded* dipole has practically 0 ohms d. c. resistance; impedance is 300 ohms at resonance.
5. (a) A yagi antenna is more highly directional, with several directors and reflectors in line.
6. (b) A 2-way splitter normally has 3.5 to 4.0 dB loss on channel 13.
7. (d) The only correct answer is to use a matching transformer to match the 72-ohm antenna to the 300-ohm line. The line is already matched to the 300-ohm receiver.
8. (d) Answers a, b, or c might well be used for specific interference problems, but a 4.5-MHz trap is used in the video-amp section of a TV receiver.
9. (a) A shorted auto antenna may still supply signal to the receiver but it has no effect on the radio power supply or fuse and would not harm the antenna input coil.
10. (d) Vertical polar pattern normally would not be important, unless the TV transmitter were located atop a nearby high mountain or on an airplane (as in the experimental educational broadcast system).


You can advance
*
COMPUTERS
ENGINEERING
ELECTRONICS
COMMUNICATIONS
Grantham School of Engineering
has conferred on
John Doe
the degree of
nce in Electronics Engineering

from electronics technician to
ELECTRONICS ENGINEER!

It's great to be a technician, but even greater to be an engineer. In becoming an engineer, you upgrade to professional status and higher pay. Employment opportunities for electronics engineers are almost unlimited.

In a recent survey, the Engineering Manpower Commission found that engineering employment in the electrical and electronic industries is expected to increase by 40% in the next ten years. The need for engineers is increasing faster than the population as a whole, and the percentage of college students who are going into engineering is decreasing. The survey indicates that in the next decade, employers expect to need *twice as many* new engineering graduates as are likely to be available.

The *accredited* Grantham *home-study* program in electronics engineering consists of five "correspondence semesters" (a total of 370 lessons) followed by a two-week seminar at the School. This program leads to the *Degree* of Associate in Science in Electronics Engineering.

Students who earn the ASEE Degree may then continue in resident classes in Hollywood to earn the BSEE Degree.

Grantham School of Engineering is *accredited* by the Accrediting Commission of the National Home Study Council, is *approved* under the G.I. Bill, and is authorized under the laws of the State of California to grant academic degrees.

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1505 N. Western Ave., Hollywood, Calif. 90027
Telephone: (213) 469-7878

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*To the best of our knowledge, GRANTHAM School of Engineering is the only school in the United States that is *authorized and accredited* to grant a degree in an engineering field, entirely on the basis of *home-study instruction* except for the final two weeks. However, this accredited degree program is available only to experienced technicians who already know the "hardware" side of electronics.

Grantham School of Engineering EW-3-70
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Please mail me your free Bulletin, which explains how the Grantham educational program can prepare me for my Associate in Science Degree in Electronics Engineering.

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I have been an electronics technician for______ years.

Color TV for 1970

(Continued from page 52)

more. That loads down the winding and reduces the pulse to normal amplitude.

The *Olympic* CT-400 uses a 6BQ5 beam pentode as a pulse-load regulator (Fig. 13). However, there's no VDR to sense the changes. Instead, the cathode is returned to "B+" and the control grid ties to a divider across boost. Anything that lowers high voltage also reduces boost. The result: less positive bias and less loading by the tube: the amplitude of the flyback pulse returns to normal, and so does high voltage.

Toshiba's C6A chassis has a 23JS6A tube in virtually the same arrangement. The 12A12C52 *Zenith* chassis has a stage something like the *Arvin* described above, but with a thermistor instead of a VDR.

A really odd one is in the *Hitachi* CWA-200. A special saturable reactor is included in the collector circuit of the horizontal-output transistor. The greater the pulse amplitude, the more average d.c. current the transistor draws—it's the nature of that class of transistor amplifier. The reactor begins to saturate. It becomes less efficient in coupling energy to the flyback transformer, and the high voltage drops back to normal.

Serviceability

Two things are generating heat among manufacturers, service technicians, and customers this year. They are: warranties and serviceability. There are at least three sides to the story, with no real answers in the offing. More and more, a fourth side is added—that of the government "consumerists."

The trouble over warranties began because buyers could not understand the terms. Government decided customers aren't really getting the kind of products or guarantees they should have.

Take warranties. Demands range from merely clarifying the wording to at least 2 years' warranty—covering all faulty parts, all labor to replace them, and all transportation and shipping that relates to making the warranty good. That latter notion will probably win out, too—with the time limit perhaps only a year. Another year or two will tell.

But a warranty has no value unless there are competent people to make whatever repairs become necessary. That's a constant problem in most parts of the country. Technicians in the field blame the more and more complex chassis with parts in hardly accessible locations. This isn't an idle complaint. You have only to open the backs of some of the chassis mentioned in this article: some sections cannot be reached for anything, even minor testing, without time-consuming and annoying disassembly.

A lot was done during 1969 to train more and better technicians and more will be done in 1970. But the best over-all gains are the construction improvements that simplify servicing. *Motorola* has taken a long stride with the modular concept; the company has also prepared a whole bookful of excellent suggestions for testing and repairing modules. *Clairtone* has a similar idea that will work well if they provide sufficient information for technicians all over the country, as *Motorola* has. *Sylvania* and *Zenith* broke the barrier to in-home service on transistor receivers by plugging transistors into sockets; they can be tested and substituted as simply as a tube, now.

More companies need to change their thinking in chassis layout and design. That will lower costs for owners, without chiseling service shops out of a fair and honest profit or technicians out of a decent wage. And think of the dollars that would be saved on in-warranty repairs! We hope that our report next year can name a lot more manufacturers who have made color-TV chassis easy and inexpensive to repair. Set-buyers will love them. ▲

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