60¢ ■ MAY 1967

Radio-Electronics

TELEVISION · SERVICING · HIGH FIDELITY

A GERNSBACK PUBLICATION

HUGO GERNSBACK, Editor-in-chief

EXTRA SECTION
Space & Underseas ELECTRONICS

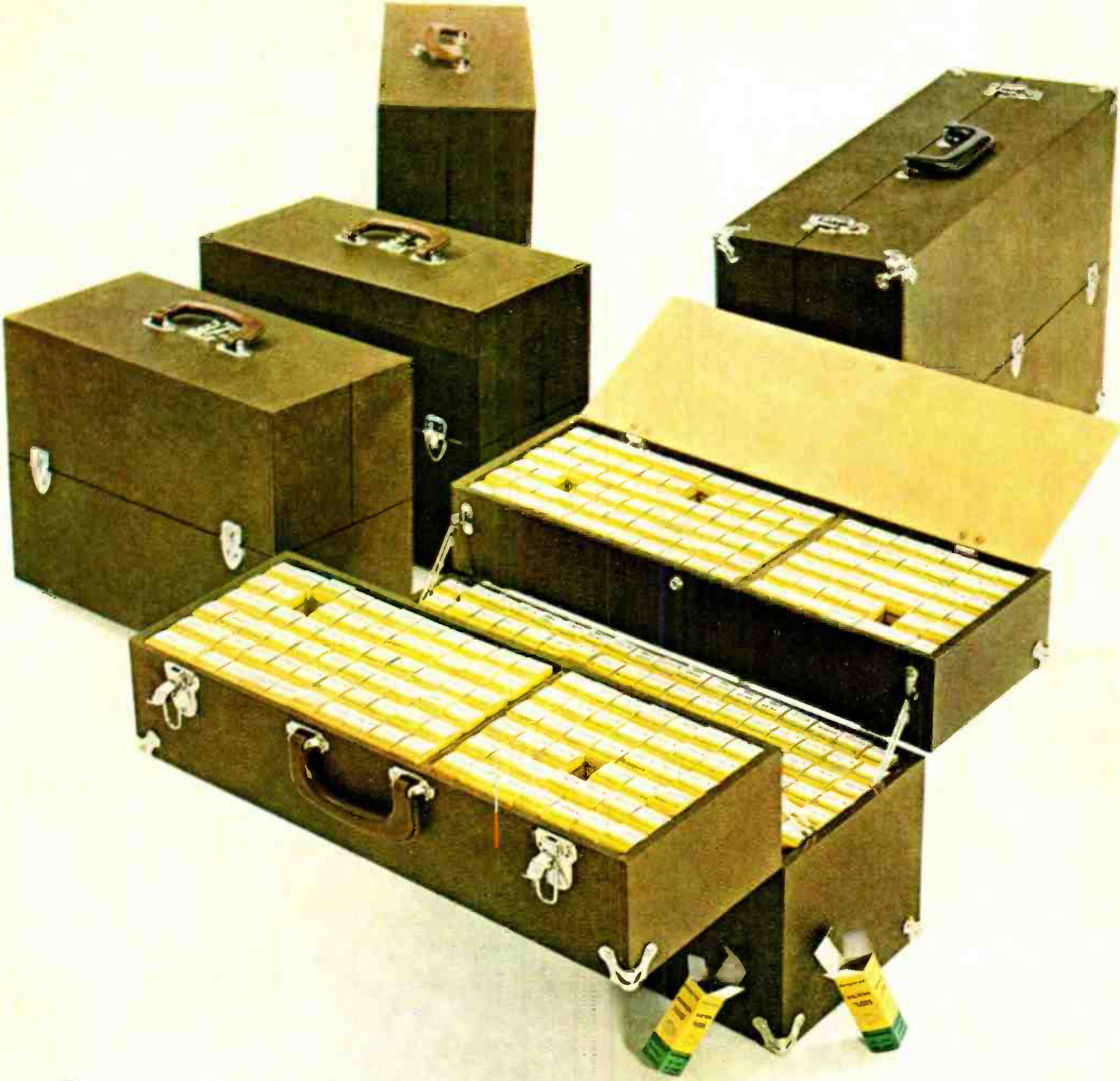
Indianapolis 500 Driver-Reaction Tests

Underwater Communicator

World's Most Complex R/C Job

DESK TOP COMPUTERS

New generation . . . What the[...]y work



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Amperex

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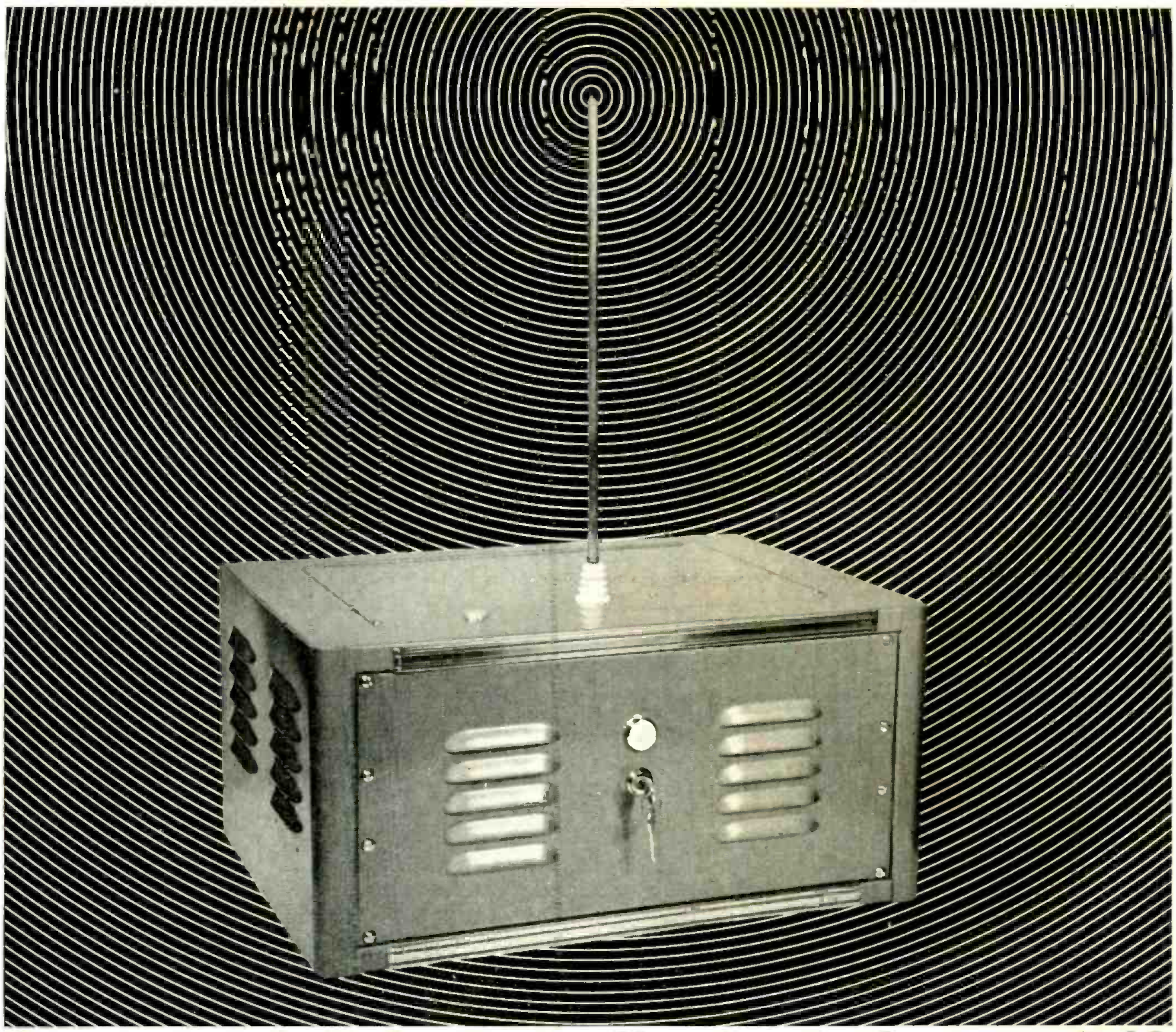

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FROM THE EDITOR

Electronics and The Worlds Beyond

As long as there's a mountain to climb, a cave to inspect, a territory to map, a sea hole to examine, or a planet to explore—curious and intrepid men will expend their time, their energy, even their lives. The February tragedy at Cape Kennedy has a counterpart in every other field of human curiosity. Undersea, the Thresher tragedy; on Mt. Eiger, John Harlin; at the South Pole, Capt. Robert Scott's party (in 1912); in Africa, David Livingstone. Major accomplishments stand in tribute to those who martyr themselves to knowledge and understanding.

This issue of RADIO-ELECTRONICS pays special attention to two modern frontiers: space and undersea. All our present technology notwithstanding, to live in either environment requires thinking radically changed from accustomed viewpoints. How much further we'll adjust before we truly unlock the riddles of these other worlds is barely conceivable.

Take the deep ocean. As the science of aquanautics develops, we plumb deeper and deeper into that murky world. Electronic devices we use right now can be adapted to make deep-sea exploration safer and more sure.

Example: A "sea-floor buggy" could crawl around controlled by radio, radar, sonar, hydronics, or some new electronic means from surface ships or shallow-sea substations. The vehicle could carry a TV system as "eyes." Maybe a new hydrosonic or other TV system would have to be developed for depths too dark even for lasers. A video tape recorder could bring back a viewable record.

To record in detail what's down there, laser-holographic equipment could take three-dimensional pictures. Electronic spectrometers, microscopes, and chemistry analyzers could be standard equipment on the sea-floor buggy, with data either recorded in the buggy's own computer storage system or sent back to the tending station by wireless telemetry. If geologic samples were required, remote-controlled laser tools could drill, cut, or chop them loose.

When we send a manned vehicle into the deepest trenches, the communication techniques used for telemetry could keep the aquanaut in touch with his tender station or ship, and could keep them informed of his well-being. Nuclear engines would supply power to drive the buggy and the life-sustaining equipment it has aboard. A large buggy, equipped to support several aquanauts, might be an outpost for smaller-buggy excursions into the so-far trackless depths.

You can surmise how important electronics will be in the watery life below the 3-mile depth.

In space, we have already made strides beyond those we have made under the sea. We have Surveyor sitting on the moon gathering data for the first Apollo landing. The success of Mariner 4, spectacular though it was, only paves the way for other Mariner and Voyager flights to give us more data about our neighbor planets, Venus and Mars.

After moon landings, the obvious followup is a manned flight to one or the other of these nearby planets. Some say by the late 1970's; sooner seems more likely. Despite electronics, the human factor remains vital. No matter how carefully we plan or how fully informed we are of conditions on either planet, the final split-second decision to land must rest in the mind and training of the astronaut commanding the flight.

You can't help thinking: Maybe we could eliminate the chance of life loss by not sending humans. Perhaps TV cameras, remote controls, robots, or other common automated devices could preclude the risk of life on these maiden voyages.

Such thoughts seem futile, at least for now. Consider the communications problem during the last minutes before a landing on Venus or Mars. A radio signal takes an average of 8 or 9 minutes to reach Earth from Venus and 12 to 13 minutes from Mars, one way. If sensors on the spacecraft flashed a warning of imminent danger, even at several hundred miles from touchdown, you can see that last-minute control from Earth would be utterly impossible from this distance.

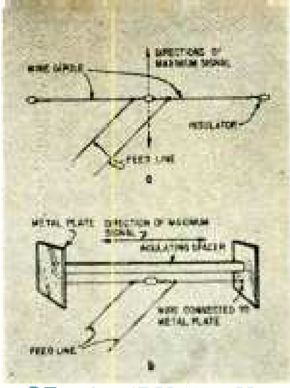
Either foolproof on-board cybernetics is needed, or the thinking ability of a human. Such high-order automation demands prior knowledge, so it seems for now that a human is necessary on such critical missions. But that human must be supported by some of the most exotic instrumentation ever conceived.

Under the sea or far out in space, electronics builds a stronger role for itself month by month. In both, electronics is only the means used by man to sample, monitor, analyze, adapt to, and control environment. In all our journeys into other realms, the pioneering, fast-thinking and quick-reacting explorer will be the frontiersman—the first line of discovery between our world and the worlds beyond.

Forest H Belt

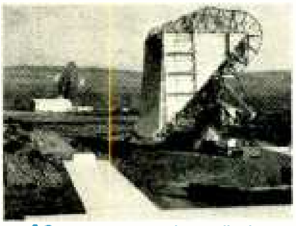
Radio-Electronics

May 1967 VOL. XXXVIII No. 5
Over 55 Years of Electronics Publishing

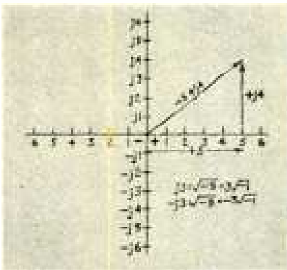


p 37—RF UNDER WATER

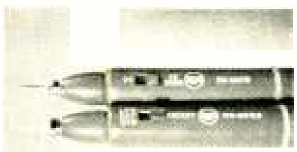
p 42—DOT(S) AND BAR(S)



p 49—"BIRD" LISTENERS

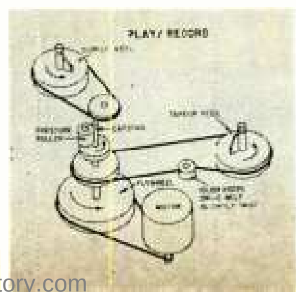


p 57—ROOT OF −1



p 60—CHROMA VTVM

p 71—TAPE SERVICE



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COVER FEATURE

p 34—The desk-top computer is the newest arrival in the field of electronic calculating machines. It's compact and can be programed to perform a series of simultaneous computations.

DRIVER TESTING

p 32—Steering a fast racer demands instant response to changing road and traffic conditions. Here's how the professionals' reflexes are measured electronically.

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Radio-Electronics is indexed in *Applied Science & Technology Index* (formerly *Industrial Arts Index*)

NEWS BRIEFS

AIRBORNE MOVIES WITHOUT VIDEO

Airlines have been showing movies on jet flights for some time. The first system used a single projector and a single screen (like a conventional theater). But it was hard for some passengers to see the screen, so a video system was tried. The film was projected into a vidicon pickup tube (like a TV station does) and the image displayed on several picture monitors scattered around the cabin. These monitors, through a master receiver, could also pick up off-the-air TV.

Now comes a nonvideo, multiple-screen movie technique for air travelers. American Airlines has begun using *Astrocolor* (developed by Bell & Howell) on their 707 Astrojets. A number of viewing screens are placed around the cabin, each illuminated by its own projector. Film is shuttled from the supply reel (in the cockpit) through a special channel from one projector to the next, and finally back to the takeup reel (also in the cockpit). Each screen serves only a few passengers, who are close enough to see the images clearly.

A separate sound head is used at each projector, and audio is fed to earphones at each seat. There's a 5-minute lag between the first and last screens on the loop.

Advice to air travelers: Get a seat near the supply-reel side; if you miss some action, you can step across the aisle and catch the repeat.

BIG BROTHER LISTENS

The FCC has authorized police agencies to use low-power transmitters on undisclosed frequencies for surveillance, "stake-outs," and raids.

Because normal police frequencies are known and may be monitored by anyone with a suitable receiver, the Commission reasoned that police were hindered in their attempts to capture criminal suspects. For instance, where citizens have been attacked and robbed in a city park, normal police procedure would be to stake out plainclothesmen in the area, equipping them with walkie-talkies. But if they had to use assigned frequencies, criminals might detect their presence and make the attempt useless.

The FCC rule change (Sec. 89.309) provides for the use of any frequency between 40 and 952 MHz which is available in the Police Radio Service, with a maximum of 2 watts' antenna input power. The Commission also emphasized that the rules ". . . in no sense authorize 'wiretapping' or 'bugging' activities by the police."

R/C COMPUTER

The math instructor enters the classroom at Harvard University in Cambridge, Mass. He assigns students a problem involving the use of a computer. Each works out his idea of how to program and command the problem to the computer. Then the instructor punches the information into the machine. Soon the answer appears on a TV screen. Each student has his chance, in turn, to successfully work the problem.

Simple? Yes—but there's one catch. The computer is over 3,000 miles away—at Santa Barbara, Calif. Telephone and microwave circuits carry coded pulses from the classroom to the computer, and then the answer to the problem is returned from California.

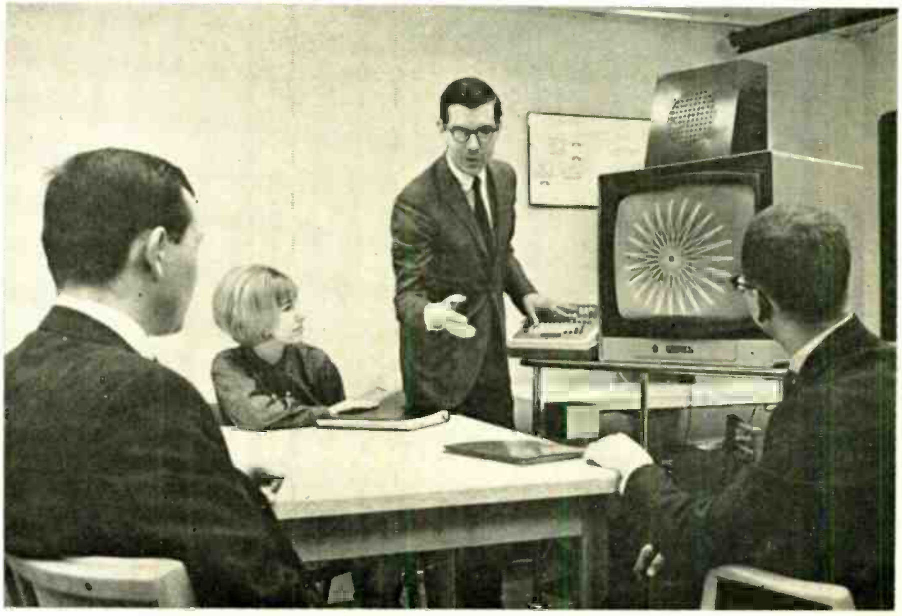
The system could eventually mean that many advanced-level classes could use a single, centrally-located computer to aid them throughout a single day.

TV SERVICE PRICING

In three surveys made last fall, TSA (Television Service Association) of Michigan determined the average service charges their member shops were using.

Average fee for a home call was $5.92 for b-w and $8.05 for color. For servicing a set in the customer's home for half an hour, the average charge was $3.03 (b-w) or $4.56 (color). Thus the total price of a completed service call averaged $8.95 (b-w) or $12.61 (color).

In-shop service bills ran $15.40



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(b-w), $24.78 (color), and $13.51 (portables). The average hourly shop rate was found to be $8.81 for b-w and $10.08 for color.

As reported in *TSA News*, the trend in Michigan seems to be toward dividing home-service fees between the home call itself (time and travel expenses) and work actually performed at the house (time only).

Some shops also reported making separate charges for pickup and delivery. The average was around $8.00 for b-w (one man) and $13.00 for color (two men)

CANNONIC IMITATION VIA HI-FI

One of the great old warhorses of the pop-concert repertory, Tchaikovsky's *1812 Overture*, contains one of the biggest stumbling blocks to a successful live performance: The score in its original form calls for real, live cannon fire—16 rounds of it, near the climax of the work.

The Washington National Symphony Orchestra once performed the work in an outdoor amphitheater with real artillery. And the Minneapolis Symphony made an LP onto which was dubbed prerecorded cannon fire. But either was hardly practical for a recent performance in Washington, D.C.'s Constitution Hall.

During a visit to the last Washington high-fidelity/music show, the orchestra's conductor, Dr. Howard Mitchell, was sufficiently impressed with one manufacturer's speakers (Jensen) to try a new approach. He had a recording made during a firing exercise at the Marine Corps school in Quantico, Va., then had it played back at appropriate points during the performance.

AIRLINER LANDS AUTOMATICALLY

The big jet—a Pan American Boeing 727—left its holding pattern and began an approach run into New York's Kennedy Airport one night last February. The pilot manipulated the controls as usual up to the point where he locked the plane's instruments onto the airfield ILS (instrument landing system). Then he stopped flying the plane, and a computer aboard the jet brought her smoothly in. It was the first time an American-built airliner on a regular passenger flight had made a completely automatic landing.

The automatic landing system promises true all-weather flying in the near future. Aircraft will be able to

Radio-Electronics

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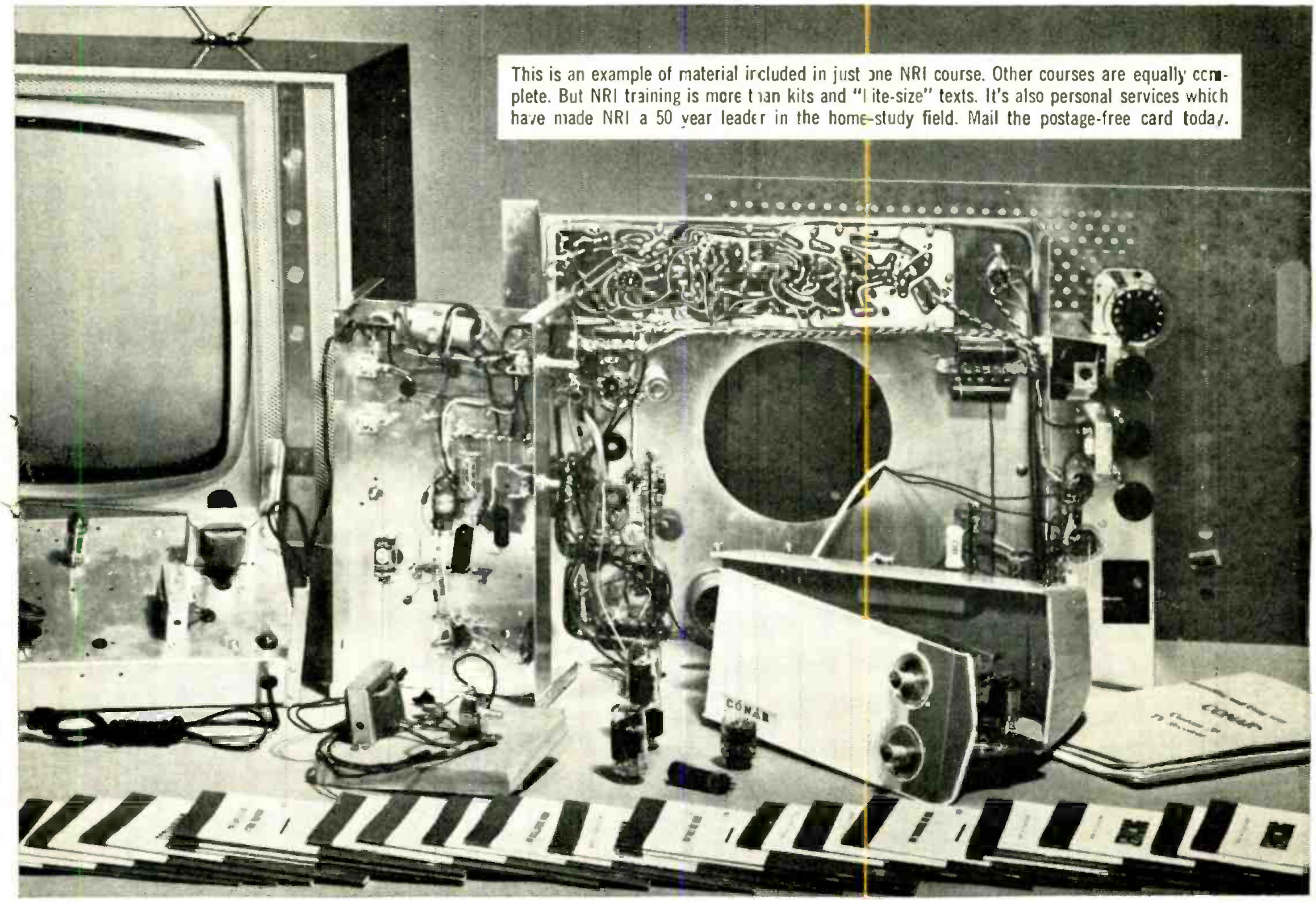

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NEWS BRIEFS continued

land despite weather conditions. "Even though visibility was not poor," the Pan Am pilot announced to his 98 passengers afterward, "the landing would have been exactly the same with zero-zero visibility."

The system, developed by Boeing and Sperry-Phoenix, includes an autopilot, a flight-director system, a flare computer, an auto-throttle, and a radio altimeter. Complete redundancy is used; every unit has its twin to provide backup in case of equipment failure. Furthermore, the system continuously monitors itself; if not functioning properly, it won't permit activation. If it fails during operation, it disconnects itself from the aircraft controls.

Using ALS, the pilot does not relinquish his command, for he can override the computer at any time.

Pan American has two Boeing 727's equipped for automatic landings, and plans to outfit more planes soon.

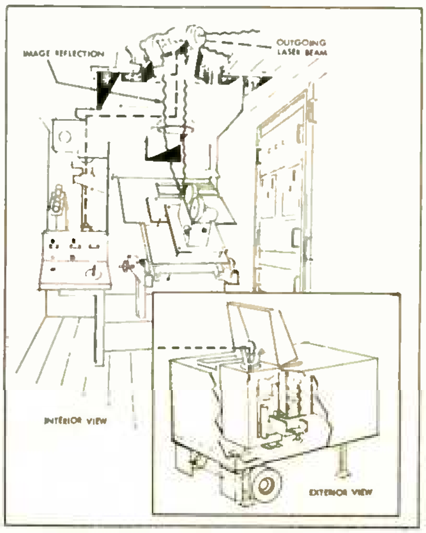
LATEST ON LASERS

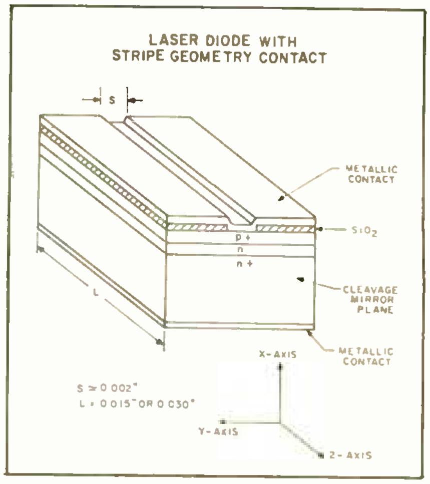
How do you take motion pictures of a rocket sled going 4,000 mph? It's simple, now—you use a laser tracker.

Developed by Sylvania for an Air Force testing program, the laser system is used like radar, bouncing a beam off the moving object. The return beam generates an error signal which controls the mirror angle (see diagram) to keep the target "on camera."

The sleds, which move at twice the speed of a rifle bullet, are impossible to photograph manually. Once the laser system is aimed at the vehicle, however, it tracks with an accuracy of 1¼ feet at 10 miles.

Symmetrical radiation patterns—which make it easier to couple into optical devices—have been obtained for the first time from a laser. The Bell



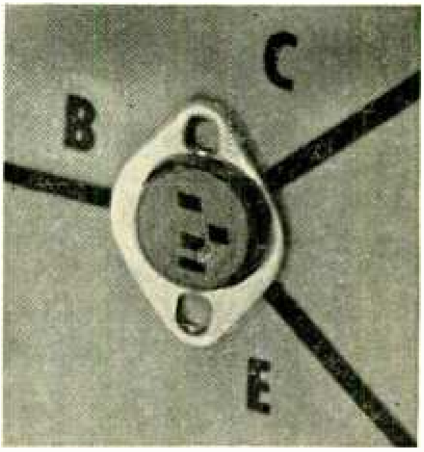


Telephone Labs development is a Gallium Arsenide laser using a p+ layer only 2 microns thick, and a stripe contact on narrow strip of metal, which touches the semiconductor exciting area.

The radiation pattern produced by the device is said to facilitate laser-beam transmission over long distances.

A more consumer-oriented use of lasers is a new system which is neither television nor movie. General Telephone & Electronics has built an experimental laser display system which uses photoelectric cells for pickup of a live scene. This image is transmitted electronically to a light-beam "steering" device which projects three focused laser beams on a conventional movie screen. Since each beam is a different primary color—red, green and blue—the combination on the screen produces full-color images.

RE: TRANSISTOR TEST SET

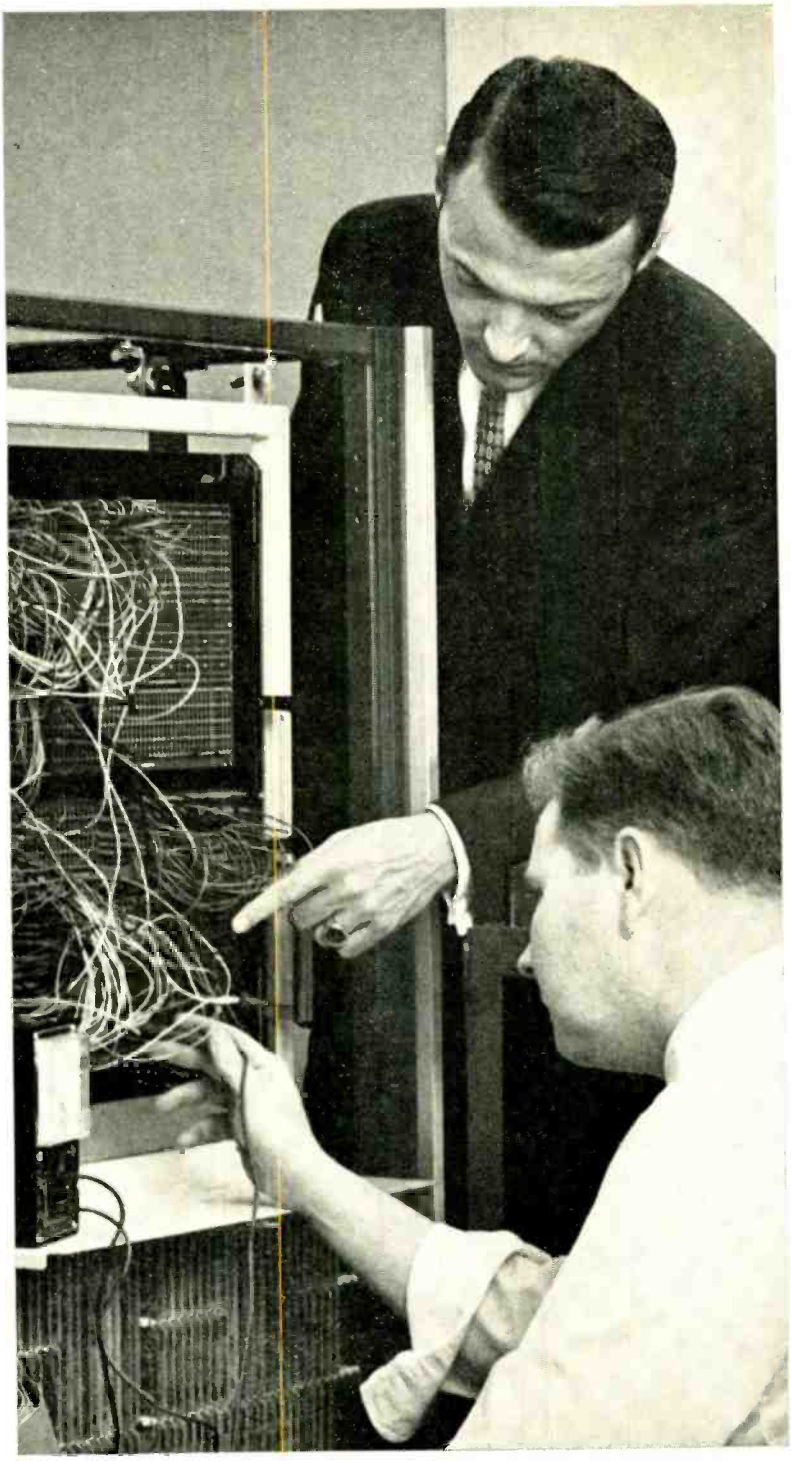


Several readers have questioned the transistor socket markings on the panel of the transistor test set on page 57 of the March issue. They assumed that the socket is mounted so the base (B)) pin terminal is on the left. The closeup shows that this is not the case.

END

Why does one of these men earn so much more than the other?

More brains? More ambition?



No, just more education in electronics.

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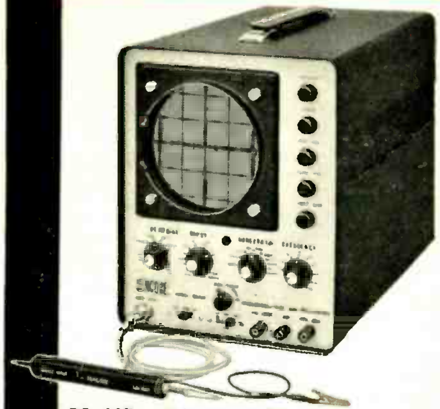

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Circle 14 on reader's service card

Correspondence

NOT ALL BAD

Dear Editor:

Recent correspondence in your magazine berates manufacturers for their negligence in answering correspondence.

I've written to very few, but my results have been most favorable. I was constructing a single-sideband transmitter, and needed a 1,500-kHz discriminator detector transformer which wasn't available locally. A letter to J. W. Miller Co. of Los Angeles not only brought the transformer but also gave me the capacitance change necessary to retune the transformer to the 160-meter amateur band—all for the sale of one transformer.

A similar response was received from their chief competitor regarding a power-type transformer needed.

In both cases, the part number and the proposed application for the part were described to me in detail. I suppose it's from such letters as mine that manufacturers find new uses for parts they advertise.

WILLARD WAITE

Wellington, Ohio

ENG-A-LAND SWING LIKE . . .

Dear Editor:

Rereading your October 1966 editorial about a shortage of service technicians, I was again struck by how similar the situation is here. Firms who seek to economize on wages complain of the poor standard of TV mechanics, because anyone worth his salt soon moves on. The poor payers cannot fire an incompetent workman as they find it hard to hire anyone else; even an incompetent is better then no one.

A good bench man backed by comprehensive equipment may seem dear, but it's cheaper than two so-so's without instruments. A shop is only as good as the man wielding the soldering iron.

Here in England we seem to be plagued with incompetent outside men. Not that this worries me unduly. I am an outside man myself, working for a top-paying company with top fringe benefits. I take pride in repairing sets in the house and regard it as a personal defeat to bring the set into the shop. For myself and those like me, this mass of tube pullers makes our limited talents stand out. But they do no good to the industry.

I am in full agreement with your many articles that say: Be efficient, get value for work, give value for money.

P. M. LEYDEN

Nottingham, England

AND HERE, TOO

Dear Editor:

Regarding the current discussion of the scarcity of good trained technicians, the public is too difficult to please. I gave up the five shops I had 20 years back after I realized that radio and TV repairs were sought only as a necessary evil. Almost everyone would far rather buy a new set than pay for repairs and service.

And their character assassinations are frequently too much for the average stomach of the poor tech or shop owner. After all, who wants to be called a gyp, crook, etc., for the "munificent" earnings of $2 to $4 per hour.

It is still hard, even in 1967, to get across to the average set owner that repairs to a circuit cannot guarantee against failure in another circuit. Golly, we only repair 'em, not manufacture 'em. Even the service people who make calls for manufacturers get the same abuse.

A. H. FISH

Alexandria, Va.

EASIER SWITCH

Dear Editor:

As always, we enjoy receiving and reading RADIO-ELECTRONICS. The March 1967 issue was no exception. We were especially interested in the construction article on the "Walkie-Talkie Power Booster" (page 60).

In the text, the author asks the readers to modify the switch. Open-leaf-type switching blades require proper adjustment to give proper "make" and "break" switching. To modify this switch would require skilled hands and a knowledge of how to adjust it.

If your readers have difficulty modifying this switch, they can purchase our FF switch, part No. 1006. This will give them a switch with the two break-make (dpdt). Their wiring, therefore, would be to the C circuit and B circuit combination from the second C circuit on the stack.

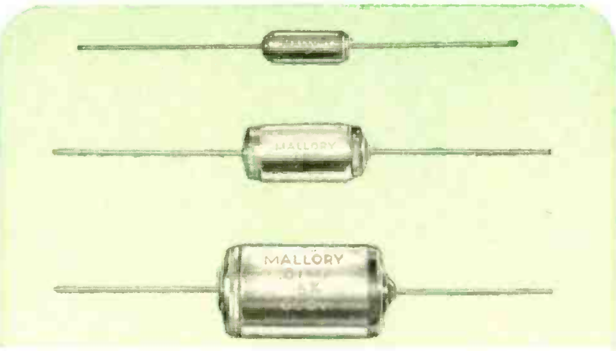
C. J. SCHULTZ

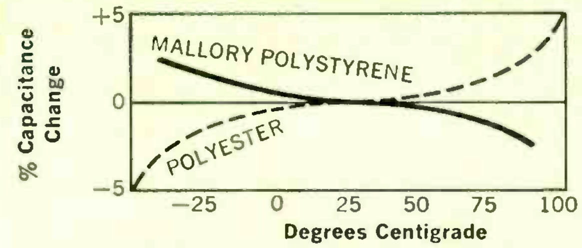
Switchcraft
Chicago, Ill.

END

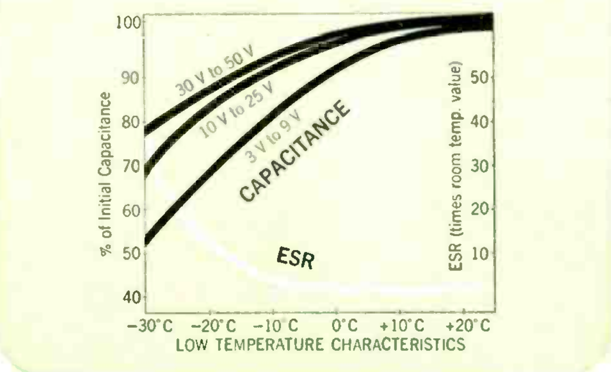
MALLORY Tips for Technicians

Capacitor stability at bargain prices





Capacitance vs. Temperature



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

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

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

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

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

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

Circle 16 on reader's service card

How to get into

One of the hottest money-making fields in electronics today–servicing two-way radios!

HE'S FLYING HIGH. Before he got his CIE training and FCC License, Ed Dulaney's only professional skill was as a commercial pilot engaged in crop dusting. Today he has his own two-way radio company, with seven full-time employees. "I am much better off financially, and really enjoy my work," he says. Read here how you can break into this profitable field.

More than 5 million two-way transmitters have skyrocketed the demand for service men and field, system, and R&D engineers. Topnotch licensed experts can earn $12,000 a year or more. You can be your own boss, build your own company. And you don't need a college education to break in.

HOW WOULD YOU LIKE to start collecting your share of the big money being made in electronics today? To start earning $5 to $7 an hour... $200 to $300 a week... $10,000 to $15,000 a year?

Your best bet today, especially if you don't have a college education, is probably in the field of two-way radio.

Two-way radio is booming. Today there are more than *five million* two-way transmitters for police cars, fire department vehicles, taxis, trucks, boats, planes, etc. and Citizen's Band uses—and the number is still growing at the rate of 80,000 new transmitters per month.

This wildfire boom presents a solid gold opportunity for trained two-way radio service experts. Many of them are earning $5,000 to $10,000 a year *more* than the average radio-TV repair man.

Why You'll Earn Top Pay

One reason is that the United States Government doesn't permit anyone to service two-way radio systems unless he is *licensed* by the Federal Communications Commission. And there simply aren't enough licensed electronics experts to go around.

Circle 13 on reader's service card

Another reason two-way radio men earn so much more than radio-TV service men is that they are needed more often and more desperately. A home radio or television set may need repair only once every year or two, and there's no real emergency when it does. But a two-way radio user must keep those transmitters operating at all times, and *must* have their frequency modulation and plate power input checked at regular intervals by licensed personnel to meet FCC requirements.

This means that the available licensed experts can "write their own ticket" when it comes to earnings. Some work by the hour and usually charge at least $5.00 per hour, $7.50 on evenings and Sundays, plus travel expenses. A more common arrangement is to be paid a monthly retainer fee by each customer. Although rates vary widely, this fixed charge might be $20 a month for the base station and $7.50 for each mobile station. A survey showed that one man can easily maintain at least 100 stations, averaging 15 base stations and 85 mobiles. This would add up to at least $12,000 a year.

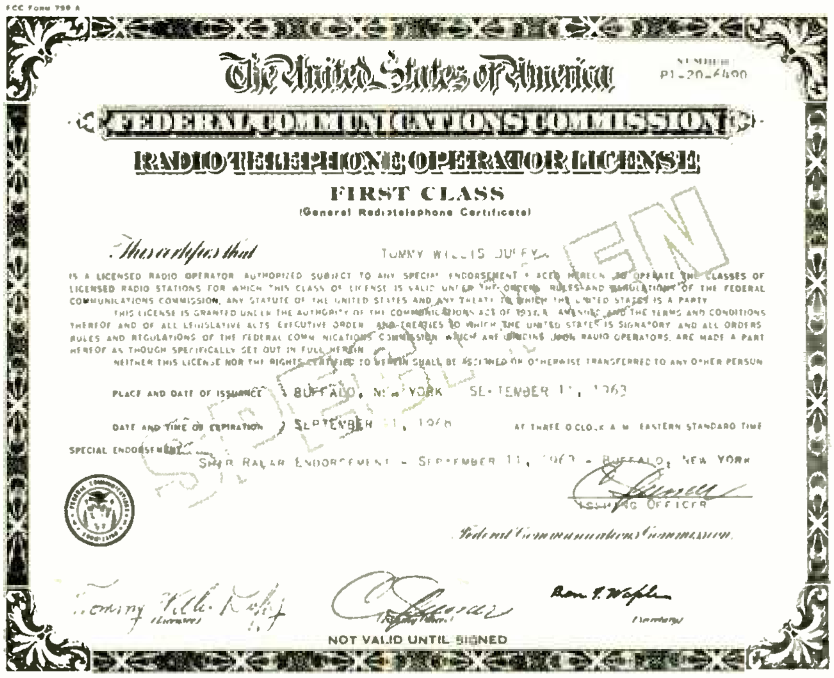
Be Your Own Boss

There are other advantages too. You can become your own boss—work entirely by yourself or gradually build your own fully staffed service company. Instead of being chained to a workbench, machine, or desk all day, you'll move around, see lots of action, rub shoulders with important police and fire officials and business executives who depend on two-way radio for their daily operations. You may even be tapped for a big job working for one of the two-way radio manufacturers in field service, factory quality control, or laboratory research and development.

How To Get Started

How do you break into the ranks of the big-money earners in two-way radio? This is probably the best way

1. Without quitting your present job, learn enough about electronics fundamentals to pass the Government FCC Exam and get your Commercial FCC License.
2. Then get a job in a two-way radio service shop and "learn the ropes" of the business.
3. As soon as you've earned a reputation as an expert, there are several ways you can go. You can move *out* and start signing up and servicing your own customers. You might become a franchised service representative of a big manufacturer and then start getting into two-way radio sales, where one sales contract might net you $5,000. Or you may even be invited to move *up* into a high-prestige salaried job with one of the major manufacturers either in the plant or out in the field.



THIS COULD BE YOUR "TICKET" TO A GOOD LIVING. You must have a Commercial FCC License to service two-way radios. Two out of three men who take the FCC exam flunk it... but nine out of ten CIE graduates pass it the first time they try!

The first step—mastering the fundamentals of Electronics in your spare time and getting your FCC License—can be easier than you think.

Cleveland Institute of Electronics has been successfully teaching electronics by mail for over thirty years. Right at home, in your spare time, you learn electronics step by step. Our AUTO-PROGRAMMED™ lessons and coaching by expert instructors make everything clear and easy, even for men who thought they were "poor learners." You'll learn not only the fundamentals that apply to all electronics design and servicing, but also the specific procedures for installing, troubleshooting, and maintaining two-way mobile equipment.

Get Your FCC License... or Your Money Back!

By the time you've finished your CIE course, you'll be able to pass the FCC License Exam with ease. Better than nine out of ten CIE-trained men pass the FCC Exam the first time they try, even though two out of three non-CIE men fail. This startling record of achievement makes possible the famous CIE warranty: you'll pass the FCC Exam upon completion of your course or your tuition will be refunded in full.

Ed Dulaney is an outstanding example of the success possible through CIE training. Before he studied with CIE, Dulaney was a crop duster. Today he owns the Dulaney Communications Service, with seven people working for him repairing and manufacturing two-way equipment. Says Dulaney: "I found the CIE training thorough and the lessons easy to understand. No question about it—the CIE course was the best investment I ever made."

Find out more about how to get ahead in all fields of electronics, including two-way radio. Mail the bound-in postpaid reply card for two FREE books, "How To Get A Commercial FCC License" and "How To Succeed In Electronics." If card has been removed, just send us your name and address on a postcard.

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In the Shop . . . With Jack

By JACK DARR

FOR A LONG TIME, ONE OF THE MOST frequent questions in my mailbag was "How can I change my old Gizmo color TV set to use the new sulphide tubes?" Then, after a while, it was "How can I change my old obsolete sulphide-tube color set to one of the new rare-earth type tubes?"

About all I could give was sympathy. Conversion of a b-w TV set from 70° to 90° tubes was bad enough, but conversion from one kind of color tube to another was worse. None of the set manufacturers would even recommend it. Since it was such an expensive deal, with such a big, fat chance for errors, I didn't *dare* recommend any rash experimenting!

However, things have changed (as usual). Now, the "converters" can upgrade a lot of TV sets. To be honest about it, the process won't make a brand-new set out of an old CTC4, for instance, but it will produce slightly better pictures if the chassis is in good shape. RCA has brought out a little leaflet giving instructions; they also have conversion kits for replacing the old metal tubes with new glass ones.

The leaflet covers sets like the 21CT55, 21CT660 (up through the 700 and 800 series), CTC5 chassis up through the -N and -W, as well as the -F and -H series; roughly: through 1957. The replacement tube, a glass-bulb 21-CYP22, is electrically identical to the original 21AXP22. This means there won't be any great bother, outside of setting up the new tube with the regular screen and background controls.

The major part of this conversion is "mechanical"—changing the original suspension of the metal-cone tube to hold the glass bulb. RCA's 12B101 conversion kit has all the necessary hardware to do the job. Incidentally, since a great many color TV sets built during that period used RCA chassis, this conversion kit will apply to many other brands as well as RCA.

The 21CYP22 tubes have two HV connectors instead of one. One is a "blank," used to hold one end of a 56K current-limiting resistor. The regular HV lead goes to the blank terminal, with one end of the tension spring (see Fig. 1). This is the lower terminal, with the set in normal position.

The heavy insulator around the metal cone of the old CRT is discarded; a new plastic cover is provided for the bell of the tube. You'll notice that instructions emphasize the use of ground straps, springs, etc. on several connections. Be sure that these are installed, and in the right places, so that the conductive coating on the outside of the bulb will be well grounded. If you've got any doubts, add a couple more grounds!

In later chassis, which were designed with the glass 21CYP22's from the CTC7 on up, you can convert to the rare-earth tubes; late-production 21CYP22's were sulphide-phosphor types. Mounting changes will be minor, since these chassis are made to take the glass-bulb tubes. The 21FBP22 is the recommended replacement. This tube doesn't have the current-limiting resistor connection, as in the -CYP22, so this is taken off and discarded.

Some electrical changes will have to be made in the chassis, if the full benefit of the more efficient rare-earth phosphor is to be realized. The red is much better. (Remember, a long time ago, when a picture tube went out, it was always the red gun? Or, it seemed that way.)

In this conversion, you may have to make some alterations in the shielding, hardware and so on, to avoid any chance of arc-overs to grounded objects. Magnetic shielding can be notched out to keep it away from the HV connector. Keep any grounded object at least 6

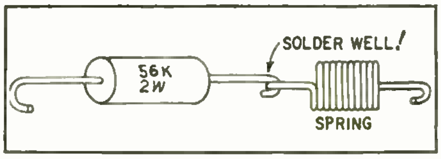

Fig 1—Current-limiting HV resistor is used with the 21CYP22 color CRT.

This column is for your service problems—TV, radio, audio or general and industrial electronics. We answer all questions individually by mail, free of charge, and the more interesting ones will be printed here.

If you're really stuck, write us. We'll do our best to help you. Don't forget to enclose a stamped, self-addressed envelope. Write: Service Editor, Radio-Electronics, 154 West 14th Street, New York 10011.

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Circle 17 on reader's service card

inches from the hot stuff, and you will be pretty safe.

Be sure that the cover or cup on the end of the HV lead is in good shape. If this has aged, it will crack, and dust and dirt gathering in these cracks will hold moisture. This can cause a flashover from the cup to the shield. Replace the old one with one of the later versions with much higher insulation resistance.

In all cases, polish the surface of the bulb around the HV connector, and keep it clean and dry. Waxing this sometimes helps, by avoiding moisture accumulation on the bulb itself.

In the chassis, the drive circuits will have to be changed slightly. The rare-earth phosphors are much more "even" in response than the old ones. Fig. 2 shows the typical change. The blue and

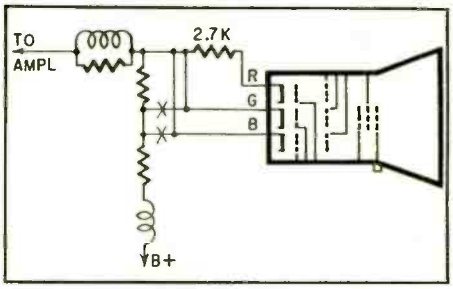

Fig. 2—Modification for sulfide tube.

green gun cathodes are connected to the red cathode, instead of to a higher voltage, as shown. If the 2,700-ohm resistor is used, the blue and green cathodes are connected to the amplifier end of it.

In the very early chassis, the red (R–Y) amplifier's plate circuit should be changed. The load resistor is reduced in size, to keep the three colors the same. Fig. 3 illustrates: Instead of a single 15K resistor as in the original circuit, at (a), 4,700 ohms and 10K are used. The 10K resistor is shunted by a 15-pF NPO

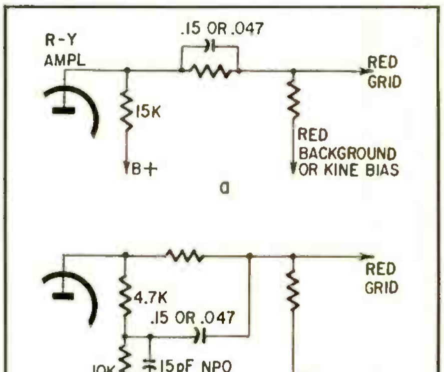

Fig. 3-a—Original R-Y amplifier circuit. b—Same circuit modified for new CRT.


Remington PREMIER

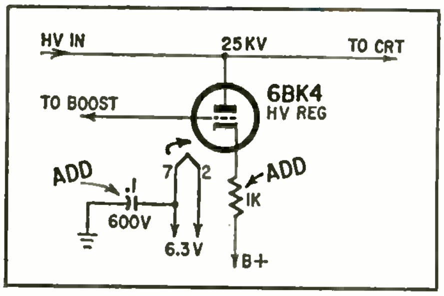

Fig. 4—This modification will prevent damage if new CRT should arc over.

capacitor. The 0.15 μF capacitor (.047 μF in CTC7's) is disconnected from the R—Y amplifier plate, and hooked to the junction of the two new resistors.

In all these conversions, a 0.1-μF 600-volt bypass capacitor should be added from pin 7 of the 6BK4 high-voltage regulator to ground. The picture-tube heater is connected to the same winding to protect it against damage from possible flashovers, inside the tube neck. Add a 1,000-ohm resistor from the 6BK4 cathode to B+; same purpose. These changes are shown in Fig. 4.

After the mechanical part of the job is done, and the set fired up, check the color temperatures, brightness tracking, and so on. If you have trouble getting highlights to track, take the red cathode lead off, at the chassis tie point, and exchange it with either the blue or green cathode, whichever gives the best results.

There is one thing you *pos-i-tively* cannot do! It's bad enough in b-w sets, but in color it's a sheer impossibility. This is to swap a 70° round tube for a 90° rectangular tube! A 25GP22A is not a replacement for a 21AXP22, that's all there is to it!

Why? Well, in b-w sets, our problem in such swaps is to get enough sweep *power*. It takes 25% more horizontal sweep power and 50% more vertical, to change from a 70° to a 90° tube: 110° tubes I'd rather not even think of! In a color set, we'd have all of these problems, *plus* the convergence!

Besides, a rectangular b-w tube can be corrected for pincushioning with a pair of simple PM magnets. In a rectangular color tube, the same job requires a very complex built-in pincushion corrector, involving the yoke, vertical output transformer, and so on! We would probably wind up putting on a new yoke, flyback, and a few other goodies.

At any rate, there isn't much difference in cost between the newer tubes and the originals, and the conversion kits aren't expensive. So, if you've got to replace the color picture tube anyhow, you might as well go first class. END

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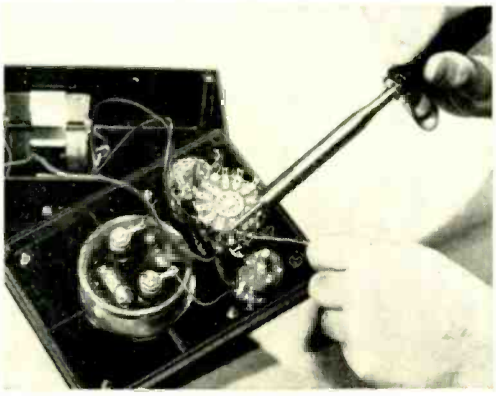
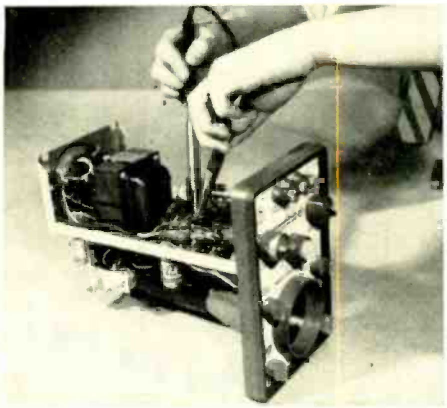
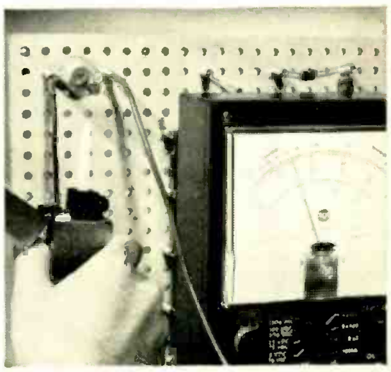
Construction of Multimeter.





Construction of Oscilloscope.

Temperature experiment with transistors.



Reaction-Time Testing of Race Drivers

High-speed competition driving requires fast reflexes—abilities that can be measured only by electronics

By DON DAVIS

AUTOMOBILE RACING DRIVERS, AS viewed by an enthusiast who also is an audio engineer, have interesting characteristics that demand analysis. And, surprisingly, such an analysis reveals patterns similar to those commonly encountered in evaluating audio and acoustical phenomena.

As an example, consider the two weekends in May during which drivers and cars compete to enter the world-famous Indianapolis 500-mile race. Only 33 starting positions are available, yet as many as 70 cars and drivers arrive at the track to prove themselves fast enough and talented enough to race on Memorial Day. Each aspirant runs 4 laps (2½ miles a lap) at the fastest speed he can maintain for the 10-mile test. The 33 fastest qualifiers are in; the others are out. The fastest and the slowest cars in the lineup are separated by fewer than 3 seconds a lap.

If the speed of 33 racing cars varies less than 3 seconds a lap from the slowest to the fastest, it would appear that the cars and drivers are almost equal. Fig. 1-a, however, shows this assumption to be incorrect. Plotted on this first chart are the 1964 qualifying speeds in 1-mph increments versus the number of drivers who qualified at each speed. When rough curve A is smoothed to form curve B, it assumes the classical Gaussian or Laplacian distribution pattern. Fig. 1-b (1965) shows clearly what happened when the very best European drivers were in competition with the best US drivers. Those who were below norm (and the norm at Indianapolis is extraordinary compared to the norm of the man on the street) have been eliminated.

Distribution of the sharpness of the five physical senses in any group of people would follow a similar pattern. If, for example, you were to test the visual perception of 1,000 people selected at random, your measurements would produce a curve like that shown in Fig. 1-a. The curve would plot visual acuity (sharpness) against the percentage of the total sample taken. Similar curves would apply for tests of hearing, balance, touch, smell, and reaction time. One can therefore conclude that what happens out on the race track depends greatly on a driver's physical abilities. Some drivers are going to have better basic abilities than others.

The literature (sparse), observations (emotionally tainted) and speculations (rampant) all suggest that supernormal eyesight and acute reaction time are the two most important abilities a race driver requires as natural endowments. Because eyesight can be measured and evaluated very accurately, Dr. Thomas Hanna, medical director of the Indianapolis Motor Speedway, has been able to confirm that the eyesight of competition drivers tends to be exceptional, particularly in regard to equal abilities with both eyes.

There is, however, little data available on how to measure reaction time. How this all-important physical characteristic affects the race driver can best be illustrated by a brief look at the speeds racing cars travel. On the main straightaway at the Indy speedway, they reach speeds of 200 mph, or 293 ft/sec. (mph × 1.466 = ft/sec.). At this speed, a misjudgment as small as 0.2 sec would carry the car almost 60 extra feet (a disastrous mistake on the walled corners at Indianapolis). It's ap-

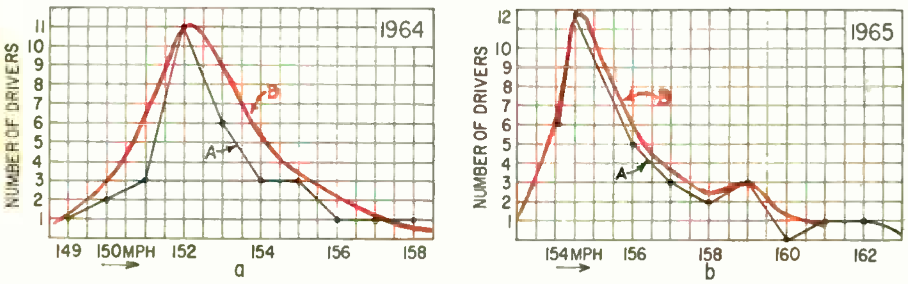
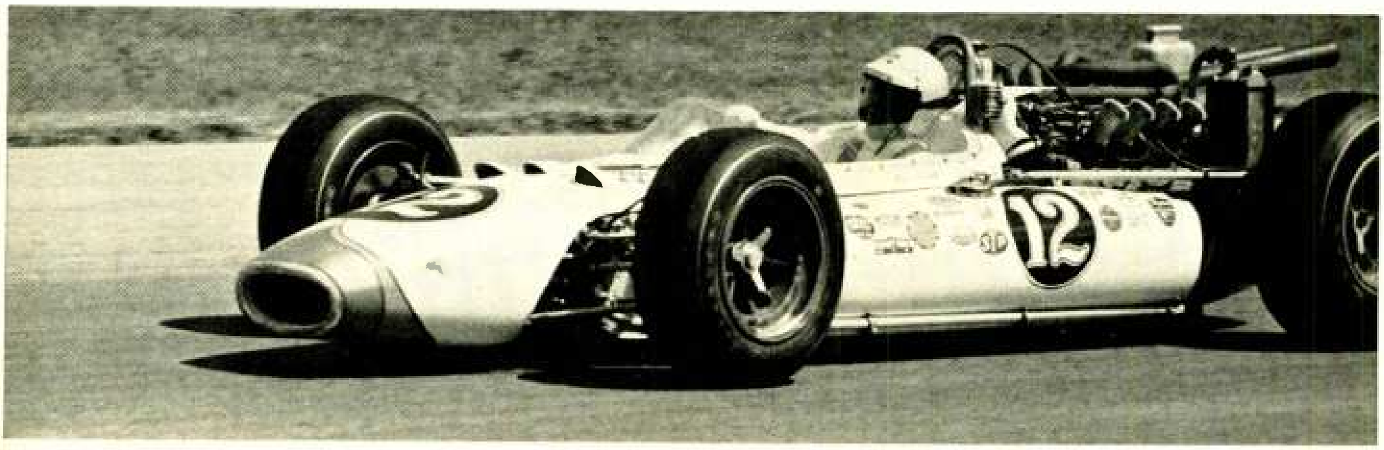


Fig. 1—Qualifying speeds at the 500-mile race. a—Nearly all drivers were from US in 1964. b—European drivers raised the speed norm in 1965, eliminating some low scorers.

Reaction time of a top professional driver like 1965 Indianapolis champion Mario Andretti is far faster than that of the noncompetition driver. Slow reflexes in a race can mean disaster or a poor showing.



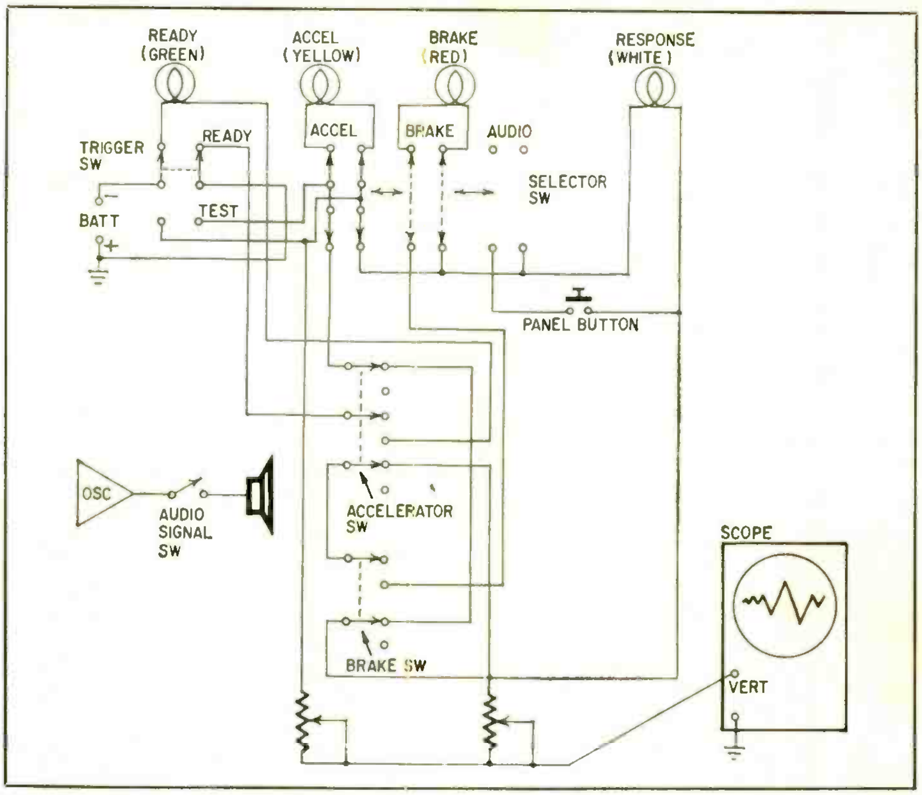
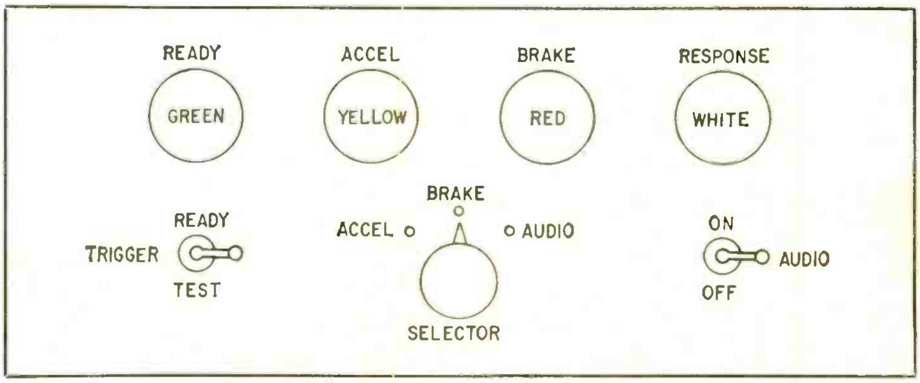


Fig. 2—The reaction-time tester displays a scope trace which denotes the speed and dexterity of the driver being tested. Lights tell driver what he is expected to do.



TESTER'S PANEL

Fig. 3—Pilot lamps on the operator's panel monitor operational modes. The driver's panel contains similar pilots wired in parallel to the operator's, along with a speaker. On the floor are accelerator and brake pedals which operate switches and trigger the scope.

parent that if one driver's reaction time is great enough to permit him to delay 0.3 sec in applying his brakes when entering a corner, he will be able to sustain his maximum speed an additional 87.9 feet with safety at the end of each straightaway.

For the same level of controllability, a driver with lesser abilities has no choice but to apply his brakes well ahead of the point of no return. Normal reaction time on the Gaussian distribution curve for an average man on the street is about 0.7 sec, while that of a top-rank racing driver is about one-half that.

The oscilloscope provides a readily available, accurate and standard instrument easily adapted to reaction-time measurements. Fig. 2 shows a schematic for a reaction-time tester using an oscilloscope indicator and a camera as the recording instrument.

A simple procedure for using the circuit shown is: The panel-mounted TRIGGER switch (Fig. 3) is set so the battery is connected to the green indicator light which won't light until the accelerator pedal on the subjects console is pushed down. The driver being tested faces a panel on which there are four lights—green, yellow, red and white—plus an AUDIO pushbutton. Just below the driver's panel on the floor are the brake and accelerator pedals. The driver sits on a chair in front of the panel and grips two handles at the side of the chair (to keep his hands away from the panel).

The operator's panel also has four lights wired in parallel with the subject's console lights. In addition, the operator has a TRIGGER switch. When this switch is set at READY, the green light will glow as soon as the driver presses the accelerator. A mode-selector switch and an audio switch also are mounted on the operator's panel.

With the driver in position and the accelerator depressed, the operator may choose which driver reactions he will test. He can, by choosing the proper position on the selector switch, (1) measure how long it takes for the driver's foot to come off of the accelerator; (2) measure how long it takes the driver to lift his foot from the accelerator and hit the brake, and (3) measure the time required by the driver to let go of the seat handles and depress the audio pushbutton on his panel after hearing an audible signal.

A simple "light on" push-the-button test was not used, because in actual racing situations, not only is a reaction required, but a sound decision must precede it. Therefore, the testing panel was designed to force a decision and then the reaction.

To perform a test, the operator turns the SELECTOR switch to ACCELERATOR. When he throws the TRIGGER switch from READY to TEST, the green light goes out, the yellow light comes on, and a small dc voltage is fed to the oscilloscope variable trigger. This signal starts a sweep across the scope. Sweep time on the scope can be varied, but 0.1 sec/cm allows a full second of time to be displayed in large 0.1-sec increments. The driver being tested sees the yellow light come on and, if he makes the correct decision, lifts his foot from the accelerator. As soon as his foot lifts, the white RESPONSE light comes on and a second small dc voltage is fed to the vertical input of the oscilloscope. This causes a "blip" to appear on the scope tube. The distance from the beginning of the sweep at the left-hand marker on the scope face to the "blip" is elapsed reaction time.

If the driver makes a wrong decision when the yellow light flashes and hits the brake instead, no voltage can get to the white light or to the oscilloscope. The selector switch not only selects the test but blocks any response other than the correct one.

Interesting data will be taken using this equipment this May at the Indianapolis track. Once enough data are gathered, meaningful criteria can be established to provide a useful analysis of what constitutes excellence in the demanding profession of driving racing cars. END

Thinking Computers? Think Small

They're everywhere—simple-to-operate, desk-top electronic calculating instruments

By **MELVIN WHITMER**

AS RECENTLY AS 15 YEARS AGO, ACCORDing to the American Federation of Information Processing Societies (AFIPS), there were fewer than 25 computers at work in all of the US. That number has grown today to well over 35,000, and the AFIPS predicts that by 1975 there will be more than 85,000—representing an annual investment of $30 billion.

Understandably, the greatest increase—because of their lower initial cost—will come in the area of compact and desk-type computers. Though physically small, many of this new generation of time-savers are capable of a wider range of computations than some of the huge multi-rack installations of a decade or so ago.

Strictly speaking, the subject of this article is a hybrid. An electromechanical calculator, or adding machine, can perform only simple operations. A true computer has large-capacity memory banks and can be programed, or instructed, to "learn" a long and intricate series of computations. A desk-top computer can do more than an adding machine but less than a true computer. It is becoming a popular item with many businesses, and will be used so much in the future it will open many job opportunities. Electronics technicians will be needed to service these computers.

In all but a few isolated instances, factory-service opportunities include extensive training programs for technicians with a good technical background. Factory-trained technicians service and repair computer hardware directly for the factory or for local franchised distributors of the equipment.

Although service during warranty will be performed by the factory or by its authorized distributors, most manufacturers later will encourage in-plant electronics personnel to perform all routine computer maintenance. Service information and short training courses will be made available to the personnel of qualified plants. Many users obviously will have to add technicians to their existing staffs when complex computer equipment becomes a significant part of the company's office equipment.

Manufacturers of desk-top computers agree, however, that independent industrial-service organizations will be unable to enter the field of desk-top computers. Few, indeed, would want to. Sales and service functions of this magnitude are best performed under factory direction. Service information, therefore, seldom will be available to independents.

Personnel requirements

It's hard to generalize about what talents and training are required for factory-service work. Each manufacturer has his own employment standards. Very few require applicants to hold degrees for field and shop work—high school and an interest in electronics generally are minimum requirements. Technical-school graduates should have no trouble being accepted as trainees in any manufacturer's sales and service department. Experience in office-machine servicing is most desirable, but an electronics technician with this type of background is rare indeed. The market is wide open, and most companies are expanding their sales and service staffs for the time when their electronic calculators become part of every corporation's office-machine budget.

Integrated circuitry is largely responsible for stuffing a useful measure of large-computer capability into a small package. And some manufacturers use interchangeable printed-circuit cards to hold several IC's at one time. These modules are stacked compactly in a holder or "bin."

The capabilities of a typical desk-top computer reach far beyond those of mechanical calculators or adding machines. Operations include adding, subtracting, multiplying, dividing, working with powers and roots, logarithms, factorials, and trigonometric functions. These and other capabilities of small computers will add efficiency to business offices and engineering departments. Full-scale data-handling systems won't become obsolete, of course, but only those problems requiring very complex processing will be sent to the central computer.

Simple problems, or preliminary steps in a more complex program, will be

Sage 1 (Dero Research & Development) has 20-digit register.

IME-86 has 7 registers to store various parts of a problem.

Canon 161 is a self-contained unit with Nixie-tube display and integrated circuits.

Operators (+, —, etc.) are printed in red on paper tape of Monroe's Epic 3000.

SCM's COGITO 240 SR has 31 keys for insertion, selection, and storage control.

accomplished with the desk-top computer. This elimination of trivial tasks will greatly increase the usefulness of the central computer. Since operating a small computer is similar to operating a mechanical calculator, it's a job easily assigned to non-technically trained employees.

An integrated circuit deposited and etched on a chip of silicon or other semiconductor material performs the same function as a conventional multicomponent stage. Resistors, diodes, capacitors and transistors that normally would be used to build a typical transistorized stage are replaced by small areas of deposited metallic oxides.

The circuit shown in Fig. 1-a is the equivalent of that constructed on a single integrated-circuit chip. In operation the circuit establishes two stable conditions: The first occurs when Q1 and Q2 are conducting; the second, when Q3 and Q4 are conducting. Input pulses are applied to S_C or R_C. Clock pulses—which synchronize the advance of data through the computer—are applied at connector C. Outputs are obtained from R_D, Q, S_D, or $\overline{Q}$ and differ primarily in current-output characteristics. Outputs R_D and S_D vary about 1.5 volts, based upon the stable condition. Outputs Q and $\overline{Q}$ vary about 3.5 volts, at a higher impedance than that available at R_D and S_D.

If a set pulse is applied to R_C, then Q1 and Q2 are driven into conduction by resultant decrease in base current for Q3 and Q4. The first input pulse at S_C reverses the stable state, cutting off Q1 and Q2 and driving Q3 and Q4 into conduction. A clock pulse will then produce outputs (negative pulses) at S_D and Q.

Microelectronic circuits formed in metal-oxide-semiconductor (MOS) chips often replace as many as 200 standard components; a complete 10-digit counter, for example, can be built into an MOS chip. This greatly reduces the size of the computer without sacrificing problem-solving ability.

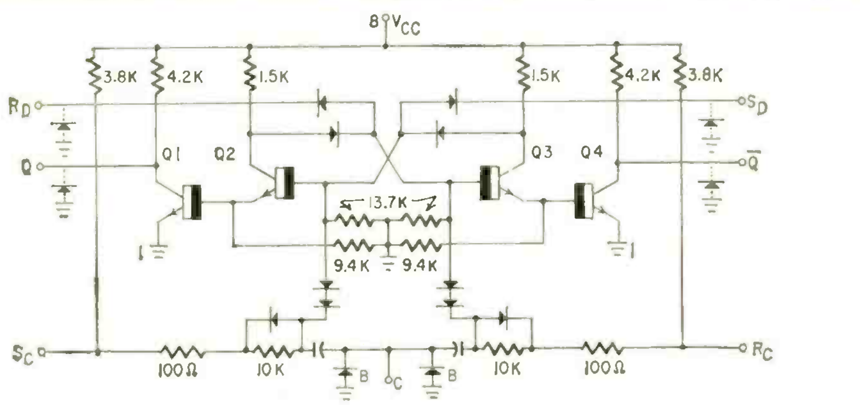
Servicing MOS circuitry requires some understanding of the computer layout, a visual inspection for open or shorted printed-circuit paths, voltage tests and finally, replacement of the defective unit. Most computer manufacturers use some form of modular design to facilitate plug-in repairs. The defecttive plug-in board module may then be returned to the manufacturer's central-repair station for detailed analysis and for repair, when that is possible. Alternatively, the digits may appear on Nixie tubes or a CRT.

The block diagram of a typical small computer is shown in Fig. 2. Keyboard output is fed to the control unit. From the control unit, input data pass to the "learn" or storage sections. The mathematic unit may accept data from the storage register or from the keyboard input (through control unit). Steps, operators and solutions are fed to the printer control circuits, then imprinted on the tape.

A computer like this may "learn" 24 or 48 steps, depending upon the model selected, and there are eight storage registers. The learn feature is the next best thing in computer capability to a completely stored program. Several steps can be stored in a program memory when a problem is repetitive. Working with progressions (1, 7, 13, 19, etc.) and factorials (17 x 16 x 15 x—etc.) could be tedious if done manually. The program memory learns a few basic steps and the operator then activates an automatic sequence.

Desk-top computers defined

All categories of computers are achieving a far greater component den-



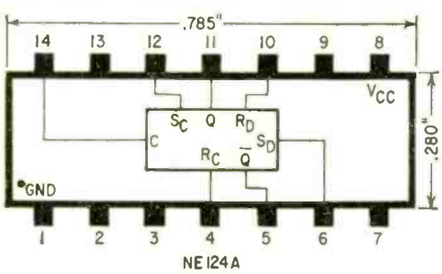


Fig. 1—The integrated circuit has made the small computer possible. The entire circuit at left is manufactured on the ¼- x ¾-in plug-in module shown above.

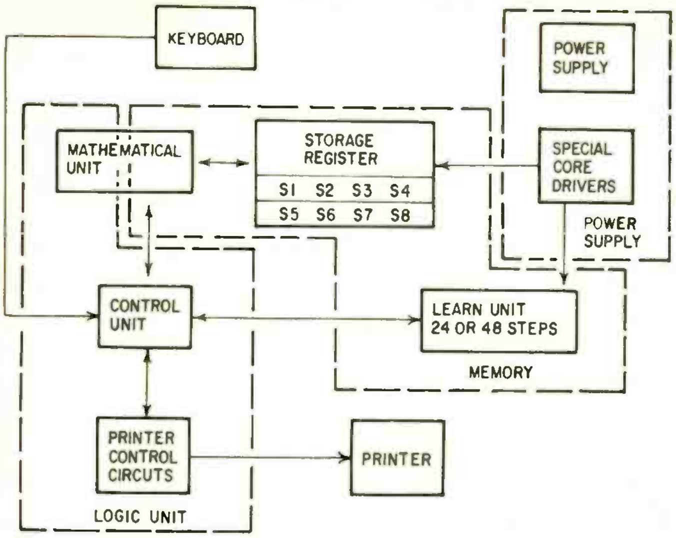
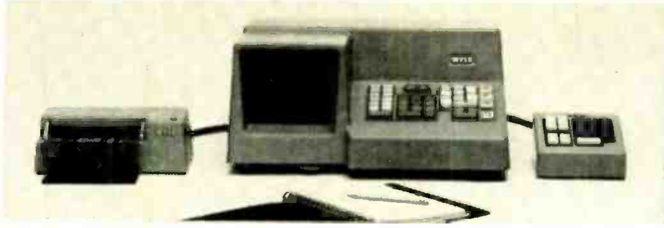


Fig. 2—This block diagram of a typical small computer shows functions used in the learning and calculating processes.



Wyle Scientific calculator uses a cathode-ray-tube display.

This microelectronics calculator by Victor employs 30 MOS (metal-oxide-semiconductor) devices for circuit reliability.

Thinking Computers? Think Small

sity through microcircuit techniques. So, the distinction between desk-top and central computers has to be drawn not only on physical size but on capability as well. A desk-top computer is generally considered to be one that requires no formally prepared stored program entered in a special language. Most desk-top computers are operated like adding machines or mechanical calculators. Problem information is inserted through a digital keyboard or typewriter in much the same sequence as it would be written by hand. When a special program language is required, the computer is properly called a general-purpose digital computer, even though the keyboard or typewriter can be placed on a desk.

Physically, desk-top calculators are either completely self contained or have only a small auxiliary unit that can be mounted under the desk. When the electronic package is built into a desk or console, the computer's computational capacity is usually so large that some form of preprograming is necessary. Typewriter, teletype, punched tape or card-reader inputs usually put a computer out of the desk-top class. The exception, of course, would be the addition of one of the above input units to a keyboard-input computer to extend its versatility.

Operation

Since a desk-top calculator seldom requires a stored program, steps to be performed are entered as the computer works the problem. Most small units have storage registers for holding partial solutions or constants. Thus, solving a problem involves step-by-step progression initiated by the operator.

As an example, the sequence of solving a parallel-resistance problem might go like this:

$$\frac{R1 \times R2}{R1 + R2} = R_t$$

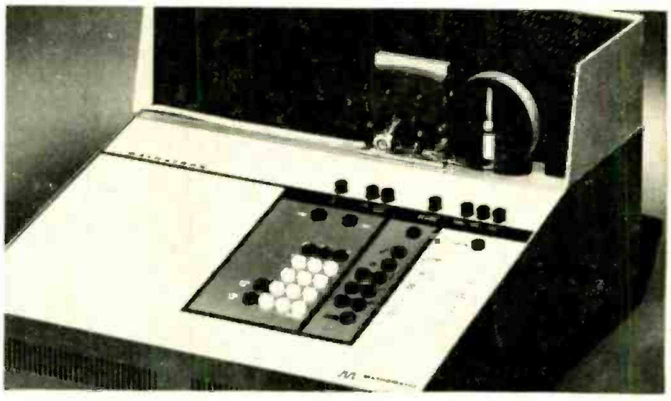
1. Enter value for R1.
2. Add value for R2.
3. Store sum in a register.
4. Enter value for R1.
5. Multiply by value for R2.
6. Divide by sum stored in register.

The operator takes the place of the program that is normally stored in a big computer. The 10-digit keyboard is used by most manufacturers for data entry, and additional keys select the function to be performed.

There seems little doubt that desk-top computers will increase in number by the tens of thousands during the next decade. Indeed, some expert observers compare the effect of the "computer revolution" to that of the machine-based technology that sparked and nourished the industrial revolution of the last century. If that is true, and it seems to be, the predictions of the AFIPS may prove to be extremely conservative.

In any case, opportunities for technically trained electronics specialists are certain to grow along with the expanding computer technology. Take a good, hard look at a fascinating field. You well might find yourself a part of it. END

With the Wang 360 you can find the sum of a set of digits and also the sum of their square roots at the same time.



Mathatronics Mathatron supplies a paper-tape answer showing the complete problem solution with all operational signs.

Build Hydronic-Radiation Transmitter

A new experimental radio technique

By JACK ALTHOUSE

"Scientists in Florida have discovered a new form of electromagnetic radiation which propagates under water as well as radio does in air."

"I must protest. Has a serious trade journal resorted to sensationalism? It appears that either a hoax is being perpetrated or that . . ."

"A new mode of communications—via underwater electromagnetic radiation—is being explored by Hydronics Corp. Wallace Minto, inventor of the system, says signals have been transmitted over a distance as great as 30 miles by this method."

Is "hydronic radiation" a fact or a fraud? It has raised a storm of controversy as illustrated by the quotations above, all of which were written by responsible engineers or technical editors. The fact is that hydronic radiation does work. And the equipment is easy to build once a basic understanding of the new concept is attained.

But first, let's see how the system's inventor describes hydronic radiation. Wallace Minto of Sarasota, Fla., describes it as "a new vector field related to the electromagnetic and magnetohydrodynamic forces, characteristically propagated through a water medium and associated with electronic oscillations." Translation: Hydronic radiation is the same as radio, except that it works through water instead of air.

Only the antennas distinguish the hydronic-radiation system from a conventional radio system. Receiving and transmitting antennas both have large plates, at each end of an insulating separator, to make contact with the water. A halfwave radio antenna has insulators on each end and radiates at right angles to the wire, as shown in Fig. 1-a. The hydronic-radiation antenna *appears* to radiate off the ends of its plates (Fig. 1-b).

Early hydronic-radiation experiments were made in the salt water of the Atlantic Ocean, and it's in the oceans that the most exciting possible applications for hydronic-radiation systems exist. Static-free communication between ships, dependable communication with submarines, and trans-Atlantic communication without cables have all been suggested by the concept's proponents.

But hydronic radiation also works through the fresh water found in lakes and rivers. As a matter of fact, the transmitter described here can be used in ordinary tap water to perform experiments in your bathtub.

When working in water, it's dangerous to use ac-powered equipment; the transmitter, therefore, is designed to operate from a 9-volt transistor radio battery. Power drain is low, and the battery will last for many hours. The transmitter schematic is shown in Fig. 2. Q1 is the rf oscillator, tuned by L1 to transmit in the standard broadcast band, allowing use of an ordinary transistor-type AM radio as a receiver. Q2 is an audio oscillator, operating at about 1 kHz, which modulates Q1 through transformer T. The tone-modulated signal stands out clearly among the regular stations and thus makes testing easier.

The transmitter is built in a 5 x 7 x 3-inch aluminum box, with all components mounted on a perforated board except for L1 and the terminal strip. These are mounted on one end of the box. Standard construction techniques are used, and parts placement and lead lengths are not critical.

L1 is modified by winding a 25-turn coupling coil at its lower end. The two terminals marked TRANSMIT are used as the on–off switch. When the terminals are connected by a shorting wire, the transmitter will operate.

To test the transmitter, leave the box open and place a transistor radio next to the circuit board. Tune across the band and listen for the modulated tone signal. It should appear between 550 and 800 kHz. If you can't find it, set the receiver dial at 550 kHz and tune L1 until the tone is received.

The transistor radio becomes our hydronic-radiation receiver with a simple modification. Open the case and wind 25 turns of No. 24 enameled wire

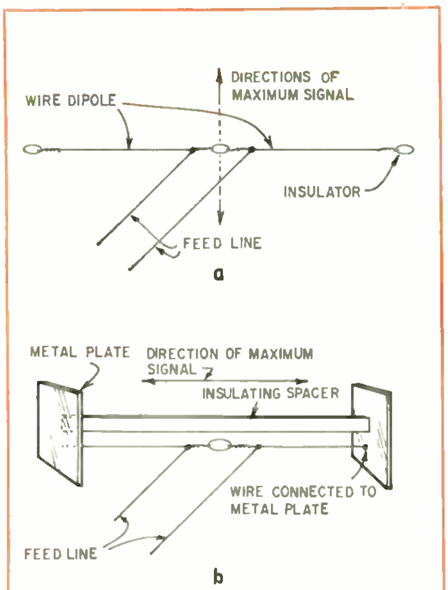


Fig. 1—Differences between conventional dipole antenna (a) and hydronic-radiation antenna (b) lie in the configuration of the brass endplates and spacer. Radiation patterns are also completely different though no one knows why.

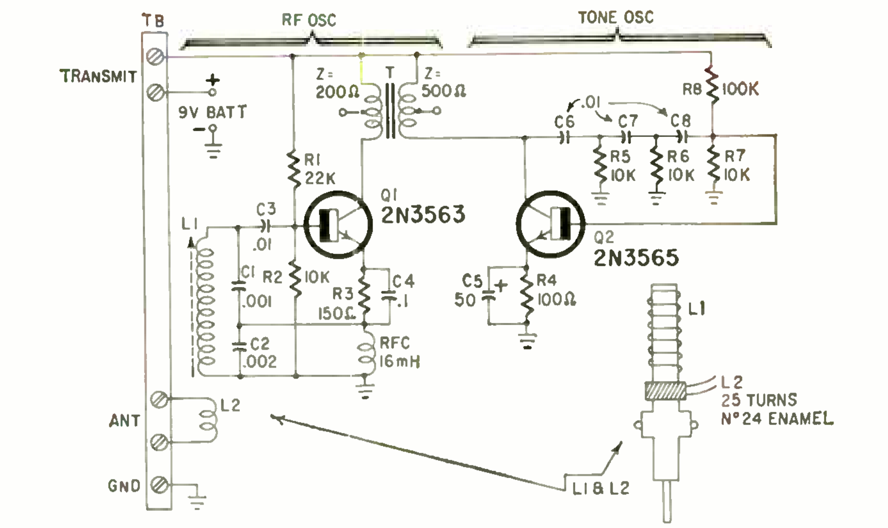


Fig. 2—Hydronic transmitter is a simple rf oscillator modulated by a tone.

C1—.001 μF, disc
C2—.002 μF, disc
C3, C6, C7, C8—.01 μF, paper
C4—0.1 μF, paper
C5—50 μF, 10 volts
L—slug-tuned inductor 0.15 to 1 mH (J. W. Miller No. 9002)
Q1—Fairchild 2N3563
Q2—Fairchild 2N3565
R1—22K
R2, R5, R6, R7—10K
R3—150 ohms
R4—100 ohms
R8—100K
RFC—rf choke, 16 mH (Bud CH-1227)
T—Driver transformer 0–500 ohm; 200-ohm Stancor TA-59
TS—Terminal strip (Cinch-Jones 17-5)
BATT—9-volt transistor radio battery and connector
Aluminum box (LMB TF-782 7 x 5 x 3 in.), perf board (Vector 85G24EP), terminals (Vector T-28)

around its ferrite-loop antenna. Leave about 6 inches of wire at each end of the winding and twist the ends together to hold the winding in place. Bring the wires out of the case and snap the cover shut to hold them in place.

Two identical antennas are needed, one for the transmitter and one for the receiver. Fig. 3 illustrates the simple construction. End plates are 2 inches square, of 18-gauge brass cleaned to the bare metal to make good contact with the water. The 6-inch spacer can be of Bakelite, Lucite or other insulating material.

Two 6-foot lengths of plastic-insulated hookup wire are used for the feeder. One wire is connected to each plate by a solder lug passed over the end of the plate, then fed through holes in the spacer which allow the wires to be stretched taut. The rest of the wire is twisted together to make a balanced feed line.

Strip the enamel insulation from the ends of the antenna-feeder wires and from the two receiver leads, then solder them together. Tape the connections to prevent shorting.

Connect the second antenna to the transmitter. Place the antennas close together and check to see that the tone-modulated signal can still be heard at 550 kHz. Adjust L1 if necessary.

Final equipment checks should be made with the antennas in water. A pool of water at least the size of a bathtub is needed, and the water should be a foot or more deep. Place the antennas facing each other about 3 feet apart. Retune the receiver to find the tone. It will appear at about 700 kHz (the water loads the transmitter heavily and shifts its frequency).

To make sure that the hydronic-radiation signals are being received through the water, lift the receiving antenna out of the water. The signal should disappear or at least drop considerably in volume.

With the gear ready, we can perform a few experiments, to see how the system operates. A few questions may be answered, and a few more may be raised.

Hydronic-radiation experiments

One of the interesting characteristics of a hydronic-radiation communications system is the apparent directional pattern of its antennas.

Place the antennas underwater with the end plates parallel to each other. Rotate one antenna 90° horizontally or vertically so the edges of its end plates are perpendicular to the other antenna's end plates. The signal will fade as you rotate, disappearing completely at the 90° position. As you turn toward 180°, the signal will come back and become strong again as the end plates once again become parallel. This experiment appears to show that the antennas radiate off the ends of the plates.

Antenna engineers, however, say, "No. The signal does *not* radiate from the surface of the plates." Instead, they explain, the signal radiates from the wires that connect the plates. These wires actually form a dipole antenna; the plates, they say, are just "ground rods." Furthermore, the signals do not go straight through the water at all. They travel from the transmitting antenna upward to the surface of the water, along the surface, then back down to the receiving antenna.

This description of hydronic radiation suggests that the behavior of signal radiation is opposed to our general experience. It is true that a horizontal-wire antenna will radiate its signal upward. The up-over-down theory implies that when hydronic waves reach the surface of the water, they must bend at right angles to travel along the surface. Then, when they are above the receiving antenna, they must bend downward so the antenna can pick them up.

Long-range antennas

The maximum distance for effective communication by hydronic radiation apparently depends on the spacing between the antenna plates. The greater the spacing, the longer the range. Plate spacings of 1,000 feet have been used to communicate over several miles.

For our experiment, a plate spacing of 6 feet is convenient and will provide a range of 100 feet or more. The antenna will use a 6-foot 2 x 2 wood spacer and 1-foot-square brass plates. The plates don't have to be that big, but they must be heavy enough so the antenna will sink in the water (the wood spacer tends to float, of course). A good electrical connection is made to each plate, the connecting wires are brought directly to the center of the antenna and twisted to form the transmission line, which should be about 15 feet long. As before, two identical antennas are required.

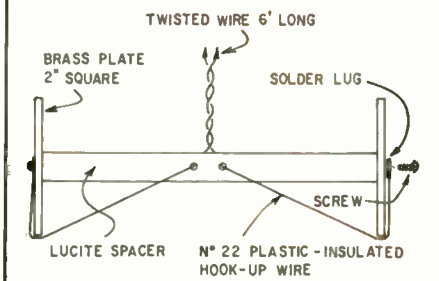


Fig. 3—Here's how to attach feedline.

Up-over-down experiment

The antennas should be placed about 50 feet apart in water at least 6 feet deep. With the antennas just below the surface and pointed at each other, the signal should be received loud and clear. Now, if both antennas are slowly lowered deeper into the water, the distance between them being kept the same, we observe an interesting result. The deeper the antennas go, the weaker the signal becomes. If we put the antennas deep enough, the signal disappears completely. Since the distance between the end plates hasn't changed, we would expect the signal strength to remain the same.

If the antenna engineers are correct, however, the up-over-down path is 50 feet long when the antennas are 10 feet below the surface. Thus, if the up-over-down theory is true, we would *expect* the signal to become weaker as the antennas go deeper into the water. Since the signal is, in fact, weaker with the antennas deeply submerged, our experiment apparently shows that the antenna engineers are right. The signal probably *does* go up-over-down.

Future of hydronic radiation

One experiment seems to "prove" that hydronic radiation travels off the ends of the antenna plates. Another seems to "prove" the signal somehow goes up-over-down. Is there an experiment that could prove that neither explanation is correct? If so, engineers haven't yet discovered it. But there is no reason you can't experiment with your radiation transmitter to see what conclusions might be drawn. After all, the last word on the concept isn't in yet.

So far, experimenters are strongly divided on whether hydronic radiation actually is a different form of electromagnetic radiation that will prove useful in underwater communication systems. One camp holds that rf energy generated by the "hydronic" transmitter is radiated through water in much the same manner as it would be through the air, though with some differences. Obviously the circuits employed are identical in equipment used for both propagation media: air and water. The second group feels there is some basically different phenomenon at work, one that promises efficient underwater communication.

Only extensive experimentation under carefully controlled conditions will provide the complete answer, of course. But, you can explore a phenomenon that's in the news today, and do it with very little cash outlay. The "hydronic" transmitter *does* work: why it does isn't apparent, at the moment. END

WORLD'S TOUGHEST R/C JOB

—Guidance in Outer Space

By ALLEN B. SMITH

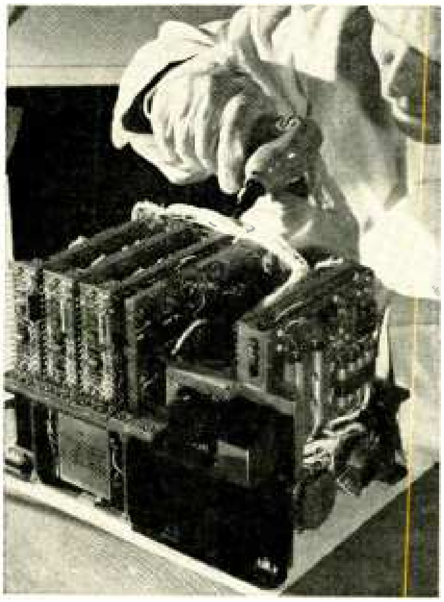
NASA'S SPECTACULAR SUCCESS IN SOFT-landing Surveyor 1 on the moon, and in obtaining high-resolution photographs of the lunar surface from Lunar Orbiter, has generated a tremendous surge of interest in America's plans to explore outer space. Project Apollo, though struck by the tragic fire that took the lives of astronauts Grissom, White and Chaffee, continues to captivate the interest of the world public. By the end of 1968 or early in 1969, three American astronauts will embark on an historic 8-day trip to the moon and return to earth. Two of the three-man Apollo crew will explore the moon's surface during a projected 35-hour encampment.

Virtually every system in NASA's diversified collection of spacecraft depends heavily on electronic instrumentation. Of all the electronics, the guidance and navigation package in all missiles and spacecraft is particularly interesting.

In NASA's space-exploration program there is a bewildering array of spacecraft. They fall roughly into three major categories: missiles, unmanned probes, and manned spaceships and capsules. Each is designed for a specific purpose, and each has a unique physical configuration. Yet in the center of all those vehicles nestles a group of gyroscopes and accelerometers, a computer and other precision components. These comprise the nucleus of the remarkable *inertial guidance and navigation* unit.

Ballistics missiles like Redstone, Jupiter, Atlas and Titan, originally conceived as force-deterrent weapons, have been developed into highly dependable vehicles for thrusting American satellites and spacecraft into space. This family of rocket-engined craft uses the most direct form of inertial guidance. The system's computer is preprogramed to control the vehicle during its flight without reference to external signals.

Unmanned, instrumented spacecraft are far more varied than missiles. Explorer, Pioneer, Nimbus, Tiros, Early Bird and other orbital craft employ an inertial-guidance system, but only to maintain or correct the attitude of the satellite relative to the earth. Lunar probes of the Ranger and Lunar Orbiter series are equipped with restartable rocket engines and may be required to make midcourse corrections. They must, therefore, be able to receive commands from ground-based stations so that their computers can develop course-change commands to the attitude-control system and the main propulsion engine. Surveyor-series craft can do that also.



Containing over 1,500 components, this IRU device guided the Lunar Orbiter.

Inertial guidance and navigation equipment in manned spacecraft is much more complex. It has a variety of subsystems that augment the basic inertial system and insure absolute control and pinpoint accuracy.

In simplest terms, an inertial-guidance system is a self-contained instrument package requiring no external reference signals or commands once it has been programed to guide a vehicle to its destination. It must have three basic elements: (1) a directional reference provided by gyroscopes, (2) a memory device—usually a compact computer, and (3) velocity-sensitive accelerometers to detect external forces that alter the vehicle's course in any direction. The computer integrates information obtained from the gyros and accelerometers to produce electrical error signals that command the attitude-control system and main rocket engine.

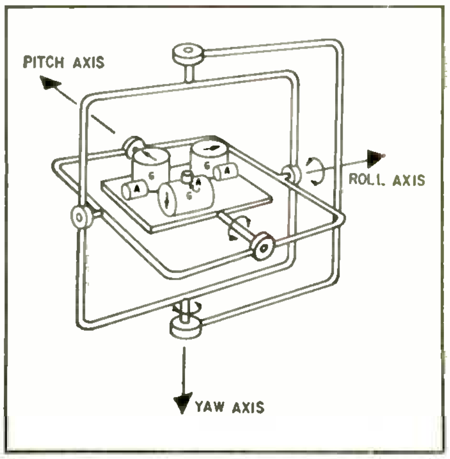


Fig. 1—Heart of inertial-guidance system is gimballed platform with three gyros.

The heart of the inertial system consists of the *stable platform,* also known as the *inertial reference unit* (IRU), or the *inertial measuring unit* (IMU). The platform is a three-axis gyro system. It establishes a stable element to which the accelerometers are mounted. Fig. 1 shows how the three gyros (G) and three accelerometers (A) are suspended by the innermost member of a gimballed support framework. Gimbals permit the gyro assembly to tilt freely in any direction. Axes of the gyros and accelerometers coincide to make a kind of artificial horizontal/vertical frame of reference against which spacecraft motion is measured and computed.

The gyro platform "wants" to remain fixed as the vehicle tips and pitches around it. When the gyros are disturbed in any axis or combination of axes, output signals are obtained. These signals are applied to small torque motors which reposition the stable platform. This action compensates for the axial disturbance and restores the correct frame of reference. Gyro output information also is fed into the computer to record the history of the flight for reference in future computations. As long as the computer knows where it is going and where it has been (in the form of integrated data from the stable platform), it can compute flight-path corrections to arrive exactly at the destination.

A gyro used in inertial systems is so sensitive that the weight of an oily fingerprint on its balance wheel would cause the entire gyro to drift enough to cause a serious aiming error and throw the spacecraft completely off course. The accelerometers, too, have startling capabilities. A typical unit is capable of measuring velocity changes as great as 10 G's (equivalent to accelerating a body from 0 to 60 mph in ¼ sec) or as slight as .0008 G (from 0 to 6 mph in 3 hours).

These elements are necessary to any inertial system. While such basic packages have been used in orbiting spacecraft and in missle and booster rockets, most of the state-of-the-art inertial systems (Lunar Orbiter and Apollo particularly) have complementary subsystems to increase the effectiveness of the guidance and navigation equipment. The Apollo, for example, uses a scheme like the one diagramed in Fig. 2.

The most spectacular performances of inertial guidance and navigation equipment to date have occurred in the Mariner. Lunar Orbiter and Surveyor spacecraft.

Launched on November 28, 1964, Mariner IV was lofted into an initial parking orbit around the earth by an Atlas booster. Reaching the optimum point on this orbital path from which it would begin its trajectory to Mars, the restartable Agena second stage thrust the craft into its interplanetary path. Separated from the booster, Mariner then was free to follow the commands programed into its computer sequencer or to receive commands from the control center on earth.

In flight for more than 7.375 hours before passing beyond the range of the Deep Space Network. Mariner performed literally thousands of attitude corrections and major orientation changes. Data, both from the scientific instruments carried on board and from the spacecraft support telemetry system, were fed back to earth continuously. The final signals, received far beyond the orbit of Mars, were at a level of 10^{-18} (a billion-billionth) watt!

The first operation required of Mariner after separating itself from the Agena booster was to position itself to receive light from the sun. The craft's sun sensor locked on the sun, positioning the solar-cell power panels that generated electrical power for all systems. This maneuver assured a continuing supply of power for the duration of the flight.

With Mariner locked onto the sun along its roll axis, the CC&S (central computer and sequencer) activated a second optical unit, this time to identify the bright star Canopus. Lying about 15° from the spacecraft's south rotational pole, perpendicular to the sun-lock roll axis, Canopus was used to position the craft's antenna systems. This maneuver enabled Mariner to receive ground-control commands required for midcourse correction. It also aimed the two 10-watt transmitters used to relay scientific data back to the earth-based stations.

Midcourse commands were the only signals Mariner *had* to receive from ground control; the CC&S was capable of handling all other en-route computations and commands. Still, Mariner's computer could respond to 28 additional ground-based commands, if an unplanned series of operations had to be performed during the voyage.

Midcourse trajectory was corrected December 5, 1964. Commands received by Mariner resulted in a change in attitude of 39° in pitch, 156° in roll. A burn of 20 seconds by the rocket propulsion system changed the craft's course 0.25° and increased its speed 37 mph. Mariner IV was now on a trajectory that intercepted Mars on the 228th day of its voyage. At the time of the Mars encounter, Mariner was 134 million miles from earth. The CC&S then triggered the television tape-recording system which transmitted pictures back to the ground-control stations.

Twenty-two complete electronic photographs were recorded by Mariner's camera system, and data on tape were transmitted to earth at 8⅓ bits per sec, requiring 8⅔ hr for each of the 22 pictures. The tape was played back twice to make sure a complete set of video data had been sent down. Signals required slightly more than 12 minutes to make the trip from Mars.

The inertial guidance system had to do two things during this epic solar-system exploration: It had first to position the craft by the sun and Canopus sensors. Second, it had to function in harmony with the ground-control commands to execute the midcourse maneuver and assure an accurate trajectory. Because gyros do drift and because magnetic, gravitational and light-pressure forces tend to change the attitude of spacecraft, the inertial system had constantly to detect minute variations in attitude and correct them to maintain the craft's position in space. No other kind of system could do the job.

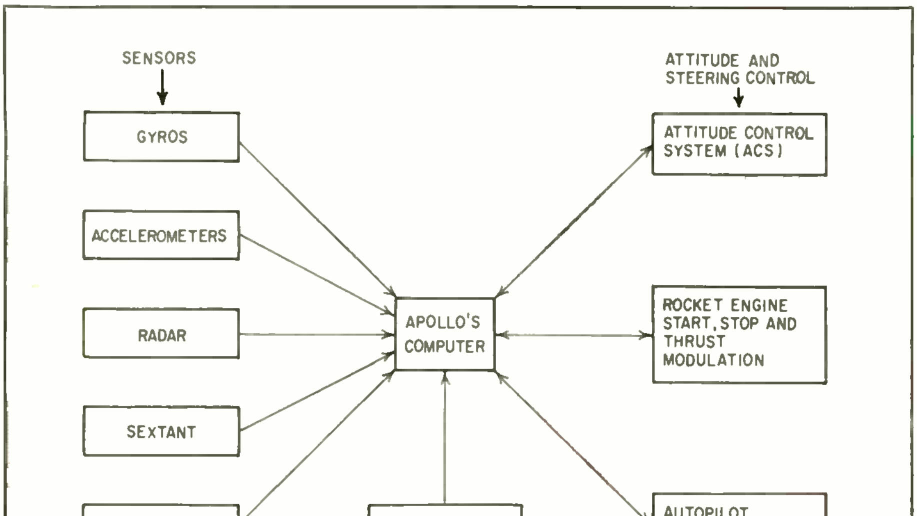


Fig. 2—The man-and-systems-augmented inertial-guidance package designed for the Apollo spacecraft is a brilliantly versatile and fantastically accurate vehicle control system.

Lunar orbiter

A more recent unmanned flight, the highly productive photoreconnaissance mission of Lunar Orbiter, also had an eventful space history. As you'll note in Fig. 3, several complex maneuvers were executed successfully during the 90-hr trip to the moon. Launched from Cape Kennedy at 19 hr 26 min GMT on August 10, 1966, the 850-lb photographic spacecraft was boosted into its initial parking orbit by the reliable Atlas/Agena rocket launch system. After 38 min and 3 sec in this preliminary orbit, during which the inertial system positioned the craft correctly for injection into the translunar trajectory, the Agena was restarted. The vehicle reached its escape velocity of approximately 25,000 mph, and the Agena parted from the spacecraft. Within 3 minutes, the high-gain and omnidirectional antennas and the four solar-power panels were deployed. The Woomera, Australia, station of the Deep Space Net picked up the craft at 20 hr 13 min 38 sec GMT. From that moment on, the spacecraft was under the control of NASA and Boeing Co. scientists and engineers from the Langley Research Center.

The success of these early operations was due to the 13.2-lb inertial reference unit (IRU) shown in the photo. Designed and built by Sperry Gyroscope, the IRU supplied continuous attitude- and rate-error signals for the computer sequencer to use in executing commands from its programer and from ground-based stations.

Like Mariner IV, Lunar Orbiter carried sun and Canopus sensors for positional references during the lunar voyage. Sun-lock was achieved without trouble at 20 hr 32 min; but when the Canopus sensor was activated, it saw a visual light level of nearly 3 volts rather than the expected dark level of 0.56 volt, as shown by an examination of the telemetric data tapes. The 3-volt level was more than enough to blind the Canopus sensor, preventing it from locking on the star to position the craft before midcourse maneuver. Scientists eventually determined that the sensor was seeing light reflected from some part of the spacecraft itself, probably from the omnidirectional antenna.

For several hours it seemed that the mission might be doomed by this unforeseen development. By analyzing the telemetric data received from Orbiter, however, and by rolling the craft around its sun-locked axis, scientists in the control center discovered that the sensor could be locked onto the moon itself. Appearing to the sensor as a thin crescent, the angular dimension of the moon was small enough to provide an accurate position referenced to the IRU. This was possible only because a 1-day delay in launching put Orbiter in the only translunar flight path on which it would be able to see the moon within the narrow angle of recognition of the Canopus sensor! So coincidence, telemetric data analysis and remote-control capability all contributed together to the mission's success.

Once locked to the moon and the sun, the spacecraft was commanded to realign itself at midnight GMT on August 11. The needed thrust, computed from data received from the IRU and from the ground-control center, was supplied by the craft's 100-lb-thrust reaction engine, which burned for 32 sec. This maneuver changed the craft's course from a lunar-miss distance of 5,200 miles to an aiming point 3,950 miles behind the moon's trailing edge. Attaining the planned trajectory got the mission over one major obstacle, but for the critical retro-firing that would place the craft into an orbit around the moon, the Canopus sensor had somehow to be locked onto its star. Locked onto the moon, positional accuracy was rather crude—about 2°; an error signal accurate to 0.1° was required for the de-boost engine to start.

By rotating the spacecraft so the Canopus sensor's viewing angle began to include the sun, a protective bright-object sensor was triggered into closing a shutter over the Canopus sensor's eye, and a normal background level of 0.56 volt was obtained. This confirmed that the electronics in the star tracker was operating as designed.

A specialist on the system was flown to the control center from Boeing's Seattle plant, and he suggested that the sensor might lock on Canopus despite the high background that reappeared when the craft was once again stabilized in its sun-lock axis, *if* the spacecraft could be pointed directly at the star *before* the lock circuits were energized. Orbiter was then stepped in small rotational increments around its sun-lock axis across the area in which Canopus was expected to be found. After several attempts, the star was located, and the system locked on at 13 hr 49 min GMT on August 13.

Rather than place the sensor in its automatic-track mode, however, the loop was kept open to include corrections fed from ground-control equipment. This removed the possibility that the sensor might lose the star momentarily and begin a searching-mode roll that could not be stopped by the attitude-control system.

The retro-fire maneuver was executed at 15 hr 34 min GMT August 14, and the spacecraft was injected into its intended lunar orbit. The craft's rocket engine fired for 9 min 49 sec, the IRU accelerometer cutting off the engine when the velocity reached 790 meters/sec. The planned orbit was inclined at an angle of 12.04° to the lunar equator and had an apolune (high point) of 1,150 miles and a perilune (low point) of 124 miles. So great was the accuracy of the inertial system that the actual orbit was inclined at 12.18° with an apolune of 1,158.7 miles and a perilune of 117.4 miles. The orbital period was 3 hr 37 min 45 sec.

On August 18, Orbiter began taking the first pictures of the moon from a lunar orbit, and the IRU once again correctly positioned the spacecraft to point the cameras to the desired sectors of the lunar surface. On August 21, a second retro-fire burn of 24 sec was calculated by the inertial system, lowering the craft to within 30 miles of the surface. Velocity data supplied by the PIP accelerometers provided the cutoff signal at the calculated de-boost speed. Picture-taking continued through August 29, at which time the IRU locked onto earth to permit transmission of the video information. Everyone is aware by now of the spectacular quality of Orbiter's photography.

Thanks to the remarkable capability of the Deep Space Network, and to the analytical ability of the scientists at the control center, Lunar Orbiter was an outstanding success. It furnished us new scientific data about the moon.

We're on our way

Inertial systems like those in Mariner and Lunar Orbiter have enabled NASA's space scientists to expand tremendously the range of man's exploration in our solar system and of what lies far beyond. Within 2 or 3 years, the mighty Apollo moonship—364 feet high on its launching pad—will soar to the moon carrying three astronauts, two of whom will step out of their lunar module onto the moon's surface. Guided by inertial systems and a full range of complementary systems, men will take their first steps toward the stars. END

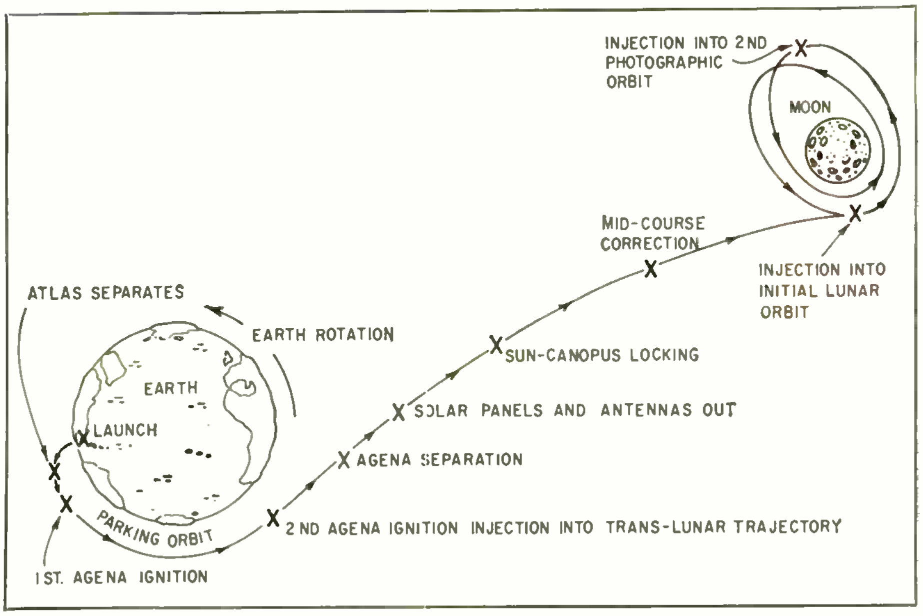


Fig. 3—During the voyage of Lunar Orbiter, many critical maneuvers were fed into the craft's computer sequencer from the ground-based control center. Orbiter then received the sequencer commands and followed them throughout the indicated trajectories.

Something New in Color Generators

This one has two unique features

By LARRY ALLEN

"FIND A NEED AND FILL IT."

Good philosophy for any business anxious to prosper. I ran across it in Addison, Ill., recently while I was investigating a lead about a new color generator. This one was supposed to be a new design that would eliminate the problems service technicians have been having with color generators since color-TV servicing began.

When someone tells me a new test instrument is unique, I can't suppress a twinge of doubt; *unique* means "single in kind"—"no other like it." I'll tell you what I found out about this one. You can decide for yourself if it solves the problems you've been having with color generators.

The company is Sencore, Inc. The new generator is their Color King model CG-141.

The first thing I did was talk with Sencore president Herb Bowden, engineering vp Bob Baum, and sales manager Dick Reed. How do they decide what goes into an instrument; indeed, why does the industry need another color generator anyway?

Herb Bowden answered first: "We evaluate what we hear from our distributors, reps and field men. For the Color King, we asked them and ourselves what are the chief problems service technicians have when they use color generators."

"And they were . . . ?"

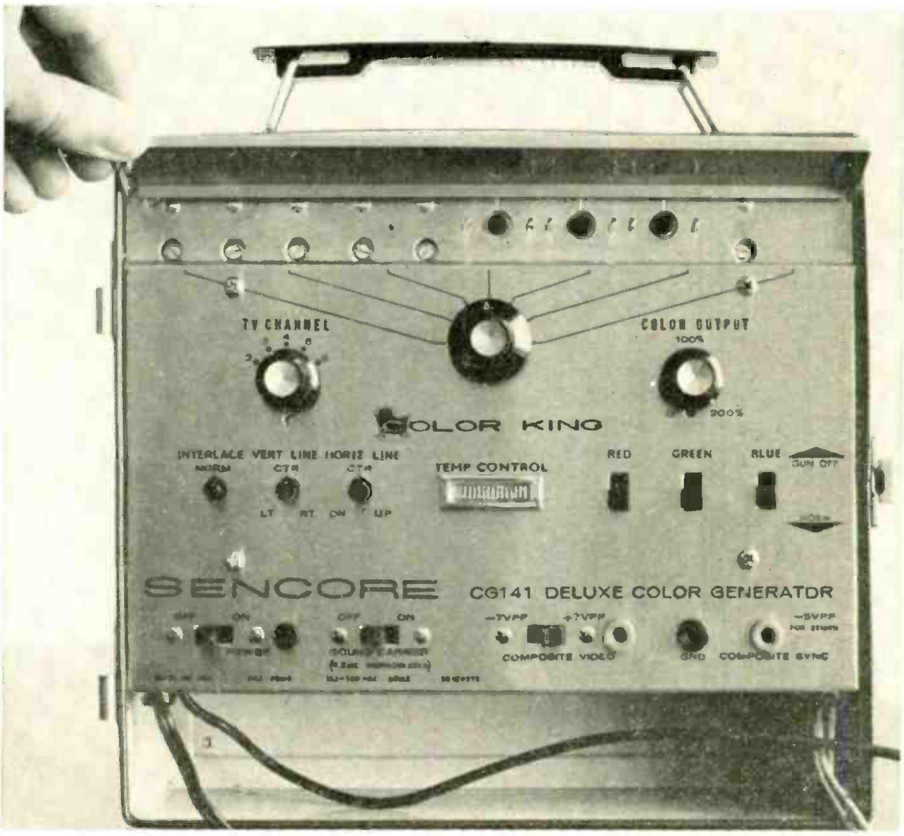
Bob Baum supplied the answer: "One thing is stability. It seems impossible to make a solid-state timer circuit that isn't sensitive to temperature. You bring the generator in out of a cold truck and it's at least a 30-minute waste of time trying to get a pattern to stop jumping and jittering. The Color King licks that problem."

"Anything else?"

Dick Reed fielded this one. "In the servicing seminars we hold all year long, we've found that another trouble is trying to figure out which dot is the center one while looking in a mirror. Our answer is a single dot."

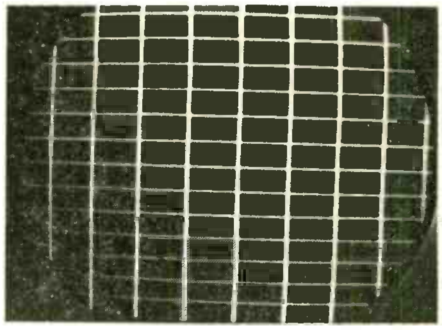
"Is that anything new?"

"Ours is movable," Dick pointed out with a trace of triumph. "You can move it to other places on the screen, too, for careful analysis of exactly how

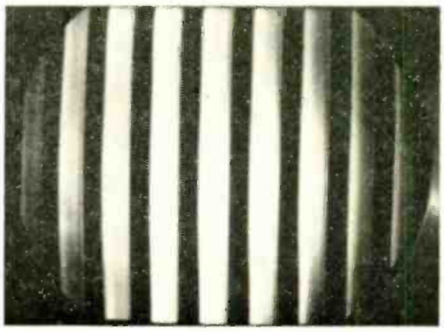


Like the lid of a soapdish, this panel flips up to expose calibration adjustments. The 5 screwdriver controls at upper left are used to zero-beat the 5 TV channel outputs.

The Color King, like other color generators, makes a screenful of dots in usual manner.



Conventional crosshatch pattern is useful for checking linearity on both b-w and color.



The CG-141 uses a keyed rainbow display for chroma-circuit setup and troubleshooting.

the convergence is off. No lines around it to hide the edges of the dot."

Maybe I didn't look convinced, because Dick went on: "But that isn't all. We've also heard many technicians complain about the difficulty of dynamic convergence. It seems the crosshatch gets confusing after you've watched it for a while. We decided what was needed was a pattern that could be moved to whatever section of the screen was called for on the convergence chart. Then adjustments could be made for each part of the screen without the distraction of seeing other parts of the pattern shift.

"We all know that convergence adjustments are easy if they're done in the proper order. Our movable single-line crosshatch takes away the temptation to correct other parts of the pattern before the first steps are done. We think this will simplify dynamic convergence for technicians."

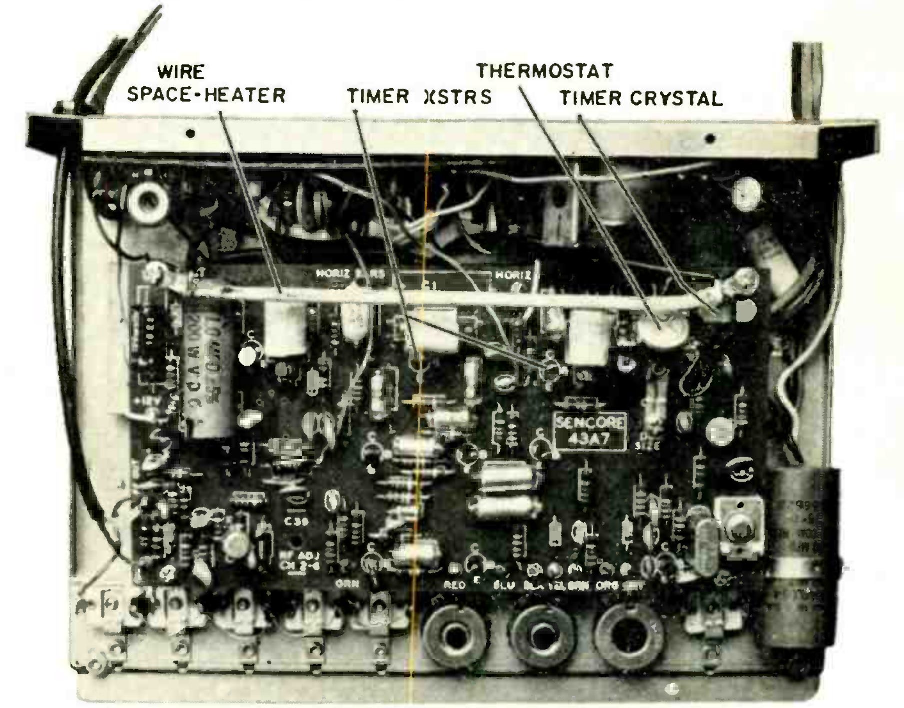
Dick speaks with some authority. He and five other Sencore men travel the entire country 26 weeks a year, holding a training meeting each night. He talks to from 30 to 50 technicians 130 nights every year. Since the meetings include training in servicing color TV, the field men hear a lot about the troubles the technicians encounter.

Then Bowden picked up the conversation again. "In conferences here at Sencore we decide what problems we're going to solve with our next piece of test equipment—what need we're going to fill. Then it's Bob Baum's job to figure out how to do it. He does, and we build trial models for the engineering staff and the field men to try out. Once all the bugs are worked out, we start planning production."

Dick Reed anticipated my next question by saying. "But we don't go into production right away. We build a few pilot models for the field men and for more lab testing. The Color King you're going to examine is one of this pilot run. We'll be field-testing others just like it before we actually release the model for production."

And so on. After our talk, I was walked out to the lab, given my choice of CG-141's from the pilot run, and left free to make whatever lab tests I could dream up.

I was curious about the temperature problem. What could they do in the CG-141 to cure that all-time headache —constant readjusting of timer or "hold" controls to keep the patterns steady? (This isn't a problem with most generators if the unit is in the shop and left on constantly, but it is when you take the generator along on calls. I know.) A temperature-compensating diode has helped in some generators, and I could see by the schematic that the Color King had this little helper, too. But that isn't enough.



Secret of Color King's stability is the space heater and thermostat which controls it.

What Sencore did in the CG-141 is simple, really. A heating element and a thermostat bring temperature inside the case, especially near the timer and counter transistors, quickly to 90° and then keep it there.

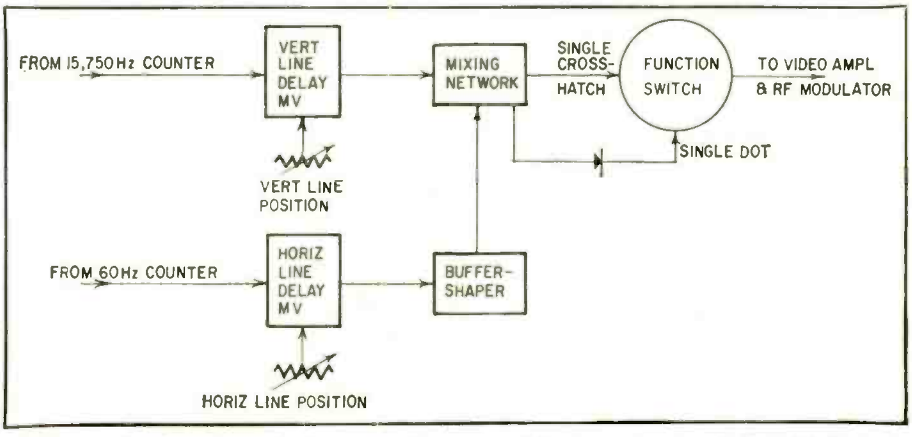
How well did it work? I put my Color King into an environmental chamber and ran it down to 30°F. After it had time to chill through and through, I took it out and connected it to a color set. Only 7 minutes after I plugged in the generator, the TEMP CONTROL light clicked off and I set the timers with the little knobs under the soapdish along the top of the front panel. Not once after that did the pattern even jitter. Repeated tests at Sencore have shown that the unit will warm up to complete stability from 20° below zero in 15 minutes or less.

Not satisfied, I ran the power cord out the access hole of the chamber. With the Color King on, I ran the chamber down to 30° again. Not a jitter. The thermostat light kept clicking on and off, but the counters stayed right on their timing.

For one last test, I unplugged the generator and let it get very cold again. Then I took it out of the chamber and turned it on. After 6 minutes, the TEMP CONTROL light went out. I didn't have to touch the timer controls; the pattern had locked in solid after the first 5 minutes of operation.

I thought this was great, but the feature Sencore seems most proud of is the CG-141's movable single-line crosshatch and movable dot. The photo series shows what the pattern looks like with the lines and dot in several positions.

In their lab, I was interested mostly in how they developed this unusual pattern. The diagram will help you follow



Single crosshatch and single dot are each produced by two cross-coupled multivibrators.

the explanation that follows.

Pulses from the 15,750-Hz counter trigger a multivibrator that develops a single output pulse for each horizontal line of sweep. As each line scans the picture tube of the receiver, this video pulse forms a single vertical line. A time delay is built into the multivibrator, controlled by the VERT LINE position pot, which determines how long after the start of the horizontal scan the pulse appears. Thus the pot determines the position of the vertical line.

The horizontal line for the movable single-line crosshatch is generated the same way. Taking its trigger from the 60-Hz counter, the horizontal-line delay multivibrator puts out one pulse for each frame. The timing of that pulse is set by the HORIZ LINE position control, thus selecting the location of the line on the screen.

The two are mixed in a resistive network and fed to the video section through the FUNCTION switch just like any other pattern. To form the dot, the two lines are fed through a clipping diode, and the dot is formed from their point of intersection. Thus the dot is movable by the same controls as the two crosshatch lines.

While I was still in the lab, Bob Baum pointed out other features of the Color King. The ones I particularly noted were the Zener-regulated line to the critical stages and the individually tuned rf channels. The CG-141 can be fed into channel 2, 3, 4, 5 or 6, and each is separately tunable by a screwdriver adjustment in the soapdish.

Lab work is okay, but I wanted to use the Color King. So I took my unit along with me when I left Sencore. Lugging it around with me might have some effect on it.

First thing I did was leave it outside in the cold overnight in below-zero weather. Next morning, connected to a color set, it warmed up in 10 minutes and never once shifted pattern again through more than 30 hours of continuous operation. I didn't even have to reset the timers after the Color King warmed up; they had held their stability just the way they were set when I left Sencore.

It wasn't long after that when I had a chance to try out that convergence gimmick. Would a movable crosshatch really make much difference?

Maybe a full-screen crosshatch doesn't make your eyes cross after staring at it steadily a while. Maybe you have the self-control to concentrate on only the part of the pattern you're adjusting in each step. I don't. Consequently, yes, the single-line crosshatch helped me. Step by step, here's how I used it.

Static convergence. The rf cable was connected to the antenna input and the three gun-killer leads to the solid-color CRT-grid leads coming from the demodulator board in the receiver. (Ground for the gun killer is via the rf cable and the balun transformer in the tuner input circuit.) I set the pattern for single dot and put the dot in the center of the CRT screen.

I killed the blue gun and ran the red and green together with the static magnets on the CRT neck. I reactivated the blue gun and superimposed the blue dot on the yellow one with the other static magnet and the blue lateral (that ion-trap-looking thing just behind the static convergence magnets). At this point, I also set up the gray-scale tracking adjustments.

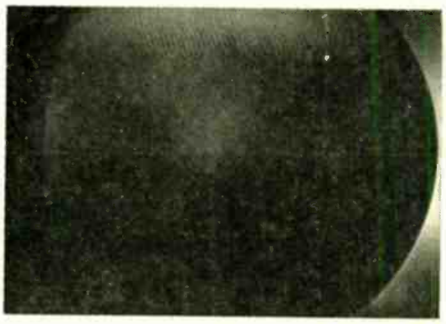
Dynamic convergence. How you use the Color King depends on the procedures recommended by the manufacturer of the color receiver. Nevertheless, the versatility of the Color King's patterns permits uncluttered examination of convergence in any portion of the CRT screen. You can inspect how the dots go together over all the screen with the main dot pattern, or inspect one spot with the single dot.

In the set I was converging, I killed the blue gun and used the single vertical line, moved to the middle of the screen, to check convergence at top and bottom center. With the blue gun back on, I adjusted convergence controls for a single vertical white line from top to bottom.

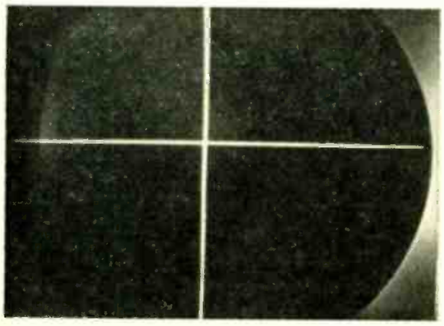
The horizontal single line served the same purpose, first with red and green only, then with blue added.

Once, in the dynamic convergence, I reached a point where the lines (red, green and blue) simply wouldn't merge at top and bottom and still remain converged in the center. I lined them all up as parallel as possible, then used the single dot and the static magnets to reconverge the center. When I tried again to superimpose all three lines, it was no longer a problem.

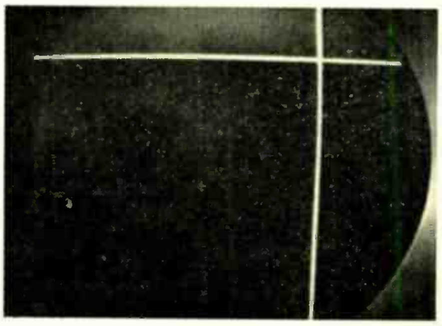
The single dot eliminates confusion and makes static color convergence easy.



You can check dynamic convergence by moving the dot around the entire screen.



To set dynamic convergence, the single crosshatch is most useful on the CG-141.



The two single lines can also be moved anywhere on the raster by the operator.

One other feature I noticed and liked was the INTERLACE control. By choosing exactly where on the raster each field begins, the operator can make the horizontal line(s) separate into two thin lines or merge as a thick line(s). For dots this is even more helpful; you'll like it best if you merge the two thin pips into one square or oblong dot. You do this with the INTERLACE control on the front panel, right next to the single-line positioning controls.

There you have my impressions of the Color King. It is stable, it warms up fast and stays there, and it has the movable single-line crosshatch and movable single dot. It is fully solid-state. Those are the facts. You decide for yourself if it is unique and if Sencore has "found a need and filled it." END

Why Servicers Like Servicing

By DICK GLASS* and JEFF TRACY

A REPRESENTATIVE FROM THE STATE general assembly. President of a state electronic association. Precinct committeeman of the largest Republican district in the metropolitan area. Chairman of the church finance committee. Silver Beaver in the Boy Scouts of America. Pilot and commander in the Naval Air Reserve.

What does a group of men so varied in accomplishments have in common? Each one is a service technician. The pursuits mentioned above are all part-time; these men work full time as technicians servicing home electronic equipment.

Why are these fellows in a business that carries little glamor and has been tagged as one of the toughest and most unrewarding jobs around? With the skill needed to do a good job of servicing the countless varieties of home entertainment, any of them could have a job in industry with an impressive title and a good salary.

We decided to go to men in shops and try to get the picture. We picked three that we felt were representative: a one-man dealer-technician shop where the owner both services and sells; a service-only establishment with several technicians, and a three-man partnership.

Woody's TV (not the real name) was first. Essentially a one-man operator, Woody does use a part-time college student in his 1,600-square-foot shop. The front is a neat TV and stereo display area. Woody's wife, Flo, helps in the office, but Woody does most of the paperwork himself. The day we walked in, Woody was in the back, tied up on a portable transistor TV.

Our first question was, "Have you had much experience on transistor TV, Woody?"

"No, this is about the tenth one I've ever touched. But I'm making out okay by following the manufacturer's service notes. I'm getting more familiar every time I get one in. Not too many shops will take them, I hear, so it makes me feel sort of special."

"Do you charge extra?"

"A little. These things are harder to get into than most portables. And I don't have as much chance to substitute; when a transistor is bad, it isn't like just popping in another tube."

"What do you have planned for this afternoon?"

"Well," he looked thoughtful. "If Flo gets in to mind the store, I've got to deliver and set up a new 19-inch color set I sold last night. Then there's a callback on a 1960 Sylvania I looked at last week. It's started flipping again, and I'll bet I'm going to find a bad lead-in since it didn't start until today. I guess you noticed the wind."

We nodded and he went on. "That means I'll get to play Tarzan all over their roof. Then I have another call on a stereo right across the street, and, if I have time, the church wants me to check their PA."

"How do you feel about the service business, Woody?"

"I like it or I wouldn't be in it. We do pretty well, but we really have to stay on top of things. I get my biggest kicks out of fixing sets like this one. Sort of proves to me that I'm pretty good. It took enough time and study to get good at it. So I charge enough to make it worth my while, and the customers must not mind too much—they keep coming back."

We turned to go. "Then we'd better let you get back to work. Thanks, Woody. We'll see you at the association meeting Tuesday night."

Next stop was Video Service Corp. (again disguised). With 13 full-time men, three part-time helpers, and a pair of office girls, VSC is the biggest independent service shop in town. VSC covers the entire metropolitan area and handles service for several department stores and appliance dealers.

Bruce Herald, president and manager, is a good promoter. He's been in electronics servicing since the KCS 47 was a new chassis. He wasn't in, so we talked to one of the employees, Jim Jones. Jim has been with VSC for 12 years.

"Jim, where did you get your training?" we asked.

"In the Air Force, mainly. After I got out, I went to a local school for a year and studied TV servicing. Bruce also sends me to all the service clinics the distributors hold, and I'm going evenings right now to a 12-week transistor course the association is sponsoring."

"What do you like most about your job here?"

Jim grinned a little. "Sometimes it's hard to be sure I like anything about it except payday." We waited, and he went on. "To be fair about it, I have it pretty good. I only do bench work. I don't care much for slopping around in the snow and rain, and Mrs. Customer can be downright unreasonable at times. I let the outside men worry with that; they bring them in and I troubleshoot them."

Jim led us over to his workbench. It and the rest of the benches were neat, even though all of them had work in progress. "You see, I'm all set up to check alignment if a set looks suspicious. The scope is always hot, of course, so I use it every chance I get—saves me a lot of time. I have just about every piece of troubleshooting equipment I could want to make servicing fast and easy."

We asked Jim, "Do you ever get bored with just bench work?"

"No. We work on all makes, and there always seems to be something new. I guess that's what keeps us in this hectic business. We like to solve problems."

VSC's top outside service technician walked in, so we decided to quiz him a little. Ed has worked for VSC about 10 years.

"Ed, you don't seem to like inside work. Why?"

"Well, I don't really dislike bench work. In fact, I enjoy getting my hand in occasionally. You get rusty if you stay away from a schematic too long. But mainly, I like to meet people, and dealing with some of the people you meet in TV servicing is a real challenge. I like to think that I'm a public relations man as well as a good technician."

We asked Ed what equipment he uses in the home.

"We don't try to go too far in the home. There are too many other things that may be wrong when some underchassis part goes out. But we carry a soldering gun and tube checker, and we stock on–off controls, thermistors, horizontal phase diodes, and stuff like that. I carry a vom, a color generator and a degaussing coil."

"Is there anything you dislike about in-home servicing, Ed?"

"I don't like having to deal with uncorrected children and dangerous pets. And once in a while I have a customer who has been watching TV shows that

"I need a new vibrator for my car—that one was hard to unplug"

Past president, National Electronic Associations, Inc.

Why Servicers Like Servicing

say we're all crooks and so she won't let me take the set out of the house."

"What do you do about that?"

"I don't argue. I do the best job I can and the regular customers know I'm trustworthy. If someone wants to think I'm a gyp, let them find someone else. I explain and then the customer has to decide for herself."

"Do you usually convince her?"

"Yes, as a matter of fact. I usually do. But I can't help resenting that I have to do it."

Ed picked up his clipboard. "I've got six more calls to make, so I hope you'll excuse me." And with that, he left.

We decided to leave, too, and on the way out met Bruce on his way in. We had a few questions for him, too.

"As manager of such a large shop, what do you spend most of your time doing these days?"

"I keep busy, that's for sure," he answered. "I never get to service anything anymore, though. Sometimes I think I need another manager to order parts, fill out warranty forms, check the trucks and caddies out and in, do the payroll, dream up the advertising, and a hundred other things." Bruce took a deep breath. "But the bookkeeper says we're making money, so I'll keep at it."

"Wouldn't you rather be back at the factory, making 10 G's as an engineering technician?"

"No, I guess not. I make that here, and although the work is much more demanding I get a lot more than money out of it."

We thanked Bruce and moved on to our last visit. Before we got there, we noticed a truck from a local factory-service branch parked at a drive-in restaurant. A good chance to get something on *that* picture! We stopped.

Bill Grainger formerly worked for one of the independents in town. He's been with factory service now for a little over a year. We asked him why he quit his old job for this one.

"It was the pay, I guess. Jake's wasn't really a bad place to work. Here, though, we have all the fringe benefits factory workers get, days off, and I get to do what I like best: repair TV and stereo."

"Do you repair other brands of sets besides your own?"

"Only rarely," Bill replied. "That's another thing I like about it. You really get to be an expert, servicing the same sets over and over. We carry the parts we need and can fix them in the home usually."

"Then you're glad you made the move," we suggested.

"Yes. I have fewer worries and problems here. At Jake's, there was always some crisis coming up and I had to be responsible for too much sometimes."

We left Bill and drove on over to Triple TV, our final stop. Three fellows who once owned one-man service shops had banded together 5 years ago and formed Triple TV. Now, besides service, they have a display area for TV, stereo, auto radios and tape recorders. Jerry, Harold and Neal were all in the shop when we arrived. Neal was checking a car radio for an elderly man who was waiting in his car.

"Hello, Harold," we said, grinning. "Looks like Neal is doing all the work. You catching up on your reading?"

"I guess it looks that way," Harold replied. "I was reading up on these new auto tape machines. We've been thinking about adding them to our auto radio department."

"Is auto radio servicing profitable? Some techs seem to detest them."

"It is for us. It's like so many other things in electronics nowadays. There aren't many places a man can get decent service. It's especially true of anything that has a transistor in it, and car radios do. So . . . we do a good job and we get all we can handle of them."

We grinned at Jerry and said to Harold, "Why is Jerry dressed fit to kill today?"

"Oh, he has a lunch meeting. He's president of the Northside Businessmen's Association now."

"Well, congratulations, Jerry. All you guys seem active in some business or civic group. Neal is secretary of the technicians' association, isn't he?"

"Yes, we stay pretty active," Harold answered.

"Do you find it helps business?"

"It does, but that's a side benefit. We just like to work with people. In our technical association, the business community, church—everywhere we go we meet people we know and like. We all participate in many extra activities. With all three of us putting our heads together on the business problems, we find we handle them quickly and have time left over for civic duties."

It sounded good to us. But we wondered about the technical work of Triple. Who does it?

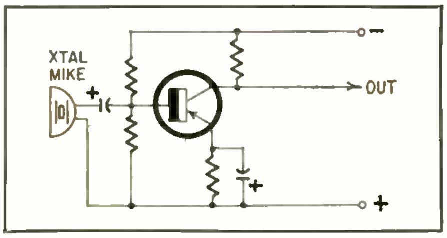
Harold answered. "We all do, and like it. No matter how much money a guy makes, he usually likes to work with his hands as well as his head. Servicing does both for us. I can't think of any other profession that is so completely fulfilling."

As we drove back to the office, we were thinking that the story was very much the same everywhere we'd been. From the one-man shop to the big incorporated service operation, servicing was the one way of life most appealing to employee and owner alike. Each has his own preferences, but all are united in wanting to do the very best job they could, in their shops, in their customers' homes, and in their communities. Electronic servicing gives them the chance. END

WHAT'S YOUR EQ?

Conducted by E. D. CLARK

Crystal Mike Input



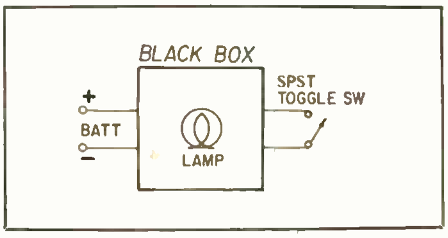
A high-impedance crystal microphone is connected, as shown, to an amplifier with low input impedance. This looks plausible, as the transistor gets more current drive than if it had a higher input impedance (say with the emitter unbypassed). Therefore the hookup should produce more output voltage at the collector. Yet this method is undesirable. Why?—*C. S. S. Shenoi*

Two puzzlers for the student, theoretician and practical man. Simple? Double-check your answers before you say you've solved them. If you have an interesting or unusual puzzle (with an answer) send it to us. We will pay $10 for each one accepted. We're especially interested in service stinkers or engineering stumpers on actual electronic equipment. We get so many letters we can't answer individual ones, but we'll print the more interesting solutions—ones the original authors never thought of.

Write EQ Editor, Radio-Electronics, 154 West 14th Street, New York, N. Y. 10011.

Answers to puzzles are on page 91.

Another Black Box



Close the switch, and the lamp lights. Then open the switch, and the lamps remains lighted. The lamp can be turned off *only* by disconnecting the battery. No diodes or relays are inside the box. What is?—*Dale Terdan*

Remote Control for PA Systems

Several clever techniques for turning the amplifier gain control up or down when you're not close to it

By JACK DARR

A REMOTE-GAIN CONTROL CAN BE A VALUable addition to any public address system. It comes in especially handy when there are several orators* on the program. No two people have the same mike technique: this is especially true of untrained speakers (oops)—sorry. At any rate, if the sound man has a remote control, he can sit with the audience and adjust the PA gain as needed.

There are a couple of particularly neat and direct systems, both of which can be added to any PA circuit very handily. Both handle any number of microphones at the same time. They also can be used on home music systems, either mono or stereo. Commercial versions can even control as many as four channels.

A workable remote-control system must be able to adjust the gain of any channel, yet have no effect on sound quality. Wiring must be simple, and no dangerous voltages should be used. Both circuits meet these requirements.

The circuit shown in Fig. 1 is used in an amplifier popular among professional sound men. Only one channel is shown since all are identical. The theory is simple—the gain of each preamplifier stage is regulated by controlling its plate voltage. B+ is applied to the plate of V through a 220K resistor and a 47K resistor with a 100K plate load. At the junction of the 220K and 47K resistors, the remote control itself is a 2-meg pot connected to ground as a rheostat.

With the remote rheostat turned to maximum resistance, the applied plate voltage is unaffected. Turned to zero resistance, the applied voltage is shunted to ground; the gain of the stage then drops to zero. This might seem poor practice, but the series resistors in the circuit are so high in value they can drop the whole plate-supply voltage without getting warm. Voltage actually is present on the remote-control-box units, but—again because of the high-value resistors—current is kept so low there is no shock hazard.

To adjust the system, the remote control is turned full on. The amplifier-chassis gain control provided for each channel should be set for a little *more* gain than actually needed. The remote control can reduce the level but can't raise it. If adjustments are made before the audience enters the auditorium, controls should be set so that words spoken into the mikes in a normal voice have a very perceptible "tail" or ring. This gain setting will be very near the point at which the system sets up the familiar feedback howl.

During the actual performance with the audience seated, sound-absorption will be much higher. Background noise, too, will be higher, so the increased gain will be needed.

This particular remote is a plug-in type; with the remote unplugged, the amplifier works normally. Wiring can be the standard intercom type. There is very little current flow, so very small conductors will do. And, since the circuit handles no signal voltages, the wires need not be shielded. Only one more wire than the total number of controlled channels is needed. Four channels, five wires: four hot wires and a common ground.

The second system also uses a variable resistor, but you'd never guess by just looking at it. The "resistor" is the "dark" resistance of a photoelectric cell (see Fig. 2). As in the first unit, this is an auxiliary circuit—one that can be unplugged without affecting the amplifier. A local gain control is used to set maxi-

*This word is used to avoid confusion with "speakers" of the kind we use!

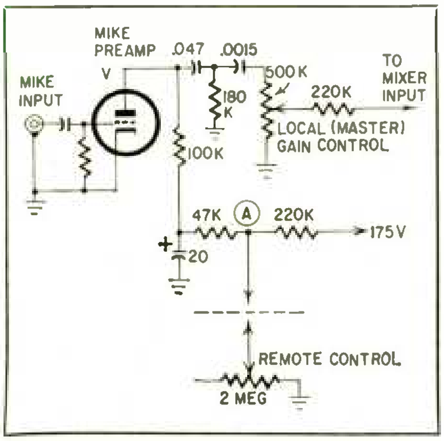


Fig. 1—Simple remote volume-control circuit which changes tube's plate voltage.

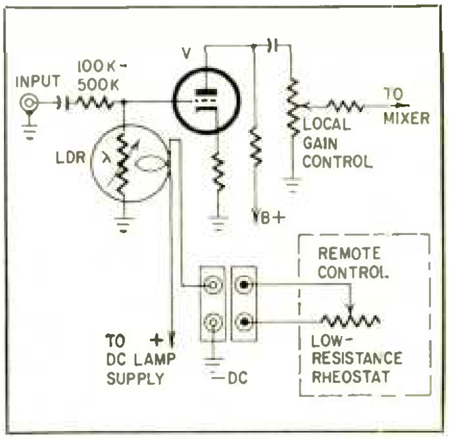


Fig. 2—A light-dependent resistor acts as a shunt gain control in the signal path.

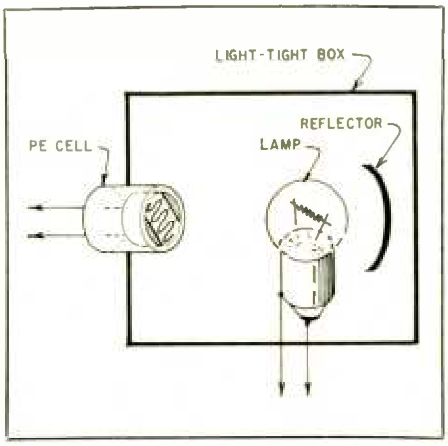


Fig. 3—LDR is merely a photoresistive (or photoelectric) cell in box with lamp.

mum gain, and the remote again can reduce but not raise it.

The variable-resistance device is called a *light-dependent resistor,* or LDR. It consists of a small photoresistive cadmium-sulphide cell built into a light-tight box along with a pilot lamp (Fig. 3). Dark resistance of the cell is high—several megohms—and drops to a very low resistance as the light falling on the cell increases in intensity. Using a low-voltage dc source and a low-resistance rheostat to adjust the brightness of the lamp, the circuit's shunt resistance can be controlled over any desired distance. A dc supply is necessary to avoid hum modulation. You can make your own cell and lamp combination or use a commercial unit such as Raytheon's Raysistor or a Clairex Photomod.

Here again, we need only simple intercom wiring. Current drawn by the lamp is very slight, and no signal voltages are present. As in the first system, one more wire than the number of controlled channels will suffice.

The first circuit probably would be most practically applied to tube-type preamplifiers. Since the LDR circuit is used as a "signal-level" control similar to a standard volume control, the second type may be used with either tube or solid-state amplifier systems.

LDR's are available from several companies. Different cell-resistance values and lamps of varied voltages and currents are available, so the circuit can be tailored to fit existing conditions. Lamps are run at slightly less than rated voltage to extend lamp life.

Either remote can be added to existing amplifiers with little trouble. For tube-type amplifiers, all you'd have to do would be to divide the existing plate-load and dropping resistors into appropriate sizes, as shown in Fig. 1. If necessary, the voltage supply can be taken from a higher voltage point to allow the use of very large resistors in the series-dropper position. Just be sure that the series resistor is big enough to handle the supply voltage with its load end grounded. This isn't critical and can be determined by the oldest engineering method known to technicians everywhere: Cut and try!

The LDR circuit can even be added to transistorized amplifiers, if you take care to insert it in the circuit at some point where it works with nothing but *signal* voltages. If necessary, put blocking capacitors on both sides of it so the shunt resistance won't upset critical transistor bias levels.

As a final thought, the same principle can be used to control a variety of other things beside sound levels: machinery, relays etc. LDR's are available in several sizes. END

Convert Your Heathkit WA-P2 To Feed Transistor Amplifiers

By HANK OLSON

THE HEATHKIT WA-P2 PREAMPLIFIER has been soldered together by literally tens of thousands of hi-fi enthusiasts. A goodly number have even been put together by hi-fi fans' wives, impatient for hubby to make music. The old preamp is still doing yeoman duty, but as the newer all-transistor power amplifiers have come upon us, many of these old "tubers" have been retired. Why? First, WA-P2 draws its B-plus and heater supply from the power amplifier. Second, its output impedance is too high to be suitable for many transistor power amplifiers.

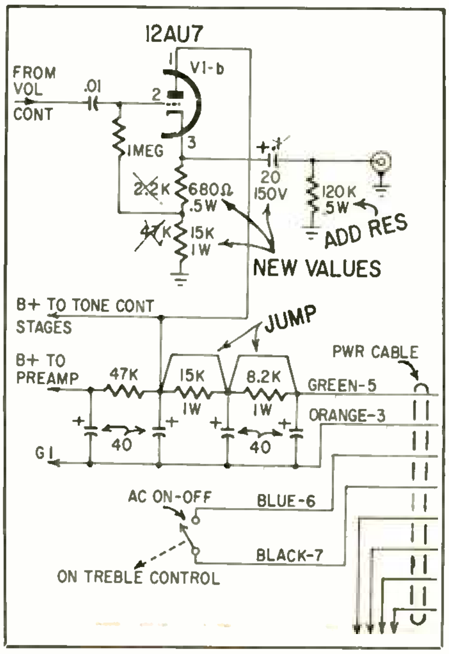


Fig. 1—Output stage and decoupling network of Heathkit WA-P2 preamp/control unit. All necessary changes are shown. Used units are available in many large audio or surplus stores from $10 to $25.

The WA-P2 can be converted easily to a fine preamp for an otherwise all-transistor hi-fi system. No one will even guess you're guilty of having a tube in your system unless he actually opens the preamp.

First build a small power supply. It need not put out the 300 volts from which the WA-P2 was originally fed, since we will not need to waste voltage in RC decoupling to isolate it from the amplifier. The circuitry needs only 180 volts: the rest of the 300 went up as BTU's in the decoupling. Therefore, short together three sections of the 40–40–40–40μF can-type electrolytic capacitor. This will be the output filter capacitor of our little power supply. See Fig. 1 for details.

The power supply is a full-wave bridge with four silicon rectifiers. Any rectifier with a piv of 400 volts or greater (M150, M500, 1N1695, etc.) can be used. My unit was constructed in an LMB No. 141 box chassis, fitted with four rubber feet. See Fig. 2 for the complete circuit.

The last change is to lower the output impedance of the cathode-follower stage. Replace the 2,200- and 47,000-ohm resistors in the cathode of V1-b with a 680-ohm ½ watt and a 15,000-ohm 1-watt resistor, respectively. Replace the output coupling capacitor (0.1 μF) with a 20-μF 150-volt tubular electrolytic as shown in Fig. 1. Then put a 120,000-ohm ½-watt resistor across the output jack to dissipate any charge that might be caused by leakage through the filter electrolytic.

Plug the new preamp into your transistor amplifier, turn it on and zero the hum control.

Of course, the modified WA-P2 will work just as well as before, if not better, with tube-type power amplifiers. END

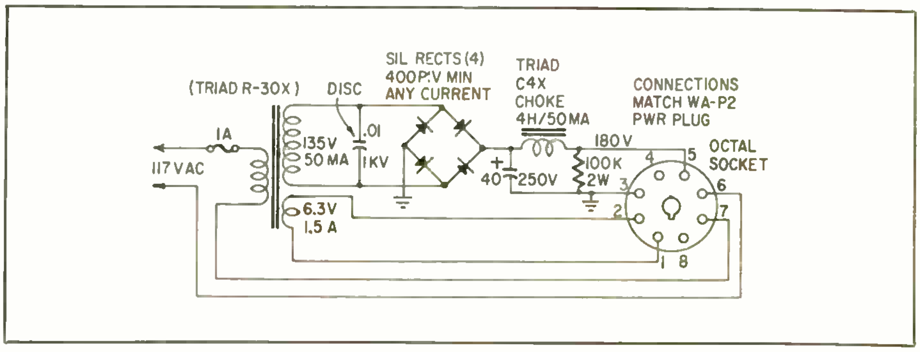


Fig. 2—Simple power supply for converted WA-P2 frees it from tube amplifier forever. Any well-filtered supply that delivers about 180 volts at 20 mA or so will work okay.

COMSAT: Communication in the Space Age

Not experimental, but commercial, instant worldwide information transmission by satellite

By RAY D. THROWER

In the 17th century, it took about 4 months for news of the New World to reach Europe. Now, with satellite communication, news whips around the globe in seconds. In less than 3 years, instant global communication will be a reality. Advanced communications equipment and the space-age vehicle, the Communications Satellite Corp. and its international partner, Intelsat, are all together responsible for that.

"Just what is COMSAT?" is a question one frequently hears. Many have the idea that COMSAT is a government agency, staffed by Federal civil-service personnel. This mistaken idea probably comes from the fact that COMSAT was authorized by the Communications Satellite Act passed by Congress in 1962. The basic Communications Act of 1934 made no specific provisions for satellite communication. In fact, in 1934, satellite communication was placed in the category of Buck Rogers space adventure stories, popular in the late 1930's. COMSAT's relationship to the Federal Government is about the same as the relationship of other communication companies such as General Telephone & Electronics, American Telephone & Telegraph, and International Telephone & Telegraph. They are all Government-regulated, profit-making stockholder-owned organizations.

RADIO-ELECTRONICS *visited the new earth-station facilities at Brewster Flat, Wash., and Paumalu, Oahu, Hawaii, and obtained an interview with Wallace M. Lauterbach, Western area manager for the Communications Satellite Corp. Lauterbach has been in communications for about 25 years.*

He was graduated in 1941 from the US Military Academy with a BS in electrical engineering. He obtained his MS from the University of Illinois. During World War II, he commanded signal troops in the Pacific Theater. Since then, he has been executive officer to the Chief Signal Officer, Department of the Army; a member of the US delegation to the International Telecommunications Union in Geneva; military assistant to the telecommunications adviser to the President; and first Commanding Officer, US Army Strategic Communications Command.

When Colonel Lauterbach retired from active duty in June, 1965, he was an obvious choice for Western area manager, Communications Satellite Corp.

After we toured the COMSAT site at Brewster Flat, Wash., Lauterbach invited us into his office for some discussion about COMSAT and the future of space-age communications.

RADIO-ELECTRONICS: What is COMSAT's purpose?

COLONEL LAUTERBACH: It's to be a world-wide commercial communications satellite network to provide communications services to business, government, and individuals. Understand one thing: When we speak in terms of "communications" here at COMSAT, we mean not just telephone conversations, though they will be an important part of COMSAT's activity. But I think the important contributions will be data transmission and, to a lesser degree, video communication.

R-E: Well, will the communications satellites be flexible enough to handle the different kinds of communications circuits you're talking about? For example, can one single satellite take care of voice, data and video traffic, too?

LAUTERBACH: I'll give you a qualified yes to that question. Qualified only because of the way it was worded. Yes, the present satellites can handle voice, data and video. But not all at the same time. They can handle a mixture of voice and data. The exact number of circuits depends on the speed, and therefore the bandwidth, of the data circuit. The real limiting factor is the terminal equipment used at the earth stations. The receivers and transmitters are the same for all modes, but the demodulating and modulating equipment is different for voice, data and video.

R-E: How many of each type circuit can satellites handle?

LAUTERBACH: Early Bird, which was our first program, can handle 240 two-way telephone conversations, or 6,200 full duplex, simultaneous teletype circuits, or one television video circuit. It can handle a few computer circuits or hundreds. As I mentioned before, the exact number of computer circuits will depend on the speed of transmission of the data.

R-E: I see. I'd guess that the communications satellites launched early this year can handle more than the 240 voice circuits of Early Bird, true? Do you have a name for the current program?

LAUTERBACH: Let's take those in reverse. Early Bird was one name for what *we* call Intelsat I. That's a single satellite located over the Atlantic off the east coast of South America. The current program, the one that affects us here at Brewster Flat and at Paumalu, is called the Intelsat II series. We have several satellites for this second phase. One did not achieve a usable orbit and is idle. The second is stationed above the Pacific Ocean about halfway between here and Australia. A third will be put on the opposite side of the globe over the Atlantic off the west coast of Africa.

As to channel capacity, Intelsat II spacecraft have the same capacity as Early Bird but more than twice the area of coverage. However, we're constructing what we call Intelsat III. That will be what we call a "multiple-access" type communications satellite. These so-called global satellites, for use starting in 1968, will have a capacity in excess of 1,200 voice circuits each.

R-E: You've mentioned Intelsat several times. What is that?

LAUTERBACH: Intelsat stands for International Telecommunications Satellite Consortium. It's an organization made up of a group of the member nations of the ITU, the International Telecommunications Union, which is an arm of the United Nations. Right now we have more than 55 member nations in Intelsat. Intelsat owns the satellites. COMSAT holds a majority interest, and acts as manager of Intelsat. Each member nation, or its commercial representative, will own its own earth station. We expect to have as many as 30 earth stations operational by 1968.

R-E: You also mentioned "multiple-access" satellites. What do you mean by that?

LAUTERBACH: Well, by using a single broadband input receiver, a large number of earth stations, say, 10 or more, can communicate through the same satellite simultaneously, even though each earth station transmits on a different frequency. In fact, for the system to work, each earth station must transmit on a different frequency. Each station is assigned a band in the satellite receiver's spectrum so one earth station's transmissions won't interfere with those of another.

Actually, you know, the communications satellite is a glorified translator, comparable to the vhf/uhf translators used to serve a lot of communities with TV. Our translation frequency is 2.225 GHz.

R-E: What bands do you operate in? I read that it was in the 6-GHz and 4-GHz bands, but there are already so many microwave systems operating in those bands, it would seem you'd have quite an interference problem.

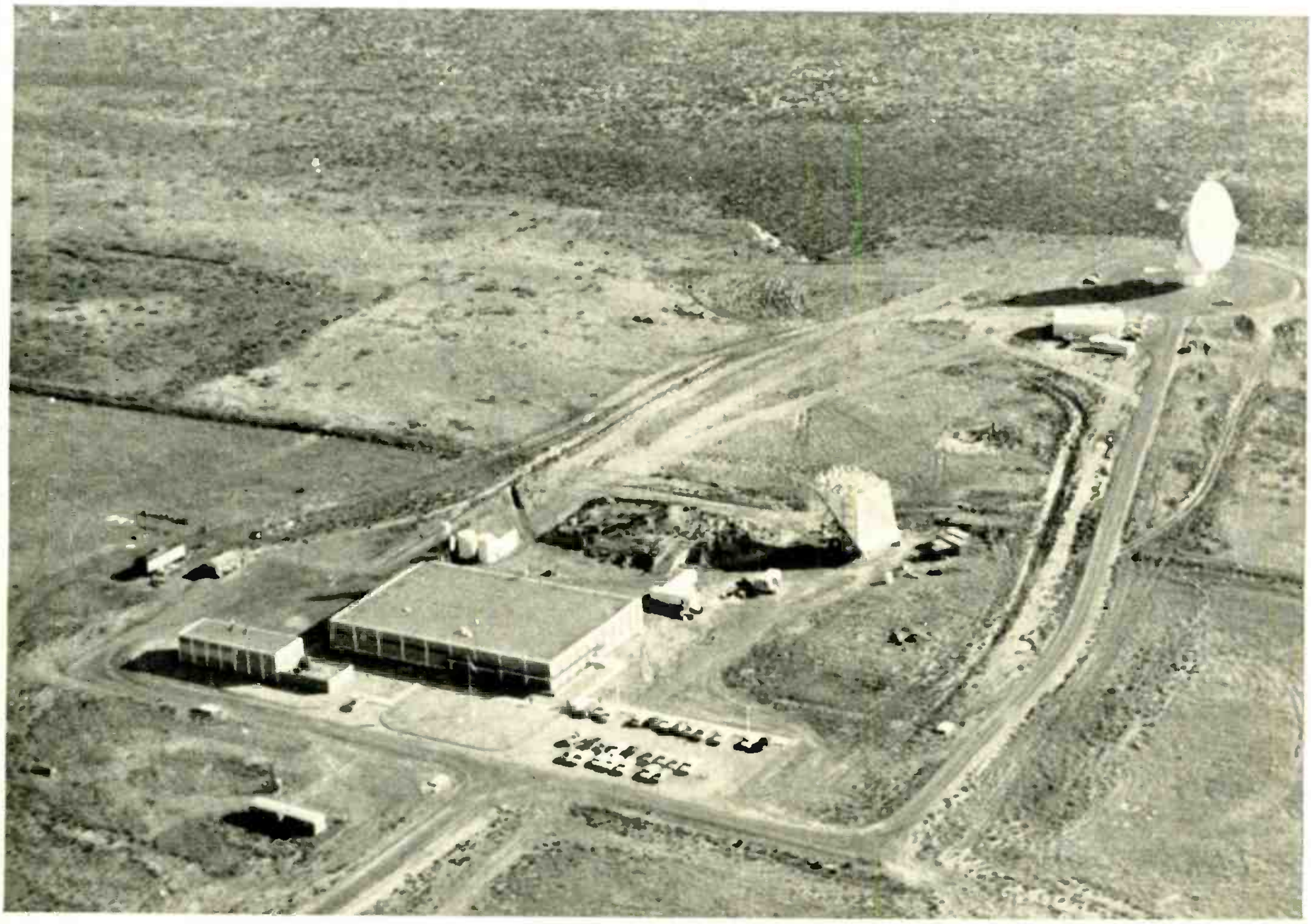
LAUTERBACH: Exactly. Actually, you have no idea of the number of common-carrier microwave systems in operation.

R-E: What are common carriers?

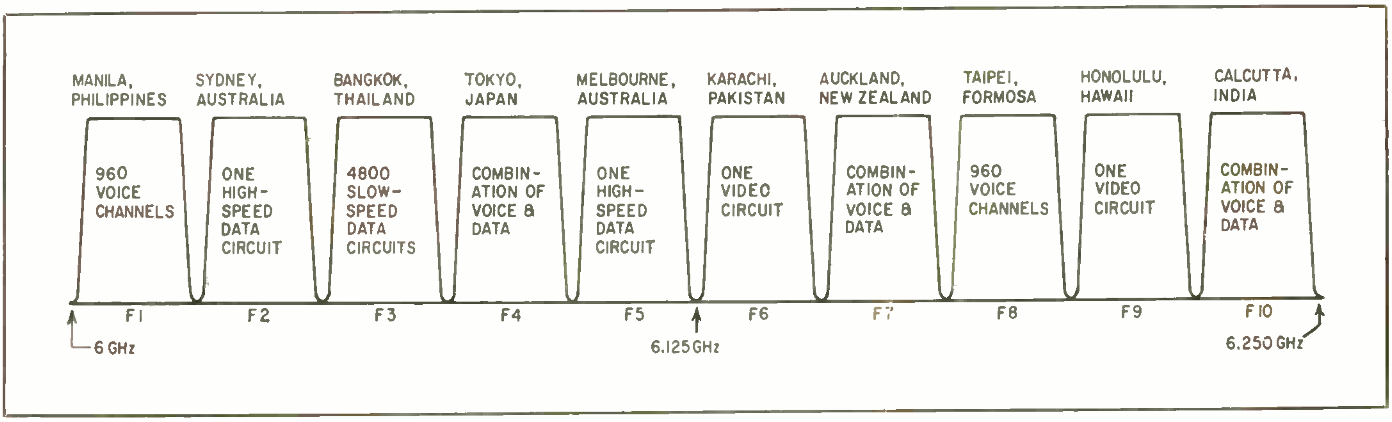
LAUTERBACH: A common carrier is an organization, like a telephone company, that sells communications services. There are so many in operation in the bands we operate in that we've had to get sort of a special dispensation from the FCC that any future systems in our vicinity will be installed and operated on a noninterference basis. General Telephone Co. of the Northwest brings in the microwave relay channels that carry the COMSAT circuits out of Brewster Flat. They had to do some special engineering to get their microwave in here in the 11-GHz band, so as not to interfere with our 4- and 6-GHz operation.

R-E: What about the case where there was already a system in operation in your band? What do you do then? I'd think this might be pretty important when it comes to site selection.

LAUTERBACH: You've just hit on one of the most difficult things



Aerial view of the Brewster Flat, Wash., COMSAT earth station. Large structure is the main administration and operations building. Small building contains emergency generators for use if commercial power fails. Modified Cassegrain horn antenna near the main building is 45 feet across and is called "sugar scoop." It is part of the transportable system that COMSAT can set up in any part of the world in about 30 days. The permanent antenna is a parabola 85 feet in diameter. It stands 110 feet high and weighs 135 tons. Underground vaults carry all supporting control and signal cables to the central communications control area.



Future satellites will use "multiple-access" receivers. They will have extremely broadband front ends and will be able to receive from 10 separate transmitters on different frequencies simultaneously. Bandwidths of 250 MHz will be divided into 25-MHz channels and each channel assigned a discrete frequency. Each frequency will be assigned to one earth station. Any one of the inputs will be able to accommodate up to 960 voice channels or one video circuit or a variety of data circuits or even combinations of data and voice circuits. This change in configuration will be done at the earth station by switching in the appropriate terminal equipment. Each channel now carries one video or 240 voice channels.

about setting up an earth station: site selection. Yes, we have to have an "electronically quiet" environment. Our receivers, which are cryogenic systems by the way, have a sensitivity of −159 dBm*, so, not just any place will do. We looked for quite a while before finding the Brewster Flat site. We're in the bottom of a saucer-shaped depression between several mountain ranges. The mountains shield us from other microwave systems. Of course, we have a certain maximum angular elevation limit on our surroundings. Anything above 4° might obstruct the path to the "bird."

R-E: You mentioned your receivers are *cryogenic* devices. This means they're supercooled to reduce the natural electron noise, doesn't it?

LAUTERBACH: Yes. They're cooled to 4° Kelvin. And that's close to absolute zero.

R-E: That should keep anything quiet!

LAUTERBACH: It does a good job of it. Actually, we're not the first to use cryogenics. Radioastronomy systems have been using them for years and many of the telemetry systems for space work use cryogenics.

R-E: Besides the use of cryogenics, are there any other specific technical details in the COMSAT system that aren't used in the usual communications system?

LAUTERBACH: Oh, yes. One thing that seems to surprise quite a few technicians and even some of the younger engineers is the fact that we transmit and receive simultaneously on the same antenna.

R-E: Could you explain how that works?

LAUTERBACH: The technique has been used for years in microwave and vhf and uhf communications. We use what we call a *duplexer*. It's a resonant-cavity device, actually two cavities, one tuned to the transmit frequency and one to the receive frequency. At the resonant frequency, the cavity represents a low impedance to any energy it sees. At any other frequency it looks like an extremely high impedance, so the transmitter output is effectively isolated from the receiver input, but the receiver can still "see" any signal that's on *its* frequency.

R-E: Sounds like something very useful. It lets you get away from having to build two of these "monster" antennas for each direction of transmission, doesn't it?

LAUTERBACH: It sure does. And that cuts down on the overhead. There are some microwave systems that connect as many as eight transmitters and eight receivers to the same antenna, all operating simultaneously.

R-E: Whew! Let's see. COMSAT was organized in 1962, and you launched your first satellite, Early Bird, in 1965, if memory serves me right . . . ?

LAUTERBACH: That's correct.

R-E: Then, how did you manage to get all the engineering talent together to design your systems on such short notice?

LAUTERBACH: Our initial ground systems were designed and built by private contractors such as Page Communication Engineers, Sylvania, ITT Federal Labs and others. This may change with COMSAT engineers designing at least portions of the systems. Also, we already find ourselves having to provide engineering and technician advisory services to many national governments. Our transportable earth stations can be taken to remote locations and made fully operational in about 30 days and for a fraction of the cost of the large fixed station. [Since this interview, the 42-foot transportable antenna at Brewster Flat has been dismantled and shipped to the Philippines, where it has been leased for a year.—*Editor*] We realize that many of the countries that install these systems won't have personnel trained. So, there is the definite possibility that COMSAT, through Intelsat, may provide the technicians and engineers to train some of the technicians and engineers of newer Intelsat members.

R-E: It seems like COMSAT will be a very interesting job opportunity. I imagine a few engineers and technicians would like to work for a prestige organization like yours.

LAUTERBACH: Definitely. And, with our expansion programs, we're always looking for people with skills we can use. At a typical earth station, we need about 40 to 50 technical people. About 20% are engineers, the rest technicians. Multiply that by those 30 earth stations I mentioned a moment ago and you have a sizable work force around the world involved in commercial satellite communications.

R-E: What kind of background do you look for in an engineer or technician?

LAUTERBACH: Experienced communications people. We need technicians with vhf and microwave experience and backgrounds in multiplex carrier communications. Solid-state and cryogenic experience is highly desirable.

R-E: Mr. Lauterbach, is a satellite communications system really necessary? Aren't the undersea cables reliable enough?

LAUTERBACH: The undersea cables? Yes, they certainly are reliable. They've served us well for many years and they'll continue. But their capacity and flexibility are limited. In 1960, there were only about 600 communication circuits out of the United States to the rest of the world overseas. Most of these were by cable, a few by radio. With the growth of the world's population and the increasing business and government com-

* 0 dBm equals 1 mW.

munication needs, we'll need 12,000 circuits by 1980. We added 240 circuits with Early Bird. This amounted to an increase of about 30%, but the most impressive improvement is the instantaneous availability of these circuits over an area of tens of thousands of square miles.

R-E: What kinds of customers will COMSAT serve?

LAUTERBACH: The most often mentioned example is NASA. We're providing just about every conceivable type communications circuit to NASA for the Apollo program. Probably one of the most interesting services we propose is to provide voice and data communication to aircraft in flight on transoceanic runs.

R-E: Oh, I think I understand. On long over-water flights, vhf communication won't work, and the hf radio bands are pretty crowded—and not always reliable.

LAUTERBACH: Exactly. Direct communication will play an important role in air traffic control in the future, especially when the 2,000-mile-per-hour passenger liners go into service. Recent estimates show that at any given moment there are over 280 aircraft over the Atlantic alone. And don't forget the ships at sea. We can provide them with telephone and data service to the home office. That way, if there's a change in the price of say, oil, in a certain port, the home office can direct the tanker to go to another port where the price is better.

R-E: What about the possibilities of satellite communications systems being used for worldwide educational television? Does COMSAT or anyone else have anything along these lines?

LAUTERBACH: Yes. ABC, CBS and NBC have already expressed interest in this area. Certainly it would be technically feasible. Actually, when we consider the ETV aspect of satellite communications, the only thing that keeps us from doing it is "doing it." The technology exists. The only thing still necessary is the political and economic backing. COMSAT has already outlined a program for a domestic US satellite system that would serve the major TV networks as well as handle ETV.

R-E: How about computers? Couldn't they be tied together by communications satellites? This would help in making data available on a world-wide scale. Hugo Gernsback, editor-in-chief of RADIO-ELECTRONICS, in editorials for December 1959 and May 1964, urged the establishment of a "national facts center." Using your facilities, a facts center could be international, couldn't it?

LAUTERBACH: Someone's been reading our mail! Seriously, though, the establishment of *information grids*, connected by relay satellite, has already been proposed. Some authorities think that in less than 10 years a student will be able to dial a local computer on his home telephone and program problems into it. This is already being done on a limited scale, but not with relay satellites for computer interconnect. But it could be done.

R-E: I'll bet engineering firms and other businesses would benefit from being able to tie into such a system.

LAUTERBACH: They certainly would. And they'd find the cost not much more than a monthly telephone bill and a lot less than owning and maintaining their own computer.

R-E: Seems like you're going to have a lot of people relying on your satellite. What happens if it goes bad after just a few days of operation? Or what if it doesn't work to begin with? You can't send a man up to fix it—not yet, anyway. What do you do?

LAUTERBACH: To begin with, our systems are designed to minimize failure. Each component and each unit is designed and tested to meet extreme requirements. The chance of failure is pretty remote. If a failure should occur in a critical component after the bird is up, we still wouldn't have a failure because the equipment has built-in *redundancy*. That means there is a parallel unit that will take over the function of the defective unit. And, if, just *if*, the bird should be a total failure, we do have a couple of spares we can send up. But that's expensive.

R-E: I guess you're pleased with Early Bird's performance. It went up in, let's see, April of 1965, wasn't it? And it's still operating.

LAUTERBACH: Yes. Early Bird had a life expectancy of 18 months. It's exceeded that by quite a margin. And looks like it will keep going for a while yet. The satellites orbited this year are designed to operate for 3 years and the ones planned for Intelsat III are being designed for a life of 5 years.

R-E: What is the power of the transmitter in the satellite?

LAUTERBACH: Six watts.

R-E: *Six watts?* But the one at the earth station is 12,000 watts!

LAUTERBACH: It does seem strange, but remember that right now our techniques don't permit a very high power-to-weight ratio. We're limited to low-powered transmitters on the satellites. We make up for this by using the large antennas and cryogenic receivers at the earth station. Going the other way, we can transmit from earth with high power and large antennas, with their high gain, and come up with a respectable signal level for the satellite receiver. This way, we can use fairly conventional circuits for the receivers in the birds and get away from having to put huge antennas and cryogenic receiver systems in orbit.

R-E: Then, actually, the complicated circuits are at the earth stations, more so than in the satellites?

LAUTERBACH: In a manner of speaking, that's true. But that isn't to say that the circuits in the satellites aren't up to the state of the art. Some of our equipment is far advanced from the equipment of the more conventional, earthbound systems. It has to be, because of size and weight limits.

There's a great future for satellite communications and its engineers and technicians—a future where not even the sky is the limit.

[In late January, Intelsat II's Pacific satellite *Lani Bird* began to serve in two major functions. AT&T started using the satellite for commercial telephone service—with 6 circuits to Hawaii and 30 to Japan. And ITT initiated commercial TV use of Intelsat II with transmission of an NBC newscast to Nippon Television Corp. Fulltime commercial service is now underway between North America, Hawaii and Japan. The Atlantic satellite *Canary Bird* was lofted March 22. —*Editor*]

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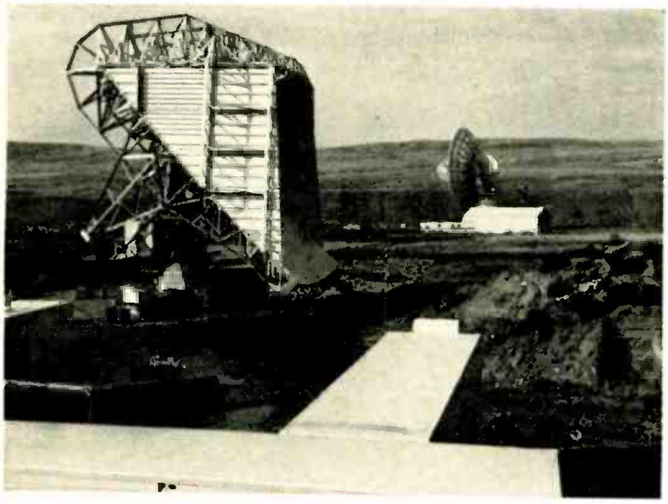


Brewster Flat, Wash., earth station antenna installations. In the foreground is the transportable 45-foot "sugar scoop" antenna. In the distance is the 85-foot parabola. Note the low hills. They provide a protective ring around the station, shielding the site from interfering radio signals. The rectangular structures at the bottom of the photo are the mobile trailer vans containing antenna aiming and multiplexing gear.

Selected Circuits from an Experimenter's File

Eight nifty circuits more people ought to know about

By ROBERT F. SCOTT

An avid experimenter, I collect and file hundreds of circuits that I hope to be able to use in one form or another. Some of the most interesting and useful of these appeared in foreign publications. Others were developed by component manufacturers and published in application notes, catalogs or ads in specialized electronic publications not generally available to experimenters. I hope you will be able to use some of these selections—or maybe add them to your files.

Remote-tuned superregenerator

Fig. 1 is one of many circuits developed by Vari-L Co. (207 Greenwich Ave., Stamford, Conn.) to show typical applications of their electrically variable inductors. The detector tunes from 20 to 50 MHz with the Vari-L type M-1 inductor as the control current is varied from 0 to 60 mA. The antenna is connected across a 100-μH rf choke in the emitter circuit. The audio output can be fed to a simple transistor or tube amplifier.

The electrically variable inductor is a two-part assembly. The control winding is wound on the legs of a U-shaped ferrite or laminated core. (There may be more than one control winding.) The signal winding—used as the tunable coil in a Colpitts oscillator or similar two-terminal network—is wound on a ferrite core placed across the open end of the U.

When current, ac or dc, is passed through the control winding, it varies the magnetic flux of the assembly and decreases the permeability of the signal-winding core. This reduces the inductance of the signal winding and increases the frequency of the tuned circuit. Vari-L current-controlled inductors in the company's Mite series are available with inductances ranging from 100 mH to .05 μH at zero control current. They cover frequency bands from 2 to 30 kHz for the 100-mH unit to 250 to 300 MHz with the .05-μH inductor.

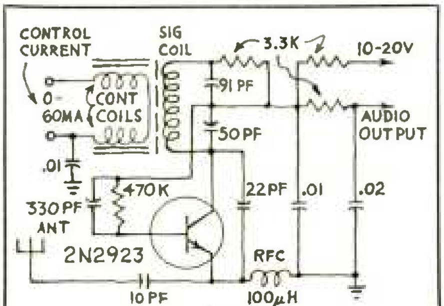


Fig. 1

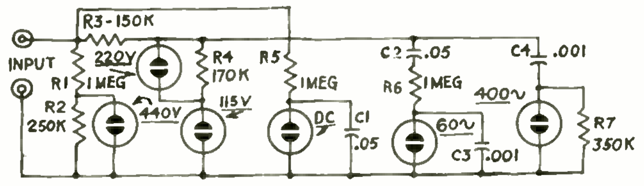


Fig. 3

SCR time-delay relay

This circuit (Fig. 2), developed by G-E, controls loads up to 100 watts direct from the 117-volt ac line without intermediate relays. When the switch is pressed, D1 conducts, charging C to around 140 volts and placing a negative voltage on the SCR gate. When the switch is released, D2 conducts and starts to charge C positive through R1 and R2. The SCR does not conduct until D2 has had sufficient time to reverse the polarity of the voltage across C and raise it to firing potential.

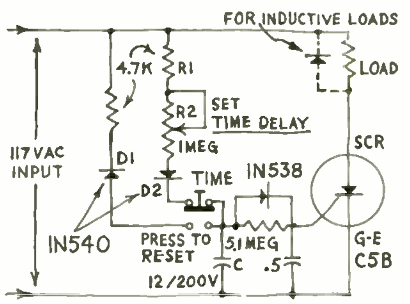


Fig. 2

The timing range is from 0.1 to 30 seconds with a maximum error of approximately 1%. Reset time is less than 0.1 second. (Note well that C is a metalized paper capacitor such as Sprague type 118P or equivalent.)

Line-voltage indicator

Technicians and plant maintenance personnel need a device to identify quickly the voltage and frequency of the various power lines installed in some plants and labs. Fig. 3 is a simple indicator that can be mounted in a nonmetallic instrument case and fitted with insulated test leads. The instrument was developed at Clevite Corp. and described in *Signalite Application News*.

The indicators are NE-2's but Signalite T2-27-1R100's are recommended because of their closer tolerance in breakdown and maintaining voltage. Breakdown voltage is 66 to 74 and maintaining voltage 52 to 59.

When the test leads are clipped across a dc source, C2 and C4 prevent the 60- and 400-Hz indicators from firing. The dc voltage appears across C1 and fires the dc indicator. Since only one electrode glows on dc, the indicator can be calibrated to show voltage polarity.

On a 400-Hz ac source, C4 and R7 form a voltage-dividing impedance network that develops enough voltage to fire the 400-Hz indicator. Dividers R5–C1 and C2–R6–C3 prevent the dc and 60-Hz indicators from firing. On 60-Hz sources, enough voltage is developed across C3 to fire the 60-Hz indicator.

When the line voltage is 115, the 115-volt indicator fires with R3 and R4 serving as current limiters. There is not enough voltage drop across R2 and R4 to fire the 440- and 220-volt indicators.

When 220 volts is applied to the test leads, the 220- and 115-volt indicators fire. Raising the input voltage to 440 causes the 440-, 220- and 115-volt lamps to fire.

Remote-controlled attenuator

The internal resistance of a vacuum tube has been used as a variable resistance in tone controls, vibratos and similar circuits. To date, transistors have not been widely used in such applications because of their low impedance. Field-effect transistors are ideal for such audio control jobs. Fig. 4 shows a remote-controlled attenuator circuit designed for the 3N98. See *RCA*

Selected Circuits from an Experimenter's File

Application Note AN-201.

The circuit is an L-attenuator with the 1-megohm resistor as the series element and the drain resistance of the transistor as the shunt element. Drain resistance is a function of gate voltage so the attenuation can be controlled by varying the dc voltage applied to the gate. With the circuit constants shown, the maximum attenuation is 60 to 70 dB and the minimum is 1 or 2 dB. Values of C1, C2 and C3 depend on the desired low-frequency limit. For 30 Hz, .05 μF is ample for C1, and 25 μF for C2. A value of 0.5 μF for C3 will be sufficient for loads of 100,000 ohms or higher.

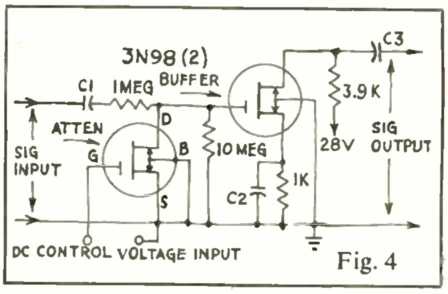


Fig. 4

(Insulated-gate field-effect transistors have extremely high input resistances and are likely to be damaged if electrostatic charges are allowed to accumulate through improper handling—allowing the leads to brush against silk or nylon fabric, for instance. These transistors can also be damaged by electrostatic charges that the human body picks up under normal conditions. *Read manufacturer's handling and operating instructions before removing FET's from their package.*)

Audio-frequency AM detector

The detection of slow changes in the amplitude of audio-frequency carriers is often used to telemeter specific operating or environmental conditions in medical electronics, communications, oceanographic and space surveys, and industrial and scientific instrumentation projects.

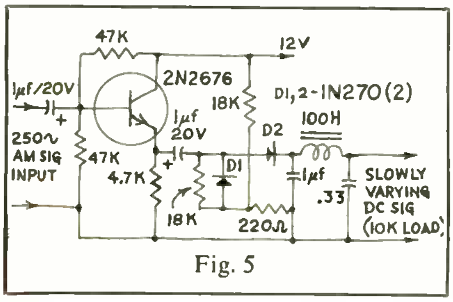


Fig. 5

Fig. 5 is the circuit of an AM detector for a 250-Hz carrier. The incoming modulated carrier is amplified, rectified and then passed through the pi-network low-pass filter to remove the carrier. (This and equivalent circuits can be replaced by the LS5-PD postage-stamp size—0.5 cubic inch—low-pass active filter developed by Guillemin Networks, Inc., 170 Brookline Ave., Boston, Mass. 02215.)

Waveform generators

Various types of signals other than sine and square waves are often used in timing circuits, triggers, sweeps and other applications. The circuit in Fig. 6 develops a symmetrical triangular waveform whose frequency is determined by the capacitor's value. The slope of the waveform is 5.5×10^5 volt per second.

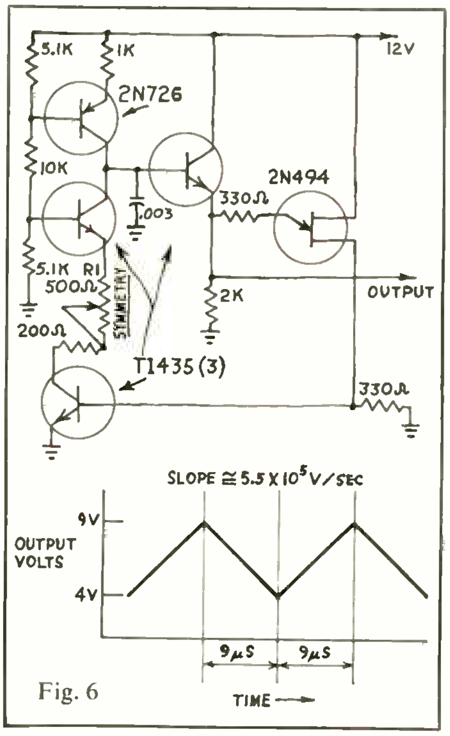


Fig. 6

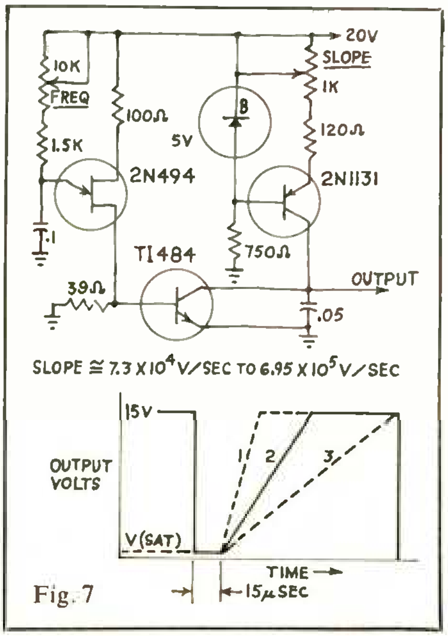


Fig. 7

The circuit in Fig. 7 is a linear-voltage ramp generator whose frequency is variable from 7.3×10^4 to 6.95×10^5 volt per second. The circuits in Fig. 6 and 7 were developed by Texas Instruments.

Polarity-reversal hint

Fig. 8 shows two circuits commonly used to reverse the direction of a dc motor or the polarity of the voltage applied to a similar inductive load. Both circuits do the job but Sigma Instruments points out that the circuit at b is the preferred arrangement.

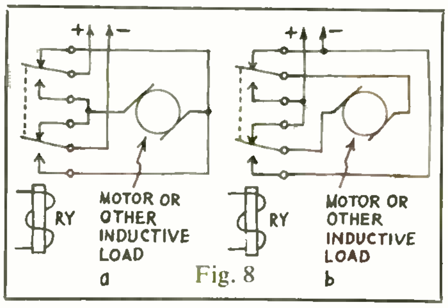


Fig. 8

In Fig. 8-a, if one contact sticks while the other switches, there will be a direct short circuit across the power supply, resulting in possible damage to the supply and the relay. When the circuit in Fig. 8-b is used, a sticking contact results only in a harmless short across the motor.

Sequential tone control

Sequential-type remote controls that operate only after a second tone pulse (of different frequency from the first) has been received are generally complex circuits requiring filters or high-Q networks and stepping or ratchet relays. This circuit (Fig. 9) is a very simple one developed by Bramco Controls Div., Ledex Inc., Piqua, Ohio, to illustrate one of the uses of their two-channel resonant-reed relays.

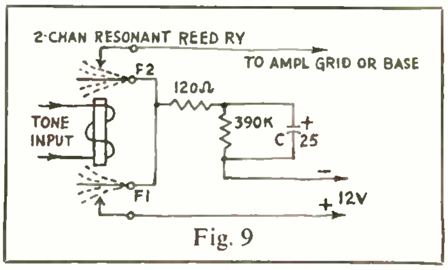


Fig. 9

When the first tone is received the F1 reed vibrates and charges C through its contact connected to one side of the power supply. When the second tone comes in, the F2 reed vibrates and transfers C's charge to the grid or base of a control tube or transistor. END

An Engineer Talks About Transistors in Audio

Part 2—A discussion of how semiconductors are used in hi-fi FM tuners

By PETER E. SUTHEIM

LAST MONTH WE DISCOVERED SOME REASONS why transistors are making better audio amplifiers possible—better than the tube amplifiers of a few years ago. The improvements, we learned, are not only smaller size and greater efficiency, but better performance as well.

In this second and final part of our Transistor Appreciation Course, we continue our conversation with Daniel R. von Recklinghausen, chief research engineer of H. H. Scott, Inc. This article, about semiconductors in tuners, comes from the same taped interview.

Dan started with a little historical background.

"The very first circuit in an FM tuner to use solid-state components was the detector: germanium diodes. Well, why was that?"

"They were small and made wiring simpler, I suppose," I said.

"That's true, but that isn't the big reason, from the designer's viewpoint. The ratio detector in an FM set is at the highest signal level in the whole circuit. Now, in a ratio detector, one diode gets the signal at its plate, from one side of the transformer, and the other diode gets it at the cathode, from the other side. So in a tube you have all this 10.7-MHz stuff being coupled into the heater wiring through heater-to-cathode capacitance in the tube.

"To filter that out and keep it from causing regeneration in the whole i.f. strip was a very rough job. That's where the germanium diodes came in."

"What was the next step?" I asked.

"The multiplex adapter: switching. Diodes or transistors make very lovely switches for stereo multiplex."

"And then?"

"The i.f. amplifier. Originally, FM i.f. amplifiers were just an extension of AM transistor-radio technology, with germanium transistors. You had to neutralize each stage to prevent regeneration—right back to the old triode rf and i.f. amplifiers. Neutralization is a tricky thing: it's quite critical, and you have to sort of tune it. Then came high-gain, high-frequency silicon planar transistors, and we could design i.f. strips without neutralization, by mismatching impedances and sacrificing a little gain.

"Now by mismatching, we gained something else. We could make transistor stages that did not load the tuned circuits and reduce their Q and selectivity. So the passive networks—transformers—alone determined the bandpass of the i.f. system."

"What followed that?"

"Well, actually, then we started putting field-effect transistors in the front end, but that's getting ahead a little. While we're on the subject of i.f. amplifiers, I should go on to the next step—the use of integrated circuits for i.f. amplifiers.

"In a transistor you always have some collector-to-base capacitance—a couple of picofarads. It limits the absolute maximum gain. An integrated circuit, such as the one we use, has a fraction of a pF—more like pentode tubes. So the gain–bandwidth product of an IC is higher than that of most transistors, and the input and output impedances are higher. Now you can either go to still higher gain per stage or get a lot less dependence on individual IC characteristics affecting the tuning or Q of transformers. A 2-to-1 change in the gain of an IC affects the tuned circuit maybe 5%; with old germanium transistors it's more like 50%. Silicon transistors are somewhere in between."

"Is that pretty much all? I mean, that's nice enough, but is it just that IC's do the same job somewhat better?"

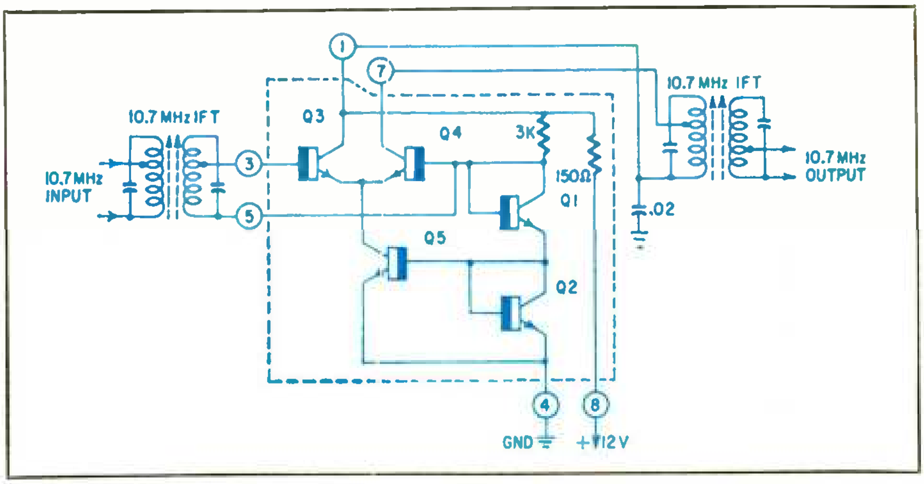
"No. Let's look at something else. Suppose you get a big, fat ignition pulse riding in on top of your FM signal. Now the agc is too slow to change the system gain that quickly. So something will overload. The base–emitter junction of a transistor is like a diode and so at least one of the transistors will rectify the pulse and store up the current from that in the filter capacitors of the bias network. That changes the operating point for a time, until the capacitors discharge down to normal. So you get a lump in your signal.

"Now the IC we use as an i.f. amplifier is an emitter-coupled circuit, which is a beautiful current limiter. It limits before it can change voltages and currents. Not only that, but the IC operating points are set by built-in diodes, not by resistor networks. The diodes have a very low impedance, so they don't need to be bypassed with capacitors. So there's a tremendous improvement in overload recovery.

"Let's look at another facet: capture ratio."

Dan digressed here for several minutes to explain some of the intricacies of capture effect.

Briefly, capture effect is the ability of one FM signal only slightly stronger than another on the same or a nearby frequency to "capture" the detector and dominate the other—almost to the complete exclusion of the weaker signal. The arbitrarily chosen figure for gaging this exclusion is 30 dB (audio ratio) at the output of the detector. Capture *ratio* is the ratio of the two incoming signals, expressed in decibels, that the tuner must "see" to achieve 30-dB suppression of the weaker one compared to the stronger. The smaller the number, the better the tuner. The best modern FM tuners



The Fairchild differential-amp integrated circuit. Q5 functions as a high series impedance holding the sum of currents through the two transistors of the differential pair (Q3, Q4) constant. The last two transistors function as bias-source diodes.

offer capture ratios between 1 and 2 dB—quite remarkable.

Dan continued.

"I said before that an emitter-coupled circuit is a fine symmetrical limiter. But it's very hard and very expensive to make one with separate transistors. In transistors with the same type number, there are often differences of 50 to 100 mV of bias for the same current. The diffusion is slightly different, and so on. Now this can give you a current variation between two transistors of as much as maybe 30 to 1. So the variations in transistors, even within the same batch, make it necessary to have separate adjustable bias networks for each one of the pair. Otherwise, it's not symmetrical.

"Which brings up this operating-point shift again."

"Right. Now in an IC, the advantage is that the transistors in it are formed close together, on the same silicon chip. They're bound to be nearly alike. A typical variation is perhaps *1* mV for the same current—5 mV is often a reject limit. So this gives you your first chance to make a *good* emitter-coupled limiter.

"And the current in an IC emitter-coupled amplifier is limited by a current-source transistor—the emitters of the emitter-coupled pair are tied together and fed from the collector of another transistor, connected as a constant-current source. So all the pair can do is divide that current between them. As we drive one to zero, we drive the other one toward maximum, or back the other way. When the transistors are alike, this has to be symmetrical."

"Now what about FM front ends? Why do you use field-effect transistors there?"

"I explained before that the input impedance of a transistor is that of a diode. If a diode, or a transistor, is subjected to one signal, its nonlinearity will make harmonics come out. Assuming we have a tuned amplifier, the harmonics of one signal won't bother you, because they're way outside the tuning range. If the signal is at 100 MHz, the second harmonic is at 200, which is way beyond the tuning range of the receiver. Now let's put in two signals. Because of the nonlinearity, you'll get intermodulation.

"First-order intermodulation, which corresponds to second-harmonic distortion, gets you sum-and-difference frequencies. If one signal is 100 MHz and the other 101, the sum is 201 and the difference is 1. Still no problem. So having a second-harmonic characteristic isn't bad. It may even be convenient—we can apply two signals and come up with the product, like the desired signal and dc. We can change the gain with that trick. This is what we call a square-law device.

"Let's look at second-order intermodulation, third harmonics."

Dan pointed out that you could get "harmonic babies" at 99 and 102 MHz, which is well within the FM tuning range.

"So we want, in an FM front end, a device that does not create any third- or higher-order harmonics. Or as few as possible. A diode is pretty bad. A tube is better—it works on a three-halves-power law instead of a square law. You have some higher-order products, but not so many. That's why some of the better tuners that used transistors everywhere else used nuvistors or some other kind of tube in the front-end.

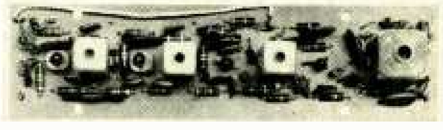
"So, the world was looking for that perfect square-law device. Turns out it was described back in 1952 by one of the inventors of the transistor—Shockley. A unipolar field-effect transistor. Strictly theory. It wasn't until a few years ago that the first ones came on the market—at $30 apiece in production quantities! With transconductances of only a few hundred micromhos and capacitances of plenty of picofarads. Not too good for high-frequency work.

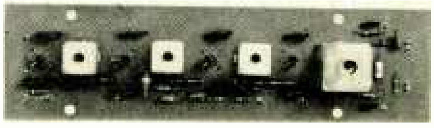
"Nobody even thought of using them for rf—everybody looked at that high input impedance and out came timing circuits, dc amplifiers and so forth. Manufacturers tried to make FET's with a *constant* transconductance—a nice, linear class-A amplifier. Not linearly *changing* transconductance, which is what was needed so we could apply agc.

"Well, we cooperated with Texas Instruments to go back to the original Shockley thing—high transconductance, low capacitance, and square-law."

"So that explains why you use field-effect transistors."

"Yes, that's one reason. But there's another. Are you familiar with the concept of equivalent noise resistance?"





The upper circuit board is the i.f. strip of some recent Scott tuners with all conventional transistors. Compare it with the lower board, in which the transistor i.f. stages have been replaced with IC's.

"A bit vaguely, yes."

"Equivalent noise resistance is a fictitious resistor connected in series with the input of an amplifier. You can't ever short it out, and it makes noise. This equivalent noise resistance is what determines noise figure. Now in a triode tube, which is what is most commonly used now as a low-noise rf amplifier, the equivalent noise resistance is equal to 2.5 divided by the transconductance. Say a good rf tube has a transconductance or G_m of 10,000 micromhos. Its noise resistance would be 250 ohms.

"Now where does that 2.5 come from? The formula says noise resistance is inversely proportional to G_m—in other words, proportional to $1/G_m$. A tube works about 2.5 times higher than room temperature, expressed in absolute temperature (°K). That's about 750°K, which is quite hot.

"In a field-effect transistor, which operates around room temperature, the noise resistance really *is* $1/G_m$. You can get many thousands of micromhos transconductance now in FET's, but with much less noise than the same value in tubes."

"Better than transistors?"

"Oh yes—better. Far better than transistors. Also, high-G_m tubes lose G_m as they age. FET's don't seem to do that.

"So I think you see we've improved things at both ends. Lower noise gives a higher usable sensitivity, and less cross-modulation means you can handle bigger signals. You've increased the *dynamic range*. You know how everybody fights to get a fraction of a dB more sensitivity. Well, that fraction of a dB at the other end—high signal level—is perhaps more important."

"I see."

"Now let's look at figures. With tubes we had maybe 80 to 85 dB cross-modulation rejection. With conventional transistor circuitry, you run 60, 70—maybe 75 dB. If you're really careful. With FET's, we have measured in excess of 100 dB."

So that's the story. If you've noticed the repeated trend in the introduction of new semiconductors and circuits from esoteric military/industrial applications, to high-quality high-fidelity equipment, to low-cost radio-phono sets, you can predict that FET's will soon begin appearing in less and less expensive equipment as their cost drops and designers become more familiar with them. While there will always be manufacturers eager to produce junk, recent developments make it almost impossible to avoid producing radios and amplifiers considerably better than those of a few years ago.

For most of the home-entertainment equipment we're likely to run across in our daily work, it seems safe to say that tubes are pretty much extinct!

END

Imaginary Numbers are a Cinch

Part 1—Math tools that aren't real, but which work in a real way **By NORMAN H. CROWHURST**

IT ALL STARTED WHEN GEORGE NEEDED a filter for the new cross-multiplexing system he was developing. He called me up about his problem and I asked what he wanted the filter to do.

"Come on over, bring your design stuff, and I'll show you," was his response.

I went over to his lab and he explained the problem to me. After a little figuring, which he watched, I sketched a schematic and put the values in.

"We'll have that made up in a jiffy," he said, as he picked up the phone to call the storeroom for parts.

In less than an hour a messenger brought the parts. George's technician wired them, and George had a working filter. Satisfied that George had what he wanted, I turned to leave, but he called me back.

"Just a cotton-pickin' minute," he said. "Can't you show a fellow how you figured those values in such short order, so I can do it myself next time?"

It took me twice as long to explain it as it had taken me to figure it. He realized that what made the calculation difficult for him was the use of imaginary numbers, although that was what made it easy for me. As I left, he made me promise to explain imaginary numbers to him in easy stages.

One slack afternoon about a week later, not long before closing time, George and I got together again. "Let's see why the idea seems difficult," was how I started.

"Do you remember when you first encountered irrational numbers?"

George remembered learning about them, but couldn't remember what they were.

To clarify them, I quickly went over rational numbers, particularly fractions. I showed, using a number line (Fig. 1), that $3/5$ and $5/8$ are fractions of close to the same magnitude. "If we compare various fractions, it seems as if we can make up just about any size of part we want by taking a suitable denominator, or bottom, and then selecting an appropriate count, or numerator, of that denominator." I illustrated this by fitting $49/80$ between $3/5$ and $5/8$.

"That seems logical," George said, "but you say it as if there's a catch. What is it?"

"Well now, George, I'm sure you remember some numbers that could not be accurately written, either as decimals or as fractions. No matter what denominators and numerators you use, nor how many decimal places you use, you can reach only an approximation."

"You mean like pi?" George asked, and then before I could answer he added, "or root two?"

"That's it. You do remember. That's the difference between rational and irrational numbers. Any number that can be written accurately with fractions using whole numbers for numerator and denominator, or that can be written with a terminating decimal, is called a *rational number*. It fits the known pattern of numbers before irrational numbers were admitted to exist. Then mathematicians found impossible-seeming numbers like root two, or pi. . . ."

"And they're irrational numbers?" George butted in.

"That's right."

"Makes sense," he responded, "although I don't remember learning it that way in school. But irrational numbers aren't the same as imaginary numbers, are they?"

"No, they're not, but notice this: At one time math scholars thought *any* number could be represented by a fraction. Later they realized that irrational numbers belong to a different class than rational numbers. And do you remember when you first learned about negative numbers?"

"I should say," George replied. "They gave me a hard time. Especially that bit about minus times a minus making a plus. I never did understand that fully."

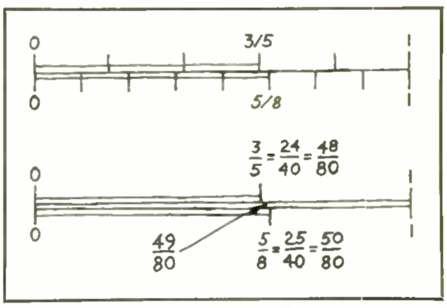


Fig. 1—Fractions are both real and rational numbers, denote exact quantities.

"Oddly enough, understanding imaginary numbers will make that easier too." I then asked him, "Do you know how negative numbers differ from positive numbers?"

"Well, as I see it," he said, "it's like another world, an upside-down world. When you combine negative numbers with positive numbers, you subtract the negative ones whereas you would add them if they were all positive."

"You're right. I don't know if a math teacher would accept that answer, but it shows you know. Now, do you remember doing squares and square roots?"

"It's a bit rusty," he replied, "but I remember it."

"Let's take some simple cases," I suggested, "What is 2 times 2?"

He looked at me as if I must think him stupid, volunteered "4" and then looked quizzical, as if he thought that answer might somehow be wrong in higher mathematics.

"Right. Now 3 times 3?"

"Nine," he replied, still puzzled.

"So you know what squares are. Now what is -3 times -3?"

"Nine," he replied, hesitantly.

"Yes, but is it $+9$ or -9?"

"Well, I remember having trouble with that," he admitted, "but if I remember right I got it through my head that it was $+9$."

"Right." Then I asked, "So what's the square root of $+9$?"

"Three," he replied.

"Plus 3 or minus 3?" I asked.

He thought for a moment and then said, "It could be either, couldn't it?"

"That's right," I assured him. "So, if the square root of $+9$ can be $+3$ or -3, what is the square root of -9?"

"Didn't we learn that you can't actually have a square root of a minus number?"

"Maybe, but let's recap a little. Before we knew about irrational numbers, no such number as *pi* or *root two* seemed possible. Before we knew about negative numbers, we were told we couldn't subtract 8 from 3. Later, we accepted the existence of irrational and negative numbers, and these impossible numbers became possible. So let's *imagine* there *are* roots of negative numbers."

"You mean we just accept them, and then learn to use them." I could see his interest growing; he wanted to find out where imaginary numbers would come from.

"What we do," I went on, "is to write the letter *j* and assign it the meaning *square root of −1*. All along we have believed there isn't such a thing. Now we imagine there is, although all we know so far is that we just gave it a name: *square root of −1*. But from that very fact, we know that squaring it will make −1."

"That's right enough, but aren't we going round in circles?"

"We soon will be," I replied, "but not in the way you think."

I showed him that, just as the square root of +1 is either plus 1 or −1, the square root of −1 can have two signs, +*j* or −*j*. The square root of −9, for example, is either +*j*3 or −*j*3.

"It doesn't make sense yet," said George, "but go on, 'cause it's getting interesting."

"Remember that minus times a minus makes a plus," I said, drawing out vectors to illustrate (Fig. 2-a). "A minus reverses direction and the second minus reverses it again, bringing us to the original direction. With *j* numbers, multiplying *j* by *j* brings us to negative. As a math teacher would say, 'By definition, *j* times *j* makes a minus.' So, if negative represents reversal, what does the *j* sign mean?"

"From the way you twiddled your pencil," George responded, "I'd say it could mean halfway to reversal, or 90°. Is that it?"

"You've spotted it, George," I said, sketching a vector representation (Fig. 2-b) for him. "The vector diagrams illustrate. . . ."

"Hey, I begin to see daylight," he interrrupted me. "It's a way of writing quadrature in math symbols, without spelling it out. But does it make the calculations easier too?"

"Yes, the *j* tells you what to do with the number that follows it, just like plus and minus signs have been doing."

"Just a minute, why *j*? What does it stand for? Wouldn't *i* be better—for imaginary?"

"As a matter of fact, that's what mathematicians and physicists use. But in electrical and electronic work, *i* already stands for current—although I never knew why—so, to avoid confusion, electrical people started using the next letter of the alphabet—*j*—for *root of −1*."

"Is that what they call the operator *j*?" George again butted in.

"That's right."

"And operator *j* means *the root of minus one?*"

"Correct again."

"Well, I'll be a monkey's uncle!" George exclaimed. "I don't know whether that clarifies anything for me, but I've a suspicion it will."

"In modern math classes," I went on, "they use number lines, as I did to demonstrate the fractions in my first sketch. Lengths along the line represent numbers." And I showed him how the concept of negative numbers is developed on a number line, following the concept of reversal a step further.

"They didn't use number lines when I was in school," George commented. "Maybe things would have come easier if they had."

"The main thing to note," I continued, "is how you add numbers on a number line. Start the second number from where the first one finishes; the result, or sum, is at the end of the second line segment."

"Makes sense," said George. "In fact, it seems obvious."

"Do you think now you could add an imaginary number to a real number, either positive or negative?"

"Is it at right angles?"

"That's right. So we have a right-triangle vector addition," I went on, sketching Fig. 3 as I talked.

"Hey, that really is familiar, though the old right-triangle bit always gave me a headache!"

"Then how would you go about finding the total, or resultant vector?" was my next question.

"Oh, that's old Pythag . . . what's his name? The sum of the squares on the other two sides—what did they call it, hypot . . . ?" George wondered aloud.

"It's Pythagoras' theorem," I filled in, "and the side opposite the right angle is call the *hypotenuse*. I'll bet you've done quite a few exercises in school, squaring two sides and finding the square root of their sum for the result."

"Yes," George said, "we seemed to have endless exercises in that at technical school. Will imaginary numbers take the sweat out of all that?"

"Sure will. Right now, it may seem just another name for what you've done before. But as we move along, you'll find imaginary numbers lead to more and more shortcuts, making calculations easier."

"That's for me," declared George.

"Now to complete the picture. For this one vector in my sketch, do you know how to find the phase angle?"

"You have me there. It has something to do with the ratio of two sides—is that right?"

I nodded and he went on. "I had some trig. It's called the sine or cosine or something like that, isn't it?"

"The sine and cosine are two other ratios," I told him. "This one's the tangent. It's the side opposite the phase angle, divided by the side adjacent." And I sketched it (Fig. 4).

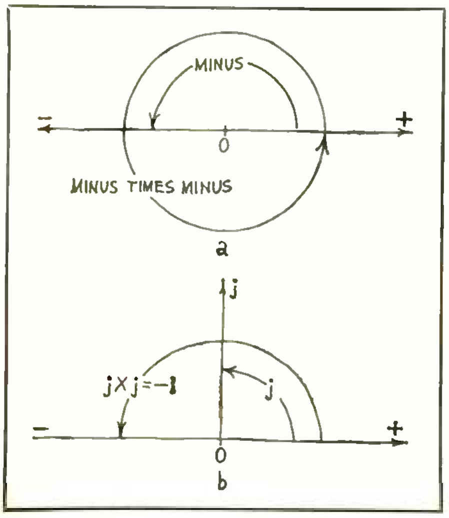


Fig. 2-a—Minus times minus makes plus. b—J denotes only 90° change in phase.

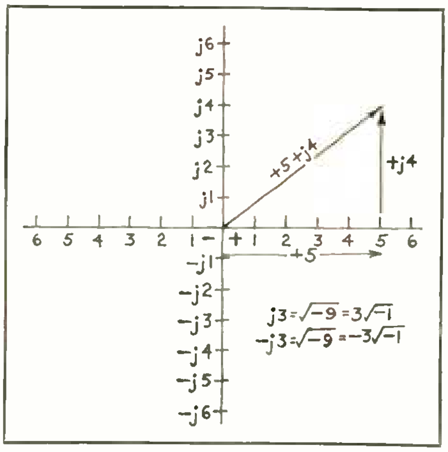


Fig. 3—A complex number is a combination of a real and an imaginary number. It is shown graphically as a vector quantity, the result of two other numbers.

"The one opposite is the imaginary part, while the one adjacent is the real part. Now, to every angle there is just one tangent ratio, and to every tangent ratio there is just one angle. So we can find the angle from the tangent ratio, or the tangent ratio from the angle—either way, so long as we have one of them to start with."

George said, "Let's get this straight: I know the ratio between imaginary and real parts, so I look up the tangent of this ratio to find the angle. Is that right?"

"Ordinarily, it's the other way round. If you knew the angle in degrees, you'd look up the tangent of the angle to find the ratio between the imaginary and real parts. Here, you know the ratio, so you look up the arctan to find the angle. As we don't happen to have arctan tables, we can use the tangent table backward, or a slide rule.

"Let's take something practical and relatively simple, like an inductance with some series resistance. The *real* part of its impedance, producing in-phase voltage and current, is the coil resistance. The *imaginary* part, producing quadrature voltage and current, is the inductive reactance of the coil. Do you remember inductive reactance?"

"Let's see," pondered George, "it depends on L—the inductance in henrys—and there's a 2-pi-f in it, isn't there?"

"When we're using it a lot, it's much easier to write a lower-case *omega* for 2-pi-f." I wrote this equation on our scrap paper (Fig. 5). "Now, does inductive reactance get bigger or smaller as we increase frequency?"

"Isn't inductive reactance *directly* proportional to frequency?"

"Right. If L is in henrys, and f is in hertz and omega is 2-pi-f, then inductive reactance is simply omega times L."

"That does make it look simple," commented George.

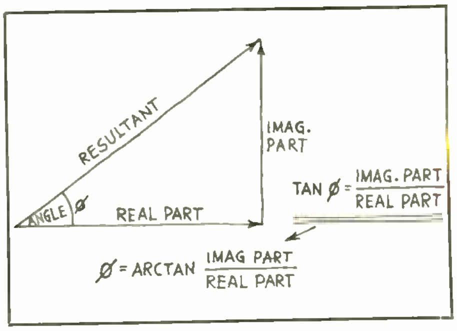


Fig. 4—The phase angle of a complex-number vector is a function of the two amounts of both the real and imaginary parts. The relationship is described simply by trigonometry. Hence trig computations always yield the complex angle.

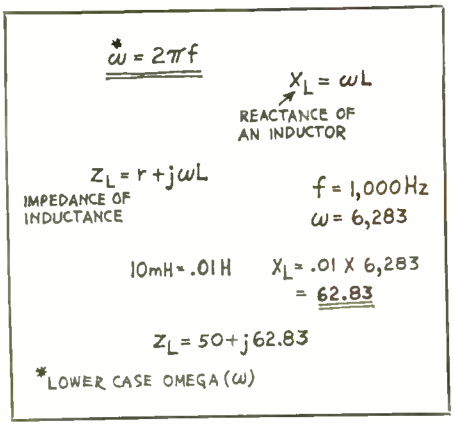


Fig. 5—Here's how to compute the impedance of an inductance at one frequency.

"A reactive voltage is in quadrature with current," I went on, "so that means we need a *j* to represent the value properly. If the coil resistance is R ohms and the inductance is L henrys, the complete expression for impedance is $Z = R + j\omega L$. By multiplying various values of f by 2π to get omega, we can make this expression tell the whole story, at all frequencies. Now what's the numerical value, or magnitude, of this expression?"

"From what we were saying earlier," George replied, "you'd square R and square omega-L, add the two squares together and then take the square root."

"You're catching on fast. Now what's the phase angle?"

"That's not so easy, but I know it has to do with the ratio between R and omega-L," he replied.

"Let's put in some numbers, and see how this works," I suggested, turning again to Fig. 5. "Suppose a 10-mH coil has a resistance of 50 ohms. Let's figure its impedance and phase at a few frequencies. To start with, take 1,000 Hz. First, what is omega at 1,000 Hz?"

"Well, 2-pi is 6.283, so 1,000 Hz makes omega 6,283."

"Correct. So what is omega-L at 1,000 Hz?"

"10 mH is one-hundredth of a henry," George mused, and doodled a moment, "so omega-L comes out to 62.83, right?"

I showed him how to use his slide rule to sum the squares and take the square root at that sum, getting 80.3 ohms as the impedance Z. I asked him about the phase angle. He had the idea, but needed to be shown how to do it.

He solved the ratio of imaginary to real, which was 1.257, and I showed him on the slide rule the angle—about 51½°. Then he took the slide rule and calculated impedance and phase angle for several other frequencies, while I watched. His results are shown in the table. He was thrilled at how simple it seemed.

Then I threw in the notion of using admittance values instead of impedance values for parallel combinations whose phase is in quadrature. He wanted to know why. He'd always preferred thinking in impedances.

I showed him that, with a specific voltage, he'd have to divide by the complex number representing impedance to figure out current. With admittance, he could simply multiply.

"Is that so much easier?" he wanted to know.

Just then the evening whistle blew. George and I both had to be going.

"If you don't have too much work ahead of you," George asked, "can you drop by another time soon and finish telling me that bit?"

"Sure thing," I replied.

TO BE CONTINUED

Table of Impedance and Phase Angles

Freq (Hz)	W	X_L	X_L^2	Z^2	Z	Ø
500	3,142	31.42	985	3,485	59.1	32.1°
1,000	6,283	62.83	3,950	6,450	80.3	51.5°
1,500	9,425	94.25	8,880	11,380	106.6	62°
2,000	12,570	125.70	15,760	18,260	134.8	68.35°
3,000	18,850	188.50	35,600	38,100	194.8	75.15°
5,000	31,420	314.20	98,500	101,000	318.0	80.95°

Where R is 50 ohms and L is .01 henry

Troubleshooting Chroma with VTVM

It's not always what service instruments you have, but how well you know them and how skillfully and carefully you can use each of them

By CARL H. BABCOKE

THE OSCILLOSCOPE HAS BEEN REPRESENTED as the perfect TV servicing instrument. Leaders in the electronics servicing industry have persuaded and cajoled technicians to increase their skill in using it. In many circumstances the scope *is* certainly useful. In other troubleshooting situations, however, a scope can waste valuable time.

When you test a chroma circuit, does your scope light up in beautiful green letters that say, "Secondary of the burst transformer is open?" Mine does not. Instead, the corner of the pattern tilts up in a sardonic leer as if to say, "This is the voltage and waveform at the end of my low-capacitance probe. Interpret it if you can." As can any skilled scope jockey, I eventually arrive at a correct diagnosis, but only after using a vtvm to pinpoint the defective part or parts.

Many chroma defects exhibit visual symptoms on the picture tube that suggest the general trouble area, thus eliminating that part of the troubleshooting usually reserved for the scope. These symptoms are half of the chroma troubleshooting technique to be described here. [The same is true for black-and-white.—*Editor*] The other half is multiplying the usefulness of the lowly vtvm by minor probe modifications.

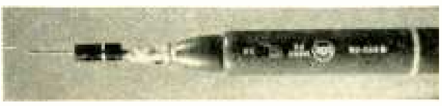
A basic problem in obtaining accurate readings with any test instrument is that the device itself may radically change the circuit being tested. Vtvm's are recommended over vom's because of higher input impedance (especially on the low scales, where it is the most important). But a dc vtvm can still upset a tuned circuit and make it oscillate, or detune it, because of capacitance in the probe.

There is a simple way to minimize the stray capacitance of any dc probe (see photo). The exposed resistor lead should be kept as short as possible. The 1-meg resistor decreases readings by about 10%, unless you use a probe without an internal resistor or slide the switch to the AC–OHMS position to restore the original calibration.

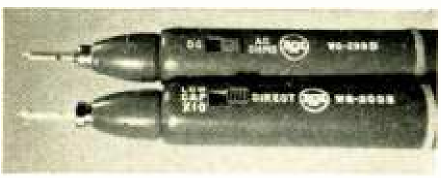
In spite of the fact that the ac response of many vtvm's is flat to 3 MHz or higher, any attempt to measure the signal at the chroma-bandpass plate or at the grid of a 3.58-MHz oscillator is doomed to failure. The combined capacitance of the probe, cable and meter will kill the signal. This occurs because the total meter capacitance is approximately 60 pF, equal to about 1,000 ohms of capacitive reactance at 3.58 MHz.

The situation is not completely discouraging, however. The low-C probe used with most scopes has a capacitance of about 11 pF and can be used with the vtvm (Fig. 1). Of course, it no longer will give an exact 10-to-1 reduction in reading, so you'll have to check the loss ratio of your own meter and probe, for accuracy.

To do this, measure the 6.3-volt heater supply with the probe in the DIRECT position and record the peak-to-peak reading. Change the probe switch to LOW CAP × 10, measure again and record the second reading. Divide the second reading into the first, and you have the ratio at 60 Hz. Now find a low-impedance point in a 3.58-MHz oscillator (for example, secondary terminal C of the oscillator plate transformer, as



A 1-meg resistor "unloads" vtvm probe.



Use scope and vtvm probes for tests.

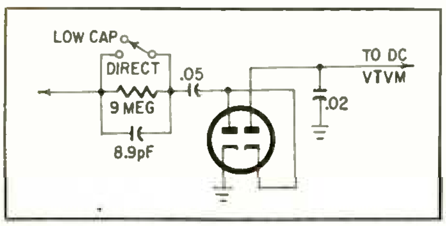


Fig. 1—Oscilloscope low-capacitance probe can be used with almost all vtvm's.

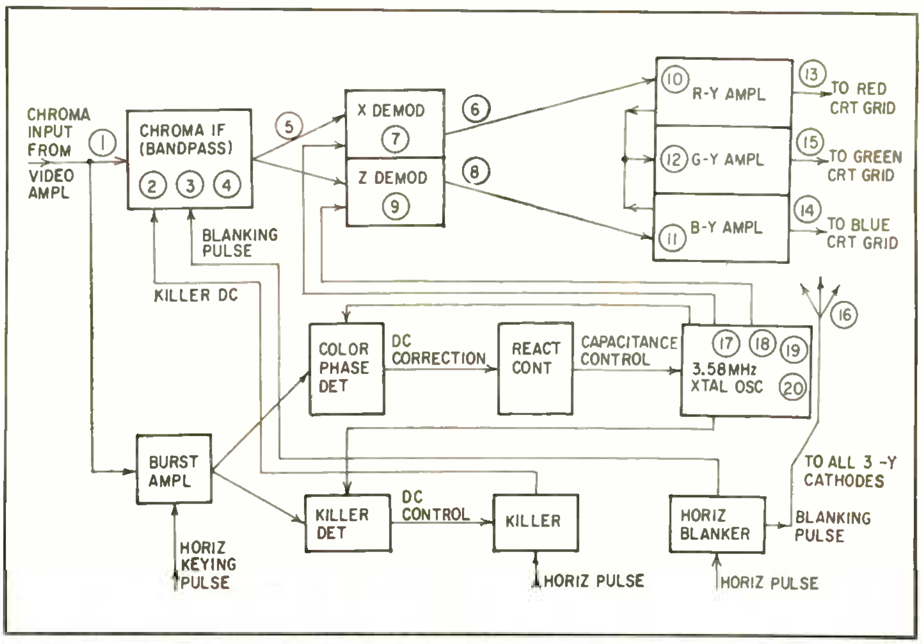


Fig. 2—Experiments were made in this color receiver to compare vtvm with scope.

indicated in Table I) and measure this in the DIRECT and LOW CAP positions. Calculate the ratio for the higher frequency. The two ratios differed in my own calibration, so I used the one for 3.58 MHz—approximately 12.

Even with this relatively high level of attenuation, the low-capacitance probe will permit us to read virtually any signal in the entire chroma circuit, even at the bandpass grid, where the signal typically would be about 12 volts peak to peak.

Fig. 2 is a block diagram of chroma circuits in an RCA CTC16X color chassis. The circles contain numbers corresponding to measurement conditions given in Table I. Let's use these two illustrations to find out how much of the circuit can be investigated with a vtvm compared to a scope. (A color-bar generator was used for a signal source.) Table I gives the circuit test point, the readings with the vtvm (using two kinds of probes) and a reading with a calibrated scope (using low-C probe). Any change in color-bar display when a probe was touched to the circuit is also listed—as a guide to the loading effect of the testing equipment.

Several conclusions can be drawn from the chart. The first is that the vtvm plus the low-capacitance probe will give fast and fairly accurate readings on any circuit where a good scope could be used. Furthermore, the vtvm will not change receiver performance any more than the scope would. An unexpected bonus is the news that the existing probe can be used with fair accuracy on 14 out of the 20 tests. Only one chroma voltage was too small to read on the low-capacitance probe—the grid of the G−Y amplifier—and it has only some crosstalk on it and is a point seldom measured.

One more hint if you prefer to use the normal vtvm probe: Almost any circuit that's detuned badly by a probe has another branch that's not so affected. The bandpass-amplifier plate-transformer primary is greatly changed by probe capacitance, while the secondary (also the top of the color control) is virtually unchanged. The oscillator plate transformer is a similar example. While primary measurement with a normal probe may kill all color, the secondary (the suppressor grid of the X demodulator) can easily be measured. This will tell you if the oscillator is running and has enough output.

To avoid the bother of changing probes, just keep a scope probe on the vtvm at all times and use the switch for normal or low-cap functions. For dc readings attach the external 1-meg resistor to the tip, as described earlier.

Regardless of the probe used, a 1-meg resistor on the probe tip is a *must* for fast, efficient measurements

TABLE I

Probe Comparison—Voltage and Effect

Circuit Position	Vtvm normal probe	Vtvm low-C probe actual	Vtvm low-C probe corrected	Scope low-C probe
1. Chroma input coil	4.5 changes phase much less color	2.4	28.8 more color, changes phase	26 more color, changes phase
2. Bandpass grid	6.0 less color	1.03	12.36 little change	13 little change
3. Bandpass plate	11 much less color, much phase change	4.8	19 slightly less color, some phase change	18 slightly less color, some phase change
4. Top of color control	18.5 slight phase change	1.6	19 no change	18 no change
5. Arm of color control	10 slight phase change	0.8	10 no change	12 no change
6. Plate pin 6 of X demod	18 phase change	2.2	26.4 no change	26 no change
7. Supp. pin 7 of X demod	21 no change	2.2	26 no change	26 no change
8. Plate pin 6 of Z demod	26 phase change	3.0	36 no change	38 no change
9. Supp. pin 7 of Z demod	20.5 blue to right	2.6	29 slight phase change	25 slight phase change
10. Grid pin 2 R−Y ampl	17 slight phase change	1.85	22 no change	21 no change
11. Grid pin 7 B−Y ampl	24.5 slight phase change	2.5	30 no change	30 no change
12. Grid pin 7 G−Y ampl	3.6 no phase change	(can't read)	no change	5 no change
13. Plate pin 1 R−Y ampl	200 blanking & chroma 115 no color blurs picture	22 both 11 no color	264 132 no change	20 color 110 blanking no change
14. Plate pin 6 B−Y ampl	220 both 110 no color blurs picture	24 both 11 no color	288 132 no change	260 color 210 blanking no change
15. Plate pin 6 G−Y ampl	145 both 120 no color blurs picture	14.5 both 11 no color	174 132 no change	75 color 120 blanking no change
16. −Y amplifiers common cathode	10.8 both 9.8 no color no change	0.9 both 0.85 no color	10.8 10.2 no change	6 color 9.5 blanking no change
17. Oscillator grid pin 2	12 far off freq.	1.2	14 slightly off freq.	14 slightly off freq.
18. Oscillator plate pin 6	8 no color	5.6 little color	67	50 little color
19. Oscillator screen pin 3	zero no color	0.42	5 no change	6 no change
20. Osc. plate transformer terminal C	21 no change	2.2	26 no change	21 no change

TABLE II

Variations in Phase- and Killer-Detector Voltages

Test point	Black-and-white program	No antenna, no signal	100 Percent color bars
6JU8 pin 1 (phase det plate)	−15	−28.5	−56
6JU8 pin 3 (phase det cath)	+15	+29	+56
Junction of two matched resistors	+.05	+0.3	+.05
6JU8 pin 7 (killer det plate)	−15	−27.5	−55
6JU8 pin 9 (killer det cath)	+13	+24	+47
Junction of two matched resistors*	−0.83	−1.0	−3.3
*With color-killer control correctly set			

NOTE: Pin 1 had −8.5 volts with burst tube removed.

Troubleshooting Chroma with VTVM

where grids and diodes in the circuit are actually built-in ac rectifiers. The 6JU8 phase and killer detectors shown in Fig. 3 are prime examples. Let's measure the dc voltages on pins 1, 3, 7 and 9 under several signal conditions and record them in the chart of Table II. Where do these voltages come from? On color bars from burst rectification, on black-and-white from video harmonics above 3 MHz and on snow from random-noise harmonics.

But that's not all. With the burst tube removed from its socket, there is still −8.5 volts on pin 1. Where did this voltage come from? From a source we may have neglected, the sample of 3.58 MHz from the oscillator applied to the plate and cathode of pin 2. This 3.58 signal is compared against the burst and, if the phase or frequency of the two are different, error dc voltage is formed at the junction of the two matched 1-meg resistors (point A). This error voltage controls the reactance tube and thus the 3.58-MHz oscillator.

At the moment we are only concerned with the diode voltage, and there are two important things we can learn by measuring the voltage on plate pin 1. If the voltage is −40 or more we can conclude there is burst present. However, this does not prove the oscillator signal is there. Disable the burst stage, and the voltage should be −8 to −9 if the oscillator is running.

Now let's see how we can use several of these techniques to make a fast diagnosis on a colorless color set. Tune the receiver to a color-bar pattern from a generator, with the sound carrier switched on at the generator. Tune into the beat pattern on the faint vertical bars that mark the proper color-bar position. Then back off the smallest amount necessary to eliminate the beat. This will assure that the fine tuning is correctly set to receive color. Preset the color control almost full up and the tint control to the center of its range. Now measure the voltage (with external resistor on the probe) at pin 1 of the 6JU8. Less than −30 volts indicates there is no burst coming from the burst keyer, but −40 or more is normal for good burst.

You will notice in Fig. 2 that the bandpass amplifier (color) and burst keyer stages are nearly in parallel—they share a common input from the takeoff coil. Therefore, if we have good burst to the 6JU8, it is nearly 100% certain we have chrominance sideband information at the grid circuit of the bandpass amplifier. Since there are two demodulators and three −Y amplifiers, a complete loss of color is most likely to be in the bandpass amplifier.

To check this the easy way, we use the normal ac probe at the top end of the color control. Any voltage above about 10 p-p should be sufficient for good color, and we would go next to the demodulator stages. But just suppose we measured *no* ac voltage on the color control. This positively isolates the trouble to the bandpass amplifier. A bad tube or wrong plate, screen or cathode voltage can stop the color, but the best bet is the grid voltage because of the color-killer connection. Fig. 4 is a simplified diagram of this grid circuit including a very important test point. The photo shows the physical location. Negative 8 or 9 volts is enough to cut off the 6GH8. As a rule, −3 volts or less will permit normal amplification while −8 or more indicates the tube is biased for no gain.

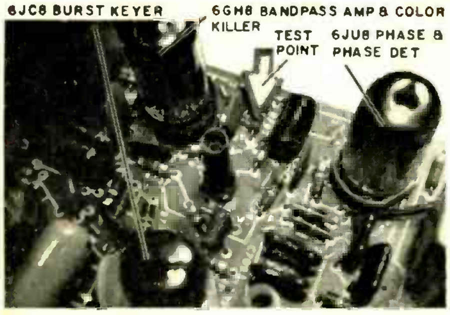
A shortcut here is to ground resistor R703 or capacitor C702 with a clip lead and see if color of any kind appears on the screen. The color may be normal and stable if the sole defect is in the killer stage or its adjustment. More likely is the possibility of seeing out-of-lock color stripes, because the killer is noise-immune. It biases the bandpass amplifier to cutoff unless the burst and local 3.58 signal are phase-locked. In this event, correct the poor locking and check tint range. Finally, remove the ground and set the color killer.

Should the burst-keyer and bandpass-amplifier stages check normal in this series of tests, we would check the 3.58 oscillator by one of two methods. The low-capacitance probe could be applied to pin 7—the suppressor of the X demodulator—where we would normally expect 2 volts p-p (24 volts p-p corrected). Or we could remove the burst-keyer tube and check the dc voltage at pin 1 of the 6JU8, expecting to find −8 to −9 if the oscillator is normal or zero if it's dead.

The demodulators and −Y amplifiers can be checked similarly, using ac and dc tests alternately, to pinpoint any possible loss of color there.

All kidding aside, a scope is a fine instrument to have and use effectively, but the familiar vtvm with its three kinds of probes has the advantage in two important characteristics: *speed* and *accuracy of measurement.* A calibrated voltage-reading scope is frustrating to use with calibration to check, centering controls to adjust, scales to select and finally a reading to be made by squinting and wondering if the trace is lined up right. By comparison, a vtvm reading is quick and easy. A scale is selected, the pointer rises to a definite point on the scale, where you find large, easy-to-read numbers.

Try it yourself, and you will probably use the vtvm for 90% of your chroma testing. **END**



Location of test point shown in Fig. 4.

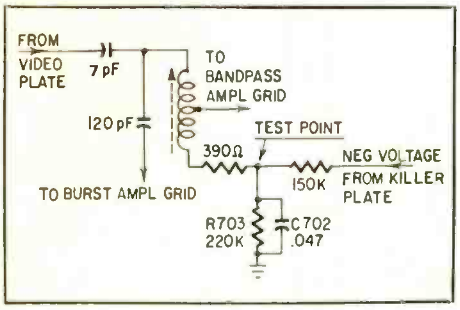


Fig. 4—Check color-killer voltage here.

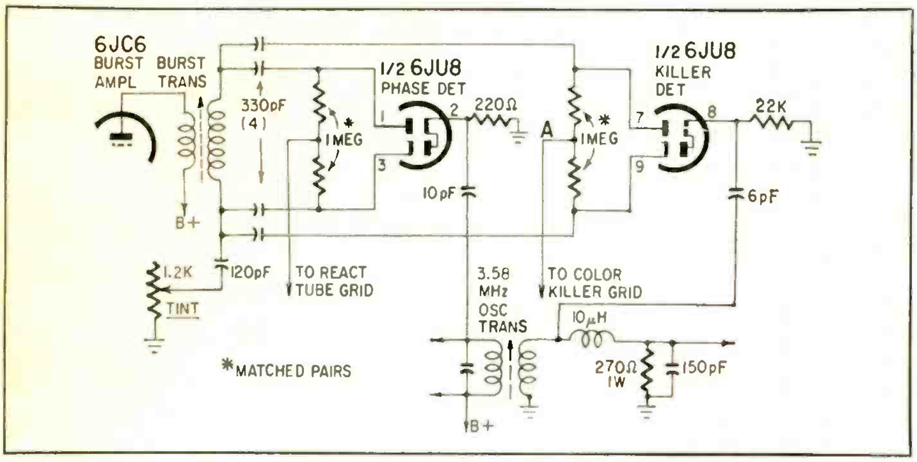


Fig. 3—These detectors are built-in rectifiers; dc readings show amount of signal.

A Mechanical Look at Tape Recorder Servicing

Get to know the nonelectronic side of this branch of service work and you'll enlarge your troubleshooting ability

By JOHN MOHAN

THERE'S MORE TO HOME-ENTERTAINMENT servicing these days than simple electronic repair work. The modern technician is confronted daily with mechanical devices of all descriptions—motorized TV tuners, pushbutton auto radios, record changers, and the ever-popular tape recorder.

This latter product is attaining huge numbers, and the troubles in them are as often mechanical as they are electronic. But your customer expects you to handle *all* the problems in his home-entertainment equipment. It matters not if your training was electronic, not mechanical.

How can you meet this challenge? . . . Here, I feel, are the best steps: (1) Study the mechanism. (2) Observe its actions. (3) Try to visualize correct operations; then (4) figure the why's of incorrect operation. In brief, you must understand the mechanism if you are to solve its mechanical problems. Good facilities such as lighting, tools, lubricants and cleaners, and reliable service literature (many hints are given in service data) are important aids.

TAPE-TRANSPORT SERVICING HINTS

1. Equip your service bench with the necessary tools and facilities.
2. Figure out how the mechanism operates.
3. Be sure all driving surfaces are clean (use alcohol) and free of oil or grease.
4. Avoid excessive lubrication. Use only recommended lubricants.
5. Don't bend or distort mechanical parts.
6. Refer to service literature for guidance in adjustment and servicing.
7. Be sure the electronic performance is good before suspecting the mechanism.
8. Operate this machine for a reasonable period of time to check your repair.
9. Test all modes of operation (at all speeds).

And please note—use care . . . don't start by bending mechanisms or forcing moving parts until something breaks! Something we might call "courage over caution" causes parts to be bent or distorted to achieve what *appears* to be a repair but invariably results in more problems. Careless use of lubricants can also compound mechanical problems and result in annoying callbacks.

Each mechanism—whether it's the gear train of a television tuner, the change slide of a record player, or the mixed-up inside of a tape recorder—must be treated separately, because each accomplishes its mechanical results a different way.

Tape-recorder drive systems are of four types. Although the basic principles of operation are similar, the manner in which the driving force is delivered to the moving parts differs.

A belt drive

Fig. 1 illustrates the essential elements of a typical belt-drive system. In spite of its simplicity, this system works well. The chassis plate and control knobs or pushbuttons and associated linkages are omitted from the sketch for clarity. The mechanism is shown in Fig. 1-a in the *play* position. (The only difference between this and the record position is in how the amplifier circuits are switched.)

One drive belt couples the motor to the flywheel, and another couples the flywheel assembly to the takeup reel. The pressure roller holds the tape against the capstan shaft, which pulls the tape past play/record heads.

The takeup reel, also driven by a belt, winds up the tape. Excess slack is removed from the drive belt by an idler pulley, but enough is left to allow slight slippage—so the tape won't be stretched too taut. The supply reel feeds the tape and turns counterclockwise solely from the pull of the tape. Uniform tape speed past the heads is maintained because the capstan shaft actually controls the travel speed of the tape. The capstan shaft is maintained at constant speed by the inertia of the flywheel and a governor in the motor. In this machine, a choice of tape speeds is provided by an accessory sleeve which can be placed on the capstan shaft to change its diameter.

When this recorder is in the rewind position, the mechanical drive conditions change. Fig. 1-b shows how rewind is accomplished. The pressure roller is pulled away from the capstan shaft. The idler pulley is pushed back, leaving the takeup belt slack. The pulley coupled to the supply reel is pushed into contact with the flywheel assembly. Under these conditions, the capstan and pressure roller no longer provide the driving force for the tape: instead, the *supply* reel is now the primary drive for the tape, being driven in a clockwise direction by the flywheel assembly. The takeup reel also is pulled clockwise (opposing the very slight force of the slack drive belt on the takeup reel).

Now consider mechanical problems which could arise. Suppose that in

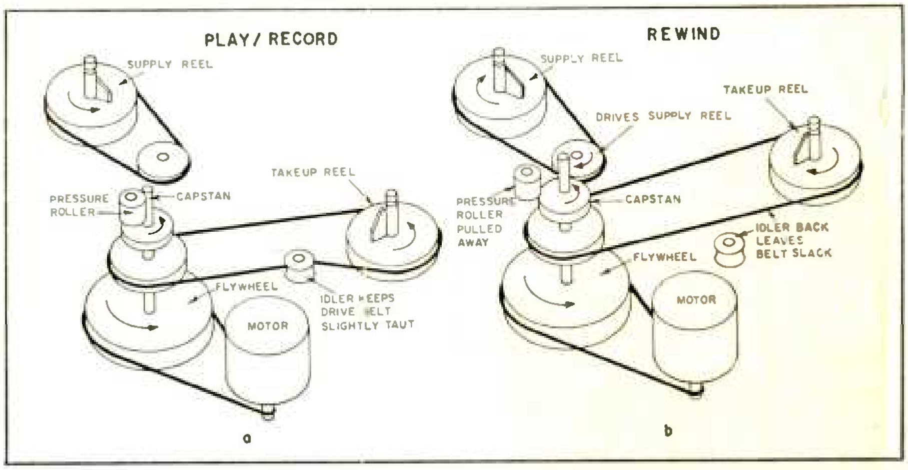


Fig. 1—In a simple belt-drive tape recorder the basic mechanism is not so complicated.

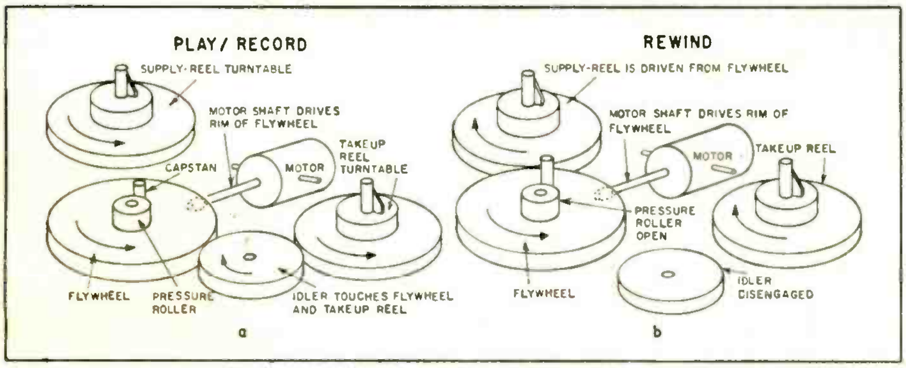


Fig. 2—Simple mechanics transforms rim-drive unit from PLAY/RECORD to REWIND.

A Mechanical Look at Tape Recorder Servicing

the PLAY or RECORD position the tape piles up at the heads, failing to accumulate properly on the takeup reel. Analyze Fig. 1. The takeup reel is obviously not receiving drive enough to wind the tape as it leaves the capstan. Dirt or grease on the takeup-reel drive belt might cause this. Or the idler may not be keeping the belt tight enough—check the control linkage that actuates the idler. Another check would be for excessive friction which may prevent the takeup reel from turning freely.

Failure to rewind properly suggests inspection of the supply reel and its drive belt, which might be broken, slipped off, oily, or too loose. Check the pulley that drives the suppy reel for freedom of motion. Make sure it is in good contact with the flywheel assembly.

Uneven tape speed when recording or playing back requires a check of the motor, the power source (batteries in some cases), the drive belt from the motor to the flywheel, and the capstan shaft and pressure roller. Dirt or oil on the drive belt or pressure roller, or too little pressure between roller and shaft, could cause the trouble. If a sleeve is used on the capstan, the sleeve may be loose or improperly installed.

By understanding how the mechanism operates normally, you will find it is easy to analyze where a difficulty might originate.

A rim drive

Another tape-recorder mechanism variation is the rim drive. Power is transferred through rim-to-rim contact of the various rotating parts.

Fig. 2-a illustrates the basic components of a rim-drive mechanism in the PLAY or RECORD position. The horizontal motor is free to pivot in a vertical plane. By spring action, the motor shaft contacts the underside of the flywheel, driving it at the rim. An idler wheel contacts the outer rim of the flywheel and also the rim of the takeup reel. The supply reel is free to turn since it is disengaged from the mechanism. The main drive for the tape is again provided by the "pinching" action of the pressure roller and capstan shaft. The takeup reel is in two parts: the upper, or turntable, is coupled to the lower, or drive, by a slip clutch. The takeup reel winds up the tape as it leaves the capstan. The slip clutch prevents the takeup reel from upsetting the established constant tape speed by preventing the reel from pulling too hard on the tape as it comes through the capstan shaft and pressure roller. Inertia of the flywheel and controlled motor speed insure constant-speed tape travel. The supply reel simply gives up the tape, rotated counterclockwise by the pull of the tape.

In the rewind position, the drive conditions change as shown in Fig. 2-b. The idler that furnished drive to the takeup reel is disengaged, and the pressure roller is separated from the capstan. The supply reel becomes the driving force, because it is pressed into rim-to-rim contact with the flywheel. The tape travels from right to left, accumulating at a fast rate on the supply reel.

The service approach for this mechanism is also based on understanding its normal operation, then determining where trouble could arise. Take special care to clean the driving-rim surfaces with alcohol. Make sure good contact is being made, and that rotating parts are free.

A reel-to-reel transport

A study of the seemingly more complex mechanism of Figs. 3-a and 3-b will show that basic operation and the servicing approach are similar to other mechanisms.

This recorder provides a FAST FORWARD in addition to the usual PLAY/RECORD and REWIND. The PLAY and RECORD positions are shown in Fig. 3-a. The pressure roller is against the capstan shaft. Pressure pads also hold the tape against the play/record head and the tape guide. The motor drives the flywheel (and capstan shaft) through a belt. Another drive belt runs from the motor to the takeup reel. Light drive pressure is applied to the takeup pulley by its clutch assembly. As the tape is propelled by the capstan shaft and pressure roller, the right-hand (takeup) turntable winds up the tape but does not exert excessive pull on the tape coming through the capstan shaft and pressure roller because of the slippage inherent in the takeup clutch.

Both the right and left turntables have brakes, but both brakes are disengaged in the PLAY and RECORD modes. By a special system actuated by the counterclockwise motion of the left-hand turntable, only the left (supply-reel) brake is applied when the mechanism is stopped, thus avoiding tape spillage due to coasting.

A PAUSE function, when actuated, simply moves the pressure roller slightly away from the capstan shaft and applies the left-hand brake. This stops the movement of tape. Takeup clutch slippage is continuous during the pause.

In the FAST FORWARD position (Fig. 3-b), the pressure roller is moved away from the capstan shaft, and the pressure pads are released. Strong pressure is applied to the takeup pulley clutch, and the takeup reel becomes the primary driv-

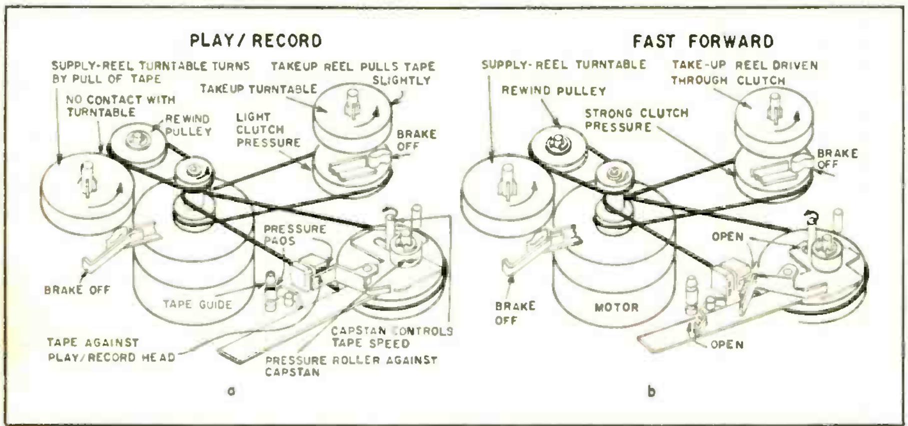


Fig. 3—Here the basic mechanics of a more complex recorder are diagramed to show the different functions. This recorder has a FAST FORWARD function which may not be found in simpler or less expensive tape transports, as it requires more parts.

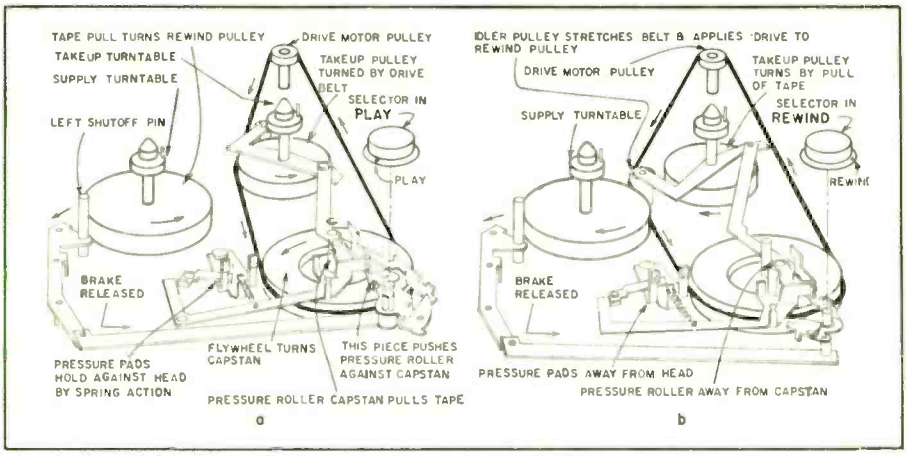


Fig. 4—The basic mechanical system for a popular cartridge-type tape player. A FAST FORWARD function (not shown) moves the pressure roller away from the capstan and the pressure pads away from the playback head. The drive belt can then move the takeup pulley much faster instead of acting as a slip clutch as in the PLAY position.

ing force for the tape, winding it up at high speed. The left-hand reel simply feeds out the tape as it is pulled by the takeup reel. When the mechanism is stopped, only the left brake is applied to prevent tape spillage.

Conditions in the REWIND position change very much as in other systems. A rewind pulley which is coupled to the motor by a small belt comes into contact with the rim of the left-hand supply turntable. This turntable becomes the primary driving force, rotating clockwise. The takeup-pulley slip clutch is released, and the pressure roller and pressure pads are pulled away. The tape travels rapidly from right to left, winding up on the left-hand reel. When the mechanism is stopped at the end of rewind, the brake system applies only the right-hand brake, and spillage is again prevented.

The servicing procedure, once normal operation is understood, is to associate failure with function. Then check to see why the mechanism does not perform. Give extra attention to clutch pressures, brake action and brake pressures, and the usual cleaning and lubrication aspects.

A tape-cartridge transport

This mechanism handles preloaded two-hub tape cartridges. The same basic elements of any transport are found in the tape-cartridge machine. The top deck of this type mechanism is dimensioned and shaped so that the tape cartridge drops into place, engaging the hubs of the cartridge with the turntables of the mechanism and aligning the tape so it fits between the capstan and pressure roller.

Fig. 4-a shows a partial view of a tape-cartridge mechanism in PLAY position. Driving force is transmitted from the motor to the flywheel (and capstan shaft) by a drive belt. The same belt rotates the takeup turntable. The tape is pulled across the play/record head in the usual way by the pressure roller and capstan. The takeup turntable winds the tape as it leaves the capstan. Here again, a clutch permits the tape to wind up without upsetting the tape speed established by the capstan. Pressure pads hold the tape against the play/record head. (NOTE: In this system, the tape heads face toward the turntables, so the oxide side of the tape faces outward in the tape cartridge.)

When the tape-cartridge mechanism is in the REWIND position (Fig. 4-b) the idler pulley pushes the drive belt away from the takeup pulley and against the rewind pulley. The flywheel and capstan still turn, but the pressure roller is away from the capstan, so the tape can travel freely from right to left. The rewind pulley turns in the direction shown in Fig. 4-b. Tape accumulates on the supply hub of the cartridge.

A FAST FORWARD is also provided by releasing the pinch action of the pressure roller and capstan shaft, releasing the brake, and tightening the clutch pressure of the takeup pulley. The right-hand turntable then becomes the driving force, winding the tape at high speed onto the takeup hub of the cartridge.

As in the other mechanisms described, the service procedure is to study normal operation, then consider the various causes of trouble which could prevent proper operation.

Through cleaning and proper lubrication are vital. Also check the condition of the drive belt, pressure roller, and driving surfaces. Binding within the tape cartridge itself should be considered as a possible trouble.

Again let me stress that the few minutes required to study a tape mechanism and learn how it operates is time well spent. After gaining some experience in mechanical servicing, you can find it as interesting and rewarding as electronics. END

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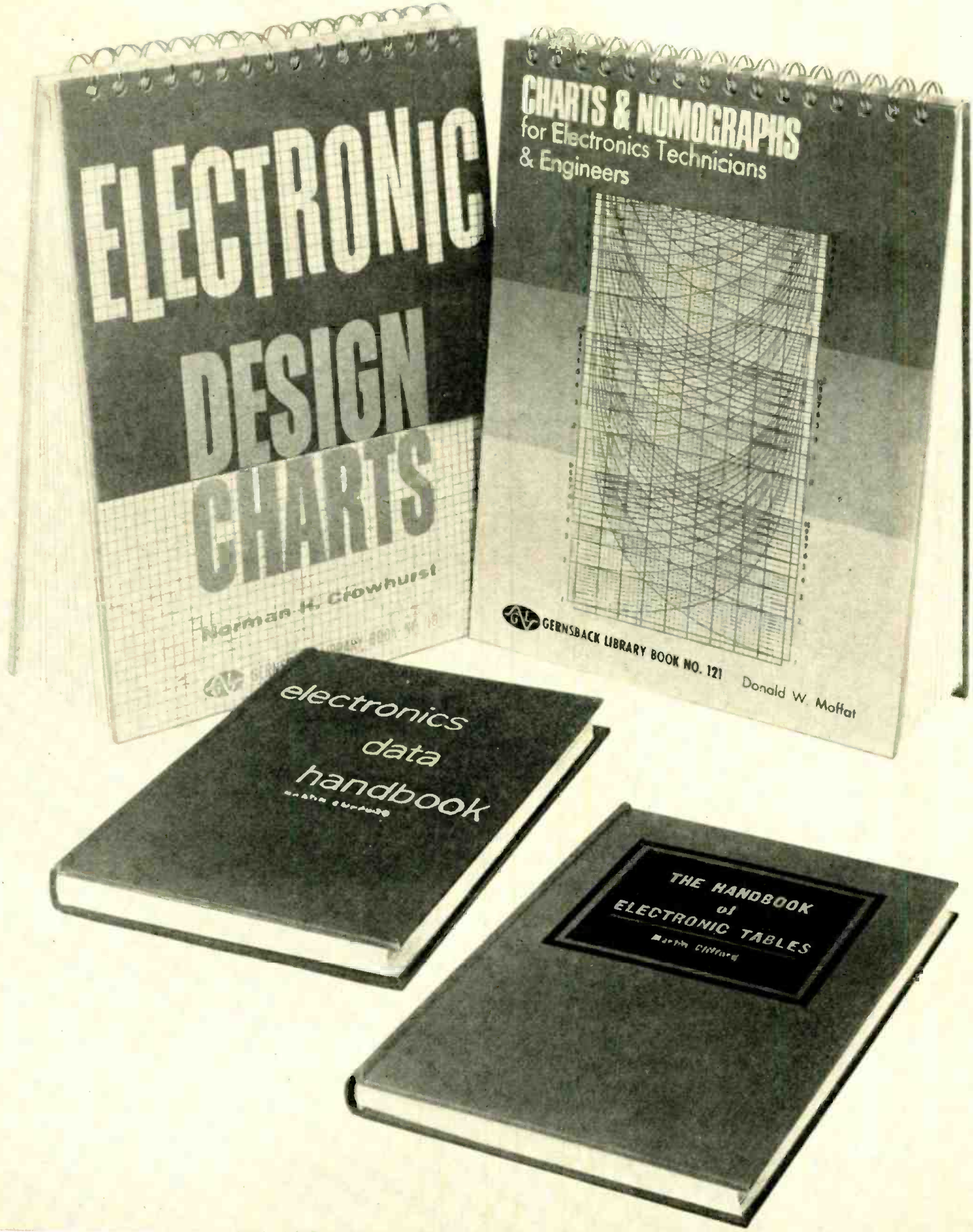

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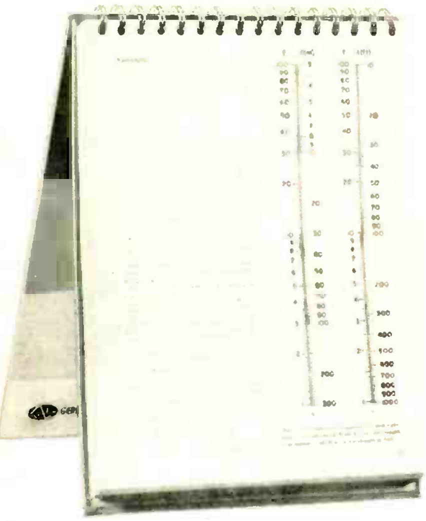

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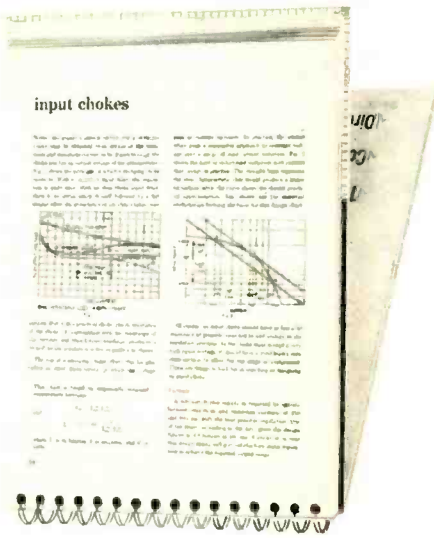

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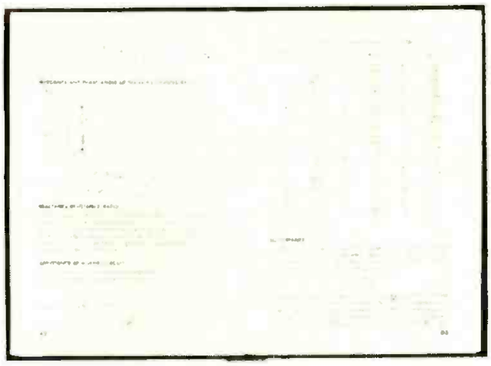

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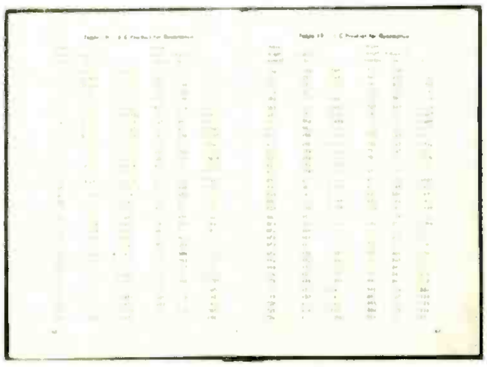

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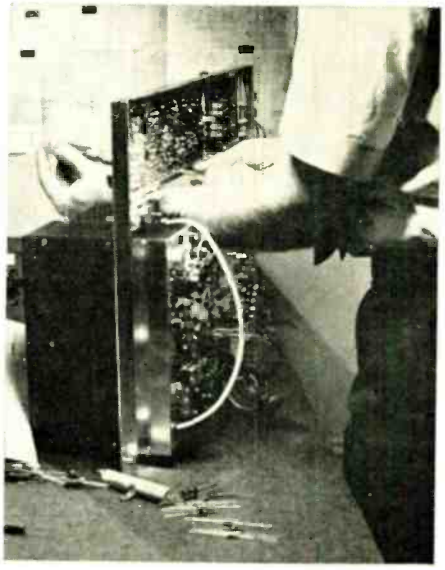
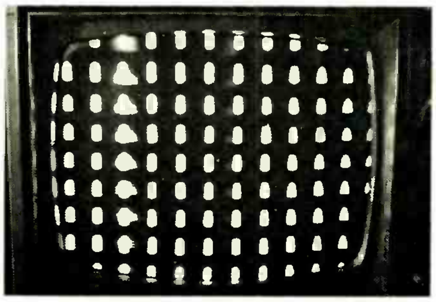
EQUIPMENT REPORT

Heathkit GR-180 Color TV Receiver

Circle 26 on reader's service card

YOU RAZOR OPEN THE BIG BOX MARKED *Heath Co.* and lift out some cardboard packing. The thick yellow booklet lying there looks like it might be the construction manual, so it's the first thing you pick up.





You sit down and thumb through the booklet. Lists of parts, pictorial sketches of printed boards, columns and columns of instructions, pages with colored pictures to show how your GR-180 color TV set should look when you get it built. Even hints and charts that show what to do if it doesn't work the first time you turn it on. You get the impression, too, that here's a lot of work.

Well, you're anxious to watch it, and sitting there admiring the manual won't get anything built. Out comes more packing, a bunch of smaller boxes, metal plates, a plastic facepanel.

This latest color TV creation from Heath is a 19-inch set (called 180 square inches now to please the FTC). Smaller and less expensive than the GR-53 series or the recent 25-inch (oops, 'scuse me—295-square-inch) model GRA-295, the new GR-180 is nevertheless filled with virtually the same circuits used in the larger models, including the automatic degaussing system of the 25-inch model.

You tape the big folded schematic to the wall, not because it will help you build the set but so you can study it while you rest between sessions of building. And it's worth getting acquainted with. Not that it's much different from the earlier models, but you don't recall much about them, either.

Let's see . . . X and Y demodulation, with separate red, green and blue amplifiers feeding the picture-tube grids. A video cathode follower precedes the high-gain pentode video (Y-channel) amplifier. Three high-gain i.f. stages, with the first two stacked—a well-designed i.f. strip with four traps to shape the response precisely. Sync and sound have their own separate detector diode (not the video detector) and are amplified together in one sound-i.f. stage before the sync is taken off for the 6HS8 sync circuit. Shunt HV regulator, with the usual 6BK4. Nothing very unusual, but really designed for performance.

You like to build kits, so the job is fascinatingly simple though time-consuming. It would seem monotonous at times, were you not so anxious to get it finished and see the result. You mount and solder all the small parts onto the printed boards. Bolt together the larger parts and subassemblies. Install the wiring harness.

The whole job of putting together

the chassis is simplified by an already-wired i.f. board and high-voltage cage. The chassis mounts vertically around the picture-tube neck and swings out on hinges from a cabinetlike metal "shield." Once all the hardware is in place, you set the chassis aside, open the other box and set about putting the picture tube and the plastic faceplate together. Then the deflection-yoke and convergence-yoke assemblies. Bolt the faceplate, CRT, chassis "shield" and chassis all together and now you're ready to turn the set on.

This is one of those rare times when you've done everything exactly by the instructions and the GR-180 works the first time you try it. Well . . . it shows three images, but the book says that's normal until you converge the beams.

Convergence turns out to be surprisingly simple. The instructions are easy to understand and are illustrated. Using the built-in dot generator (see pattern in photo), you get the first part done in short order—5 minutes for static convergence of the center dot. Next you do purity, then gray-scale adjustments.

Finally, what is usually the toughest part of all: dynamic convergence. This time it seems so simple. Everything just slides into place. You follow the book step by step, and suddenly the GR-180 is converged. You tune in a station and the black-and-white picture looks great.

Well, it's a color set, so you try a color program. Odd colors? You twist the phase coil just a little with the alignment stick furnished (the same one you used for convergence) and now the TINT control will get those flesh tones.

Gee, a kit without any problems? You wonder. Aha! . . . the picture looks funny. It seems grainy. Takes a while, but you finally notice the graininess can't be seen from a few feet away. Closer examination solves the riddle. The raster lines are forming an optical moire with the triad dot pattern of the small picture tube. Natural, you conclude.

Better let it cook out. For hours it runs, and runs, and runs. Colors are bright, black and white is pure.

You've run it now for a few weeks and played with it, learning all you can about how it operates—getting the "feel" of it. So far it is still in solid sonvergence and showing no signs of any kind of trouble. You like it, don't you?—*Jeff Tracy* END

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There's a few things about your electronic shark chaser I think you ought to know.

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1. Tear out the post card on the facing page. Clearly print or type your name and address.

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2. Circle the number on the card that corresponds to the number appearing at the bottom of the **New Products, New Literature** or **Equipment Report** in which you are interested.
   For literature on products **advertised** in this issue, circle the number on the card that corresponds to the number appearing at the bottom of the advertisement in which you are interested. Use the convenient index below to locate quickly a particular advertisement.

3. Mail the card to us (no postage required in U.S.A.)

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ARROW FASTENER CO., INC. (Pg. 86) Circle 112
ARTISAN ORGANS (Pg. 88) Circle 115

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1 Articles on service-business management
2 How-to-repair articles
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4 Articles on how-to-build
5 Short seasonal service-promotion ideas
6 How to sell as well as service

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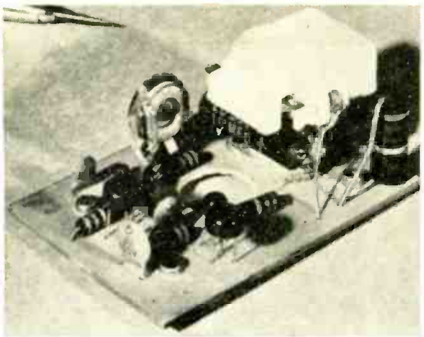
UNITED RADIO CO. (Pg. 101) Circle 143

WARREN ELECTRONIC COMPONENTS (Pg. 102) Circle 145

NEW PRODUCTS

More information on new products is available free from the manufacturers of items identified by a Reader's Service number. Turn to the Reader's Service Card facing page 78 and circle the numbers of the new products on which you would like further information. Detach and mail the postage-paid card.

CAPACITANCE SWITCHES, the *TSM-114B* and the *TSM-94B*. Dynaquad touch control switches operate either as contact or proximity switches, depending on sensitivity setting. Stray rf signals will not cause false firing. Stable operation over temperature range of −20° to +170°F. Basic mechanism is relaxation oscillator with matched pair of transistors. Control 100-W lamp load. Handle larger external loads with external switching pro-



vision. Operate on 105–125 Vac and 45–100 Hz. Both trigger on 1pF capacitance change. Sensitivity level of *TSM-114B* is adjustable from 6–25 pF. It operates as a momentary switch. The *TSM-94B* has a sensitivity level adjustable from 25–175 pF and operates as a momentary or a latching switch. Plug-in connections. 3 x 2 x 1½ in.—**Tung-Sol Div., Wagner Electric Corp.**

Circle 46 on reader's service card

SELF-CONTAINED BATTERY PACK, the *Port-A-Pak, model PAP-1*. Makes all *Courier* solid-state CB rigs completely portable. Rechargeable NiCad battery provides continuous operation in receive position up to 8 hr. Can be left on trickle-charge for ready-to-go operation. Rechargeable while in standby. Reliable at temperatures from −30° to +140° F. No damage from overcharge when used with the *Charge-A-Pak* battery charger, *model CAP-1*. When these two units are used together, CB rig can be used as a base station. Collapsible antenna, Texicon case, battery meter, charging connector, mounting hardware, microphone bracket and shoulder strap. *Port-A-Pak*, $59.95; *Charge-A-Pak*, $12.95.—**Courier Communications, Inc.**

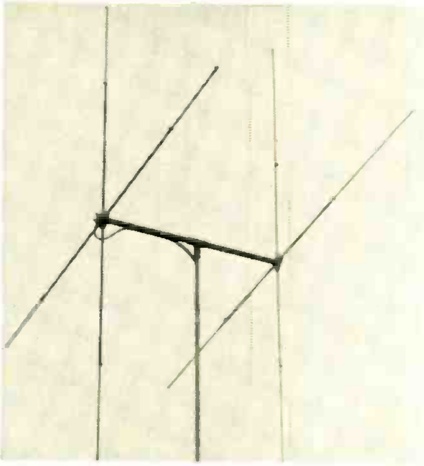
Circle 47 on reader's service card

TRANSISTOR TESTER AND SET ANALYZER, *model 1000*. Self-powered, portable. Checks all transistors for gain, leakage and oscillating ability, in or out of circuit. Determines transistor pnp or npn. Can be used as signal tracer. Checks battery voltage and current drain. Tests

diodes and rectifiers. Sockets mounted on face of instrument. Comes with *Interchangeability Guide*, which gives replacement information on approximately 5,000 semiconductors, and operation booklet. For limited time, also free transistor and pair of rubber-covered, color-coded needlepoint test prods. $34.95—**Semitronics Corp.**

Circle 48 on reader's service card

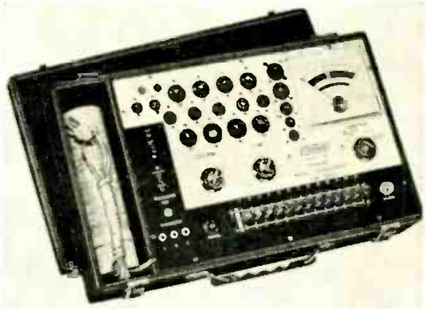
POLAR DIVERSITY LOOP ANTENNA, the *Avanti PDL, models PDL-27A* and *PDL-27B*, for the 27-MHz Citizens band. Provide for switching between horizontally and vertically polarized signals using a common loop radiator and special crossed-feed elements. Gives 23 dB isolation between polarities. Forward gain of 8.12 dB over an isotropic radiator and front-to-back ratio of 30 dB. All necessary parts, including boom, mount for attachment to vertical pipe, and switch box for use near operator's transceiver come with array. Aluminum and fiberglass arms, polypropylene hubs. 20 lb. Two-element array. $89.—**The Antenna Div., Avanti Research & Development, Inc.**



Circle 49 on reader's service card

23-CHANNEL SIDEBAND AND AM TRANSCEIVER, the *Imperial*. Receives on three modes in each of 23 CB channels, provides 69-signal reception capability. Transmits on 2 modes within each CB channel for 46-signal capability. Operator can conduct 2-way transmissions with receivers tuned to either upper or lower sideband. Receiver R/VFO control permits tuning to exact frequency of incoming signal. Double conversion is used with 23-channel synthesized circuit with 0.5 μV or less sensitivity. Transmitter is capable of 30-watt peak-to-peak modulation. "Pi-L" network built in for matching 30–75-ohm antenna loads. Illuminated channel-selector switch; 2-scale, 4-function S-meter. Final tune control. Adjustable squelch, volume control, and microphone plug. Operates on 120 Vac or 12 Vdc. Optional mounting bracket. $299.—**Regency Electronics, Inc.**

Circle 50 on reader's service card



MUTUAL-CONDUCTANCE TUBE TESTER, *Mercury model 2000*, for testing latest tube and transistor types. Tests new magnovals, 7-pin nuvistors, 10-pin decals, transistors, diodes and power rectifiers. Tests for dynamic mutual conductance, gas and grid emission (sensitivity over 100 megohms) and for shorts and leakage between any tube elements. Tests color and black-and-white picture tubes with use of optional multihead adapter. Leatherette case.—**Singer Products Co., Inc.**

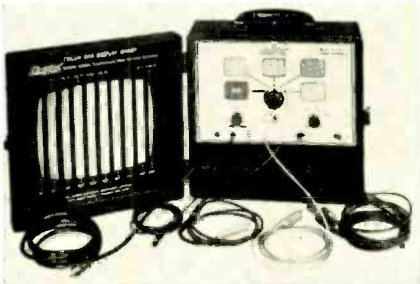
Circle 51 on reader's service card

50-W HI-FI STEREO AMPLIFIER, *Knight model KN-960*. All silicon transistors. Separate on–off switch. Power: 50-W IHF; 100-W peak; 17-W rms per channel at 8 ohms. ±1 dB, 20–20,000 Hz. Under 1% distortion. Outputs: 4 to 16 ohms, stereo headphones. 2 ac convenience out-

lets. 22 semiconductors. For 110–130 V 60-Hz. 3$^{3}/_{16}$ x 13 x 10 in. Price $99.95. Oiled walnut case, $14.95 if purchased separately; $1 if purchased with the amplifier.—Allied Radio Corp.

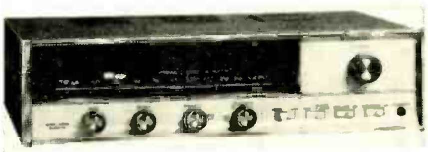
Circle 52 on reader's service card

SOLID-STATE COLOR BAR GENERATOR, *model GC660*. Gun-killer controls for fast purity checks. 4.5-MHz crystal-controlled sound carrier for setting fine tuning. Stability over temperature range from −5°F to +120°F. Color bars: gated 10-bar pattern covers all color alignment signals. Level variable from 0% to 200% for checking color sync, ACC, etc. Chroma



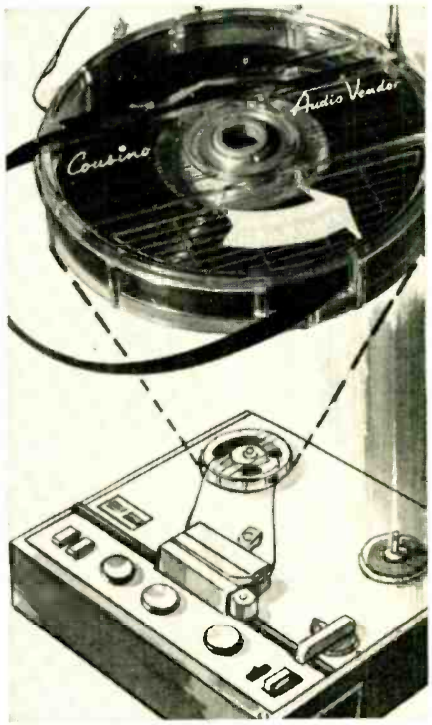
signal: crystal-controlled, provided at rf or video, controllable from 0% to 200% and referenced to zero. Crosshatch: available as crosshatch or 18 separate vertical or horizontal "thin-line" bars presented at 60-Hz rate. Dot pattern provides 324 dots of 0.1-μsec duration. Video output: provided at 2V p-p with choice of positive or negative polarity. Special separate −2V p-p sync output for sets requiring this feature. Rf output is tunable from front panel to channel 3, 4, or 5, mached to 300-ohm load. Operates from 105/125 V, 60 Hz, 3W. 10¾ x 10¾ x 5 in., 6¾ lb. Leatherette-covered portable case. $159.50.—Hickok Electrical Instrument Co.

Circle 53 on reader's service card



BOOKSHELF-SIZE ALL-SILICON RECEIVER, *model S-8600*. Amplifier powers 2 pairs of speakers. Front-panel rocker-action switches. Front-panel controls for tape monitoring, bass, treble, balance, loudness, tuning, FM/phono and mono–stereo. Stereo headphone jack. Power output: music power, 80 W at 4 ohms, 50 W at 8 ohms. Continuous power each channel: 30 W at 4 ohms, 20 W at 8 ohms for 1.0% distortion. FM (IHF) sensitivity: 1.8 μV for −30 dB noise and distortion below 100% mod. FM distortion: less than 0.25% IM at 100% mod. FM hum and noise level: 70 dB below 100% mod. Frequency response: FM mono, 20–20,000 Hz ±½ dB; FM stereo, 20–15,000 Hz ±½ dB; amplifier, 20–20,000 Hz ±½ dB at rated output. Outputs: 4 to 16 ohms, main and remote, left and right speakers, stereo headphone and record output. Power consumption: 115–125 V, 60 Hz, 30 to 120 W; fused. 35 silicon transistors, 4 silicon rectifiers, 9 silicon diodes, 1 Zener diode. 16½ x 12 x 4½ in., 26 lb (with case). Chassis $289.50, with walnut-grained leatherette case, $298.50.—Sherwood Electronic Laboratories, Inc.

Circle 54 on reader's service card

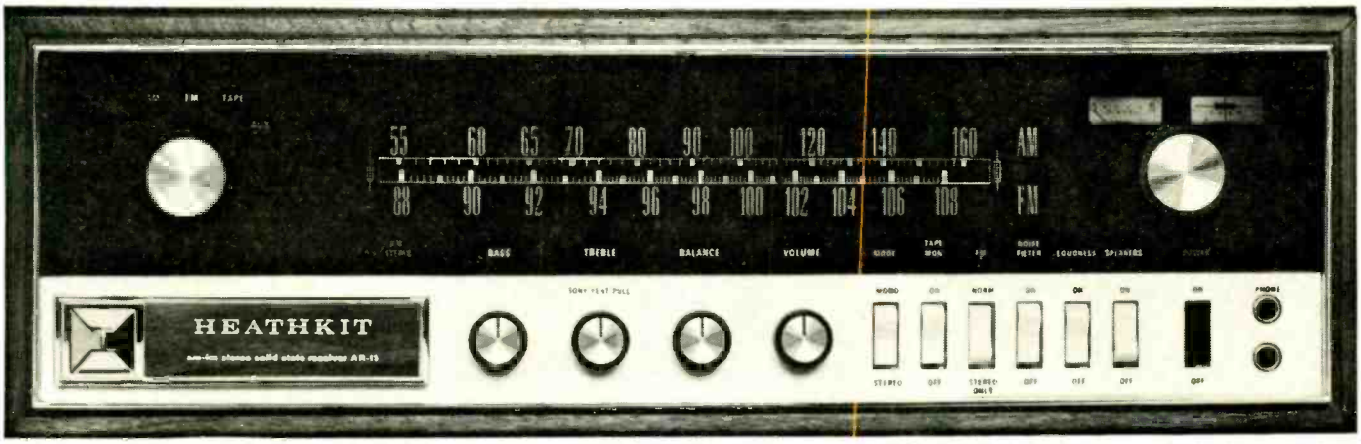


REPEATING MAGNETIC TAPE CARTRIDGE, the *Audio Vendor, model 1510*, for operation in small, battery-operated portable tape recorders. Works on standard "reel to reel" tape recorders which normally use 3- or 4-in. reels. Playing-time cycles (before repeating) of 6 or 10 min. at 1⅞-ips tape speeds. Fits over feed spindle of almost any recorder.—Orrtronics, Inc.

Circle 55 on reader's service card

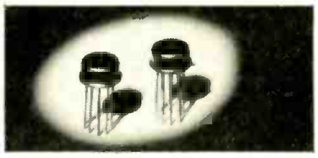
WIDE-ANGLE PAGING AND TALK-BACK SPEAKER, the *Cobra, model COP-8*. Sectoral defraction grating at 3 positions on the bell of the horn eliminates

World's Most Advanced Stereo Receiver...



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

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



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

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

AR-15 SPECIFICATIONS — AMPLIFIER SECTION: Dynamic Power Output Per Channel (Music Power Rating): 8 ohm load; 75 watts. **Continuous Power Output, Per Channel*:** 8 ohm load; 50 watts. **Power Bandwidth For Constant 0.5% Total Harmonic Distortion*:** 6 Hz to 25 kHz. **Frequency Response (1 watt level):** ±1 db, 6 to 50,000 Hz. ±3 db, 4 to 70,000 Hz. **Harmonic Distortion:** Less than 0.5% from 20 to 20,000 Hz at 50 watts output. Less than 0.2% at 1,000 Hz with 50 watts output. Less than 0.2% at 1,000 Hz with 1 watt output. **Intermodulation Distortion (60 Hz: 6,000 Hz—4:1)** Less than 0.5% with 50 watts output. Less than 0.2% with 1 watt output. **Damping Factor:** 45. **Input sensitivity:** PHONO; 2.2 millivolts (overload 155 mv). TAPE; 200 millivolts (overload 4.5v). AUX; 200 millivolts (overload 4.5v). **Hum & Noise:** Volume control at minimum position; —80 db. PHONO; (10 millivolt reference); —60 db. TAPE & AUX. (200 millivolt reference); —65 db. **Channel Separation:** PHONO; 45 db. TAPE & AUX.; 55 db. **Output impedance (each channel):** 4, 8 & 16 ohms. **Tape Output Impedance:** 100 ohms. **Input Impedance:** PHONO; 51 K ohm (**RIAA equalized). AUX., TAPE & TAPE MON.; 100 K ohm. **Tape Output:** 0.17 volt. **FM SECTION (Mono): Sensitivity:** 1.8 uv*. **Frequency Response:** ±1 db, 20 to 15,000 Hz. **Volume Sensitivity:** Below measurable level. **Selectivity:** 70 db*. **Image Rejection:** 90 db. **IF Rejection:** 90 db minimum*. **Capture Ratio:** 1.5 db*. **AM Suppression:** 50 db*. **Harmonic Distortion:** 0.5% or less*. **Intermodulation Distortion:** 0.5% or less*. **Hum & Noise:** 65 db*. **Spurious Rejection:** 100 db*. **FM SECTION (Stereophonic): Channel Separation:** 40 db or greater. **Frequency Response:** ±1 db, 20 to 15,000 Hz. **Harmonic Distortion:** Less than 1% at 1,000 Hz with 100% modulation. **19 & 38 kHz Suppression:** 55 db or greater. **SCA Suppression:** 50 db. **AM SECTION: Sensitivity:** 12 microvolts at 1,000 kHz. **Image Rejection:** 60 db at 600 kHz. 40 db at 1400 kHz. **IF Rejection:** 70 db at 1,000 kHz. **Harmonic Distortion:** Less than 1.5% at 400 Hz, 90% modulation. **Hum & Noise:** 45 db. **Power Requirements:** 105-125 or 210-250 volt 50/60 Hz AC. **Dimensions:** Overall, 16⅞" wide x 4¾" high x 14½" deep.

*Rated IHF (Institute of High Fidelity) Standards.

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

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

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

Positive Circuit Protection . . . four Zener diodes and two thermal circuit breakers protect the driver and output transistors from overloads and short circuits of any duration.

Field Effect Transistor FM Tuner . . . cascode 2-stage FET RF amplifiers and an FET mixer provide high overload capability, excellent cross modulation and image rejection. Sensitivity 1.8 uv. Features a 4-gang variable capacitor and 6 tuned circuits for extreme selectivity under the most adverse conditions. Completely shielded . . . completely assembled for best performance.

Two Calibrated Tuning Meters . . . a signal strength indicator tells you when you receive the strongest signal — doubles as a VOM for check-out *during* or after kit construction. A special "Center-Tune" meter puts you on exact station frequency.

Tone-Flat Switch . . . bypasses tone control circuit for completely flat response.

Automatic FM Squelch . . . noise and AFC operated to hush between-station noise *before* you hear it.

Stereo Only Switch . . . silences all mono when you wish to listen to stereo broadcasts only. An added tuning convenience!

Super SCA Filter . . . removes SCA and noise frequencies above 57 kHz for clean, quiet listening.

Massive Power Supply . . . for low heat and superior regulation — electrostatic and magnetic shielding for lowest hum and noise.

Electronic Filter Circuit . . . provides power supply with exceptionally low ripple and excellent regulation.

Adjustable Phase Compensator for Station Differences . . . so you can be assured of the best stereo.

Wide Range Magnetic Phono Inputs . . . extra overload characteristics (98 db dynamic range). All inputs adjustable from front panel. Plus automatic switching to stereo, transformerless design, filtered outputs and a host of other deluxe features for the discriminating audiophile. An assembled wrap-around walnut cabinet with a vented top is available at $19.95. Liberal credit terms also available.

†**Kit AR-15** (less cabinet), 28 lbs. **$329.95**
AE-16, assembled walnut cabinet, 7 lbs. **$19.95**

FREE!

World's Largest Electronic Kit Catalog

Contains full descriptions and specifications of AR-15 and over 250 easy-to-build kits . . . stereo/hi-fi, color TV, electric guitars & amplifier, organs, AM-FM-shortwave radios, test, marine, CB and ham radio. Mail coupon or write Heath Company, Benton Harbor, Michigan 49022.

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Prices & specifications subject to change without notice. HF-202

Circle 30 on reader's service card

usual "falloff" of energy at extreme ends of polar pattern. New design gives extremely flat, wide-angle vertical dispersion. Mounts vertically or horizontally. Position easily changeable with *Lever-Lock* bracket. Bell made of Implex A with molded-in color impervious to weather conditions. Frequency response, 250–13,000 Hz; power rating, 30 W; dispersion angles, 120° x 60°; microphone sensitivity, −23 dBm.—**Oxford Transducer Co.**

Circle 56 on reader's service card

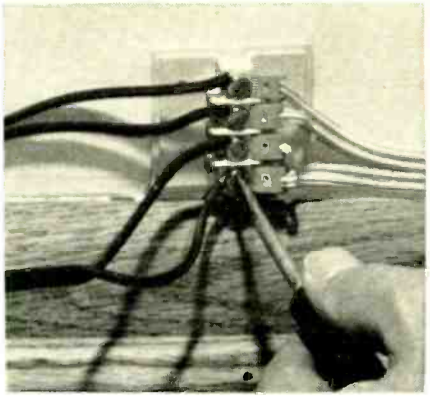
STEREO HEADPHONE CONTROL CENTER, *model PH-127.* Permits use of 2 sets of stereo headphones with separate volume control for each. 5-ft cable with 3-circuit plug connects to amplifier. Plug is removable for connection to amplifiers without a phone jack. 5¾ x 3⅜ x 3¼ in. $7.98.—**Olson Electronics, Inc.**

Circle 57 on reader's service card

SOLID-STATE CB SIGNAL GENERATOR, *model 5404.* For testing, servicing CB radio equipment. 24 crystal-controlled channels, 23 discrete CB frequencies, 1 spare. Modulation, from accurate internal 400-Hz oscillator, adjustable 0–100%. External modulation 0–100% with audio signals from 60 to beyond 5,000 Hz. —**Pace Communications Corp.**

Circle 58 on reader's service card

FLAT CABLE SYSTEM, *Scotchflex No. 500,* for music, sound and low-voltage control systems. Consists of No. 22 AWG stranded wire embedded in vinyl plastic strip to which layer of pressure-sensitive foam adhesive is applied. Mounts without nails or screws on nearly any smooth, clean surface. Accessories for terminating and



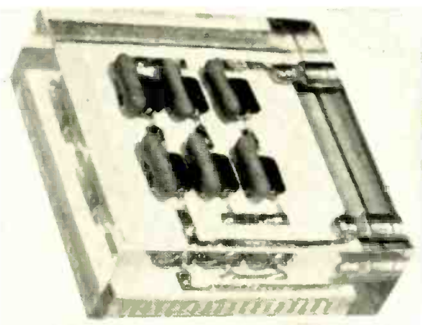
splicing include *No. 515* barrier strip terminal and *No. 516 U-Grip* terminal which presses into place, automatically strips away insulation and makes the connection. 2- or 3-conductor widths in 100-ft rolls. 2-conductor roll starts at $6.10.—3M Co.

Circle 59 on reader's service card

HEAVY-DUTY 10-IN. SPEAKER FOR GUITARS, ORGANS, *model MI-10PC.* Uses a 20-oz magnet and a 1½-in. voice coil. Each speaker handles up to 32

watts peak audio. Impedance 8 ohms. Rubberized cone edges, cotton-covered 66-strand voice coil. 3⅞ in. deep.—Utah Electronics

Circle 60 on reader's service card

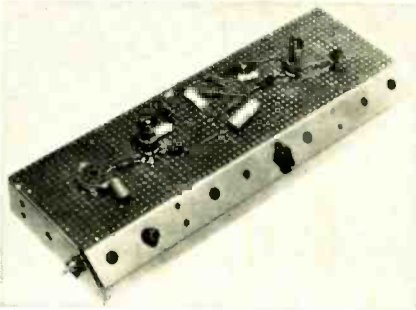


HIGH-CURRENT RECTIFIERS. *Hi-Pac* insulation process is incorporated into standard bridge rectifier assemblies from 30–1,200 PIV and from 4–20 amp dc output. Also high-voltage rectifiers from 1,600–80,000 PIV and 2–5 amp dc half-wave output. Allows size reduction on units which previously required open construction and finned assemblies. Example of typical packaging: single-phase full-wave bridge delivering 12 amps dc with 1,200 PIV per leg comes in package 2 x 2 x 1 in.; delivering 750 mA dc with 5,000 PIV per leg, in a 1-in. cube.—**Solitron Devices, Inc.**

Circle 61 on reader's service card

AUTOMATIC HEADLIGHT CONTROL UNIT, the *Twilite Sentry*. Turns auto headlights on at twilight, off at dawn. Controls lights during inclement daytime weather. Prevents driving with lights off at night. $19.95.—**Dynamic Development**

Circle 62 on reader's service card



BREADBOARDING KITS. 3/32 in.-thick phenolic deck mounts on aluminum base with slanting front. ¼-, ⅜- and ½-in. holes on all 4 sides to mount switches, potentiometers, etc. Solder-type feed-through terminals, terminal-insertion tool, universal deck-mounting Z brackets, switch and potentiometer brackets, L brackets, small pieces of phenolic punched board. Multi-compartment plastic box. Assembly nuts and bolts. Various sizes, from $6.60.—**Aladin Kits Co.**

Circle 63 on reader's service card

NEW PACKAGING FOR SOLDERING GUNS, *model 450K4* and *model 222K5* heavy- and medium-duty soldering-gun kits and *model 75* soldering "pistol." *Model 450K4* kit has single-post soldering gun, roll of rosin-core solder, 3 separate tips for light, medium and heavy work; plastic carrying case. *Model 222K5* kit contains single-post soldering gun with medium and light tips, 2 accessory

tips for cutting plastic and for sealing plastic bags, roll of rosin-core solder. Carrying case. *Model 450K4*, $15.95; *model 222K5*, $11.95, and *model 75C*, $4.95.—**Wen Products, Inc.**

Circle 64 on reader's service card

HANDS-FREE 2-WAY RADIO, the *Marco Shoulder Talk*. Antenna–speaker–microphone unit. Shoulder harness incorporates speaker; precision microphone is on gooseneck. Provision for variety of an-

tennas, permanent or removable. Model illustrated uses safety hard hat as antenna. One model permits 2-way communication when wearing a gas mask. Units are compatible with all existing 2-way radio receivers. 5 oz.—**American Teletronics Corp.**

END

Circle 65 on reader's service card

ELECTRONICS THROUGHOUT THE HOME

Consumer Electronics special issue next month will cover all aspects of home entertainment, hobby, and professional electronics. Big midyear report on entire industry. Don't miss

June RADIO-ELECTRONICS

NEW LITERATURE

All booklets, catalogs, charts, data sheets and other literature listed here are free for the asking with a Reader's Service number. Turn to the Reader's Service Card facing page 78 and circle the numbers of the items you want. Then detach and mail the card. No postage required!

GENERAL HAND-TOOL CATALOG. *No. 166.* 24 pages. Includes recent additions to line of professional screwdrivers, nutdrivers, pliers, snips, Seizers, adjustable wrenches and specialized automotive tools.—**Xcelite Inc.**

Circle 66 on reader's service card

CARBON FILM RESISTORS FOLDER, 4 pages, looseleaf-punched. Describes *Pyrofilm HR* series high-resistance and *PT* series commercial and MIL resistors. Includes load-life data. TC data, and detailed specifications. Applications and ordering information.—**Pyrofilm Resistor Co., Inc.**

Circle 67 on reader's service card

STYLUS FORCE REQUIREMENTS BROCHURE. *Stylus Force Requirements for Current Cartridges,* 4-page brochure. Based on laboratory tests. Includes hints on record care.—**Acoustic Research, Inc.**

Circle 68 on reader's service card

1967 CLOSED-CIRCUIT TV CATALOG, 20 pages. Includes TV camera kits (both tube and transistor), focus/deflection coils, monitors, lenses, vidicons, tripods and other items. Illustrations, descriptions, specifications, prices, order blank.—**ATV Research**

Circle 69 on reader's service card

BUSINESS RADIO BROCHURE, *No. D, Form 52A,* 6 pages, looseleaf-punched. Describes portable *models C-75G, C-75GK* and *625C*. Includes drawings, photos, system features, accessories, engineering specifications and prices.—**Amphenol Distributor Div.**

Circle 70 on reader's service card

1967 AUDIOTAPE CATALOG. 12 pages. Describes 5 *Audiotape* formulations for specific recording applications. List of bases, lengths and reel sizes. Reference chart shows recording times for various tape lengths and speeds. Type and code numbers included.—**Audio Devices Inc.**

Circle 71 on reader's service card

Write direct to the manufacturers for information on the items listed below:

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HEP PROJECT BOOK, *Field Effect Transistor Projects,* 93 pages. List of projects utilizing the field-effect transistor (FET). Oriented toward the hobbyist-experimenter. Available at HEP distributors or for $1.10 postpaid from **Motorola Semiconductor Products, Inc., HEP Program, P.O. Box 955, Phoenix, Ariz. 85008.**

END

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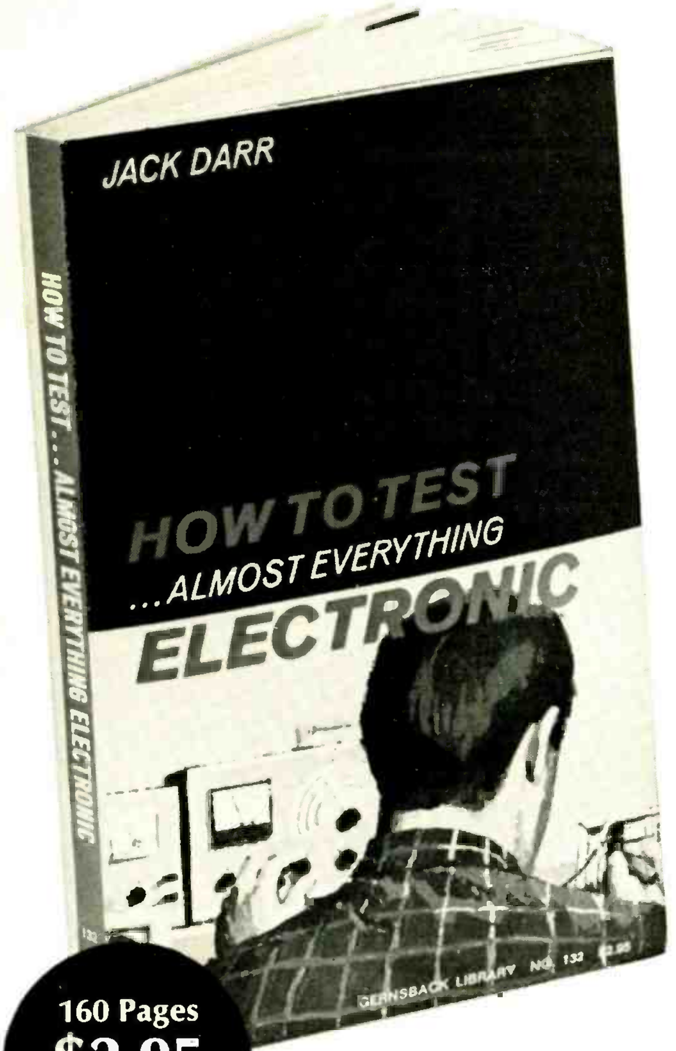

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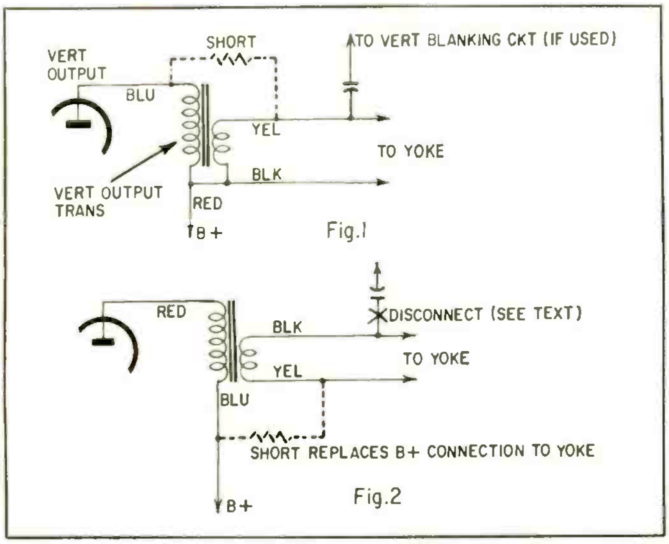
TECHNOTES

VERTICAL OUTPUT TRANSFORMER

A fairly common trouble in four-lead vertical output transformers (those having separate primary and secondary, not autotransformers) is a short from the plate end of the primary to the secondary. In sets using a circuit similar to Fig. 1 the shorted transformer can often still be used if the



primary leads are reversed to place the short at the B+ end of the primary. This will make the picture "upside down," but it can be righted by reversing the secondary leads, as shown in Fig. 2. (Color codes will vary on different transformers. Typical color codes are shown on the diagrams to better illustrate the manner of changing connections.) The connection between primary and secondary should be removed; the short between windings replaces it. If the set takes a vertical blanking pulse from the secondary, the blanking may not work properly, and may have to be disconnected until a new transformer is installed.

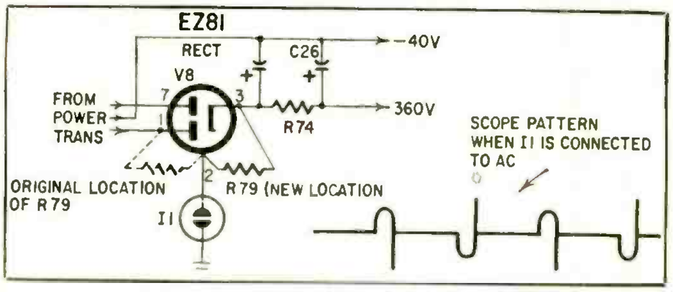
Although this is recommended only as a temporary repair until a new transformer can be obtained, my own set

"Smith has a lot to learn about public relations."

has operated with a shorted transformer. reconnected as in Fig. 2, for over a year. I have a new transformer, but have been waiting to see how long the shorted one would last.

—W. J. Stiles

EICO 435 OSCILLOSCOPE



The peculiar waveshape shown in the sketch was observed on a recently completed EICO 435 oscilloscope with no signal applied. It was very pronounced on the ×1 (50 mV/cm) scale and interfered with proper use of the scope. Shorting the vertical input circuit to ground. either before or after the attenuator switch. removed the pattern. When a 10× probe was used, however. the pips were present even with the probe tip shorted to ground.

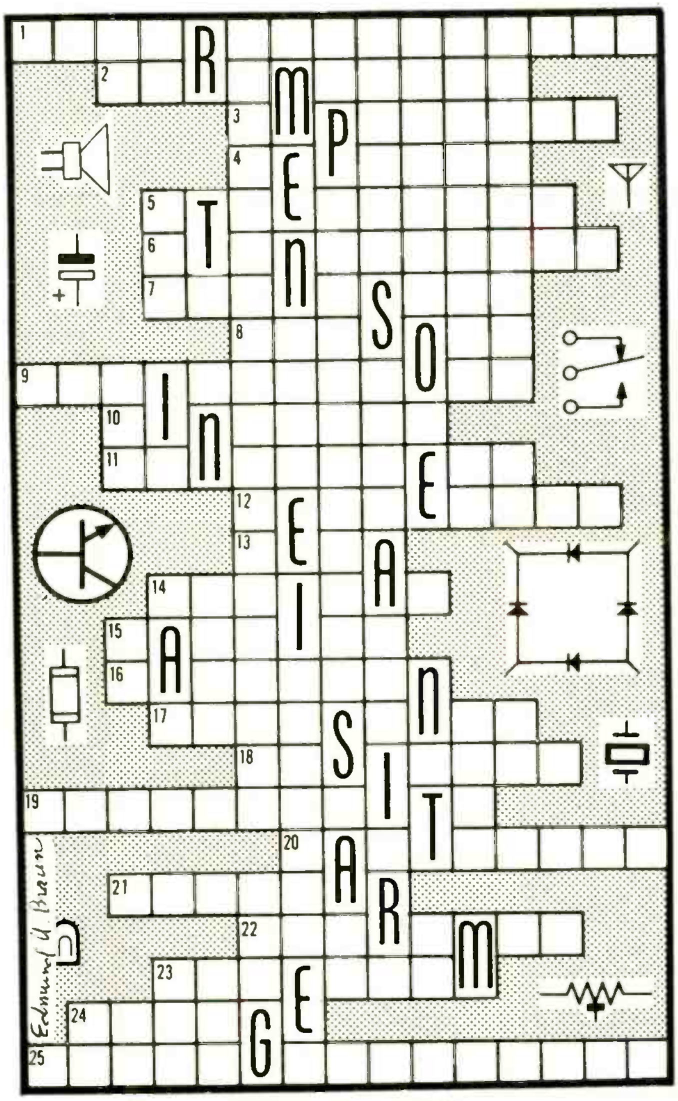
Checkout with a laboratory-type scope eliminated the heater and B+ lines and the square-wave generator as possible causes. The problem was finally traced to neon indicator I1, which apparently radiates large amounts of energy when it conducts on every half-cycle. The pips were eliminated by running the lamp on dc instead of ac.

To make the change. disconnect resistor R79 from pin 1 of tube socket XV8 and connect it to pin 3 instead. The neon lamp will now monitor the B+ voltage. There will be a slight delay before the lamp comes on, but the annoying pips will be gone forever.—*Donald R. Hicke* END

R-E PUZZLER

No vertical sweep is required to work this puzzle, only horizontal. Can you fill in all the blanks correctly? Note position of the tie-in letters.

1 Insufficient modification of carrier wave at transmitter.
2 Type of color picture tube using one electron gun.
3 Self-saturating type of magnetic amplifier.
4 Seven-electrode vacuum tube.
5 Device to reduce signal level.
6 To make uniform.
7 Compounds of this metal are sometimes used for cathodes.
8 Receiver cabinet that stands on flool.
9 Instrument that shows waveforms on CRT screen.
10 Semiconductor device for switching and storage circuits.
11 One-millimicro unit of electrical current.
12 The reciprocal of reluctance.
13 Current transfer ratio.
14 Spiral-shaped.
15 Plating metal components with this improves surface conductivity.
16 Alloy wire with qualities ideal for precision wirewound resistors.
17 A tone that slides smoothly from one pitch to another.
18 Charge remaining on capacitor after initial discharge.
19 Degree to which receiver responds to incoming signals.
20 Instrument for measuring active power in an electrical circuit.
21 Method of winding noninductive resistors.
22 An electronic musical instrument.
23 Pattern showing variations in amplitude with time.
24 Color of three bands when resistor value is 33 K.
25 Effect which causes wrong hue on face of color CRT.



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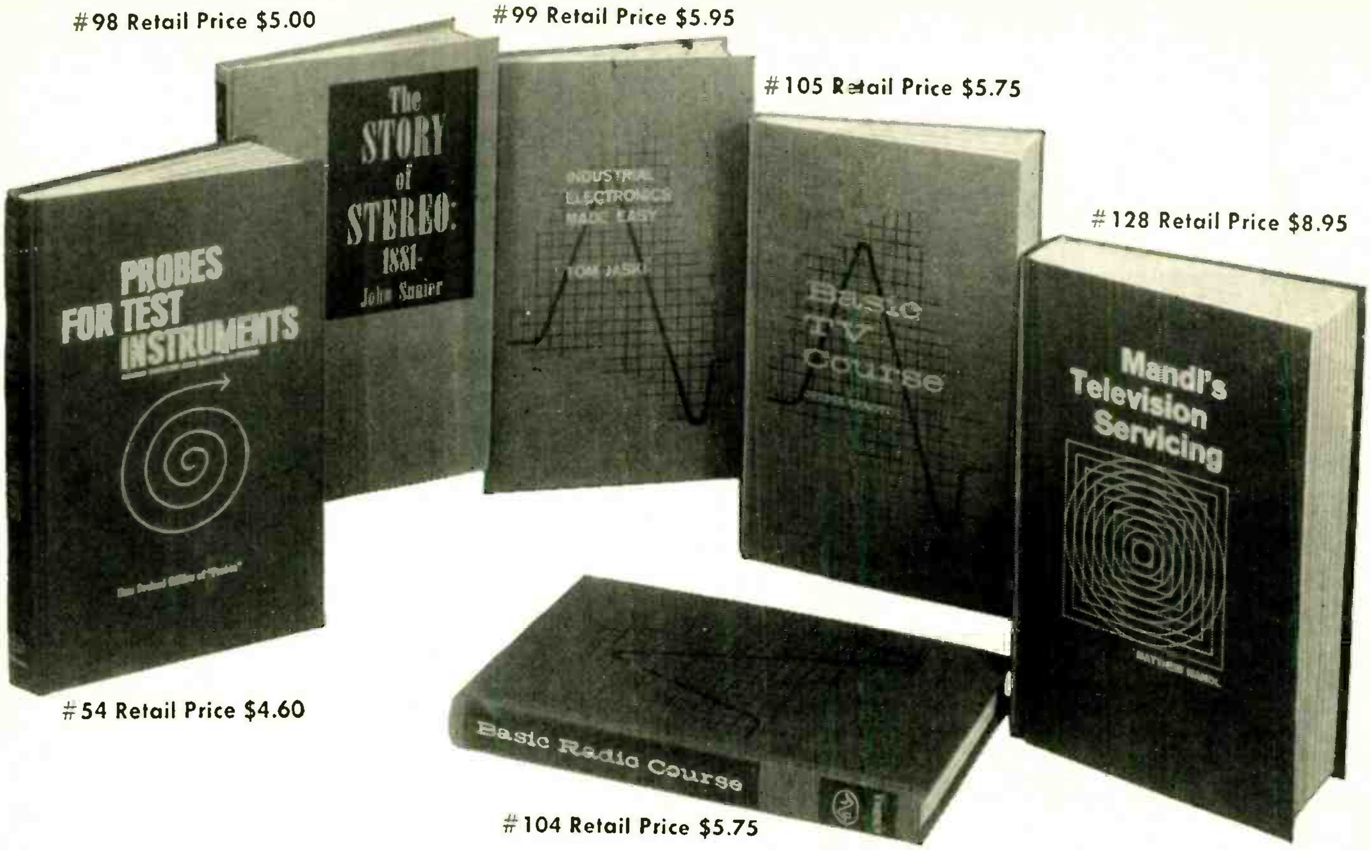

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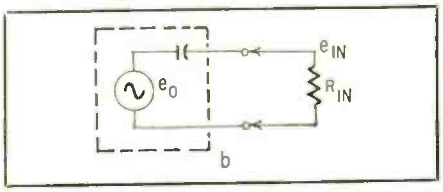
WHAT'S YOUR EQ?

These are the answers.
Puzzles are on page 46.

Crystal Mike Input

A crystal mike is a capacitive transducer at audio frequencies, and can be represented as shown below.

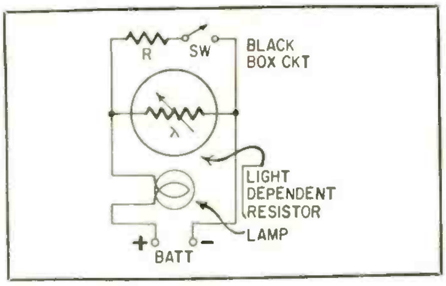
The voltage across the input resistance R_{in} of the amplifier is almost



equal to e_o at very high frequencies, when the reactance of the equivalent capacitor $\frac{1}{2}2\pi fC$ is negligible in comparison to R_{in}. But at a low frequency when $\frac{1}{2}\pi fC = R_{in}$, e_{in} falls to $\frac{e_o}{\sqrt{2}}$ (the 3-dB point). If R_{in} is high (say 100K) then the 3-dB point is a low frequency (say 30 Hz). But if R_{in} is low (say 1K) then the 3-dB point will be given by $\frac{1}{2}2\pi fC = 1K$ at $f = 3$ kHz. and so the low-frequency response is badly affected. Thus to get a good low-frequency response R_{in} should be as high as possible.

Another Black Box

The value of R equals the value of LDR when the latter is illuminated by the lamp. With the switch open, LDR



has a high resistance which prevents the lamp from lighting. When the switch is closed, the lamp lights through R. The illumination decreases the resistance of LDR, locking it "on." END

50 Years Ago

In Gernsback Publications
From May, 1917
Electrical Experimenter

War and the Radio Amateur, by Hugo Gernsback.
How the Audion Repeater Repeats
The Ionic Radio System and Theory of Ionic Tuning

BIG ISSUE ON EVERYDAY ELECTRONICS • Housewife Builds a Stereo Receiver • Midyear Report on Electronics • Organs, Speakers & Baffles, Cameras • Solid-State Appliances, Burglar Alarms • Home of the Future • All in June RADIO-ELECTRONICS

NEW SEMICONDUCTORS, MICROCIRCUITS & TUBES

SOLID-STATE THRESHOLD SWITCH

The *Ovonic Threshold Switch* (OTS) is a new development in solid-state switching. It is basically a symmetrical semiconductor that can be changed instantaneously from a high-impedance blocking state to a low-impedance conducting state simply by varying the voltage or current above or below a given threshold level. It responds to both negative and positive polarities.

The OTS is ideally suited for a wide variety of power-control applications where high switching speed is essential to circuit performance and long component life. It can also be used with a series resistor across an inductive load as a transient voltage and arc suppressor and as a staircase and square-wave generator (Fig. 1).

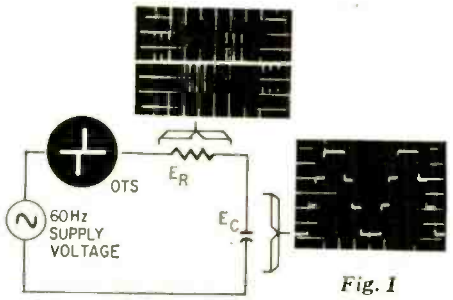


Fig. 1

Capacitor voltage E_C follows the input but varies in increments equal to the OTS threshold voltage. The number of steps depends on the ratio of input to threshold voltage. Resistor voltage E_R consists of pulse groups whose number and spacing are indicative of the magnitude and slope of the input voltage. Pulse polarity indicates the direction of the slope.

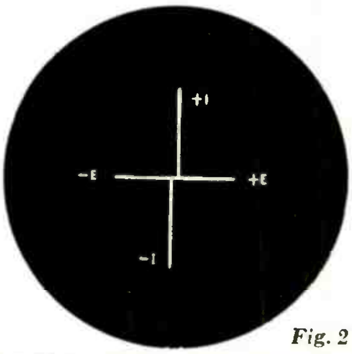


Fig. 2

The OTS symbol used by the manufacturer was developed from a plot of the E–I characteristics as seen in Fig. 2.

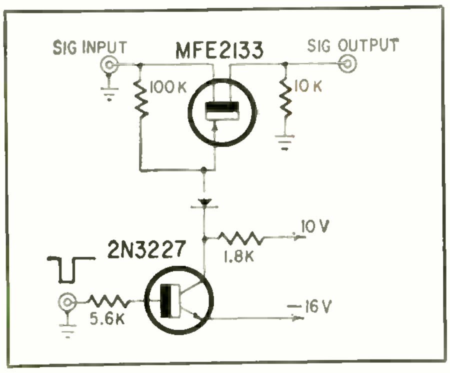
Electrical characteristics of the three OTS's in the line are:

	N-1-10	*N-1-20*	*N-1-30*
Threshold volts (V_T)	10	20	30
Conducting volts (V_C)	1.4	1.4	1.6
Breakback volts ($V_T - V_C$)	8.6	18.6	28.4
Maximum current, rms	25 mA	25 mA	25 mA
20-μsec pulse	1 amp	1 amp	1 amp
Threshold current (I_T)	30 μA	40 μA	80 μA
Holding current (I_H)	0.7 mA	0.8 mA	0.9 mA
Switching time	2 nsec	2 nsec	2 nsec

The OTS, made by Energy Conversion Devices, Troy, Mich., is encapsulated in a hermetically sealed glass case 0.31 in. long and 0.11 in. in diameter with 1-in. leads.

DTL MULTIVIBRATOR IC AND JFET CHOPPER

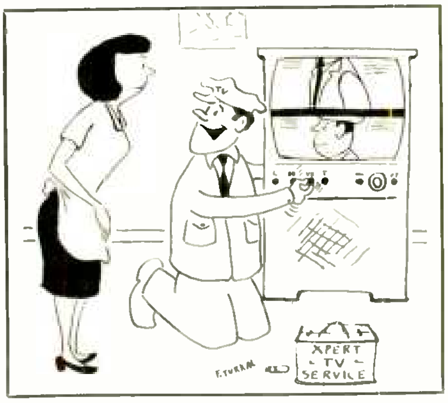
The MC851 DTL-type monostable multivibrator is an IC that develops complementary output pulses upon the dynamic zero transition of the input waveform. The output pulse width (de-



termined by an RC timing circuit) is independent of input pulse width. Internal timing components provide a nominal pulse width of 120 nsec. Pulse width can be increased by adding an external capacitor. Greater pulse stability can be obtained by using an external precision resistor in place of the internal charging resistor.

The Motorola MC851 (0 to +75°C) and MC951 (–55 to +125°C) are available in several cases. The "G" suffix indicates a 10-lead metal can. "F" and "P" indicate 14-lead ceramic and plastic cases, respectively.

The MFE2133 is a Motorola JFET featuring low drain–source resistance (60 ohms maximum when turned on) and transfer capacitance of only 5 pF. These two characteristics combine to make this transistor an ideal chopper for large gate-voltage swings and eliminate the need for a transformer. The diagram shows a chopper circuit. Maximum chopping frequency is 200 kHz, maximum input is ± 10 V. END



"Now you pick out the best picture, Ma'am, and I'll stop on that one"

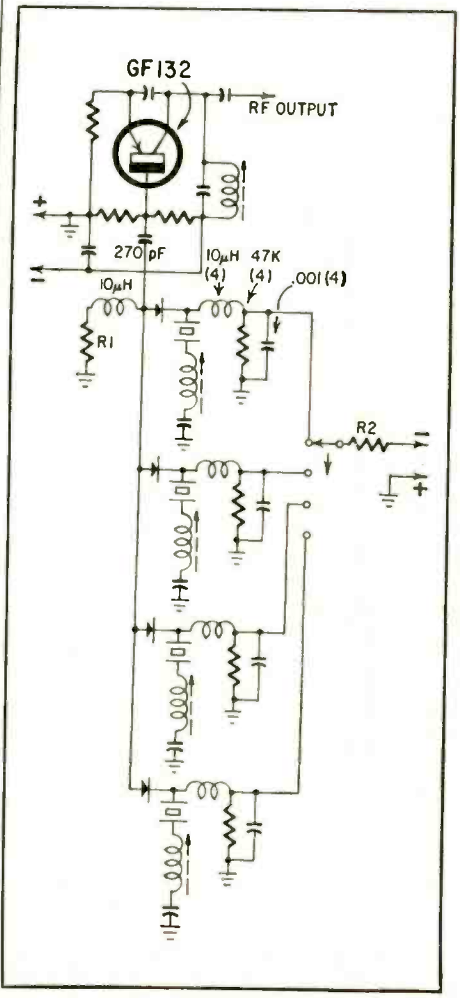
NOTEWORTHY CIRCUITS

CRYSTAL SWITCHING WITH DIODES

In a crystal-controlled oscillator the "hot" lead between the crystal and tube or transistor should be kept as short as possible for best circuit performance. This complicates the design of multichannel oscillators because lead length is often controlled by the type of channel-selector switch and its location on the chassis or panel.

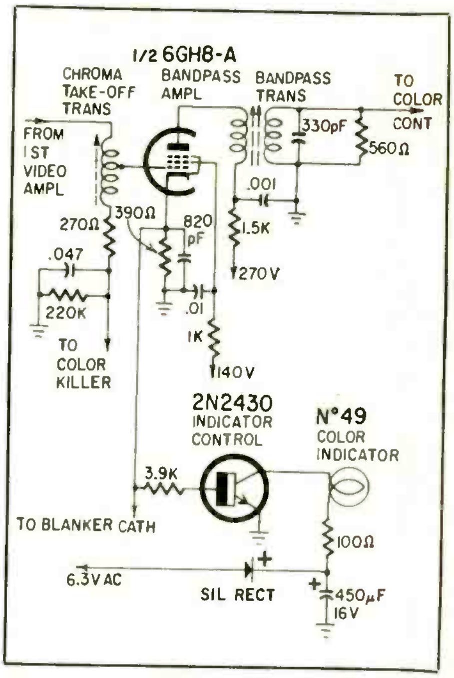
The diagram shows one method that minimizes the effects of switch and lead inductance. In this circuit, taken from *Radio und Fernsehen* (Berlin, Germany), the crystals are mounted close to the oscillator and connected to it by diode switches.

The diodes are connected through 10-μH rf chokes and RC filters to contacts on the selector switch. Crystals for the channels not being used are isolated by nonconducting diodes. The crystal for the desired channel is switched into the circuit by biasing its diode in the forward direction. This bias is a negative voltage applied to the cathode through the switch. Resistors R1 and R2 form the voltage divider that sets the bias level.



TV COLOR-INDICATOR CIRCUIT

A number of TV set manufacturers have introduced indicators to show when a color broadcast is tuned in. The diagram shows the circuit used in the Olympic CTC-18 chassis. It can be added to any set with a similar bandpass amplifier circuit.



When a color program is tuned in, the 3.58-MHz burst causes the bandpass and blanker cathode voltage to rise. This voltage biases the transistor to conduction to light the indicator. Collector supply voltage is developed by rectifying the 6.3-volt heater supply. END

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Solution to RE Puzzler for April 1967

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2	voltage	14	nonconductor
3	coaxial	15	electrothermal
4	quartz	16	baffle
5	ferrous	17	transformer
6	impedance	18	polarity
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8	galvanometer	20	calibration
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Your rating:

60–64 Umphf! 76–84 Wow!
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100 Zowie! That's perfect!

By Edmund A. Braun

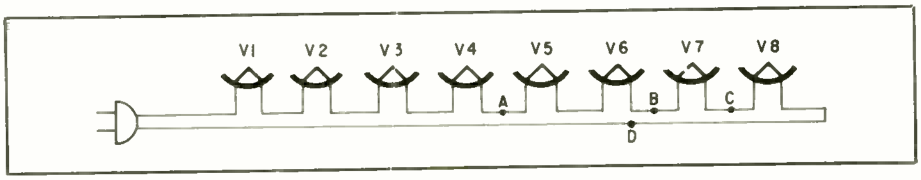
TRY THIS ONE

SPEEDING SERIES-STRING SERVICE

Locating a burned-out heater or filament in a series-string set can be time-consuming with a tube tester or an ohmmeter. Binary logic can locate the dead tube in just three quick measurements on an 8-filament string, and only four measurements for up to 16 filaments.

Plug in the line cord and turn the set on. This applies line voltage to the string, but since the string is not complete no current flows. Full line voltage will be present from the hot side of the line up to the point at which the string is broken. There will be no voltage from that point on.

Measure first at the midpoint of the string, point A in the sketch. (The other side of the meter is always at point D.) If there is line voltage, the string is complete from there back to the hot side and the break must be between point A and the cold side of the line. Make your second measurement halfway down this half of the string, point B. Line voltage here means that the break is in either V7 or V8. The third measurement, at point C, pinpoints it. With the break in V7, line voltage is absent. Were voltage present at point C, the break would be in V8.—*Jim Kyle* END



CONSUMER ELECTRONICS SHOW

Read about the first show of its kind—to be held in New York in June this year. What the companies plan to exhibit, reasons for the new Show, what you can learn there.

In June RADIO-ELECTRONICS

NEW BOOKS

THE SCIENTIFIC PAPERS OF JAMES CLERK MAXWELL, edited by W. D. Nivin. *Dover Publications, Inc., 180 Varick St., New York, N. Y. 10014. 5½ x 8½ in., 1,413 pp. Cloth, $12.50*

A republication of the work first published by Cambridge University Press in 1890. Originally two volumes, now bound as one. Contains 101 scientific papers by the 19th-century theoretical physicist. Very comprehensive and mathematical. Surprisingly easy to read, nevertheless. Covers an almost unbelievable range of physical phenomena. Electricity, magnetism, astronomy, optics, mathematics, color perception, gases, atomics, and scientific apparatus. A background in physics and mathematics will enable the reader to understand the full import of all the material in this book, but the ease of reading makes it downright interesting no matter what your education level.

SEMICONDUCTOR CIRCUITS: THEORY DESIGN AND EXPERIMENT, by J. R. Abrahams and G. J. Pridham. *Pergamon Press, Inc., 44-01 21 St., L. I. City, N. Y. 11101. 5 x 7¾ in., 320 pp. Paper, $4.95*

The first quarter of the book is devoted to the physics and construction of semiconductors. Following that, a large section is devoted to circuit design and applications. Finally, there is a small section on experiments with semiconductors. Indexed, generally mathematical in treatment, slow reading, but not forbidding. END

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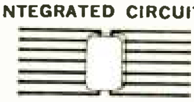

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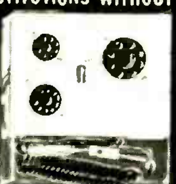

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New! FROM THE SPACE PROGRAM

ONE AMP 'GLASS AMP' SILICON RECTIFIERS

★ Outperforms Top Hats and Epoxies!
★ Handles 2 Amps Comfortably!
★ Encapsulated in Glass!
★ High Output, Temperature Reliability!
★ Only 3/16 x 1/8" Diameter!
★ Worth Many Times Our Sale Prices!

PIV	Sale	PIV	Sale	PIV	Sale
50	☐ 9c	400	☐ 19c	1000	☐ 51c
100	☐ 12c	600	☐ 27c		
200	☐ 15c	800	☐ 39c		

General Instrument ★ Handles 2 Amps ☐1 AMP 800 PIV 3 For $1
ONE AMP 'GLASS AMP' SILICON RECTIFIERS

New! 'PANCAKE' Transistors

☆ Silicon Epitaxial Planars

Like	Watts	VCB*	HFE	mc
☐ 2N706	.4	20	20	200
☐ 2N870	.5	60	120*	80
☐ 2N1613	.8	50	120*	80
☐ 2N1893	.8	100	120*	70
☐ 2N2049	.8	50	300*	85
☐ 2N2645	.5	50	300*	85
☐ 2N2314	.4	60	50	150
☐ 2N2434	1.5	80	185	100

*Maximums — 4 For $1 (NPN) TO46

New! SILICON CONTROLLED RECTIFIERS

PRV	3 AMP	7 AMP	16 AMP	25 AMP
50	☐ 30	☐ 48	☐ 70	☐ 80
100	☐ 50	☐ 70	☐ 1.05	☐ 1.20
200	☐ 80	☐ 1.05	☐ 1.30	☐ 1.70
300	☐ 1.05	☐ 1.60	☐ 1.90	☐ 2.20
400	☐ 1.60	☐ 2.10	☐ 2.30	☐ 2.70
500	☐ 2.10	☐ 2.80	☐ 3.00	☐ 3.30
600	☐ 2.50	☐ 3.00	☐ 3.30	☐ 3.90

"N" Channel Fet — Vacuum Tube Equivalent C-610 ☐ NOW ONLY $1.00

DC MICROAMMETERS

☐ 2¼" 0—100

ZENERS

☐ HALF WATT......29
☐ 1—WATT...... .45
☐ 10 WATTS...... .65

Volts	Volts	Volts	Volts
5.4	18	43	100
★ 6.4	20	47	110
★ 8.0	22	51	120
9.1	24	56	130
10	27	62	150
12	30	68	160
13	33	75	180
		82	200
		91	

★ ½W too!

SILICON POWER STUD RECTIFIERS

Factory Tested

AMPS	50 PIV	100 PIV	200 PIV
3	☐ 7¢	☐ 11¢	☐ 17¢
15	☐ 22¢	☐ 40¢	☐ 65¢
45	☐ 75¢	☐ 90¢	☐ 1.25

AMPS	400 PIV	600 PIV	800 PIV	1000 PIV
3	☐ 22¢	☐ 31¢	☐ 40¢	☐ 59¢
15	☐ 90¢	☐ 1.35	☐ 1.59	☐ 1.79
45	☐ 1.59	☐ 1.90	☐ 2.50	☐ 2.95

1-Amp SILICON RECTIFIERS

PIV	Sale	PIV	Sale	PIV	Sale
50	☐ 5¢	600	☐ 19¢	1400	☐ 69¢
100	☐ 7¢	800	☐ 25¢	1600	☐ 89¢
200	☐ 9¢	1000	☐ 45¢	1800	☐ 99¢
400	☐ 11¢	1200	☐ 59¢		

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FO-2410 ▲

FM-5000 FREQUENCY METER

25 MC to 470 MC

The FM-5000 is a beat frequency measuring device incorporating a transistor counter circuit, low RF output for receiver checking, transmitter keying circuit, audio oscillator, self contained batteries, plug-in oscillators with heating circuits covering frequencies from 100 kc to 60 mc. Stability: ±.00025% +85° to +95°F, ±.0005% +50° to +100°F, ±.001% +32° to +120°F. A separate oscillator (FO-2410) housing 24 crystals and a heater circuit is available. Shipping weight: 18 lbs.

FM-5000 with batteries, accessories, less oscillators and crystals.
Cat. No. 620-103 .... $375.00

Plug-in oscillators with crystals $20.00 to $50.00

C-12M FREQUENCY METER

For Marine Band Servicing

The C-12M is a portable secondary standard for servicing radio transmitters and receivers in the 2 mc to 15 mc range. The meter has sockets for 24 crystals. Frequency stability is ±.0025% 32° to 125°F, ±.0015% 50° to 100°F. The C-12M has a built-in transistorized frequency counter circuit, AM percentage modulation checker and modulation carrier and relative percentage field strength. Shipping wt. 9 lbs.

C-12M with PK (pick-off) box and connecting cable, batteries, but less crystals.
Cat. No. 620-104 .... $235.00

Crystals for C-12M (specify frequency) $7.00 to $10.00

Model 7212

FREQUENCY METER

The International Model 7212 portable secondary frequency standard is a self contained unit designed for servicing radio transmitters and receivers used in the 400 kc to 500 kc range (can be modified for other frequencies on special order). Frequency accuracy is ±.01% from 32°F to 104°F (0°C to 40°C). The meter holds eight crystals. Features include the transistorized frequency oscillator and built-in battery charger. Shipping weight: 18 lbs.

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CRYSTAL CONTROLLED

C-12 ALIGNMENT OSCILLATOR

The International C-12 alignment oscillator provides a standard for alignment of IF and RF circuits 200 kc to 60 mc. It makes the 12 most used frequencies instantly available through 12 crystal positions 200 kc to 15,000 kc. Special oscillators are available for use at the higher frequencies to 60 mc. Maximum output .6 volt. Power requirements: 115 vac. Shipping wt. 9 lbs.

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Circle 148 on reader's service card

Model 1110 SECONDARY

FREQUENCY STANDARD

The Model 1110 is an economy portable secondary standard for field or bench use with self contained battery. Using any general coverage communications receiver the unit provides the necessary standard signal for measuring frequencies. Easily calibrated against WWV to provide an accuracy of 1 x 10⁶. Long term stability of ±10 cycles over range 40°F to 100°F. All transistor circuits provide outputs at 1 mc, 100 kc and 10 kc. Zero adjustment for oscillator on front panel. SHIPPING WEIGHT — 12 lbs.

Model 1110 complete.
Cat. No. 620-106 .... $125.00

C-12B FREQUENCY METER

For Citizens Band Servicing

This extremely portable secondary frequency standard is a self contained unit for servicing radio transmitters and receivers used in the 27 mc Citizens Band. The meter is capable of holding 24 crystals and comes with 23 crystals installed. The 23 crystals cover Channel 1 through 23. The frequency stability of the C-12B is ±.0025% 32° to 125°F, .0015% 50° to 100°F. Other features include a transistorized frequency counter circuit, AM percentage modulation checker and power output meter. Shipping weight: 9 lbs.

C-12B with PK (pick-off) box, dummy load, connecting cable, crystals, batteries.
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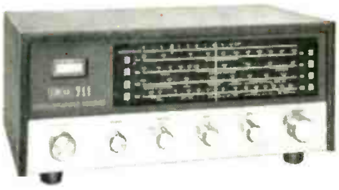

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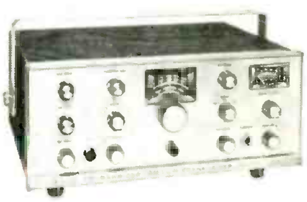

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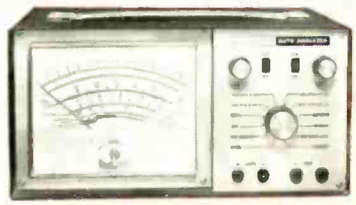

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Now you can tune-up, trouble-shoot and test your own car or boat.

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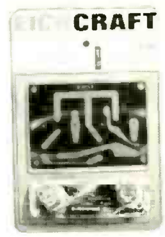

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