60c ■ FEB. 1972

Radio-Electronics

FOR MEN WITH IDEAS IN ELECTRONICS

TRANSISTOR TESTING IS A CINCH

Exciting New World Of The Liquid Crystal

Experiment with a Binary Counting Demonstrator

Build Don Lancaster's Dual-Clock Generator

All About Electrolytics

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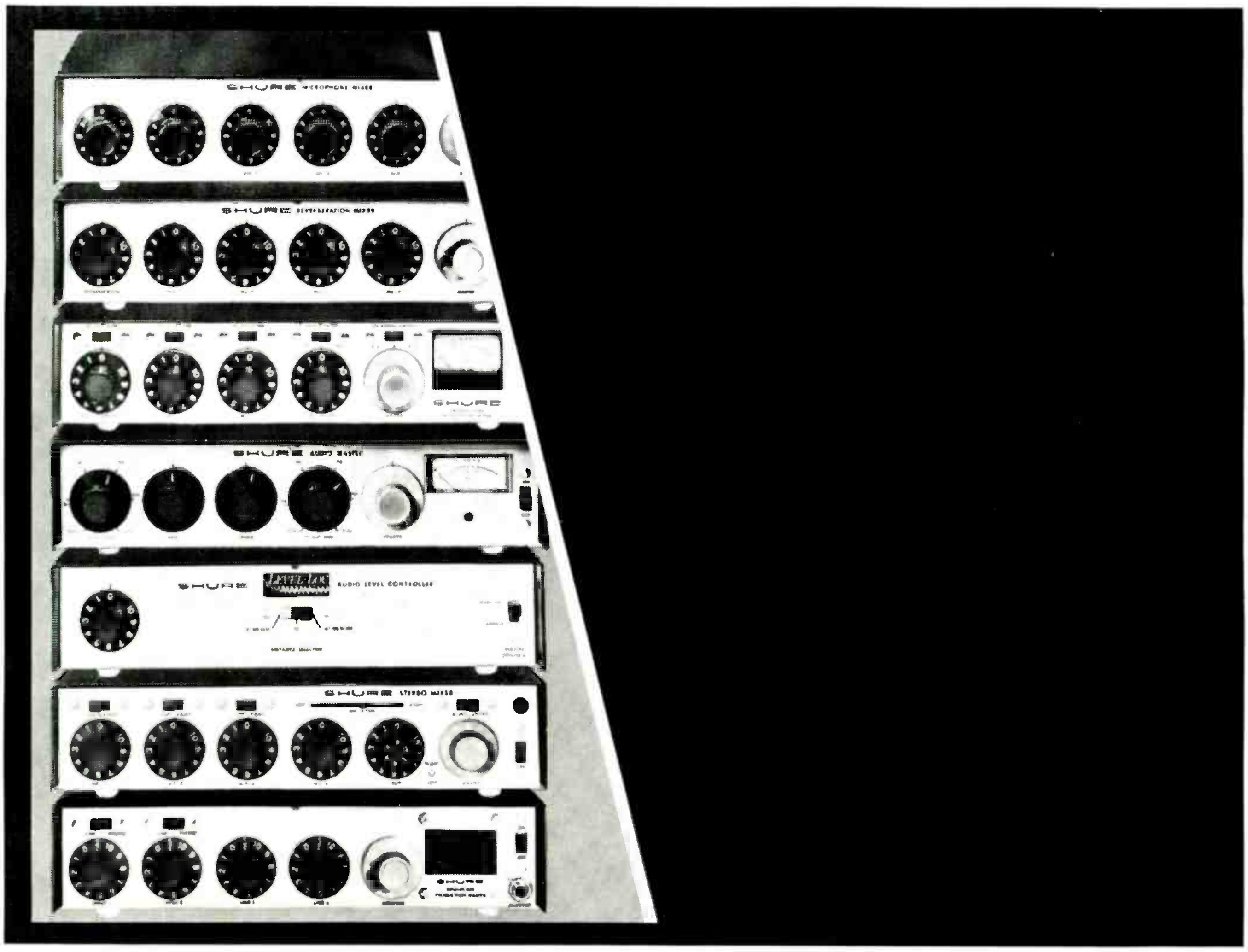


Universal tap simplifies MATV design

by Bert Wolf
Manager Jerrold DSD/ECSD Division

Until now, MATV system design has been somewhat complex. You had to calculate losses in decibels and specify a fixed tap-off isolation value at each receiver location.

The new Jerrold OMNI-TAPs have changed all this. OMNI-TAPs are universal. That is, *any* OMNI-TAP can be used *anywhere* in *any* MATV system. The secret is adjustable isolation, which you can vary simply by turning a screwdriver after the system has been installed.

Aside from simplifying system design, OMNI-TAPs also reduce your inventory problems. Since OMNI-TAPs can be varied continuously over a 12 to 25 dB range, one type of OMNI-TAP replaces three types of conventional tap-offs.

Figure 1, for example, shows a typical 8 story apartment house, older school or hotel, with eight TV outlets per floor. OMNI-TAPs are used for every TV outlet. Because tap insertion loss is very low (average about 0.6 dB per tap at VHF), isolation is adjustable, and Jerrold CAC-6 cable loss is minimal, (3.2 dB/100' at VHF), your system calculations are greatly simplified. Just use a Jerrold Gibralter 3550 amplifier, fed by a Paralog Plus antenna. A new motel or school would be similar, except that trunklines would be run horizontally.

If your particular system is smaller, reduce the number of trunklines and tapoffs, but nothing else. The 3550 is economical enough even for small systems. If the system is bigger, add trunklines and tap-offs, but nothing else. The 3550 can easily handle up to 100 OMNI-TAPs. (For systems over 100 tap-offs, use the 3661 or 3880.)

Choose the antenna as you would an ordinary home TV antenna, except that it usually pays to choose the next larger model. If signals are weak, simply add a Powermate preamplifier.

Figure 1 is a VHF-only system. But adding UHF channels is no problem. Simply use a VU-FINDER PLUS antenna instead of the PARALOG PLUS, and a 4400 82 channel amplifier in place of the 3550. No other changes are required because the OMNI-TAPs, the splitters and the cable can handle UHF frequencies with no difficulty.

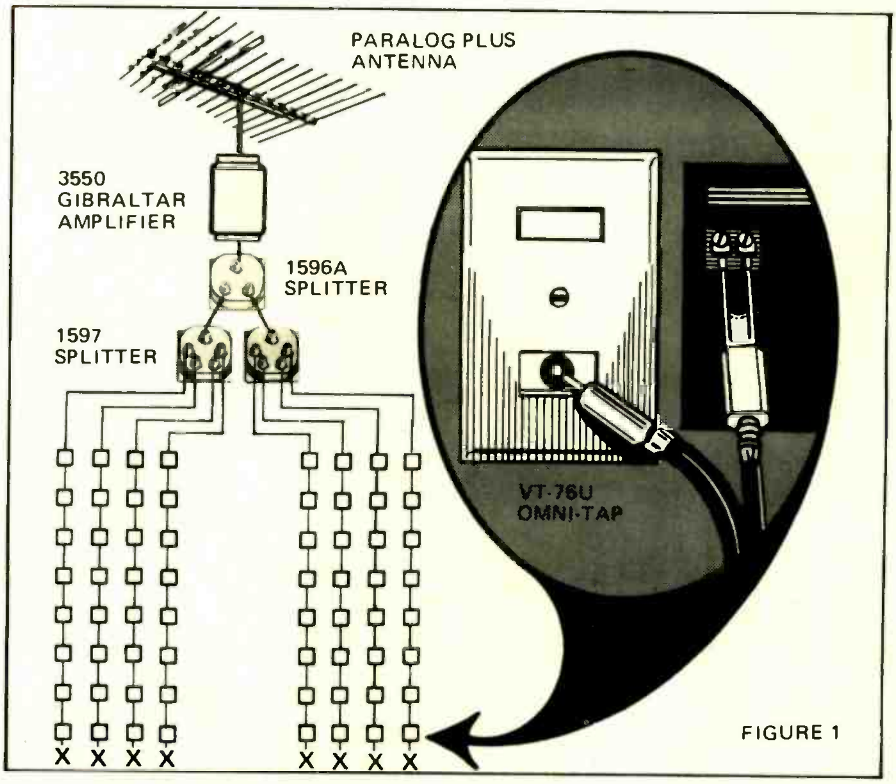


FIGURE 1

Adjusting Omni-Tap Isolation

Once the system is installed, you have to make sure it works properly. In many cases, no adjustments will be necessary. The OMNI-TAPs will work fine in the system just as you receive them.

In large systems, however, you will have to adjust the OMNI-TAPs so that they provide more isolation near the Head End amplifier than they do at the ends of the trunklines.

There are two ways to adjust OMNI-TAP isolation:

1. With a Field Strength Meter, such as the Jerrold 747. You should have a Field Strength Meter for MATV work anyhow, and this is the easiest way to adjust OMNI-TAP isolation.

Start by turning all of the OMNI-TAPs fully clockwise, for maximum attenuation. Then, go to a tap in the middle of the trunkline and make sure you can read at least 1000 microvolts of picture carrier signal on the highest channel the system carries. If the reading is less than 1000 microvolts, turn the OMNI-TAP counterclockwise until you get 1000 microvolts. Repeat for each tap until you get to the end of the line.

2. With an Ohmmeter. Connect the Ohmmeter between the arm of the OMNI-TAP potentiometer and the center conductor of the tap output. Set the first four OMNI-TAPs in each trunkline (nearest the Head End) to 700 ohms. Set the next two OMNI-TAPs in each trunkline to 500 ohms. Then, reduce each tap-off in the line by 100 ohms until you get to the end of the line.

For help in laying out a system or solving specific system problems, contact Jerrold via your local Jerrold distributor.

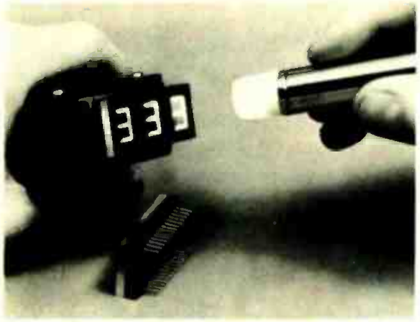
Or, for more information on MATV systems, write Jerrold Electronics, P.O. Box A, Philadelphia, Pa.

Circle 3 on reader service card

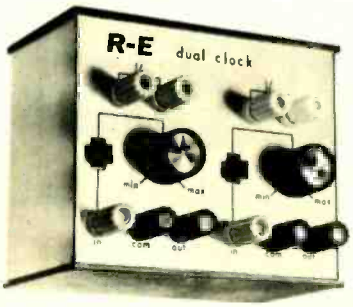
Radio-Electronics

FOR MEN WITH IDEAS IN ELECTRONICS

February 1972



TYPICAL DISPLAY is made from liquid crystals. This is a commercially available unit. For entire liquid crystal story. . . . **see page 33**



DUAL CLOCK GENERATOR provides test signals for many different useful applications. . . . **see page 55**

Radio-Electronics is indexed in *Applied Science & Technology Index and Readers Guide to Periodical Literature.*

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looking ahead

Super-8 TV

You're going to be able to play your home movies through your color set if two of the world's leading film and camera manufacturers have their way. In addition, they anticipate that a wide variety of educational and entertainment film eventually will be released for a la carte TV viewing. Eastman Kodak has been demonstrating a film videoplayer which it says could be on the market in about two years as an attachment to television sets. Japan's Fuji Photo Film is in pilot production of its own version which it plans to export to the United States late this year. Both units run silently, using continuous-pulldown systems, eliminating intermittent motion and shutter noise common to film projectors. The Kodak version uses an all-electronic shutter system, the Fuji a 16-face revolving prism. Both use flying-spot scanning systems and accommodate cartridged film. Prices will be steep at first—Fuji's is $750-$800 in Japan, the Kodak unit may cost as much as $1,000—but both companies claim prices will come down with the type of quantity production required for the consumer market.

Cable TV thaw

Thaw in the FCC's nearly-seven-year-old CATV freeze is finally in sight, and many cable experts see the beginning of cable TV expansion starting later this year. Broadcasters, cable operators and copyright owners all have agreed to a compromise formula engineered by the White House's Office of Telecommunications Policy. The complex agreement sets guidelines as to which signals may be carried by cable systems in communities of various sizes, and establishes other ground rules, such as respect for copyrights on programs by cable operators. It will still take some time for the FCC to set out the agreement in terms of formal rules, but it is expected to pave the way for the establishment of new CATV systems in larger cities, which has been banned in the recent past under the Commission's freeze.

4-channel disc war

Just when it appeared that peace was in sight in the battle over quadraphonic record standards (Looking Ahead, **Radio Electronics** January 1972), a real war has broken out. Once again, it's between RCA and CBS, and it could be another struggle reminiscent of the titanic fights over postwar record (45 vs 33) and color TV (compatible vs field-sequential) standards.

CBS, with Sony as its prime manufacturing ally, has introduced and is selling the SQ matrix disc system. Now RCA Records has revealed that it is working to improve some characteristics of the discrete CD-4 four-channel system developed by the Victor Company of Japan and will introduce discs some time this year. (Victor's system was described in **Radio-Electronics** in December 1970.) Allied with RCA Records in this venture are Japanese manufacturers Panasonic and Victor, both owned by the powerful Matsushita Electric Company. Although RCA's own manufacturing arm appears to be taking a less active role, an official statement said it favors the discrete concept and has no plans to market matrix disc-playing equipment. In the CD-4 system, the two rear channels are modulated on a high-frequency carrier (around 30,000 Hz). The record is compatible with two-channel stereo playing equipment, which simply ignores the carrier. A CD-4 player uses a special "demodulator" to unscramble the rear channels.

RCA's main effort now is to improve the durability of the four-channel disc when played using a regular stereo cartridge, which tends to destroy some of the four-channel capability. RCA says it has had remarkable success so far toward achieving that goal. The obvious advantage of the RCA system is that it presents four completely independent channels, providing a truer four-channel sound than matrix records, in which front and rear channels are intermixed, with rear channels encoded. It has two principal disadvantages: (1) The playback equipment promises to be more costly than that for the SQ system, since it requires a special high-quality cartridge capable of picking up the 30,000-Hz carrier, in addition to the demodulator. (2) Discrete discs can't be broadcast over stereo-FM stations under current FCC rules, while matrix discs can. Nor can the output of a discrete disc be fed into a standard two-channel tape recorder and played back through a decoder to produce four-channel sound. With SQ discs already on the market under the Columbia Records, Vanguard and Ampex labels, and with equipment being offered by Masterwork, Sony, Lafayette and Sherwood, the RCA-CBS quadraphonic war threatens to intensify in the months ahead. **Radio-Electronics** will present complete details of both CBS and RCA systems next month.

Hotel pay TV

Talk of pay-as-you-watch subscription TV is as old as television itself—and so far it's been mainly talk. The FCC has authorized pay-TV transmission to homes, and perhaps some pilot projects will get under way soon. But the first working pay TV systems more likely will be in hotel and motel rooms. Two competing systems, in fact, are already well under way—both having undergone test runs, and one of them scheduled to be in regular operation by the time this issue of **Radio-Electronics** appears. Both systems operate in a similar manner. The pay-TV attraction—which could be a first-run movie or a sporting event not broadcast over free TV—is fed via the hotel's master antenna system to all guest rooms in scrambled form on an unoccupied channel. To receive the attraction unscrambled, the hotel guest calls the desk. His picture is unscrambled and the "admission charge" is added to his hotel bill.

The movies will be shown continually throughout the day and evening with staggered starting times, so that at each hour a new film begins.

Both of the systems announced so far will depend largely on movies as their first attractions. One system, developed by a subsidiary of Columbia Pictures, has been tested at the Regency Hyatt House Hotel in Atlanta, and is scheduled to be installed soon in hotels and motels in major U.S. cities and in London. The other system, owned by Computer Television Inc., underwent a long testing period in a motel in Newark, N.J., where it was found that a susbtantial percentage of guests would gladly pay three dollars to view a current feature film. The films, in color, are transferred to video tape, and shown at specified times. If this new type of pay TV succeeds, it could open up a big new field in maintenance of closed-circuit and video tape equipment for hotels and motels. **R-E**

by DAVID LACHENBRUCH
CONTRIBUTING EDITOR

MCR-1211... the tonal truth, and nothing but the truth.

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Circle 4 on reader service card

new & timely

THE CONTENTS OF A LADY'S PURSE show up on a storage-type radiographic amplifier screen.

Radiographic screens

Westinghouse has developed two new solid-state radiographic amplifier screens which quickly convert X-ray images into visible images with energy gain. The screens are available in both storage and nonstorage types for industrial nondestructive testing and for special medical applications.

The storage-type amplifier screen displays its visible image for several hours or until it is electrically erased. This permits long, detailed study of an X-ray image without continuous exposure to radiation. The screen can be photographed to keep a permanent record, but no delay for photographic processing is necessary since the screen can be studied directly.

As a direct replacement for existing fluoroscopic screens, the nonstorage radiographic screen has a reasonably fast response so it can effectively view both static and dynamic X-ray images. Its main applications include production line inspections and nondestructive testing. It can be photographed if a permanent record is needed.

The panels are solid-state photoconductor-electroluminescent types. The photoconductive layer is sensitive to X-rays. The electroluminescent layer provides the visible image and is deposited on top of the photoconductive layer. A voltage is applied across the two layers. When the photoconductive layer is exposed to X-rays, its electrical resistance decreases, causing more of the applied voltage to be dropped across the electroluminescent layer. With this higher voltage applied, the electroluminescent layer emits more light. The light pattern emitted exactly corresponds to the pattern of incident X-rays.

Warranty plan

General Electric has introduced a TV warranty certificate program enabling a consumer to get service on his set anywhere in the country from any of 5,000 franchised service centers registered with the company. Home Furnishings Daily reports that it will not make any difference where the set was purchased, because under the new program servicing dealers will continue to provide warranty service for their customers, even if the buyer has moved to a different state.

Laser communicator

A new laser communicator, designed to be as easy to use as a pair of binoculars, was developed and demonstrated by the Santa Barbara Research Center, a subsidiary of Hughes Aircraft Company. The self-contained transceiver weighs three pounds, and uses a gallium arsenide laser with output in the infrared to provide point-to-point communications. The device operates from a small rechargeable nickel cadmium battery mounted within the body of the receiver unit.

To transmit the signal the operator pulses the laser diode at a reference pulse repetition rate which is then frequency modulated by the voice signal inputs. Each light pulse has a time duration of 100 nanoseconds and reaches a peak power output of ten watts. Pulse transmission is started by talking into a built-in microphone.

The receiving portion of the communicator is optically aligned to receive the transmitted light pulses through a 2.5-inch receiver aperture. The infrared energy received is then processed using special techniques to enhance the signal-to-noise ratio. The pulses are amplified and the repetition rate demodulated to convert the received pulses into audio or data signals.

Because of its wide-angle transmitter beam design, the communicator may be used under any conditions that allow the

(continued on page 12)

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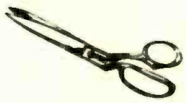

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new & timely *(continued from page 6)*

use of binoculars, its range being dependent on visibility and the degree of divergence desired. Possible applications include ship-to-ship communications, riot control, tower-to-tower transmission in the forestry service, and various battlefield uses.

Hugo Gernsback scholarship winner

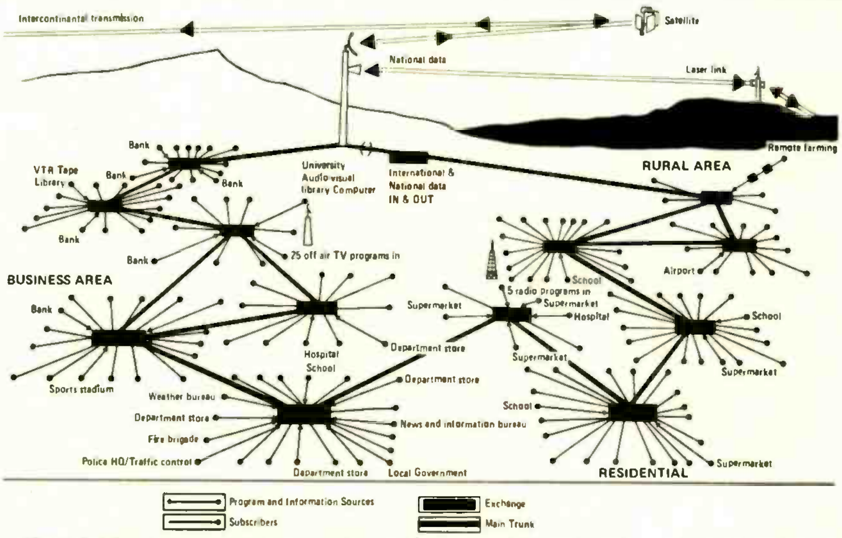
Career Academy has awarded its Second Annual Hugo Gernsback Scholarship for 1972 to Gordon E. Shepard of Ionia, Michigan. Gordon receives $125.00 from **Radio-Electronics** as an outstanding student at one of eight home-study schools of electronics.

When he completed high school Gordon went to work as a welder at General Motors, but, after two years, enrolled with Career Academy's home-study program to pursue his major interest, electronics. Although he says he has acquired enough knowledge now to hold a better job, Gordon is planning to study full-time to learn still more in his field.

Two-way cable TV system

A one-year pilot trial of a complete two-way cable television system at Cape Cod, with about 200 homes participating, has shown that the idea of an interlinked city is a practical possibility. Rediffusion International Ltd., a British firm, is offering the system to operators of telephone and TV cable systems in the United States.

Called *Dial-a-Program,* the setup offers subscribers variety in information and entertainment, including access to facsimile reproduction of newspapers, to film and tape libraries and university-linked networks, and to programs for particular regions or ethnic groups within a community. Subscribers could communicate with their banks, with supermarkets and other businesses, and computers could "talk" to computers.



The system works somewhat like a conventional telephone network. Color or back-and-white standard TV sets can be connected to a local program exchange by two pairs of wires, one of TV bandwidth quality (5 to 10 mHz) and another slightly lower-grade pair which can be used for very high speed data, speech, control and other purposes. Signals can be carried on the high-grade pair in both directions simultaneously using different frequency channels. In this way programs may be originated at one subscriber's studio or home and relayed to others via the exchange.

An ordinary telephone-type dial that actuates a reed selector switch designed

(continued on page 14)

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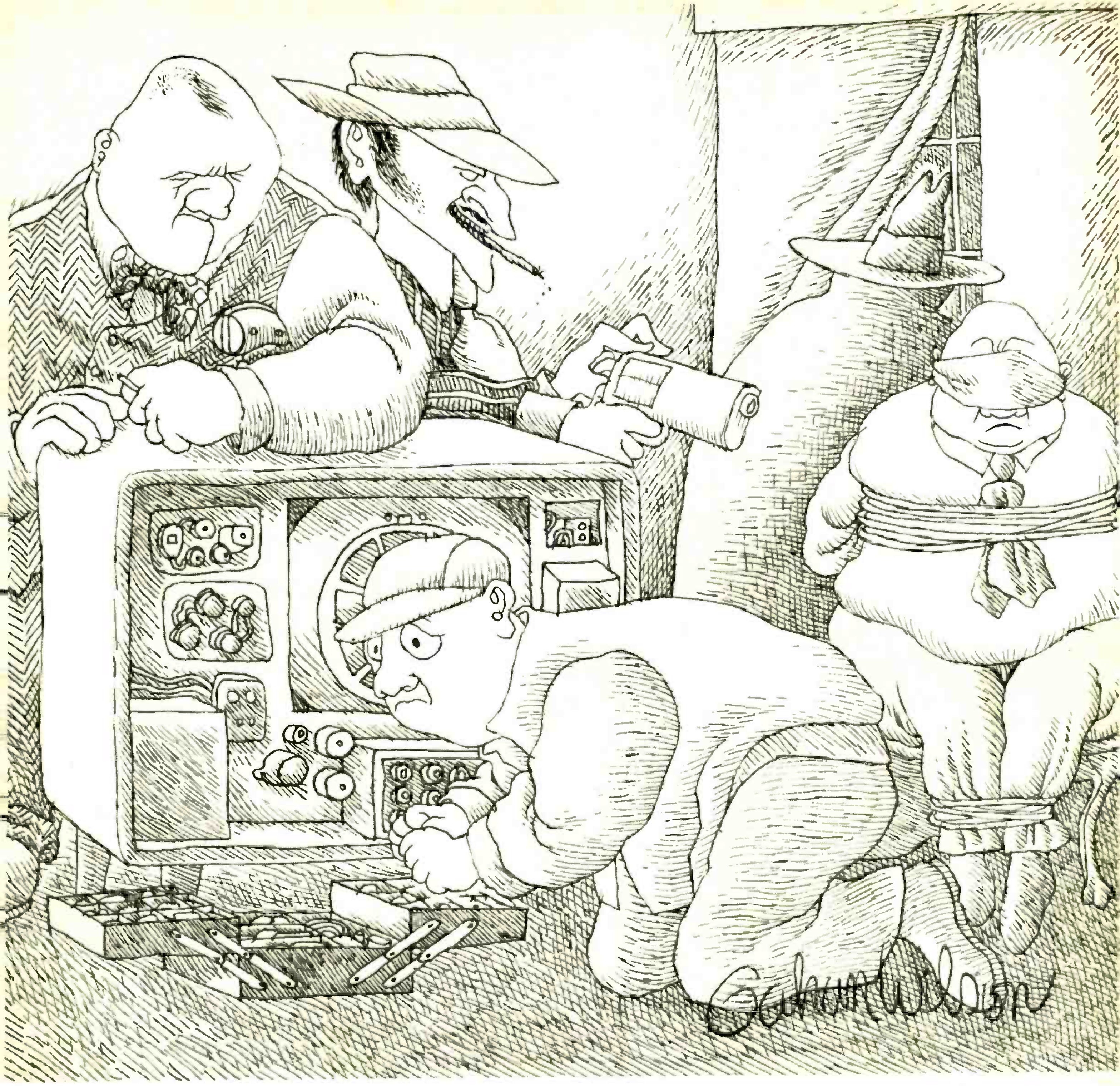


 (continued from page 12)

for 36 channels is used to select programs. An individual selector mechanism permits record-keeping of audience rated figures and subscriber money paid or due.

Local exchanges, each covering about fifteen city blocks, would be linked by a coaxial cable network of circular trunk routes. Signals starting at any point in the system could be injected at any program exchange and circulated throughout the network or retained within a local loop.

Rediffusion's system requires the installation of a simple cable, known as "Qwist", which carries both audio and video. In effect, it extends the technology of the telephone to the point where full band width for color transmission is carried on a wide bandwidth which is two-way and switched.

Expected cost to the subscriber will lie in the range of $5 to $6 per month, to cover all the broadcast channels an operator could pick up off the air. Other channels could be rented to anyone interested in communicating visually with the public.

Laser resistor-trimming set-up at Motorola. Resistors on hybrid circuit substrates are trimmed to tight ohmic tolerance by a laser beam which cuts into the film resistors used. The TV monitor displays hybrid circuit workpiece, while the computer/measurement system (on the right) monitors and controls the trimming operations.

A Raytheon plan view display is given a microscopic examination prior to acceptance tests by the U.S. Federal Aviation Administration. The high resolution screen displays aircraft information and movements clearly in alphanumeric characters and lines considered superior to air traffic control displays currently in use.

Alec Reeves dies

The developer of pulse-code modulation, Alec Harley Reeves, died of cancer on October 14th. He was 69 years old. Best known for his revolutionary method of transmitting telephone conversations, other electronic messages or data, Dr. Reeves spent his entire professional career, until retirement, with International Telephone & Telegraph Corporation (ITT). He left no family.

Dr. Reeves was born in England in 1902, graduated from London University, and was a member of the British Institution of Electrical Engineers. At ITT he worked on the first transatlantic radiotelephone system. Later he aided in implementing the first Spain-to-South America high-frequency radio link and the first microwave radio system across the English Channel. During World War II he developed the "Oboe" radio navigation system, for which he was made a Member of the Order of the British Empire in 1945.

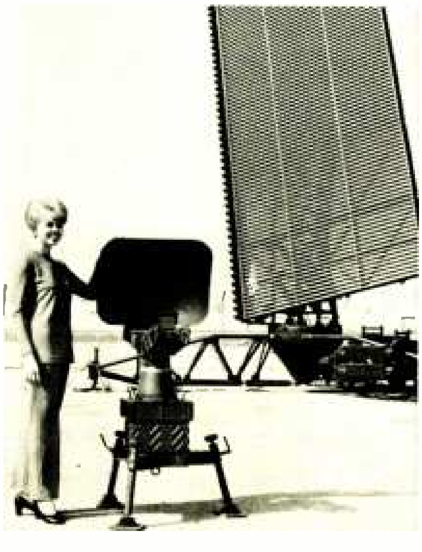
First case of healing fractures by electricity reported

University of Pennsylvania surgeons have reported the first successful case of healing a bone fracture in a human by electricity. The research, begun nine years ago, has culminated with repair of an ankle fracture in a 51-year-old woman. Details on the technique were reported in *New & Timely*, July 1971, **Radio-Electronics.**

Peruvian government seizes TV

The revolutionary military government of Peru has taken control of the TV and radio industry. The reasons given by the Minister of Communications and Transport, Brig. Gen. Anibal Meza Cuadra were basically that the 19 TV and 222 radio stations were in the hands of a few families and not designed to aid the cultural, social and economic development of the people; only 36% of the mass media shows are of Peruvian origin, the rest are mostly dubbed programs from the US, Europe, Mexico and Argentina; commercials take up nearly 40% of broadcast time; and most stations are concentrated in a few large urban centers and do not service the majority of people who live in rural areas.

While most industry sources conceded that many of the military's complaints and aims were justified, they denied responsibility for the shortcomings, claiming that the way they ran their stations reflected life in Peru, as well as in many other Latin American countries.



ANTENNAS FOR A US ARMY ground surveillance radar (foreground) and a long-range surveillance radar used by the Marine Corps. Both are developed and produced by ITT. R-E

letters

TOO MUCH TUNING

I would like to take exception to part of the article "Break Through Radio Pollution" by Robert B. Cooper in your June 1971 issue of **Radio-Electronics.**

I'm sure that most of us would rather "tweek and re-tweek" once in a while in preference to adjusting four dials every time we tune in a new station on FM. Mr. Cooper's statement that modern FM sets use one rf stage shows poor contact with the FM broadcast receiver field. Oak Products' FM tuner, which is used in several FM sets on the market, including the Heathkit AR-15, has two rf stages, and FET's in the front end, and has been in production and general use for three years. There is no evidence of front end overloading as a result of large adjacent signals.

The use of printed-circuit coils seems to be a panacea, since we're all going printed-circuit these days, but Mr. Cooper's claim that they are more stable than wire coils is just not true. The best of the printed-circuit material—epoxy glass—has a far higher temperature coefficient of expansion than wire, and therefore would be more unstable. Further, the process of etching the PC leaves very sharp edges on the copper. This, along with the fact that the wire is laid the way it is, leads to very high losses at the edges, and his 1/16 flat wire assumes the proportions of a No. 34 wire or less. This does not contribute to a very high Q in the tuned circuit.

Also, we at Radio Aids have used a tube-type tuner, with much the same characteristics as Mr. Cooper claims for his FET tuner, for 22 years, although we use tubes rather than transistors, of course. Our requirements call for sensitivities in the order of 0.3 μV for 20 dB silencing at the front end. Our tuner operates with one dial.

HOWARD S. KNAACK
Radio Aids
Lake Bluff, Ill.

MR. COOPER REPLIES

I find that you have not grasped the purpose of my article on the FM preamp, and I would like to present a number of facts about etched inductors.

You mention our having a lack of contact with the FM broadcast receiver field. If you will carefully check my text material, you will find that my reference to a *stage*, such as rf stage, is a semantic term covering a particular function, and not the number of active devices found within that particular section of the receiver. In other words, an rf stage is one in which radio frequency amplification takes place, regardless of whether this is done in one or a dozen active devices, such as a transistor. It is a fact, of course, that virtually all top-of-line FM tuners and/or receivers are today using FET's in the front end. This has been going on for a number of years. What has escaped you is the manner in which these FET's are being used in receivers. I am intimately familiar with their operation. We use them in our lab for reference sources. I am afraid there is considerable evidence of front-end overloading as a result of large adjacent signals. If you have never experienced front-end overloading with modern tuners you simply have not been located close to one or more local FM transmitters. If you "sweep" the rf amplifier section (stages) of these receivers you will probably discover, as we did some years ago, that the 3 dB selectivity points, as measured through the rf amplification stage, are approximately 3 MHz. In other words, signals + or – 1.5 MHz from the frequency the receiver is tuned to are being amplified by the rf stage by not less than 3 dB, reference to the station you think you are tuned to.

Stability in inductors is really a moot question unless you have had the opportunity to work with etched inductors. Stability *can* be measured as a function of rapid temperature and/or humidity changes, or as function of exact repeatability from one device to the next. Within the normal temperature ranges that are experienced by most receiving devices, the coefficient of expansion of wire and glass epoxy board is in a negligible change region and it is unlikely that in either case there is sufficient change to warrant discussion.

On the other hand, in the business of designing and building exact bandpass devices, such as filters or amplified filters, the ability to work with identical inductances from one stage to the next and from one device to the next is exceedingly important. For example, all high-quality laboratory standards bandpass filter devices which use discrete inductors wind these inductances on pregrooved forms. This is to eliminate the inherent human and mechanical errors which invariably creep into the production process of manufacturing what is supposed to be an identical series of inductors. Even this technique leaves a great deal to be desired.

Our belief in the etched inductors is based on the assumption that when working from a suitable master, each board containing one or more etched inductances is identical to all boards before. If the board master itself is correct, and can be resonated within the desired frequency range, the production personnel, the alignment technician, and the ultimate user can be assured that each device manufactured using this concept will have performance parameters that are identical to its original production claims and measurement specifications.

In short, the question really becomes one of exact repeatability from one device to another. We believe this is where the etched inductor has a very definite place in the future of electronics.

ROBERT B. COOPER, JR.
CADCO
Oklahoma City, Okla.

IS DOLBY NECESSARY?

Much has been said in your magazine about the application of Dolby processing to FM broadcasting. The whole basis of Dolby (type B) is to boost treble during low-level passages; the response is then flattened during normal or maximum-level passages. A complementary device is supposed to be used to de-process the audio. However, should we assume that there will always be level changes sufficient to derive benefit from Dolby processing?

In my opinion, the typical rock music FM station will not receive a benefit from Dolby sufficient to justify the expense. I have actually watched modulation meters at a rock station. Level changes sufficient to activate the Dolby equipment may represent 1% or less of air-time and on some days they may never happen at all!

Many radio stations in this country (rock and others) do not allow drops in audio level: they employ 20 dB or more of automatic volume-compression and an uncertain degree of manual compression (they "ride the gain"). Such stations pride themselves on being "tight"—which is broadcasting slang for allowing no lapses in audio whatsoever.

Many recordings are already highly compressed these days—even many classical recordings. While it is true that Dolby processing may extend the dynamic range of commercial recording, I believe that the final product will always be subjected to compression. This is especially true of rock music.

As a matter of fact, several rock stations on FM in this country are automated and the equipment will automatically reject the very kind of audio which would benefit from Dolby processing. It's called "silence sense" and it's intended never to allow any silence on the air that might result from an

(continued on page 22)

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LETTERS

(continued from page 17)

expired tape or a defective machine. However, this gadget is a troublemaker sometimes because it may reject the occasional soft or slow passage in the music. So, as a matter of self-defense, the tapes for the automation are subjected to lots of automatic and manual compression, and even some clipping, during preparation. Then the station compresses the tapes even more on playback. After all this, it goes to the Dolby. I think there will not be many level changes on which the Dolby can operate!

Too many of us are guilty of thinking of FM as it used to be: classical music with wide dynamic range was once FM's specialty. But is this still true today?

I don't agree with those that say that FM benefits from Dolby even if the complementary receiver circuit is not used. If the de-processing is not used the response will not be flat at all times. Isn't a flat response one of the primary objectives of FM? FCC regulations specify more flatness on FM than on AM.

If the FCC rules that Dolby can be used at all times, then they will require that all manufacturers build in the Dolby circuits in all new receivers. This will render obsolete thousands of FM receivers already in use. Nine out of ten receivers in use cannot easily be converted—only those with separate tuners and preamplifiers can be converted with ease. But that kind of set is in the minority today.

Is all the expense and bother really worthwhile? This change would be made for the sake of a minority of listeners with borderline reception. Let me point out that the FCC limits the range of a station by limiting the power which may be used. It is illogical to use a gadget such as Dolby to extend the range, and it is an attempt to bypass the reasons for limiting power.

CLYDE E. WADE, JR.
Little Rock, Arkansas

TIC-TAC-TRONIX

Two problems seem to have crept into my "Tic-Tac-Tronix" article which appeared in the December 1971 issue of **Radio Electronics.** In Figure 3, diodes D1 through D7 should come directly from the base of the first Darlington Transistor. This connection appears correct in Figure 9, Figure 10 and Figure 11.

Integrated circuit IC5 is a 74107. It is correctly called out in the parts list and Figure 11, but is garbled in Figure 5.

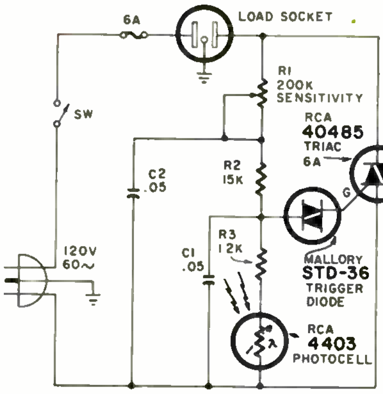
Hope these details make construction a little easier for **Radio-Electronics** readers.

DON LANCASTER **R-E**

appliance clinic

YOU'RE GOING TO RUN INTO SEVERAL kinds of appliances which are turned on or off automatically by the presence or absence of light. Not too far back, this would have meant a vacuum-tube photocell, an amplifier, dc power supply, relay, and a pretty bulky "package" of electronics. They're getting a lot smaller. There is a solid-state device that can be turned on or off by light, and guess what? It's our old friend the SCR in a new version: two SCR's back-to-back in a single package with a hole in the top, and actuated by light. This is the LASCR.

These are just like phototransistors. Actually, all transistor junctions are photo-sensitive—light falling on 'em makes 'em turn on. All they have to do to make a phototransistor is leave a hole in the top of the case so light can hit the junctions. The LASCR can be turned on by light falling on it. In other words, with light, conduction; no light, no conduction. See any good SCR Handbook for full details.



There are applications where we need full-wave conduction. So, we have to use a "double SCR" or "Triac" since the basic SCR cuts off half of the applied ac, like any diode. Also, in a lot of cases, we need an "opposite reaction": turn on when there is no light, turn off when there is. So we add a few little gubbins to the circuit, like the one shown in the diagram, from RCA's "Solid-State Controls" book, and there we are.

What Are They Used For?

There are lots of applications for this kind of thing; automatic yardlights that turn on at sunset; automatic night lights, room lights, garage door openers, and so on and on. Three resistors, two capacitors, and three solid-state devices and there you are. The RCA 40485 is a 6-amp Triac, so it will handle up to 700 watts or so. There are higher-rated types if needed.

How Does It Work?

When there is no light falling on the 4403 photocell, its resistance is high. So the ac voltage coming through SENSITIVITY control R1 and resistor R2 can charge .05-μF capacitor C1 to a high voltage, twice during each full cycle. This builds up enough voltage to fire the trigger-diode, which in turn fires the Triac and discharges the capacitor. This is the on condition: whatever load is plugged into the load socket will be energized.

In a yard-light, this would be "night"; no ambient light, so the light turns on. When day breaks, the light increases (unless the smog is too thick). The increased light falling on the photocell makes its resistance go away down. Since the photoelectric cell is actually shunted *across* C1, it prevents the voltage on the capacitor from rising to a level high enough to fire the trigger-diode. So the Triac won't fire either, and the light goes off.

This circuit, as-is, would be all you'd need for an automatic yard-light, etc. It could also be used for things such as counting packages on a conveyor belt, counting people going through a gate to a sporting event, etc.

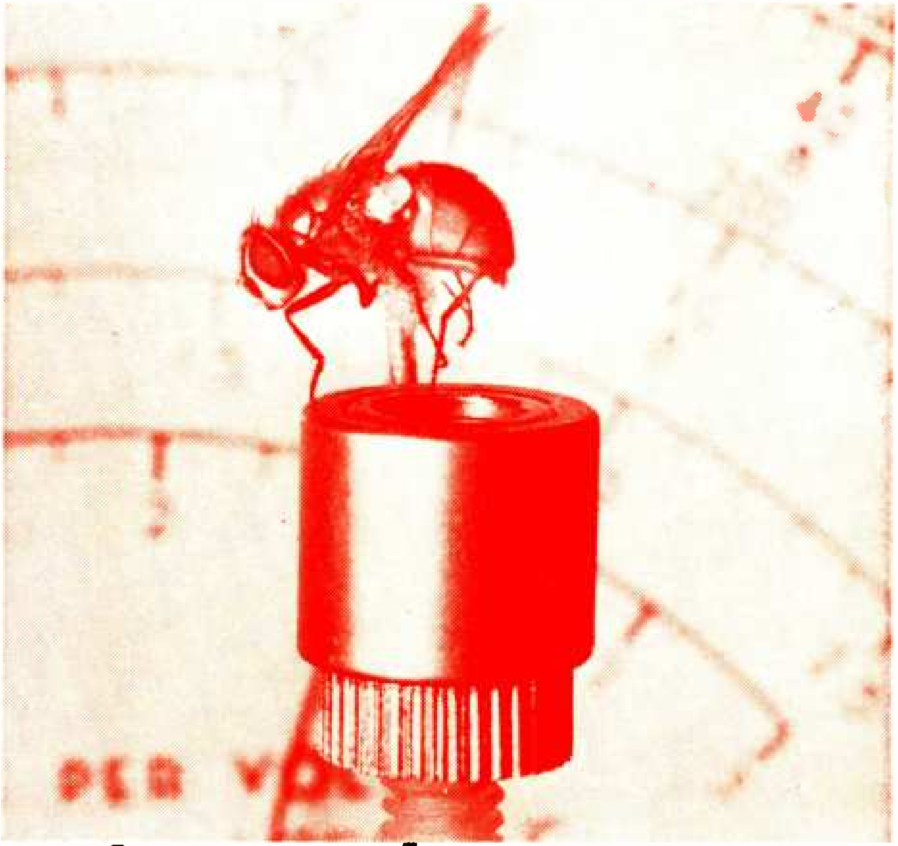
With an external relay plugged into the load socket, it could be used to start or stop a motor. A relay can open a circuit or close it, depending on which pair of contacts (on a spdt) you use, when its coil is energized.

So this could be "reversed"; made to turn lights on when light hits the photoelectric cell. (F'rinstance, automatic garage lights which turn on when the car's headlights hit the cell) or even a garage-door opener which works when the headlights shine on it, etc.

If anything goes wrong with one of these, servicing is simple. Any of these things can be checked out with an ohmmeter and an ac voltmeter. Just like checking transistors. Look for a short or

(continued on page 69)

The electronic snooper will resort to anything to listen to your conversations. See how to plug his electronic ears



outwit electronic snoopers

by JOHN E. CUNNINGHAM

"BUGGING" OR ELECTRONIC EAVESdropping, which was something strictly from science fiction, is a big business in the United States today. You don't hear much about it, because legitimate manufacturers of such devices promote their products primarily to law-enforcement agencies, and makers of illicit bugs prefer to attract as little attention as possible to their operations.

FCC regulations prohibit the sale or use of unauthorized eavesdropping devices, but the fact is that a reasonably effective bug is relatively easy to build. They usually can be readily concealed, and since their signals can only be picked up over a distance of a few hundred feet at the most, it is almost impossible to enforce the regulations.

Bugs have been used by private detectives to gather information for their clients, by employers to eavesdrop on their employees, by businessmen to gain access to their competitors secrets, and by jealous husbands to check on their wives. In fact, bugs are so easily built or purchased that it is safe to assume that anyone's conversation may be bugged if a person feels it is worth the risk.

This widespread use of eavesdropping devices has led to the development of a new profession—that of the electronic "debugging" expert. Many security consultants spend full time locating bugs and providing secure areas for private business discussions. Furthermore, many electronics technicians are being called in by companies to assure that their secrets are not leaking out to competitors by way of bugs which have been secreted on their premises.

There are four types of electronic eavesdropping devices that are in common use today:

1. High-gain directional microphones.
2. Hidden microphone wired directly to a listening or recording device.
3. Miniature radio transmitters.
4. Bugs used in connection with telephones.

The first type, the high-gain directional microphone, is the easiest to defend against. It is simply a microphone equipped with a parabolic reflector to make it highly directional. Devices of this sort are large and hard to conceal. Usually, they cannot pick up conversations at distances of more than about 150 feet. The defense is simply to hold conversations in areas with reasonably soundproof walls and closed windows. It also helps to have a distracting source of sound, such as a transistor radio in the room.

The second type is a microphone that is hidden in a room and connected by wires to a remote point where the eavesdropper listens with an amplifier and headphones, or has planted a tape recorder. This type is usually difficult to track down because it doesn't radiate.

By far the most common type of bug is the miniature radio transmitter such as the one shown in Fig. 1. This device is actually a battery-operated transmitter. The eavesdropper merely plants it and then picks up its signal from some convenient place where he is not apt to be noticed.

The fourth, and probably most sophisticated type of bug is the telephone bug. Many different types of telephone bugs are in use. They range from simple wiretaps to radio transmitters hidden in the telephone. The latter are often ar-

FIG. 1—INEXPENSIVE WIRELESS BUG transmits on an unused portion of the standard FM broadcast band.

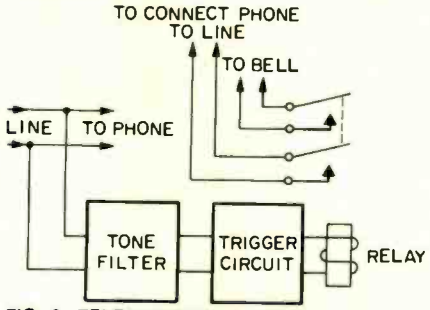


FIG. 2—TELEPHONE BUG CIRCUIT. Caller at listening point turns on phone's mike by dialing number then sending special tone.

ranged to draw power from the telephone line and use the telephone transmitter as a microphone.

A very sophisticated telephone bug, shown in Fig. 2, effectively "answers" the phone before it rings. In this circuit, a tone-operated relay is connected so when a tone of the proper frequency is transmitted on the line, a relay is actuated to disconnect the bell, and connect the transmitter to the line. Once this kind of bug is installed in the victim's phone, the eavesdropper can dial the number from any other phone in the United States. There is a short period of time between the instant that the connection is made and when the bell starts to ring. During this interval, the eavesdropper transmits a tone over the line with a small portable oscillator. The tone prevents the bell from ringing, and connects the victims telephone to the line. The eavesdropper can then listen to all of the conversation in the room from as great a distance as he wishes. The only way that the victim might become aware of the bug is when he fails to get a dial tone when placing a call. Even this usually isn't noticed, because when the eavesdropper hears someone attempting to use the phone he can quickly hang up.

This type of bug is complicated and expensive, but it has the advantage that once the bug is planted, the eavesdropper can listen in almost complete safety, to everything that is taking place.

Debugging techniques

When an electronics technician is called in to locate a bug, or to provide an electronically secure area for private conversations, he must use every bit of ingenuity at his command. The state-of-the-art at the present time seems to be on the side of the eavesdropper.

The first step in debugging a room is to conduct a painstaking and thorough physical search of the premises. This is time consuming, but is usually well worthwhile. Many experts charge fees of up to $1,000 to assure that a conference room is secure.

When conducting a search, pay particular attention to anything that is new, or temporarily present in the room. A favorite way of temporarily planting a bug is to conceal it in an item of personal property that can be left as though by accident. Thus a competitors representative may leave a briefcase, raincoat, or umbrella containing a bug during a visit to a facility. Many modern bugs are inexpensive and are considered expendable. Sometimes bugs are concealed in gifts such as pictures.

An important factor in debugging an area is the fact that a professional agent rarely plants only one bug. He plants at least two and sometimes more. So if the technician locates a single bug, he should not consider his job done. The bug that he found may have been deliberately planted in a place where it would be easily found to lull the victim into a false sense of security, while another bug is transmitting all of his conversations.

A small metal locator of the type used to locate buried objects is a valuable aid in locating wired microphones that do not radiate.

When a conference room is first built, or at a time that it is known to be secure, make a "map" with the aid of a metal locator showing the location and size of metallic objects. If during a subsequent search with a metal locator,

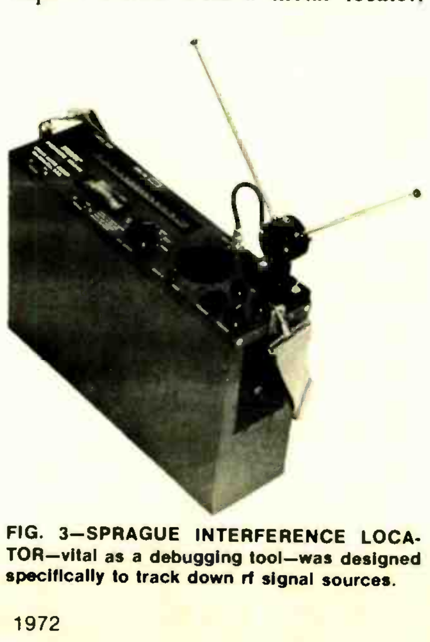


FIG. 3—SPRAGUE INTERFERENCE LOCATOR—vital as a debugging tool—was designed specifically to track down rf signal sources.

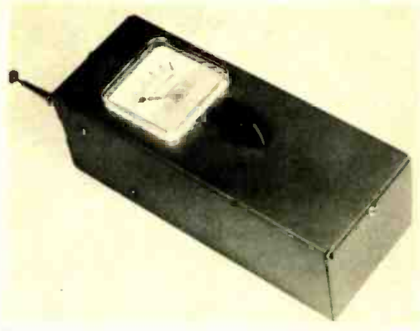


FIG. 4—THE HOUND DOG covers from below 27 to above 108 MHz and responds to both strong signals and weak signals nearby.

new metal objects are detected in the walls, ceiling, floor, or furniture, further investigation is warranted. If no new metal objects are located, carefully inspect existing ones such as lamps, vases, and electrical outlets.

Rf field-strength measurements

Most miniature-transmitter type bugs can be located with rf field-strength measurements. A typical interference locator that has been very effective in locating clandestine transmitters is shown in Fig. 3. The search is often simplified by first carefully examining all signals on frequencies that the eavesdropper is apt to use. The professional will never use a frequency where his bug is likely to be picked up by other users of the spectrum. One bug was located because it was interfering with air traffic communications. Frequencies are usually selected where sensitive receivers are readily available commercially. This factor, together with the fact that short antennas are efficient, has led to a tremendous number of bugs operating in and just outside of the standard FM band of 88 to 108 MHz. Commonly used eavesdropping frequencies are listed in table I.

Amateur eavesdroppers are apt not to be as aware as the professional of the risk of using certain frequencies. They use almost any frequency where they can build small efficient transmitters. This means almost any frequency up to about 200 MHz might be used. The search isn't complete until the entire spectrum has been checked.

Make debugging field-strength measurements by carefully identifying each signal that is picked up in the suspected area. Many bugs use voice-operated relays that turn the bug on only when a conversation is taking place. For this reason, the searcher should talk continuously while making the measurements. Otherwise, the bug might not be radiating while a measurement is made. While making measurements, if the investigator hears his own voice over the field-strength meter, it is a sure sign that a bug is operating in the vicinity.

Another popular debugging meter,

FIG. 5—THE LINE SWEEP detects tones sent over phone line to activate bug. Can be used to detect bugging on local or distant phones.

called the "hound dog" is shown in Fig. 4. This unit is not tuned, but has a broad response to signals from below the Citizens band to above the FM band. Since the majority of bugs operate in or near the standard FM broadcast band, the meter is made most sensitive over this part of the spectrum.

The meter is used to probe the walls, floors, and ceiling of the suspected area, as well as all objects in the area. Its sensitivity is adjusted to provide a minimum reading on signals from local FM and TV stations. When it is brought in close proximity to a bug, the meter indication will rise sharply. This simple meter in the hands of an expert will detect almost any bug of the radio transmitter type.

In areas where there are many strong signals, it is often advisable to make the search after 2 AM when most stations are off the air.

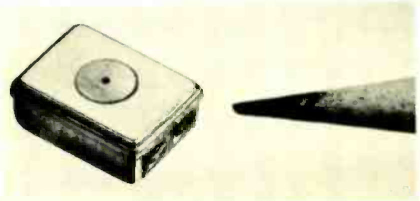
Telephone debugging

Because of the possibility of wire-tapping, a telephone should never be considered completely secure. The phone itself, however, can be debugged. Begin with a thorough search inside the phone for foreign objects. Then make field-strength measurements to detect any transmitter that wasn't discovered by the physical search.

Tone-operated telephone bugs can be detected with an instrument called the "Line Sweep", shown in Fig. 5. This device is connected to the telephone line and, as its name implies, generates a tone which is swept through the audio spectrum while a meter monitors the line voltage. The voltage on the phone line is normally approximately 50 volts. If while the line is being swept, the polarity of the voltage reverses, it means there is an incoming call.

If while the instrument is sweeping the spectrum, there a significant dip in the line voltage, there is probably a tone-operated bug on the line. More often than not it will be in the phone itself, but it could be *anywhere along the line.* Once you know there is a bug, it is simply a matter of dilligent searching to find it.

The Line Sweep can also be used to check any local or distant phone for the presence of a tone-operated bug.



TINY WIDEBAND MIKE measures 0.375 x 0.375 x 0.200 inches. Its output must be amplified for taping or transmission.

Simply advise the party on the other end not to answer his phone and then dial his number. Immediately after the number is dialed, turn on the sweep. After a few seconds of sweeping the line, the ringing sound will stop if a bug is connected to the line.

Automobiles aren't always safe

It is quite easy to bug an automobile. There are plenty of places to hide the bug, and the battery will supply plenty of power to operate a bug that will have a considerable range. The antenna can be passed through a small hole in the body, or in some instances the auto radio antenna has been used.

The proper way to search for a bug in an automobile requires two people—one inside talking continuously to trigger any voice-operated device and the other outside making field strength measurements.

BUGGING TRANSMITTER, concealed in flip-top cigarette pack, has a built-in antenna giving it a range of up to two city blocks.

TIE-CLIP MICROPHONE feeds a miniature recorder or into a concealed transmitter to send signal to distant listener or recorder.

Countermeasures

Perhaps the biggest question is not locating the bug, but taking the proper action to restore security. The electronics technician has completed his job when he has either located every bug in an area, or assured himself that there are none. If a bug is discovered, it is up to the proper security authorities to decide what action to take. One common approach, once a bug is located, is to leave it undisturbed, hoping to mislead the eavesdropper with false information. The technician should always check with his client before taking any action.

The names and addresses of manufacturers of debugging equipment are given in Table 2, and further information may be found in the following books:

Security Electronics By J. E. Cunningham, Howard W. Sams

Business Intelligence and Espionage By Richard M. Greene, Dow-Jones Irwin, Inc. Homewood, Ill. **R-E**

TABLE 1
Frequencies commonly used for bugging

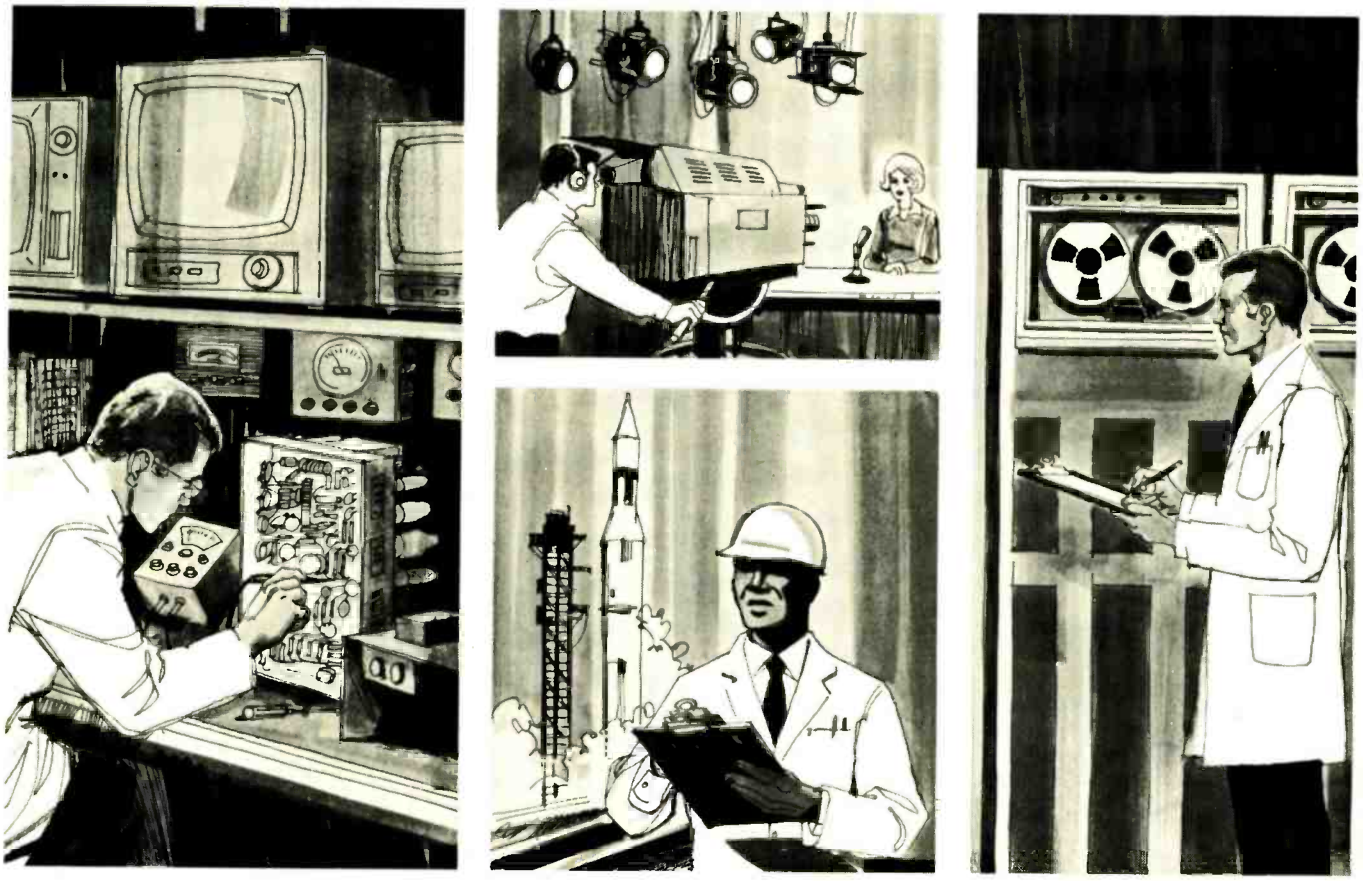
60 - 88 megahertz
88 - 108 megahertz
108 - 110 megahertz
27 - 28.4 megahertz

TABLE 2
Manufacturers of Debugging Equipment

Sprague Electric Company, North Adams, Mass—Model 600

R. B. Clifton, 11500-W N.W. 7th Ave., Miami, Fla.—Hound Dog and Line Sweep

Great careers



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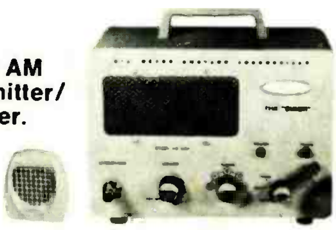
5-watt AM transmitter/ receiver.



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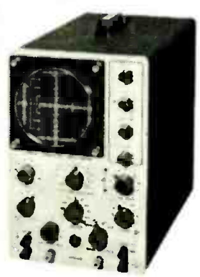

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equipment report

Ten-Tec RX-10 Communications Receiver

Circle 56 on reader service card

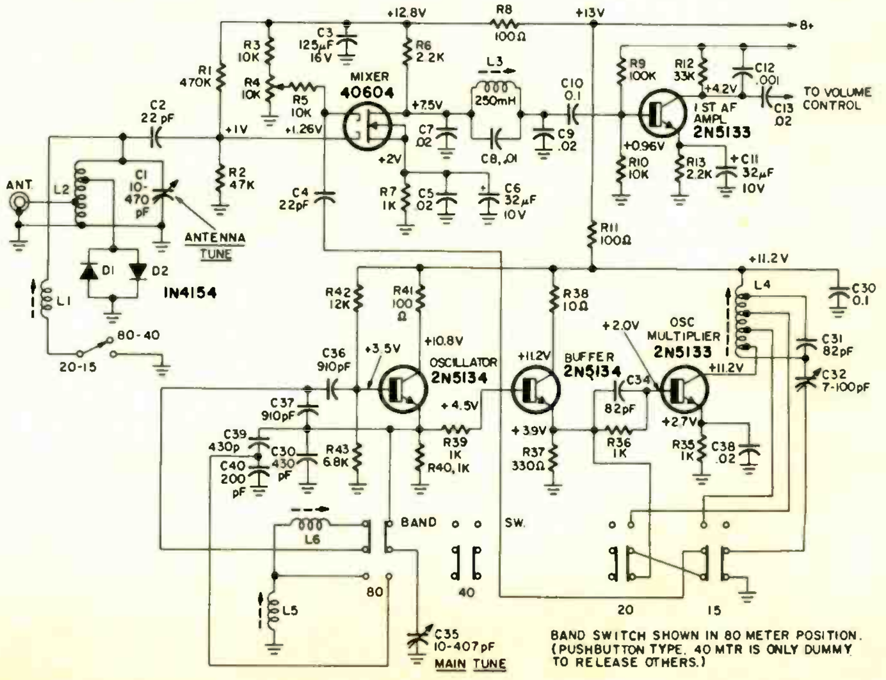
I'VE BEEN INTERESTED IN THE SYNchrodyne, homodyne and other types of direct-conversion receivers for quite a few years. So, when I saw ads on the Ten-Tec model RX-10 communications receiver, I knew this was one set that I wanted to try. What's the appeal of this receiver? To some, its low cost (around $60.00), weight (about 2 pounds) and its drain of only 35 mA from a 12-volt battery may be its major attractions. However, I was immediately intrigued because the RX-10 is advertised as using a synchrodyne circuit.

When the receiver arrived, I couldn't wait to try it. It does not have an audio power amplifier, its output is designed for headphones with an impedance greater than 1000 ohms. I knew that I had lots of headsets around and did not anticipate any problem. Well, somewhere along the line, I'd given my 2000-ohm headsets to kids for use with code oscillators and simple home-built receivers etc. and the only phones I had worked at voice-coil impedances. Local radio parts stores did not have high-impedance phones in stock or only had high-quality types costing more than I cared to spend.

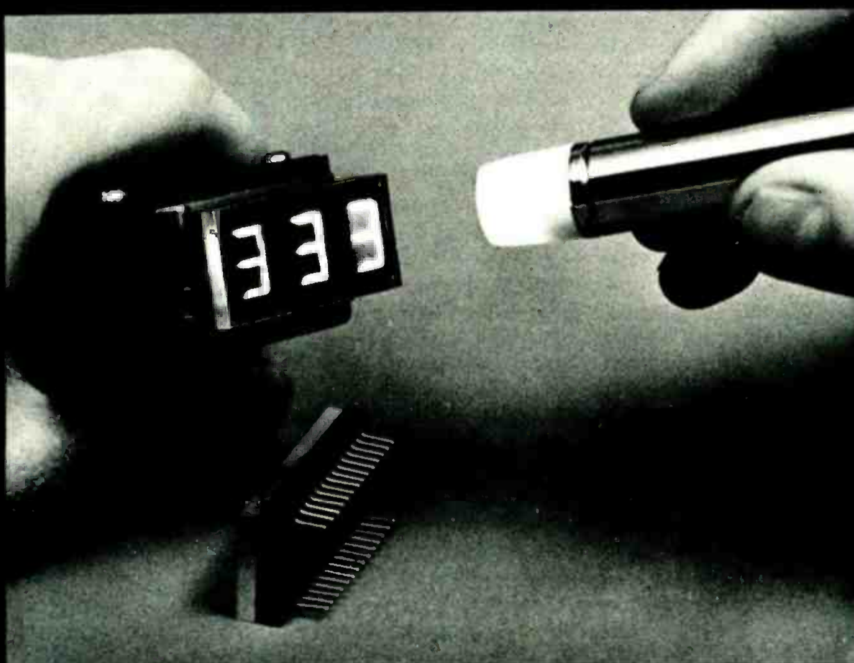
Then, a mind-blocking near-panic set in and for nearly a week I wondered how I could test the RX-10. After my 11-year-old son asked why I couldn't play it through his record player, the fog cleared and my mind was literally flooded with alternatives to the headphone dilemma. My solution was to use a small audio output transformer to match the receiver to 8-ohm phones.

The RX-10 tunes the 3.5–4.0, 7.0–7.3, 14.0–14.6 and 21.0–21.9-MHz ham bands. I tied on a long-wire antenna and fired 'er up. All I could hear was high-speed code and radioteletype

(continued on page 84)



You can now buy liquid crystal displays off the shelf as well as get the chemicals and parts for them separately. These devices have micropower supply requirements, extreme thinness, high brightness, and a bunch of other advantages. Here's how they work, what's available, how they stack up to led's, what you can do with them, and where to get materials for your own displays.



LIQUID CRYSTAL DISPLAYS

by DON LANCASTER

A LIQUID CRYSTAL IS A CHEMICAL THAT FLOWS LIKE A LIQUID, yet retains an orderly molecular structure within that flow. Many chemicals behave this way over a limited temperature range. Some of these also have unique electrical or thermal properties that make them attractive for a wide variety of electronic uses. For instance, *cholesteric* liquid crystals have a very interesting property—they change color wildly for a very small temperature change. These have been available for several years and are used widely for thermal and heat studies microwave power field analysis, medical diagnosis, and even in dime-store novelties.

A more recent development is the *nematic* liquid crystal, whose properties were first described extensively by RCA engineers in 1968. Nematic crystals are clear, but whenever you apply an electric field, they turn milky or cloudy. Chemically, the process is called *dynamic scattering* and the cloudiness or milkiness is caused by the external field interacting with the ordered liquid structure.

An obvious use for something that turns white whenever you apply voltage is an electronic display. To make things more interesting, liquid crystals are also poor conductors, which means they draw practically no current when they're in the milky state and zero current when clear. This makes liquid crystals particularly attractive for watches, clocks, miniature computers, and pocket calculators. We can also use them as *Nixie* tube replacements on electronic instruments, particularly on battery-powered versions. Liquid crystals offer quite a bit as a possible route to flat-screen TV displays. The computer people are also interested, because certain combinations of nematic and cholesteric liquid crystals can also exhibit *storage* and *memory*, important features in a terminal or computer output display where the information need only be provided once by the computer instead of having to be refreshed 60 times a second as in ordinary TV.

Liquid crystal displays do not *generate* light. They either *reflect* it or *transmit* it, depending on how you use

OPTEL MODEL 1003 liquid crystal displays are in photo above them. This means that there is no contrast problem with high ambient light levels—the brighter the room lights, the brighter the display. Normally the liquid crystal material is only a mil or two thick, making for an extremely thin display. It can be made into a display of any size, and we could even imagine room partitions or windows using liquid crystals for controllable privacy or light transmission. And, you can make liquid crystals into any color display you want—white for maximum contrast, red to alert or warn, yellow or green for easy reading, blue for attractive appearance.

Right now, you can't go out and buy liquid crystal displays for 50¢ a digit, but the potential is certainly there. Several manufacturers now offer composite displays and individual digits. These are still rather expensive in small quantities, although their quantity (1000-10,000) prices are competitive with *Nixie* and Light Emitting Diode (LED) displays, particularly if large digits or alphanumerics are needed.

Materials

One of the first nematic materials studied by RCA is an organic jawbreaker going by the name of Anisylidene-Para-Aminophenylacetate. A half-mil (0.0005-inch) thick layer of this chemical you'll be able to mix up in your kitchen sink, the stuff is readily available and ranges in price from $4 per gram in 5-gram lots to under $1 per gram in kilogram lots. Depending on the character size, a gram is enough for a hundred or so characters or digits. Thus the price per digit is around 4¢ each. Other nematics are similarly priced, ranging up to $15 per gram in small lots.

Fig. 1 shows four popular liquid crystal configurations. In Fig. 1-a, we have a simple *transmissive* display. Here the liquid crystal is sandwiched between two layers of conductive glass or any suitable transparent, rigid material with a conductive path on its *inside* surfaces. With a modern liquid crystal compound, 12 to 15 volts is needed to block light transmission through the display, while 0 volts allows light to pass through freely. Thus, this type of display is directly compatible with MOS or COSMOS integrated circuits, but will not give acceptable contrast when driven with 5-volt TTL (at least not with presently available materials). Fig. 1-b shows a *reflective* display, where the back conductor becomes a reflector that returns scattered light to the observer. This is the most popular form, because only external room lighting is needed to view the display.

To improve the contrast and to get by on lower operating voltages, we can use other optical properties of liquid crystals, as shown in the *bi-level* displays of Figs. 1-c and 1-d. Some liquid crystals have an optical property called birefringence. *If the birefringence is voltage-controllable, we can use it to selectively rotate polarized light. In 1-c we have two light polarizers that are parallel in orientation. With no voltage applied, the liquid crystal does not significantly affect the plane of polarization of the light. The first polarizer polarizes the light and the second one passes it freely. This is called a* normally open *display. When voltage is applied, the liquid crystal rotates the plane of polarization 90°* and the second polarizer blocks *the light transmission. To get the* normally closed *display of Fig. 1-d, we use* crossed *polarizers. Here, in the absence of a voltage, the first polarizer polarizes the light, the liquid crystal does nothing to it, and the second one blocks the transmission. Fancier forms of bilevel displays can be used in the reflective mode and some can even produce selectable colors.*

Some problems

Liquid crystals still have some problems and disadvantages. The cell holding the liquid must be dimensionally stable, clear, and a conductor,

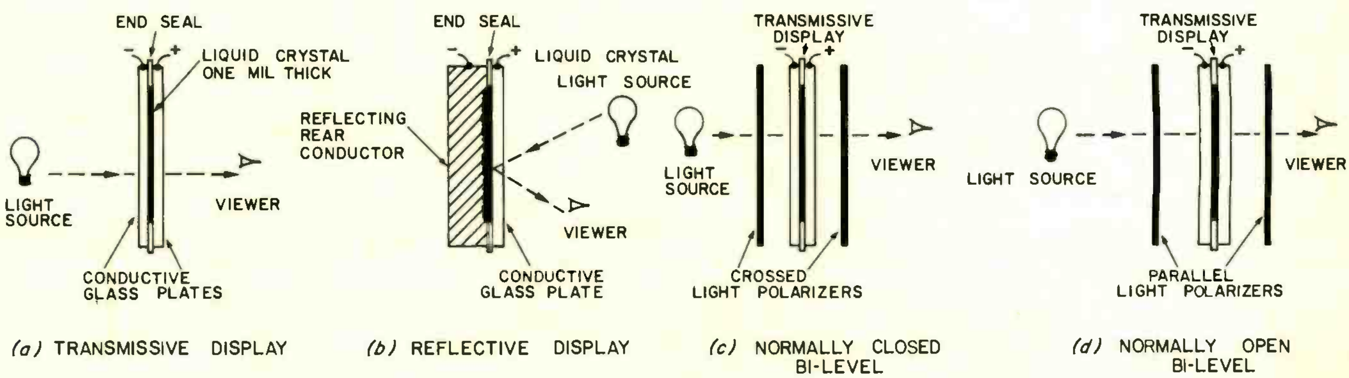
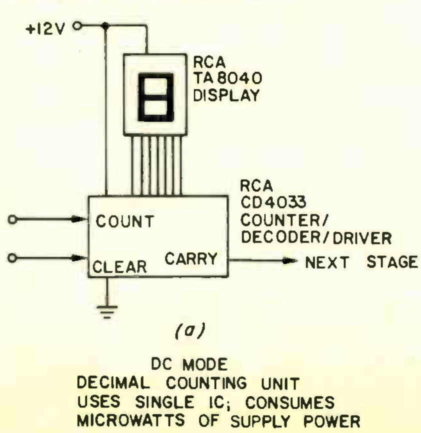


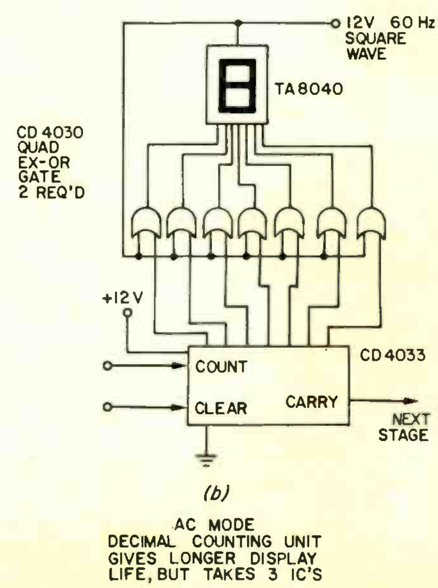
FIG. 1—FOUR COMMON CRYSTAL displays, showing transmissive and reflective effects.

was placed between two pieces of conductive, transparent glass and heated to its nematic operating range of 83° to 100° C. When 60 volts was applied, (an equivalent *field strength* of 120,000 volts per inch), the test cell turned milky, blocking transmitted light and reflecting incident light. With no voltage applied, the cell was clear. The best brightness of this early display was around half that of a good piece of writing paper.

Things have improved considerably since those early tests. Research by such people as RCA, Kent State University, Penn State University, Vari-Light Corp., Optel, Ilixco, and Liquid Crystal Industries has made a wide variety of room temperature operating liquid crystals available. One of these is p-Methoxy-Benzylidine, p-n-Butyl-Aniline 4-Methoxy, 4'n-Butyl-Benzylidene-Aniline. While this isn't the sort of

FIG. 2—DECIMAL COUNTERS using liquid crystal devices. 2-a, working with dc, uses a single IC; the ac version in Fig. 2-b has a longer display life but is more complex.





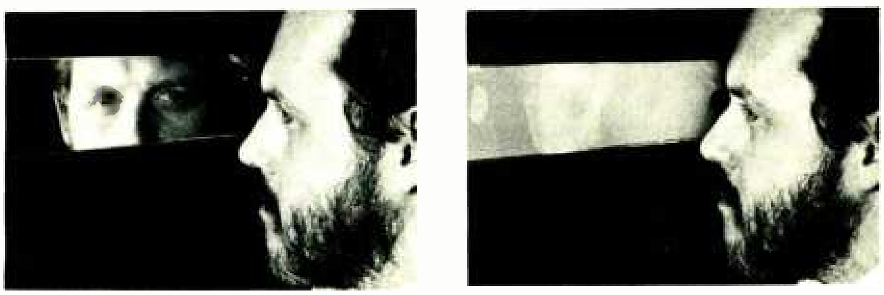
at least on its inner surfaces. There is presently no ultra-low-cost material that fits these standards, and you have to go to a fairly fancy coated glass to meet the requirements. One widely used glass is the *Nesatron* N-2 manufactured by *Pittsburgh Plate Glass Industries.* The process puts a metallic oxide on the glass surface and does it at low temperatures, preventing any stress or annealling effects from hurting the flatness of the glass. Coated glass of this type runs around $14 per square foot, dropping to $10 per square foot in quantity. This is seven to ten cents a square inch, so it turns out that the glass you look through costs twice as much as the liquid crystal material itself. The *Vari-Light* people offer a 2 x 2½-inch piece of electrically conductive glass with a busbar edge for $1.50 each in single quantities. This should be enough for either one transmissive four-digit display or two reflecting ones.

The liquid crystals are sensitive to impurities, so reliable displays must be hermetically sealed. Bubbles must obviously be avoided—they will degrade the display appearance. Capillary and edge effects present a problem with any thin liquid film. Obviously the display must not leak. Small impurities can alter the dynamic scattering drastically, and mechanical stress on the conductive glass faces can alter the optical birefringence properties dramatically.

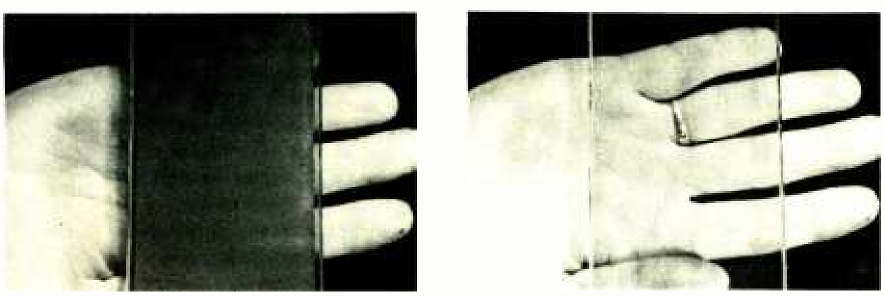
If you apply a dc voltage continuously to a liquid crystal, it loses contrast after a 2000 to 10,000-hour operating lifetime. To get around this, the displays should be run from an ac source if long lifetimes are needed. Fig. 2a shows how we might build a decimal counting unit by connecting a MOS decimal counter–decoder to a 7-segment liquid crystal display. Note that we only need two parts for the complete count-decode-display operation. We can run this on *ten microwatts* at a 1 Hz counting rate for the counter, and around 20 *microwatts* or so for the display on the average.

The trick is to run the IC's on dc, yet convince the display it is running on ac, without going to any fancy Triac drivers or anything like that. To get long life ac operation, we use the circuit of Fig. 2-b. Here seven EXCLUSIVE OR gates are added between the counter and the display, which is driven off a 60-Hz square wave. The exclusive OR gate turns the square wave upside down (inverts it) whenever you want to light a segment, and simply passes it on whenever you want the segment off. An *off* segment sees the same signal on both ends and doesn't light. An *on* segment sees 15 volts across it all the time, alternating polarity 120 times a second. Thus we get ac display operation with dc on the integrated circuits at reasonable cost and complexity.

Liquid crystal displays are somewhat slow. Normally they turn on in 10 milliseconds or so and off in 100 to 200 milliseconds. While we can speed them up a bit with "quenching" techniques, they are inherently slow devices. They're great for people, but cannot generally be used in such high-speed applications as electronic shutters, film annotation, and anywhere else a fast turnoff is needed. They *can* be used at television vertical rates, and TV displays using liquid crystals have been demonstrated. Considerable effort will be needed before a flat screen liquid crystal TV or computer display becomes a commercial reality.



REFLECTION FROM A MIRRORED SURFACE is minimized with nematic liquid crystals. Future applications may include an automatic dimming rear-view car mirror.



CONTROLLING THE TRANSMISSION OF OBJECTS opposite a viewing surface using nematic liquid crystals, makes display overlays, optical shunters and automatic dimming windows possible.

A final problem with liquid crystals is that LC displays do not *multiplex* very well. Multiplexing is a trick you use to share one decoder-driver with many digits, thus holding down system costs and the number of interconnections. For instance an eight-digit display done normally would take 57 connections and eight decoder-drivers. If we multiplex, we get by with one decoder-driver, one eight-point scanner, and 15 connections, assuming you're using 7-bar displays. To multiplex, you run each digit at eight times normal brightness for one-eighth of the time, and switch them fast enough that the human eye can't follow. The eye sees a continuously lit display of normal brightness. The breakeven point on multiplexing is four digits; the more digits, the more you gain.

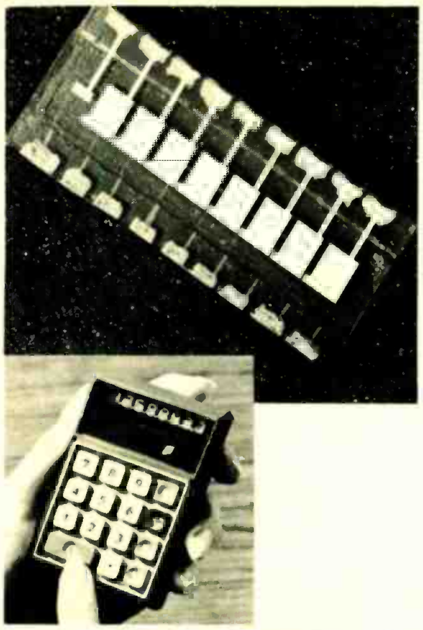
Neon lamps, *Nixie* tubes and light emitting diodes multiplex very well since they can be overdriven for short times, and more important, since they are inherently diodes that block current in the reverse direction or below a threshold value. Liquid crystals cannot reflect more light than they receive, and they do not have a well defined off-on threshold. Thus, at the very least, series diodes are needed for each segment of each digit to prevent sneak paths and ghost images. Good multiplexing techniques will eventually develop, but right now liquid crystals are not overly attractive for multiplex use.

Liquid crystals *versus* LED's

The light emitting diode, or LED, is rapidly becoming the dominant type of readout used today, replacing the now obsolete *Nixie* type with its high voltage requirements. LED's combine a long life, very attractive appearance, TTL 5=volt compatibility with a wide availability, and, recently, low cost. How do they stack up against liquid crystals?

The obvious answer is that both LEDs and liquid crystals have unique advantages and they can each serve an important segment of the display market. Where you want to *produce* light, you must go the LED route. For good multiplexing, high-speed operation, complex alphanumerics, and custom arrays, LED's are the way to go. They also have very much of a head start in the marketplace and right now are more attractive than the liquid crystal displays in appearance.

On the other hand, it always takes more power to produce light than to guide it, and liquid crystal technology is inherently simpler than semiconductor



EIGHT DIGIT liquid-crystal display (larger photograph) forms the readout of a new pocket size electronic calculator made by Ragen. The calculator will retail for about $100.

TABLE I

LIQUID CRYSTAL DISPLAYS OFF-THE-SHELF SUPPLIERS

ILIXCO
Box 184
Kent, Ohio, 44240

OPTEL CORPORATION
Box 2215
Princeton, N.J., 08540

RCA SOLID STATE
Central and Terminal Avenues
Clark, New Jersey, 07066

TABLE II

MATERIALS FOR BUILD-YOUR-OWN LIQUID CRYSTAL DISPLAYS

CHEMICALS

Liquid Crystal Industries
460 Brown Avenue
Turtle Creek, Penna., 15145

Vari-Light Corporation
9770 Conklin Road
Cincinatti, Ohio, 45242

CONDUCTIVE GLASS

P.P.G. Industries
New Products Development
One Gateway Center
Pittsburgh, Penna., 15222

Vari-Light Corporation
9770 Conklin Road
Cincinatti, Ohio, 45242

POLARIZERS, OPTICS, MISC.

Edmund Scientific Corp
101 East Glouchester Pike
Barrington, New Jersey, 08007

technology. So for lots of digits, low power, low cost, the liquid crystals are very much the better choice. We could envision eventually some gel form of liquid crystal that is silk-screened onto displays by the mile at a cost of pennies per digit. Important first applications of liquid crystals will be in pocket calculators and electronic clocks, particularly miniature, battery-powered ones. Liquid crystals generally interface with high density MOS integrated circuits without needing any high current driver stages. It doesn't take too much imagination to see a pocket add-subtract-multiply-divide-store calculator thats nothing but a keyboard, a single LSI chip and a display combined with a battery. You end up with a device that's far less complex and far simpler to manufacture than a $2.50 AM transistor radio.

What's available now?

Table I lists the manufacturers of liquid crystal displays. Commercially available units are offered by RCA, OPTEL, and ILIXCO.

RCA initially offers six units. Two are single-numeral 0.75-inch high versions that plug into a PC connector. The TA8032 is a transmissive style while the TA8034 is reflective. Total display power is 35 microwatts at a supply voltage of 12 to 15 volts. The operating temperature range is 5° to 55° Centigrade. (22° C is "room" temperature). Introductory single quantity price is $25, dropping to prices competitive with LED displays in quantity. Since, as we'll see below, the ILIXCO prices in single quantities run $8 per digit, we can expect these introductory prices to drop to reasonable levels very shortly, perhaps by the time this is in print.

The other four RCA units are four-digit ones, two with decimal points for instrument use and two with colons in the middle for clock use. One of each type is reflective and one is transmissive. This is their TA8040-43 series. These are initially offered at $75 each, dropping in quantity to competitive prices with LEDs. The characters are 0.6-inch high and the unit plugs into a conventional PC socket. Total power for four digits is around a milliwatt with all segments energized on 15 volts.

OPTEL has two units, a three-digit 1003 and a 3½-digit model 1053. The 1003 comes with decimal points, while the 1053 has a colon and is intended for clock use. The characters are 0.450 inches high and the power dissipation is 40 microwatts per segment at 20 volts. The operating temperature range is 0 to 50° C, and, as with the others, prices are competitive with LED devices in quantity.

ILIXCO presently offers the lowest prices and widest variety in stock displays. They have ten displays available, ranging from 3½ digits to 8 digits and in both 0.4-inch and 0.8-inch sizes. The 3½-digit versions are offered for clocks, while the intermediate sizes are suitable for digital instruments, and the 8-digit version is intended for pocket calculator use. The prices range from $8 per digit in single quantity down to $5 per digit in 50 lots. The ILIXCO units are bilevel and operate clear down to 5 volts, although operation is best between 7 and 15 volts. Their display appears as a dark blue character on a clear background.

Other stock liquid crystal displays should soon be available from a wide range of manufacturers and it is reasonable to expect the per-digit prices to drop dramatically once serious competition and production economies set in.

Building your own

With commercial units still somewhat expensive for an experimenter's budget, you might like to try building your own liquid crystal display. Sources of materials are listed in Table II. This should be a hot science fair, school, or university project as it is a rather exotic technology that you can still work with yourself on a lab bench or a kitchen table and still come up with a working device.

Probably for openers, 5 grams of *Vari-Light* VL462N at $12.80 and a CG-75 gold coated glass at $1.50 might be a good starting point. You can use one or two mil drafting Mylar (25¢ a sheet at any drafting or photocopy store) for spacing, and might try first building up a simple transmissive system that turns cloudy whenever you apply 15 or 20 volts. You could then try printing an invisible message on the glass with PC photoresist and turning the message on and off with the control voltage. From that point on you should be able to work up your own 7-segment readout, eventually ending up with a leakproof, bubble-free version you can stand on end. There are all sorts of possibilities.

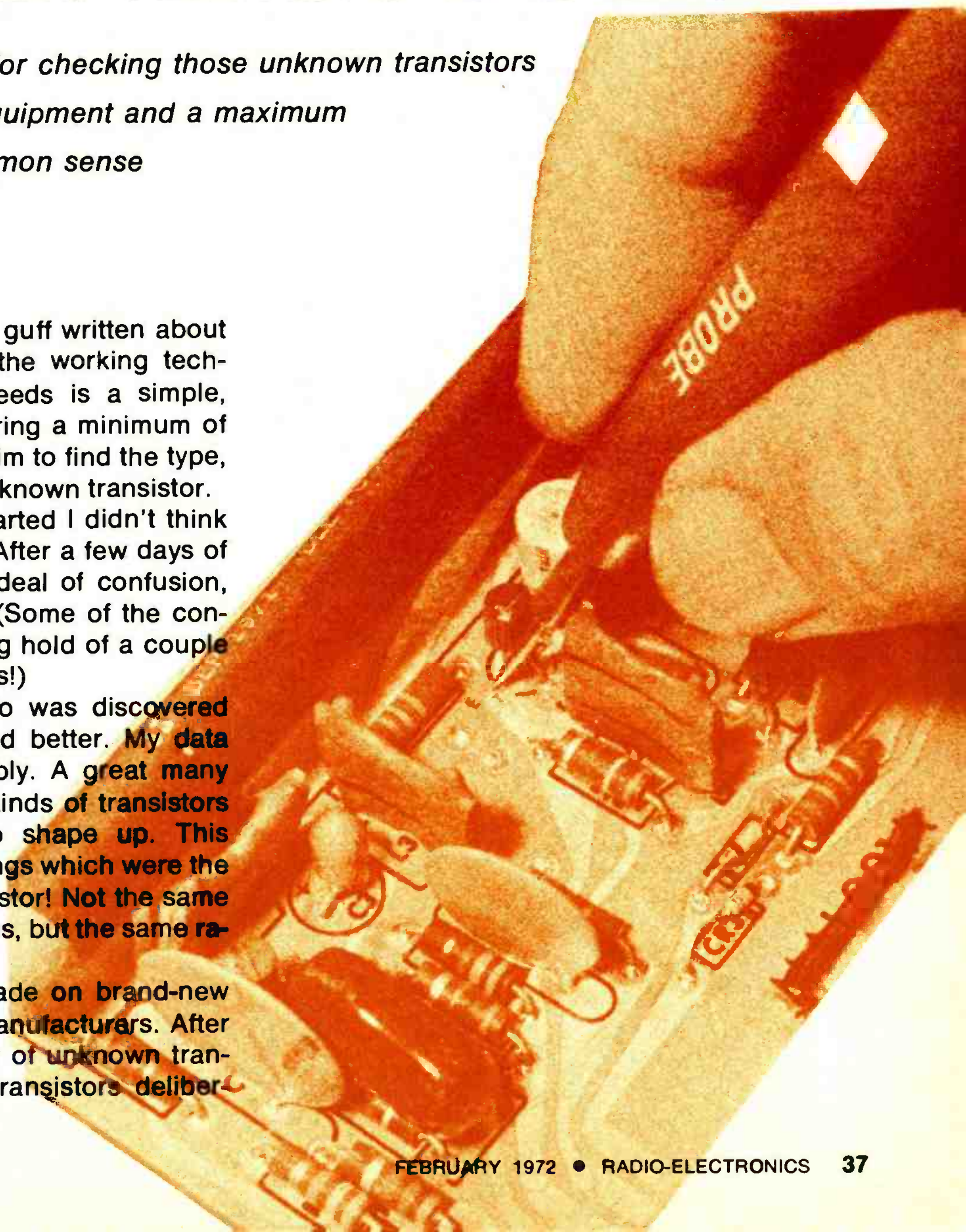
Liquid crystals aren't particularly toxic, but their long-term effects aren't really known and some of them do penetrate the human skin very easily. SO,—

(continued on page 90)

TRANSISTOR TESTING is a cinch

Here is a simple method for checking those unknown transistors with a minimum of test equipment and a maximum of good old ordinary common sense

by ARTHUR CUNNINGHAM



There has been a lot of guff written about transistors. However, what the working technician and experimenter needs is a simple, practical test method, requiring a minimum of equipment. This must help him to find the type, polarity and quality of any unknown transistor.

Quite frankly, when I started I didn't think there was a way to do this. After a few days of experimenting and a great deal of confusion, some light began to dawn. (Some of the confusion was caused by getting hold of a couple of brand-new **bad** transistors!)

After this little imbroglio was discovered and remedied, things looked better. My data began to repeat itself reliably. A great many tests were made, using all kinds of transistors and the pattern started to shape up. This showed characteristic readings which were the *same* for each type of transistor! Not the same in absolute values or readings, but the same **ratio.**

My initial tests were made on brand-new transistors by a variety of manufacturers. After this I tested a large number of unknown transistors, as well as known transistors deliberately left anonymous until tests were finished. In all cases, the method worked. The checks showed the transistors to be the type we knew they were.

Test equipment needed

You will need a minimum of one piece of test equipment—a good ohmmeter! Any good in-circuit/out-of-circuit transistor tester makes it easier and a signal generator/scope enables quick checks to get into the area of the trouble as fast as possible. (There is, of course, only one *infallible* test for any transistor; **Does it work?** If you find the right signal in and the right signal out, forget it; this one is working).

Our biggest problem is identifying unknown transistors. We need to know five things about a transistor: npn? pnp? germanium? silicon? base connections?

With the tests described in this article you can get this information. Of course, it does help to know if the transistor is good or bad, but this is simple. You'll find unmistakable reactions during the tests that will tell you.

Three diodes

The basic test used here is the familiar *three-diode method* (see Fig. 1). Checking between each pair of leads of a transistor with an ohmmeter, you should get a high reading one way, then a much lower reading by reversing the ohmmeter prods; just as if you were checking a diode. This is very obvious, out-of-circuit, and shows up fairly well incircuit, unless there is a very low resistance shunted across the transistor. Even then, you'll usually see enough to help. If you are left in doubt, take the transistor out for a definite out-of-circuit check.

The indicated resistance depends on several things; the material of the junction; the voltage applied by the ohmmeter battery, plus the polarity of the voltage applied! (By the way, despite the many warnings, *I* have never yet damaged a transistor with an ohmmeter. There is apparently enough series resistance in the circuit to hold the current to safe values.)

The "Necessities"

The first step is to determine the polarity of the voltage at your ohmmeter prods. This is the one key point we use in all of the tests to come. We'll mention polarity, and you'll see polarity markings in the diagrams. This means the polarity of the voltage applied by your ohmmeter. Remember that! You can get this by checking the schematic; faster still, just sit the thing on OHMS and read the dc voltage with another meter.

In all the transistorized meters I've seen (TVM and FETVM), the red prod is *POSITIVE*. In the VTVM's, it seems to be *NEGATIVE*. In a lot of VOM's, it will also be negative. (Incidentally, since electronics men are trained to think Red = Positive, if your ohmmeter has a "red negative", just reverse the ohmmeter prods in the jacks, so that red is positive. Believe me, it'll be easier that way, and I won't tell you how I found out.)

Two sets of test leads make it much easier; a set of needle-point prods for in-circuit tests, and another with clips for out-of-circuit test. Use the small clips, with a tight grip; those teeny leads are hard to get a grip on!

Verification

Because of the normal wide variation in transistors, junctions, ohmmeters, and so on, **you will not get exactly the same readings I did.** So, do this: make the same tests yourself, using your own test equipment. Get four new transistors out of stock. One each pnp and npn germanium, and the same in silicon. Now, verify my results! Repeat the tests until you are familiar with the readings for each type, and the connections.

I used three ohmmeters for my tests: a tvm, a vtvm and a vom. Most of the time, I used the R x 100 range. Unless otherwise specified, this is the range I mean. For most checks, use a range that will give you a "low" reading somewhere between center scale and the low part (zero).

The actual reading in ohms is not too important. What is important is the *ratio* between the two, one high and the other low. We'll use the actual (indicated) reading in one test, but once

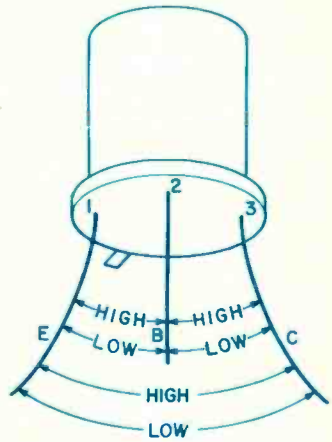


FIG. 1—HIGH-LOW READINGS between each pair of leads, by reversing the prods. This is the "diode-effect".

NPN GERMANIUM − + RESISTANCE: HIGH SHORT BASE TO: E – R GOES DOWN C – R INCREASES SLIGHTLY	NPN GERMANIUM + − RESISTANCE: LOW SHORT BASE TO: E – R GOES UP C – R GOES DOWN	TRANSISTOR: RCA SK-3010
PNP GERMANIUM − + RESISTANCE: LOW SHORT BASE TO: E – R GOES UP C – R GOES DOWN	PNP GERMANIUM + − RESISTANCE: HIGH SHORT BASE TO: E – R GOES DOWN E – R GOES UP SLIGHTLY	TRANSISTOR: RCA SK-3003 VTVM: HICKOK 209 TVM: SENCORE FE-14 VOM: TRIPLETT 625NA
NPN; SILICON − + RESISTANCE: INFINITY SHORT BASE TO: E – R GOES DOWN C – NO CHANGE	NPN SILICON + − RESISTANCE: INFINITY SHORT BASE TO: E – NO CHANGE C – R GOES DOWN	TRANSISTOR: RCA SK-3024
PNP: SILICON − + RESISTANCE: INFINITY SHORT BASE TO: E – NO CHANGE C – R GOES DOWN	PNP: SILICON + − RESISTANCE: INFINITY SHORT BASE TO: E – R GOES DOWN C – NO CHANGE	TRANSISTOR: RCA SK-3025 METERS: SAME AS BEFORE

FIG. 2—OHMMETER TESTS for identifying transistors, out of circuit. Exact resistance readings will vary, but ratios won't. Note effects of shorting base lead to other two, in different types.

more the ratio and not the actual value will be the key clue.

The "High-Low" test method

Start with the clip-leads in the ohmmeter, since it will be easier to begin with the out-of-circuit tests. Pick out any one of your test transistors. Get a piece of scratch paper and make a rough sketch of the basing, showing only the three leads. It may help you keep straightened out (it does for me)!

1. Check for the diode-effect, on all three leads, reversing the prods to make two measurements on each pair. Never mind which leads; this, and the basing, is one of the things we want to find out. If you see the diode-effect, high resistance one way, low with prods reversed, ok. This indicates a good transistor.

2. By trial and error find out which lead has about the same resistance, to the other two. This resistance may not be exactly the same, but it will be the closest match. Now you've got something. **The lead that shows the same *low* resistance to the other two is the *base*.** Mark it. (That's one!)

3. Now we know the polarity of this transistor. If the *negative* ohmmeter lead is on the base, it's a pnp. If the *positive* lead is on the base, npn. (That's two!)

4. Move the clips to the other two leads. Find out which way they show the low resistance. The *positive* lead will be on the *emitter* of a pnp; on the *collector* of an npn. (That's three and four, and we've identified all leads, and the basing!)

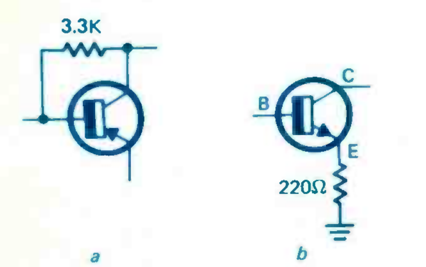


FIG. 3—POSSIBLE IN-CIRCUIT ohmmeter reactions, to different faults.

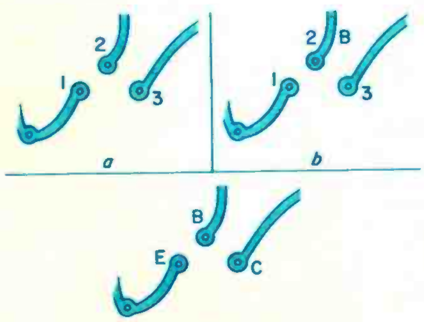


FIG. 4—FINDING THE BASING, type and location of transistor, in unknown set. One step at a time. Sketch helps.

(Up to this point, we haven't had to check the actual value of the indicated resistance. All we've needed is high or low. Having determined the polarity and basing of this transistor, we want to know whether it's germanium or silicon.)

5. Check the reading in the low direction, from collector to emitter. If this is down to a few hundred ohms (200 to 600 ohms was about where they ran for me, on the R x 100 range), and reversing the prods shows about 8 times that, but still a readable deflection, you have a germanium transistor.

If the low resistance is much greater, say around 3000 to 4000 ohms, and the high reading is infinity (no reading at all) the unit under test is a silicon transistor. (Remember to check this with your own ohmmeter!) In small silicon transistors, you will probably get a reading between collector and emitter. In the high-voltage silicon power transistors, you may get infinity in both directions! In some of these, turning up to the R x 1-megohm range may show a "low" reading. This tells you that the collector-emitter junction is not open. Some of the high-voltage silicons, such as HEP-740 (700 volts BV_{ceo}) will not show a reading even on the R x 1-megohm range. (Another test for this coming up!)

Fig. 2 is a chart of the test readings I got on my sample transistors. These tests repeated on quite a few different transistors of all sizes, ratings and makes. So I believe they will be helpful. You might cut this out and paste it on the wall! Polarities shown, I repeat, are those of the ohmmeter! Note the differences between germanium and silicon transistors.

Here is the test I mentioned, for the collector-emitter junction. With the ohmmeter hooked up as shown, note the reaction when you short the base to the other two leads. For example, with the npn and a negative collector, shorting the base to the emitter makes the indicated resistance drop way down. Reversing the polarity of the ohmmeter, and shorting the base to the *collector*, the resistance drops. I believe that this can be used as an indication of a good collector-emitter junction.

The hard part

Now we come to the hard part. Identifying unknown transistors in-circuit. Outside of actual *performance*, in-circuit testing of transistors is always an "iffy" thing. (In other words, "If it works, it's good!") So far, my experience has been that if an in-circuit transistor tester says that it's good, it is. If it says it's bad, it may or may not be. In any case, if you get a bad reading in-circuit, you're going to have to take it out anyway. Repeat the tests; out-of-circuit tests are accurate.

There is one thing which can *never* be checked in-circuit; leakage. There are always so many shunt paths around a transistor circuit that this test is meaningless. Out-of-circuit tests will show you whether it has leakage or not. One good clue to leakage problems is the "Things are almost all right but it doesn't work too well!" symptom. This is where the transistor-tester comes in. It will show you the actual leakage. (Incidentally, all germanium transistors have some leakage. Power types can have up to 200 to 300 μA and still work. Silicons, on the other hand, should normally show zero leakage! even 10 to 20 μA is too much, in power types!) The ohmmeter *will not* read transistor leakage! Don't bother.

However, the ohmmeter does a good job of finding common faults, in-circuit. Shorted transistors will give you the same reading both ways across a junction, usually zero ohms. An open junction will show up by giving you the same reading both ways, usually that of the shunt resistance. Fig. 3 shows a couple of examples. If you read 3300 ohms both ways across the base-collector junction in 3-a, it is probably open. In 3-b, if you read a dead short across the collector-emitter junction, both ways, it's probably shorted. For a definite check, pull the transistor and repeat.

The worst case tests

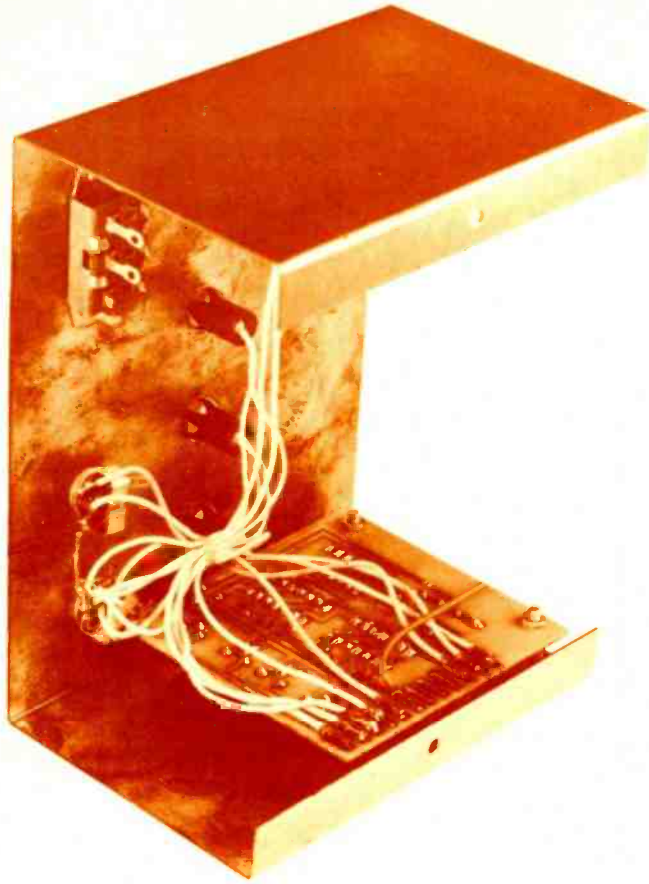
This test if often used by engineers. In our business, the worst possible case would be one of those sets with nothing but a batch of solder-blobs. No identification, no lettering, no nothing.

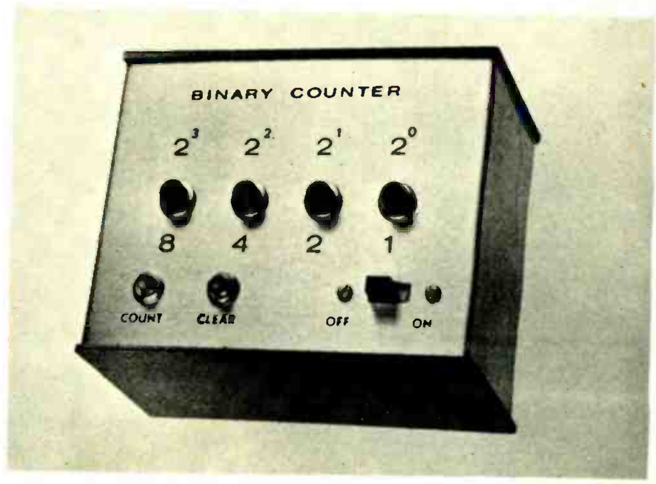
Locate the transistor on the parts-side of the board. Shine a light through the board, and locate the transistor terminals, as in Fig. 4-a. This can be sketched as shown; helps to remember! At first, all we know is that there are three blobs. Number them. Now, put the needle-point prods in the ohmmeter, and away we go.

First checks show a low reading of about the same value between 2 and 1, also 2 and 3. So, we say that 2 is the base (Fig. 4-b). The positive prod is on 2. So, this is an npn. Moving the prods to 1 and 3, we find the low-reading direction. The positive prod is on 3, so this is the collector. By a process of elimination simple enough even for me, 1 is the emitter.

Using the in-circuit transistor tester confirms this. In the LEAKAGE position, we see a full-scale reading set to pnp, and a much lower reading on npn. (We are not using the leakage tester as such; just for a double check on the polarity of the transistor.) However, the tester will not show a beta reading. So pull the transistor, repeat the test, and the tran-

(continued on page 90)





Experiment with a Binary Counting Demonstrator

It's easy to understand counting to the base two when you have a visual aid like this demonstrator to show you what's going on.

by FRANK GROSS

This binary counter demonstrator counts by two's instead of tens, showing the base two arithmetic and counting used by most computers. It counts up to sixteen and can be reset to zero at any time. You use it as a study or teaching aide, or as a science-fair or computer-technology entry, or for a school lab project. It uses three TTL integrated circuits and four transistors and may be built in an evening or two.

Why binary?

People are used to counting by tens, and before "modern math" came along, non-computer people gave very little thought to counting in any number *base* but ten. The problem with *decimal* or *base ten* counting is that you need ten

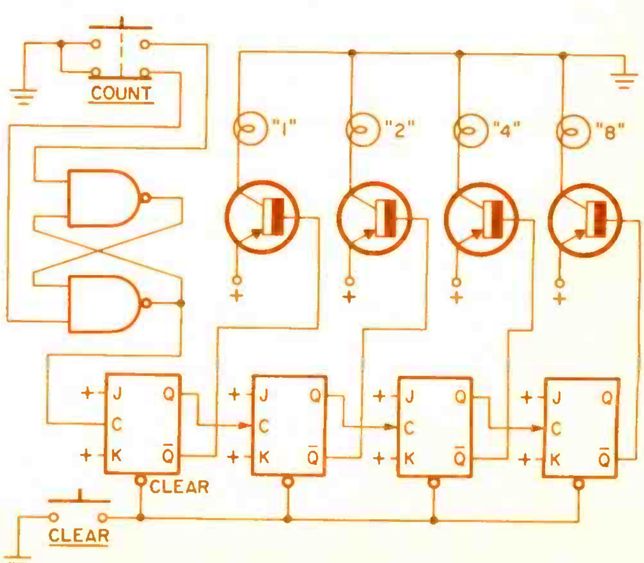


FIG. 1—BASIC LOGIC DIAGRAM of binary ripple counter

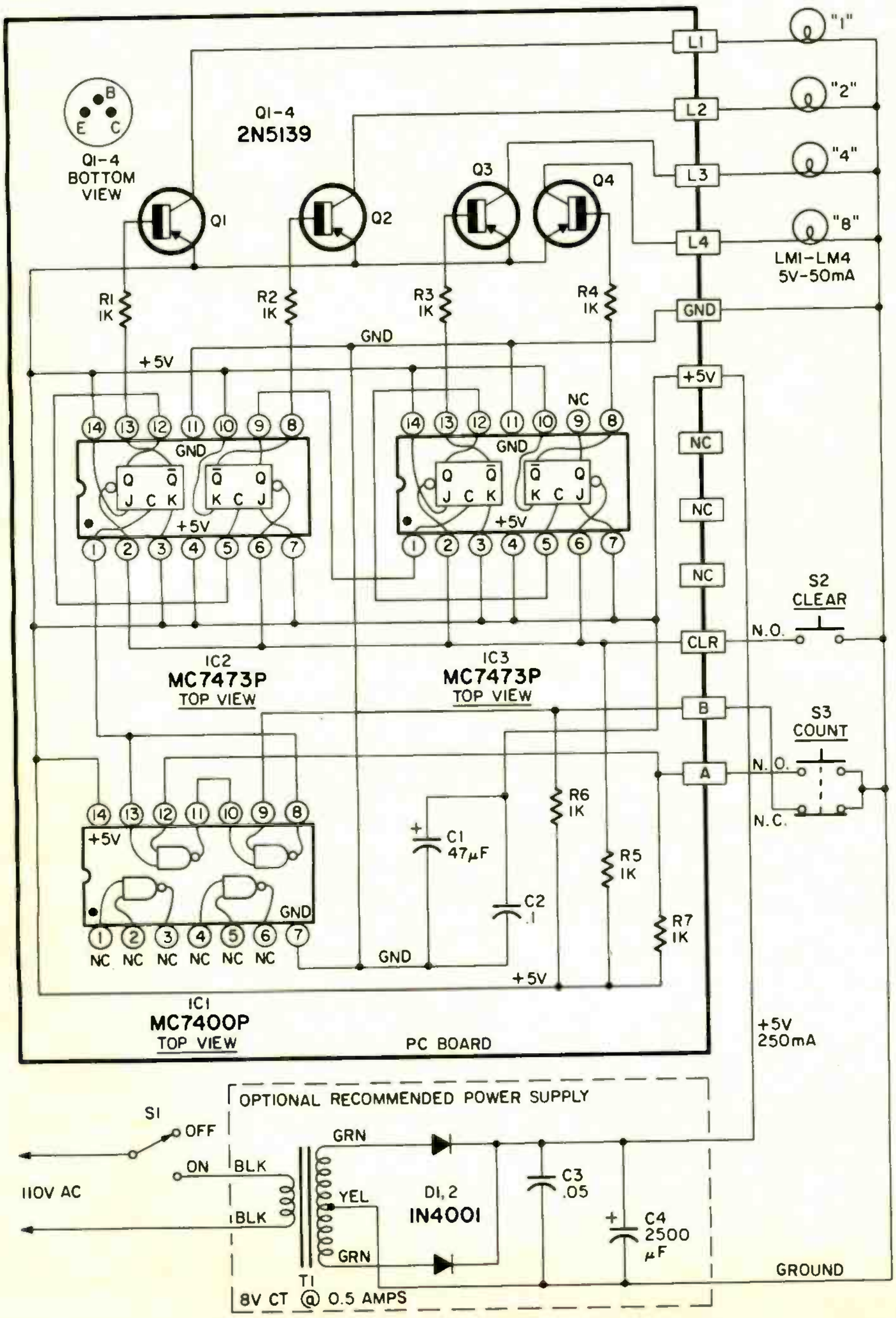
PARTS LIST

C1—47 μF, 15 volts, electrolytic
C2—0.1 μF, 10 volts, disc ceramic
*C3—0.05 μF, mylar or disc ceramic
*C4—2500 μF, 10 volts, electrolytic
*D1, D2—1 amp, 50 PIV silicon power diode, IN4001 or equal
IC1—MC7400P
IC2, IC3—MC7473P
LM1 thru LM4—5-volt 50-mA panel lamp assembly
*S1—spst slide switch
S2—spst normally open pushbutton
S3—spdt pushbutton
Q1 thru Q4—2N5139 transistor (National)
R1 thru R7—1000 ohms, ¼-watt carbon
*T1—8 Vct, 0.5-A transformer
MISC—2½" x 2⅝" PC board; PC Board stand-offs and hardware (4); case; Bottom feet (4); C4 mounting clip*; line cord and strain relief*; 4 lug terminal strip*; wirenut*; power supply hardware*; case hardware; wire; solder; etc . . .

***Parts for power supply**

NOTE: The following items are available from Southwest Technical Products, Box 16297, San Antonio, Texas, 78216:
Etched and drilled PC board No. 183, $1.80
Complete kit of all parts, including prepunched and prefinished case but less power supply, No. 183-K, $8.90

FIG. 2—COMPLETE WORKS of the binary counter. Note that the correct position of the IC's is indicated by the notch in one end.



different symbols (0,1,2,3,4,5,6,7,8, and 9) to represent any number. To do this electronically in the decimal system, we'd have to recognize either ten different voltage levels, or, to get by with loose-tolerance circuits, a signal on one of ten different lines.

In the *binary* or *base two* system, we only need remember two states "1" and "0", or simply "yes" and "no". Just as we move over one decimal point when we get to ten, we move over one *binary point* when we get to two, with the "heavier" numbers always tacked on the left. The binary equivalents for the first sixteen numbers (0-15) are:

DECIMAL		BINARY			
tens	units	8	4	2	1
0	0	0	0	0	0
0	1	0	0	0	1
0	2	0	0	1	0
0	3	0	0	1	1
0	4	0	1	0	0
0	5	0	1	0	1
0	6	0	1	1	0
0	7	0	1	1	1
0	8	1	0	0	0
0	9	1	0	0	1
1	0	1	0	1	0
1	1	1	0	1	1
1	2	1	1	0	0
1	3	1	1	0	1
1	4	1	1	1	0
1	5	1	1	1	1

While binary numbers may appear longer than decimal ones, the looks are deceiving, because ten different states go into a decimal number, while only two are used in binary. To represent a "15" in true decimal form, at least eleven leads would be needed. In binary, it takes only four.

It turns out that binary is the most efficient possible way of storing information and performing arithmetic. It uses the simplest possible storage devices and requires the fewest interconnections. Practically all computers *internally* deal with binary and then make a *binary to decimal conversion* only when they interface with people. When computers (particularly small

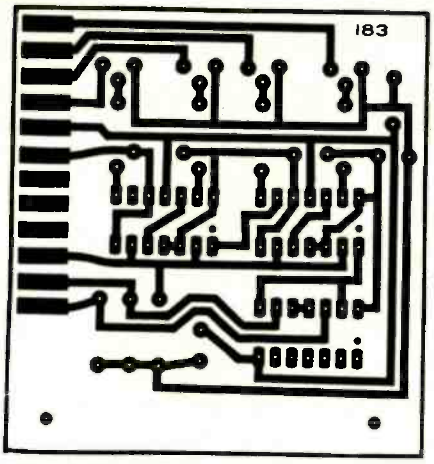
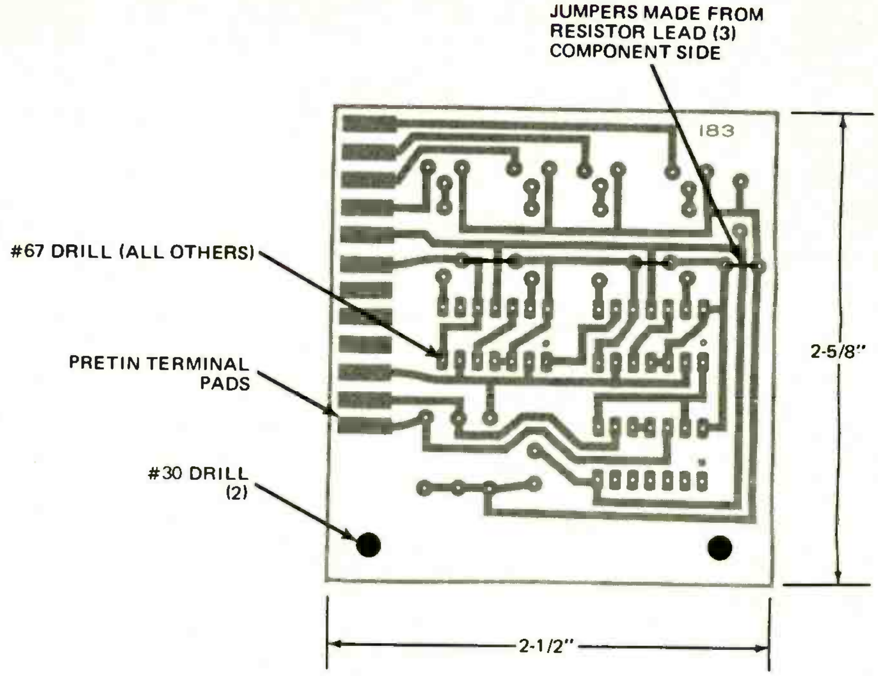
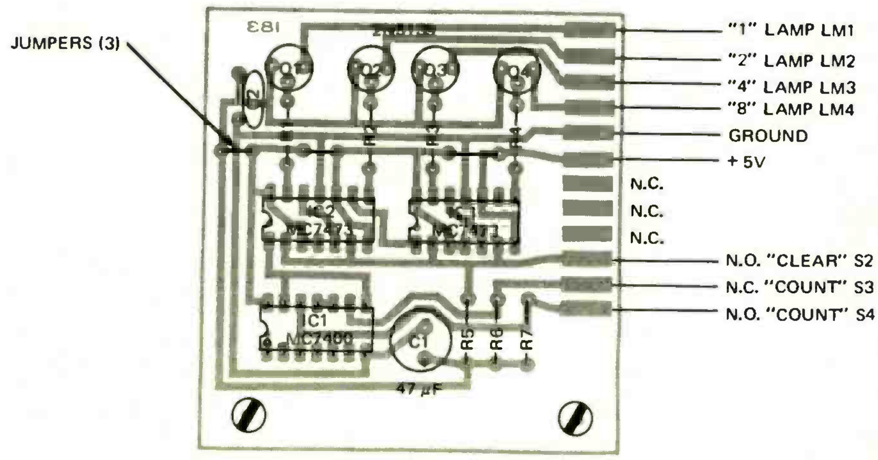


FIG. 3—FULL SIZE diagram of the printed-circuit board as seen from the foil side.

FIG. 4—DRILL AND JUMPER guide for the binary counter circuit board.

FIG. 5—OVERLAY DIAGRAM shows parts mounting positions on the circuit board.





ones) *must* deal with decimal, they re-encode it into a near-binary form, called *Binary Coded Decimal.* (BCD) Even in this form, the numbers can only be handled in 16/10 the space that would be needed for binary, a storage penalty of 60% in the size of a machine. Arithmetic operations in BCD are also proportionately more complex than in straight binary.

How it works

The logic diagram of the demonstrator is shown in Fig. 1. The circuit consists of a four-stage binary ripple counter formed by cascading two dual JK flip-flop TTL integrated circuits. The input COUNT commands from a pushbutton are made noiseless and bounceless by a set-reset contact conditioning flip-flop made of half of a quad two-input gate TTL integrated circuit. Contact conditioning on the CLEAR line is not needed, for resetting a counter to 0000 a dozen times has the same effect as only doing it once. The states of the counters are indicated by connecting the $\bar{Q}$ terminal on each flip-flop to a lamp through an inverting pnp driver transistor.

Construction hints

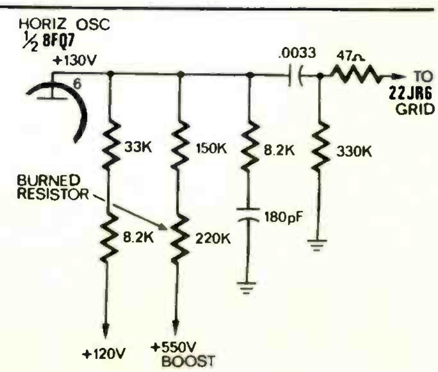
The schematic is in Fig. 2. A printed circuit board is recommended for component mounting. Figs. 3 and 4 show how the board is set up. Three jumpers are needed. These may be made out of cutoff resistor leads and are positioned as shown.

Component locations are shown in Fig. 5. Note the polarity on C1 and the three IC's. The code notch and dot is between pins 1 and 14.

The photos show the internal assembly details. The circuit board is mounted on four standoffs along one end of the case, and leads are soldered directly to their respective pretinned terminal pads. The pilot lamps snap into place. Switch S1 is mounted with suitable hardware.

The binary counter may be powered by a high-quality 5-volt 250-mA lab bench supply, or the power supply shown in Fig. 2 may be built into the bottom of the case.

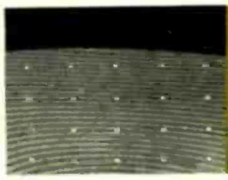
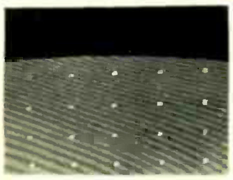
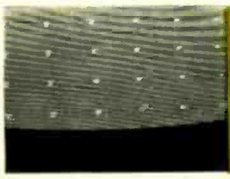
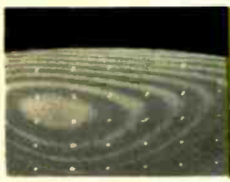
ROLLING PICTURE IN RCA KCS132A



The picture would roll constantly and would not lock-in vertically. When the vertical hold control was rotated the picture would roll up but never downward. The picture would roll slowly upward with the vertical hold control at top end of rotation. Undoubtedly, poor vertical sync. The vertical oscillator tube was changed. All voltages were quite close to what they were supposed to be, yet the picture continued to roll.

A check showed the feedback .0068-µF capacitor at the grid (pin 4) of the 6EM7 was leaky. A replacement restored normal performance. After a few years this capacitor becomes leaky and the picture has a tendency to roll.—*Homer Davidson*

Kwik-Fix™ picture and waveform charts

SCREEN SYMPTOMS AS GUIDES: SYMPTOM PIC	DESCRIPTION	WHERE TO CHECK FIRST: VOLTAGE	WAVEFORM	PART
	Normal dots in top midarea			
	Normal dots in bottom midarea			
	Red and green won't converge at top or at bottom	Point A	WF1	P/S1 open R11 open D4 shorted
	Yellow dots won't converge with blue at top and bottom	no help	WF2	P/S2 open
	Can't converge top and bottom	no help	WF2	P/S3 open R14 open
	Red dots high at top; R14 no effect	no help	WF4	P/S4 open P/S5 open R14 open
	Convergence poor; green dots won't move	no help	WF6	L10 open R11 open R13 open
	Convergence poor; red dots won't move	no help	WF5	L9 open R10 open
	Convergence poor; blue dots won't move	no help	WF4	L8 open C7 open R9 open R12 open

P/S = Plug/socket terminal

NOTES:

Use this Guide to help you find which key voltage or waveform to check first, or to guide you to the causes of symptoms that don't have voltage or waveform clues.

Study the screen with a dot pattern injected to the set. Try each vertical dynamic convergence control. You'll find the most helpful trouble clues at the key test point indicated opposite whatever symptom you observe.

Make voltage or waveform checks whenever indicated for specific screen symptoms.

Use the Voltage Guide or Waveform Guide to analyze the results of your tests.

For a quick check, substitute or test the parts listed as the most likely causes of the symptoms you observe.

The Stages

This vertical dynamic convergence section is typical of those found in most American and Japanese color television receivers. Variant versions among brands generally differ only in rearrangement of controls or occasionally in the way input waveforms are derived.

Dividing the vertical dynamic convergence section into "stages" is difficult. A multiplicity of inputs all combine to form the waveshape applied to each vertical convergence coil. This results in considerable interaction, as you'll discover when you try adjusting the controls. The section gets only vertical sweep signals. Because of the low frequency (60 Hz), no adjustable inductances are used—only resistors or potentiometers.

Each vertical convergence coil is wound on the same core as its counterpart in the horizontal dynamic convergence section. Ignore whatever effect this has on operation of the vertical convergence section.

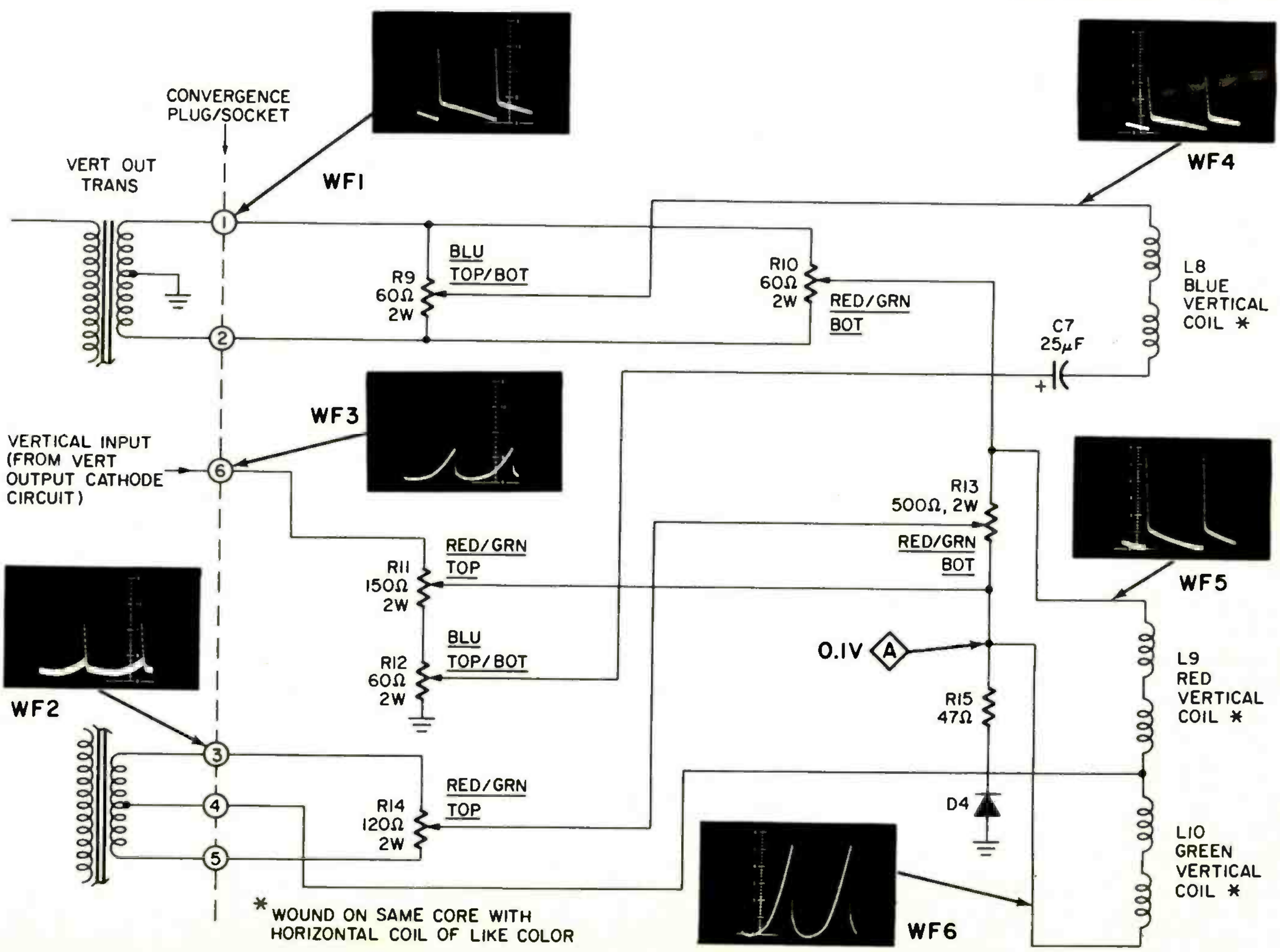
Signal Behavior

Three input signals from the vertical output section of the color receiver drive the vertical dynamic convergence circuit. Two of them come from windings on the vertical output transformer. The other is shaped a bit differently and comes from the cathode circuit of the vertical output tube.

The first input waveform, WF1, comes from a center-tapped winding on the vertical output transformer, with the center tap grounded. (Some sets omit the center-tap on this transformer winding and use a phantom ground through two equal-value resistors.) The signal feeds across a pair of potentiometers. The slider of potentiometer R9 carries the signal to one end of blue vertical convergence coil L8; the slider setting determines what phase of signal reaches that end of the coil. The other potentiometer, R10, feeds the signal to one end of the red vertical dynamic convergence coil; the pot sets the phase.

Another vertical-sweep input waveform comes from a different center-tapped winding on the vertical output transformer. The tap of this winding is not grounded. Potentiometer R14 bridges the whole winding. Its slider selects whichever phase is appropriate for the particular color-CRT gun structure. The slider of R14 carries the selected polarity of waveform to a slider on potentiometer R13, which bridges the red and green vertical coils—not in parallel, but as if the coils were in series. Adjusting R13 applies the signal from R14 more to one coil or the other. The center tap of this same winding is the common return for both red and green vertical coils.

(copy continues on page 50)



DC VOLTAGES AS GUIDES						
Voltage change	**to zero**	**very low**	**low**	**slightly low**	**slightly high**	**high**
Test point A Normal −0.1 V	D4 open D4 shorted R15 open					

NOTES:

Use this guide to help you pinpoint the faulty part.

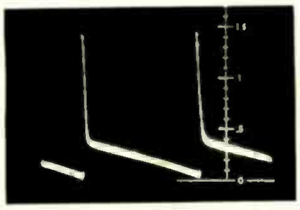
Measure the one key voltage with a vtvm or fetvom.

Notice which part is listed as possibly causing any change you find.

For more help to further narrow down the faulty part, see the Waveforms Guide.

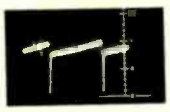
WAVEFORMS AS GUIDES

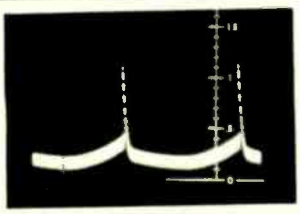
V p-p low	V p-p high	V p-p zero	Changed Shapes			



WF1 Normal 15 V p-p

Taken conveniently at the convergence plug/socket, this waveform comes from a winding of the vertical output transformer. The winding is center-grounded. Amplitude may vary with settings of VERTICAL LINEARITY and HEIGHT in the receiver, but only slightly.

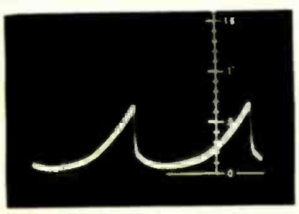
V p-p low	V p-p high	V p-p zero	Changed Shapes			
			 10 V p-p P/S1 open			



WF2 Normal 10 V p-p

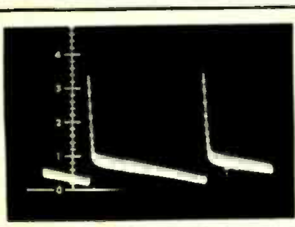
Comes from tapped (but not grounded) winding of vertical output transformer. Has trapezoidal shape, but with some parabolic signal. Some WF3 mixes in at certain settings of R14, R13, and R11. Any of these controls can alter the shape of this waveform, but shape shown is for "normal" convergence settings for average picture-tube gun structure.

V p-p low	V p-p high	V p-p zero	Changed Shapes			
P/S2 open P/S3 open R14 open			 6 V p-p P/S1 open			



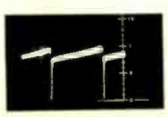
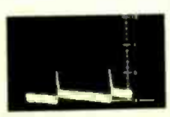
WF3 Normal 7 V p-p

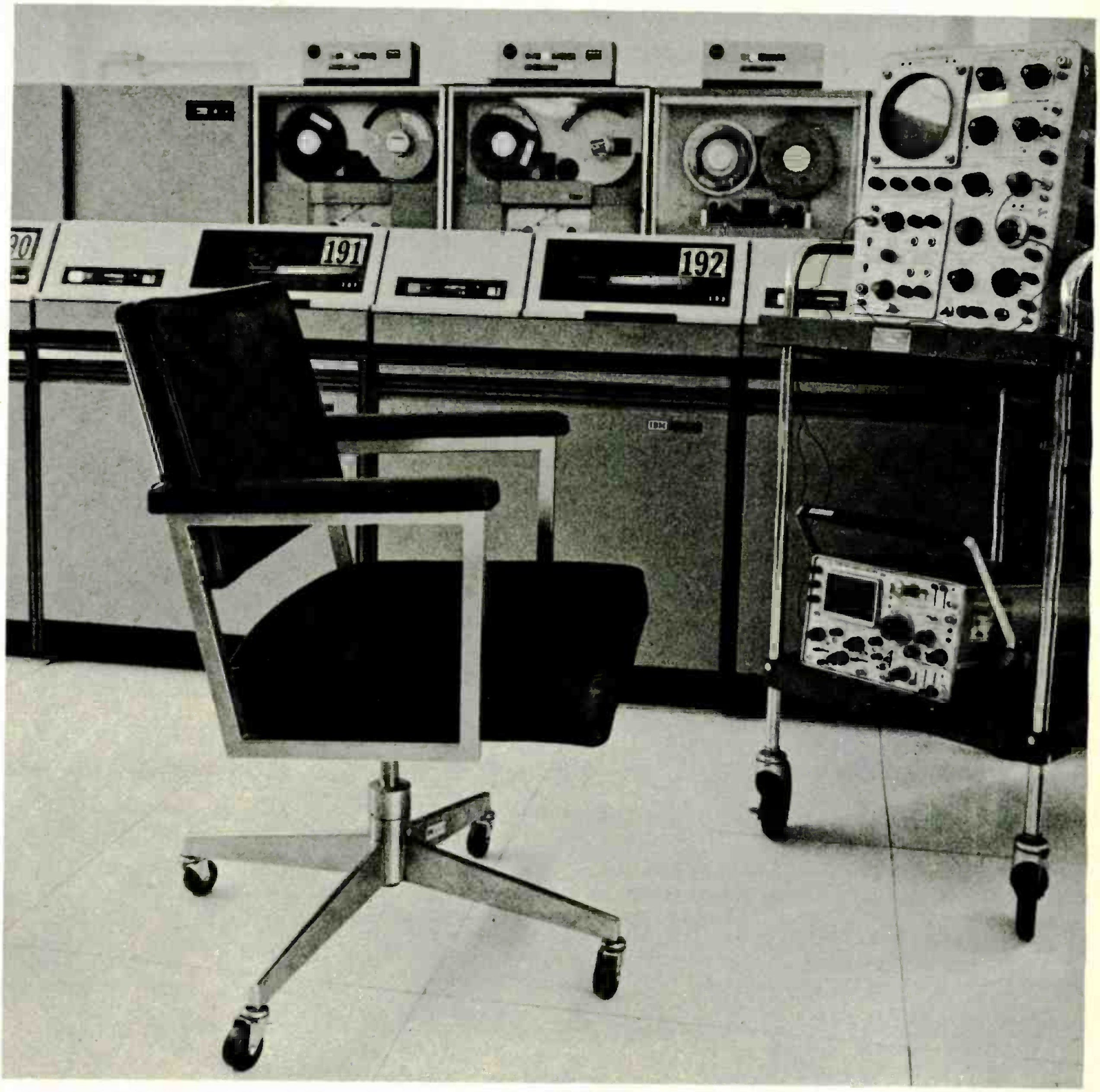
Comes from vertical output cathode, through large-value capacitive divider that imparts integrated parabolic shape. Best place to scope is at convergence plug/socket terminal. Amplitude may depend on settings of Vertical Linearity in receiver, but shape doesn't alter much.



WF4 Normal 4.5 V p-p

Taken at "high" end of blue vertical convergence coil. Consists mostly of trapezoid from vertical output transformer, with phase selected by R9. Can be completely reversed in polarity, depending on conditions, and still be normal. Amplitude, too, depends on settings of controls (R9 and R12). Value given and shape shown is average.

V p-p low	V p-p high	V p-p zero	Changed Shapes			
P/S3 open P/S5 open R14 open	P/S2 open R11 open R12 open		 10 V p-p P/S1 open	 0.5 V p-p R9 open	 10 V p-p R9 open	



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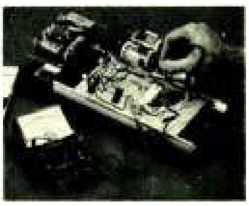

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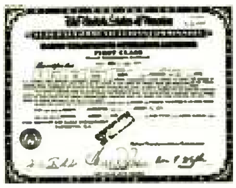

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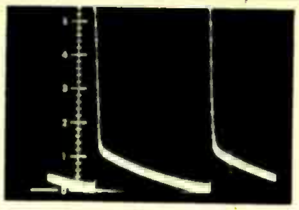
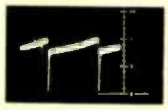
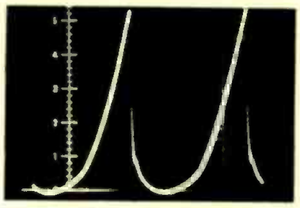
WAVEFORMS AS GUIDES



WF5 Normal 4.5 V p-p

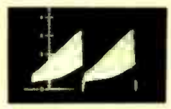
Taken at "high" end of red vertical convergence coil. Consists mainly of trapezoid from same transformer winding as WF4, but with some of WF2 and WF3 mixed in by R13. Amplitude, shape, and polarity depend on control settings needed to put the dogs nearest perfect convergence; those shown are average.

	P/S2 open P/S3 open P/S5 open R14 open		 10 V p-p P/S1 open	 10 V p-p R10 open		



WF6 Normal 4.5 V p-p

Taken at "high" end of green vertical convergence coil. Consists mainly of parabolic waveform from vertical output cathode, but modified by WF9 and WF10 that are mixed in by R13. Amplitude depends on control settings, but shape varies little. Value given is for average picture-tube gun structure.

			 4 V p-p R11 open	 3 V p-p R11 open	 2V p-p R11 open	

NOTES:

Use this Guide and the Voltages Guide to help you pin down fault possibilities.

Set controls for the best convergence possible, even if it's not correct convergence over the whole CRT face. Use dot pattern.

Use the direct probe of the scope. Set the scope sweep to about 30 Hz, to display two cycles.

Check the six waveforms at the six key test points.

Note amplitude. If it's low or high, check the parts listed under those columns.

Note waveshape. If there's a change that matches one shown, check the parts indicated.

The third signal input, taken from the cathode of the vertical output tube, feeds two potentiometers in series. (In some chassis, these potentiometers are in parallel, and one of them has a resistor between its lower end and ground.) The slider of potentiometer R11 feeds a signal to one end of the green vertical coil, much the same as R10 feeds a signal to one end of the red vertical coil. R15 and D4 shape this particular waveform to some extent.

You could consider R13 a mixing pot for signals from (a) R10, (b) R11, and (c) R14. The result goes to the red and green convergence coils.

Potentiometer R12 also takes signals from the vertical output cathode. R12 is in series with R11. (In some designs, they are in parallel.) The slider of R12 feeds signal to one end of the blue vertical coil—the end opposite that fed by R9. Capacitor C7 has a very small effect on shaping. In some chassis, C7 is omitted and replaced by direct connection.

Looking at the three coils, you can see that the waveshape developing across them—that is current developing in them—is a result of differently phased waveforms fed at each end of each coil. The resulting currents make the magnetic fields that "warp" the CRT beams that correspond to the colors of the coils.

DC Distribution

The only dc in this vertical convergence section is developed by D4. Capacitors in the feed line from the vertical output cathode block any dc that might come from there. The dc path to ground through R11 and R12 keep the voltage quite low—a mere fraction of a volt. This clamp voltage is positive (it's negative in the horizontal convergence section).

Station and Control Effects

How much or how little signal is being picked up from a station has no effect on the waveforms in the vertical convergence section. The waveforms come from the vertical output system, which runs whether there is sync or not. However, the six vertical-convergence potentiometers definitely affect waveforms. This effect is easiest to see with a dog pattern on the picture tube face.

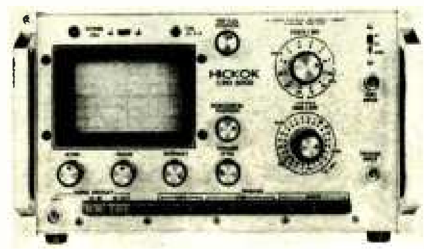
Control R10 affects red and green dots in the area midway across the bottom of the screen. As you twist the potentiometer knob, the red and green dots move further apart or squeeze closer together sideways. Control R13 affects the same dots, but it moves them vertically closer to or further away from each other. The object is alternately to adjust R10 and R13 until the red and green dots superimpose and form yellow dots (with blue killed).

R11 and R14 have a like effect on the dots midway along the top edge of the picture tube screen. As you twist the knob of R11, red and green dots are pulled closer together or pushed further apart in the sideways direction. As you twist R14, the same dots approach or spread apart vertically. Again, the task is to superimpose them to form yellow dots.

R9 and R12 move blue dots at the top and bottom midpoints on the picture tube screen. But the dots move in a little different manner than with the red/green controls. R12 moves either or both sets of dots upward or downward simul-

equipment report

Hickok CRO-5000 Triggered Sweep Scope



Circle 55 on reader service card

THE HICKOK CRO-5000 OSCILLOSCOPE is quite an instrument. It's described in the manual as a "general-purpose high-frequency scope for use in development laboratories, production testing and precision electronics servicing work." I'll take that.

The spec's are impressive: vertical amplifier bandwidth up to 25 MHz with usable response to 50 MHz; ac or dc coupled input, with the choice of a high-pass or low-pass filter for getting the best results; triggered sweep, with a selector to allow triggering on either the positive- or negative-going slope of the waveform; a horizontal sweep from 50 nsec per division up to two seconds/division; a built-in calibrator, square wave at 1.0 kHz, and so on.

The horizontal sweep (TIME/DIV) and vertical gain (VOLTS/DIV) each are controlled by a single knob. Calibration is in "1-2-5-" steps for both. A continuous control for the horizontal sweep is provided by a center-knob. To calibrate, it is turned full CCW until you feel the switch click. From then on voltage and frequency can be read directly from the dials.

Any voltage and frequency can literally be read with a "twist of the wrist," and counting the divisions of the graticule covered by the waveform. This is possibly the fastest scope I have ever used in that respect. Dc levels in the waveform can be read just as easily. The input switch is set to dc, and the undeflected line adjusted to the bottom line of the graticule. Ac peak-to-peak voltages are read by counting divisions and multiplying by the calibration setting. (4 divisions, at 1.0 V/div = 4.0 volts peak-to-peak.) On the highest voltage range, 50 V/div, you can read 300 V peak-to-peak, since the graticule has 6 major divisions. With the 10:1 low-capacitance probe, the maximum voltage is multiplied by 10, for a reading of 3,000 V peak-to-peak.

You can use any of three vertical inputs: AC-LF, which is flat from 5 Hz up to about 100 kHz; AC-HF with a high-pass filter, flat from about 500 Hz up to more than 10 MHz, with only -3 dB at 25 MHz, and usable response to 50 MHz, or dc with the same hf response as the AC-HF position, and low-frequency response all the way down.

The triggered-sweep can be used for "instant-locked" observation of any waveform. Triggering on the positive-or negative-going slope of the wave makes it easy. Just push the + or the – button. For setup, or for applications where the triggered sweep isn't necessary, the AUTO button is pushed. This switches the sweep back to manual, and it runs constantly. This is useful for the quick testing through any kind of circuitry, to find out where the signal stops. As usual, we put the CRO-5000 through its paces on the test bench on actual TV troubles. The CRO-5000 came through with flying colors. It is everything a technician could possibly want.

All of the operating controls are logically placed. Vertical and horizontal controls have large knobs, and are set close to each other. Calibration is plain and easy to read. The TRIGGER LEVEL control is near them, and these are the most-used ones. The position controls are placed below and up the right side of the screen. All the rest are pushbuttons, in a handy row along the bottom of the front panel.

External triggering can be used, as well as internal and line-sync. External horizontal sweep can also be used, through a jack on the panel. These are controlled by the pushbottons.

A special flat-face CRT is used, with a rectangular screen. This is recessed to reduce glare. However, the trace is very bright and sharp, and it could be used in any room even with high-intensity lighting.

There was only one thing I didn't like about this tremendous scope—having to send it back! **R-E**

KWIK FIX TROUBLESHOOTING CHARTS
(concluded)

taneously. R9, on the other hand, moves top blue dots upward and bottom blue dots downward or else moves bottom blue dots upward and top blue dots downward. The objective is to arrange the blue dots so they superimpose with yellow dots to form white dots.

If blue dots at the top or bottom don't align correctly, you may have to get them in nearly the same positions (with respect to yellow) as those in the center of the pix tube and then converge with the static magnets. That was done before any convergence was started, but you may have to readjust static convergence from time to time all through dynamic convergence.

Quick Troubleshooting

Almost the only components in the vertical dynamic convergence section are the six controls and the three convergence-yoke coils. The dots on the screen—or their lack of movement—generally give enough clues to tell whether a part is bad or not.

If a coil is open, none of the controls that move that particular color of dot has any effect. The same controls might affect other dots. For example, if the red coil is open, the red/green controls (all except R9 and R12) will effect green dots but red dots just sit there. If green dots won't move and red will, the green coil is probably open. If the blue coil is open, red and green dots move, but neither R9 nor R12 will move blue dots.

On the other hand, if only one control is bad, the other controls will usually affect the dots they should.

Another easy way to check out convergence-board components is with an ohmmeter. The only trouble is, you have to disconnect one end of just about any component on the board if you're going to see what its resistance is. Generally, on the vertical convergence portion of the panel, you can get a better idea from how the controls affect the dots they are supposed to control. **R-E**

Scope Analysis of

The technician's most valuable

for a specialized

ALTHOUGH THE HARMONIC-DISTORTION meter and the intermodulation analyzer are *the* specialized instruments for measuring audio distortion, the oscilloscope can also be useful. A scope is particularly helpful in identifying the type(s) of distortion in various trouble situations. The scope may be used directly, or with a harmonic-distortion meter. Nearly all tests of hi-fi equipment place exacting requirements on scope characteristics, as will be explained.

Sinewave displays

Let's start with a review of sinewave displays. Fig. 1 is the basic test setup. The load resistor should have a resistance roughly that of the rated amplifier output impedance and must also have a power rating at least equal to the maximum rated power output of the amplifier. Note that the audio oscillator must have a lower percentage distortion rating than the amplifier under test. Similarly, the vertical amplifier of the scope must have a lower distortion figure than the amplifier rating. Otherwise, the test results become meaningless—we will be measuring test-equipment deficiencies rather than amplifier performance.

Tests can be made at various levels of amplifier power output, but the most useful test is usually the one made at maximum rated power output. Most types of distortion show up most prominently at maximum output, although there are a few exceptions. For example, crossover distortion is greater at *low* levels. Therefore, low-level performance must not be ignored.

Distortion must be appreciable before it becomes easy to see, when the method shown in Fig. 1 is employed. For example, Fig. 2 shows 1-kHz sinewave patterns displayed when the output from the audio oscillator is fed directly into the vertical input terminals of the scope. Although high-quality instruments were used in this example, there is of course a slight amount of distortion. But even a highly experienced scope operator could not state the approximate percentage nor identify the types of distortion in the display.

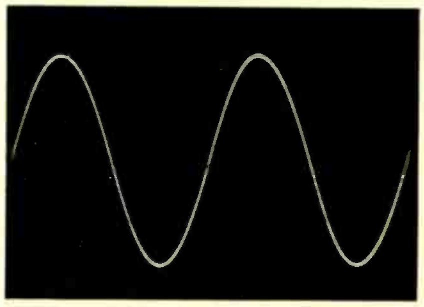


FIG. 2—REFERENCE PATTERN when audio oscillator is connected direct to the scope.

A reference pattern like that of Fig. 2 should always be set up and observed before making measurements. Not only does it serve as a check on instrument condition, but it also establishes a standard for subsequent observations. Next, let us consider the pattern that is displayed when the 1-kHz sinewave voltage is passed through an amplifier operating with 1% harmonic distortion. Fig. 3 shows the resulting pattern. Note that although this waveform contains 1% more distortion than the waveform illustrated in Fig. 2, it is very difficult to discern the difference.

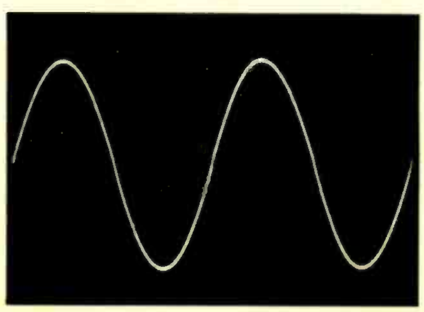


FIG. 3—THIS WAVEFORM has one percent more distortion than the one shown in Fig. 2.

When an amplifier operates at 2% harmonic distortion, the operator may be able to observe a departure from the reference pattern. For example, Fig. 4 is an example of 2% harmonic distortion. In this case, the distortion is caused by positive peak compression. This is one of the most common forms of audio distortion: it is caused by a nonlinear transfer characteristic, as depicted in Fig. 5. In this example, the bias point is incorrect. Note that even when the bias point is correct, overdriving inevitably results in double-peak compression or clipping, as shown in Fig. 6.

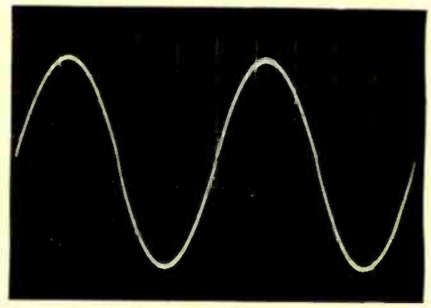


FIG. 4—TWO PER CENT MORE distortion than the waveform of Fig. 2 becomes noticeable.

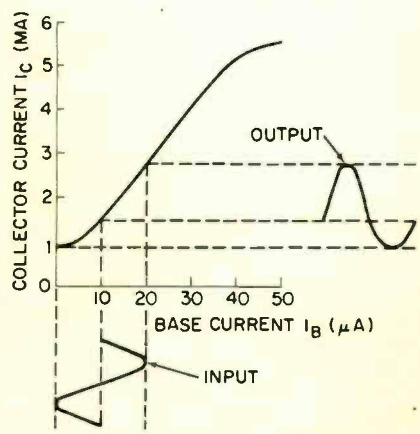


FIG. 5—DISTORTION due to wrong bias.

Higher percentages of distortion are progressively easier to observe in sine-wave patterns, as in Fig. 7. These are also examples of positive-peak compression. The relation of second-harmonic distortion to peak compression or clipping is depicted in Fig. 8. In-

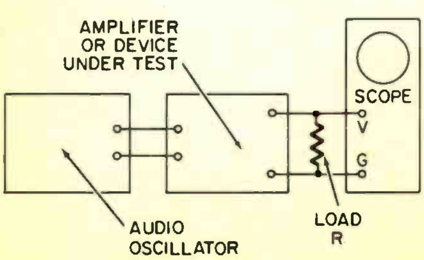


FIG. 1—TEST SETUP for sinewave display.

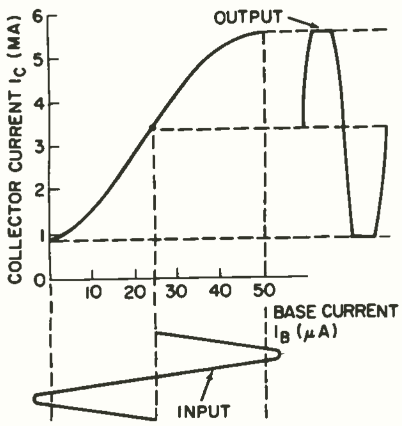


FIG. 6—OVERDRIVING, even with correct bias, will cause a clipping type of distortion.

troducing a second harmonic results in reducing one peak amplitude and increasing the other in the resultant complex waveform. (In general, we can state that unsymmetrical distortion is caused by even-order harmonics, while sym-

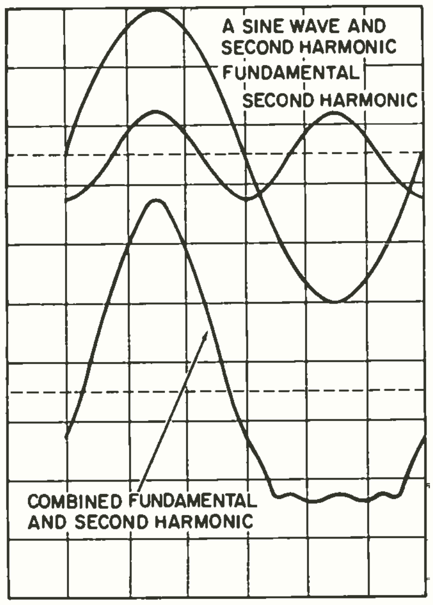


FIG. 8—SECOND HARMONIC distortion and its relation to peak compression or clipping.

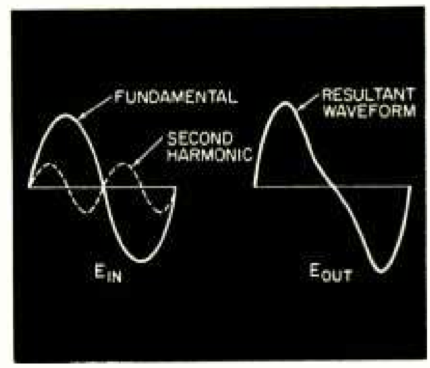


FIG. 9—MIRROR IMAGE DISTORTION due to phase of the second harmonic insertion.

more amplifier output voltage than input voltage; and since the horizontal amplifier usually has less gain than the vertical amplifier, the arrangement shown in Fig. 10 is generally most practical.

Audio Distortion

instrument can often substitute

audio analyzer

by ROBERT G. MIDDLETON

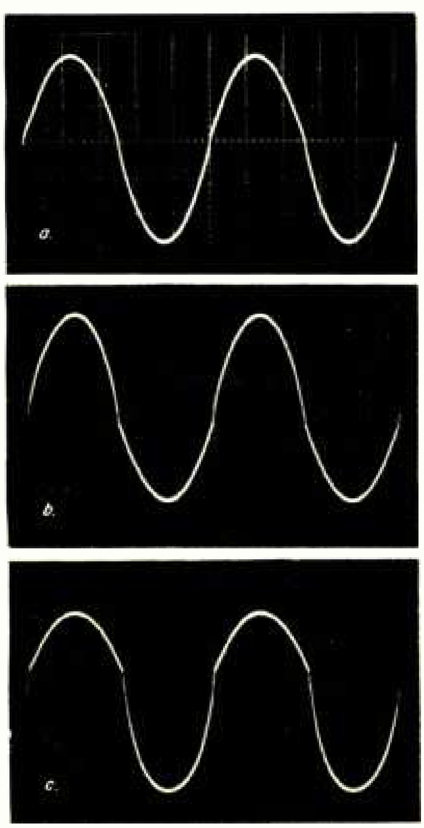


FIG. 7—POSITIVE PEAK COMPRESSION: a—3% harmonic distortion, b—5%, c—10%.

metrical distortion is caused by odd-order harmonics.)

Although the ear has little or no discrimination for phase distortion, the resultant waveform of a fundamental and second harmonic changes greatly with phase shift, and is very prominent in a scope pattern. As an example, if a second harmonic is introduced into a sine wave with the phase shown in Fig. 9, peak compression does not occur. Instead, a mirror-image type of nonlinear distortion takes place. Note also that a harmonic-distortion meter is "like" the ear in that it has little or no response to harmonic phase relations.

Lissajous displays

It is easier to discern small percentages of distortion in scope patterns if we use Lissajous patterns. Fig. 10 shows the basic test setup. A linear time base is not used. Instead, the amplifier input waveform is fed into the vertical channel of the scope, and the amplifier output waveform is fed into the horizontal channel. Although the amplifier roles could be reversed, we usually have

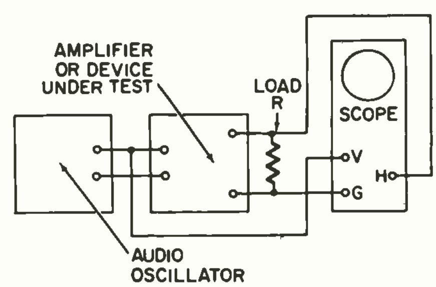


FIG. 10—LISSAJOUS DISPLAYS can be obtained with the test setup of this figure.

Note that the audio oscillator need not meet hi-fi standards to be useful in Fig. 10. That is, the test setup is largely immune to distortion in the audio-oscillator output waveform. On the other hand, the scope must have hi-fi vertical and horizontal amplifiers. Otherwise distortion in the scope will be charged against the amplifier under test in most cases. It is advisable to make a preliminary equipment check by omitting the amplifier in Fig. 10 and driving the scope's vertical and horizontal amplifiers directly from the audio oscillator. If the scope has hi-fi amplifiers, a straight diagonal line will be displayed, as illustrated in Fig. 11-a.

Since no scope can be absolutely perfect, there is a slight amount of distortion in the pattern on Fig. 11-a, although it cannot be discerned. Next, when an amplifier operating with 1% harmonic distortion is checked, we note that this amount of distortion is evident, although it might be overlooked by the inexperienced observer. Note in Fig.

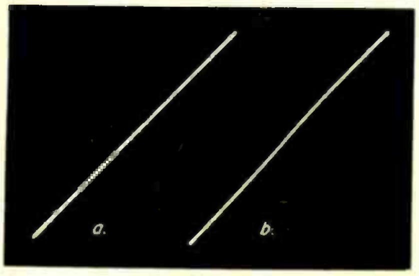


FIG. 11—AMPLIFIER OUTPUT Lissajous display. a—negligible, b—1% distortion.

11-b that if a straightedge is held against the displayed line, a definite curvature is apparent. This is also the case if we sight along the displayed line from end to end.

Although no industry standards have been established, it is generally agreed that high-fidelity reproduction entails a harmonic-distortion figure of less than 1%. Thus, the examples shown in Fig. 12 exceed high-fidelity limits.

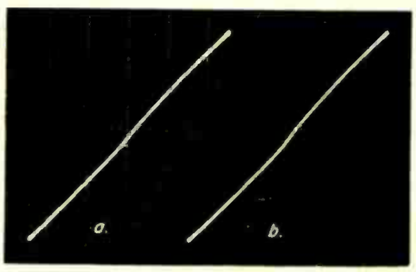


FIG. 12—INCREASING DISTORTION is easy to see. a—1.5%, b—2% harmonic distortion.

These tests were made at 1 kHz, which is the standard single-test frequency. The particular curvature in the patterns is characteristic of peak distortion, and is essentially independent of the test frequency. Fig. 13 shows similar patterns

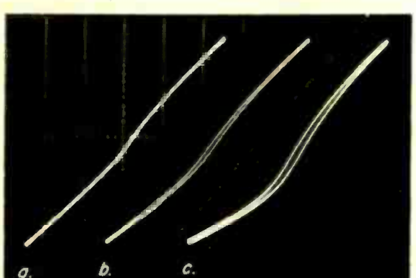


FIG. 13—LISSAJOUS PATTERNS for peak compression at 3, 5 and 10% harmonic distortion.

for higher percentages of distortion. Note that the traces are visibly separated for the examples of 5% and 10% distortion. This is an indication of harmonic phase shift, in comparison to the

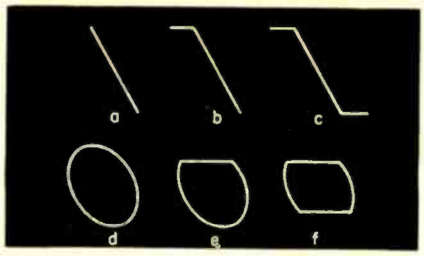


FIG. 14—CLASSIC AUDIO PATTERNS. a—no overload, no phase shift; b—peak clipping, no phase shift; c—double peak clipping, no phase shift; d—phase shift, no amplitude distortion; e—phase shift and peak clipping; f—phase shift and double peak clipping.

foregoing photos.

Fig. 14 depicts the basic amplitude and phase-shift Lissajous patterns. We observe that clipping produces a sharp discontinuity in the pattern. All ac-coupled audio amplifiers shift phase in the vicinity of their high-frequency and low-frequency cutoff points. A dc-coupled audio amplifier exhibits phase shift only in the vicinity of its high-frequency cutoff point, since its low-frequency cutoff point is zero Hz. As noted previously, the percentage of harmonic distortion due to crossover distortion increases as the output power is reduced.

Analysis of distortion products

An oscilloscope is also useful for checking harmonic-distortion products, as shown in Fig. 15. This application is

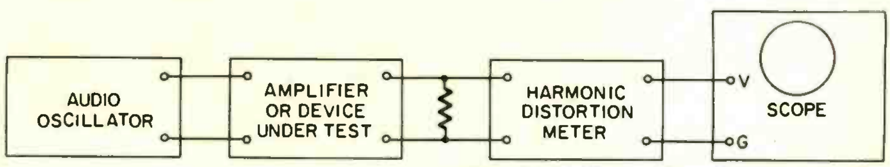


FIG. 15—HARMONIC DISTORTION TEST, setup for analyzing the distortion products.

least demanding on scope performance, and any service-type scope can be utilized. When the harmonic-distortion meter is adjusted to reject the test frequency (such as 1 kHz), the scope then displays the waveform of the distortion products. This is very seldom a second harmonic alone, a third harmonic alone, or a mixture solely of second and third harmonics. In most situations, we will find a distortion waveform that consists of a number of even and odd harmonics. However, one harmonic, such as the second or the third harmonic, is usually dominant. This can be determined by using the scope to measure the frequency of the complex distortion waveform.

Frequency can be measured easily if the scope has calibrated sweeps. For example, if the test frequency is 1 kHz, and the period of the distortion waveform is 500 μs, we know that the dominant distortion product is the second harmonic. On the other hand, if the scope does not have calibrated sweeps, a simple comparison test will determine the period of the distortion waveform. The scope is adjusted to display one complete cycle when the harmonic-distortion meter is set to feed the input waveform through. Then, when the harmonic-distortion meter is adjusted to reject the test frequency, we observe how many cycles of the distortion waveform are displayed on the scope screen. For example, if three cycles are displayed, we know that the dominant distortion product is the third harmonic.

Note that phase relations are not troublesome in most cases. For example, Fig. 16 depicts a distortion waveform made up of a dominant second harmonic with a subordinate sixth harmonic. In these two examples, the sixth harmonic has zero phase and 180° phase respectively, with respect to the second harmonic. However, the number of zero crossovers remains the same, and the period of the complex distortion waveform is unchanged.

Finally, we may note that apparent harmonic distortion might be hum distortion in whole or in part. In either case, scope analysis of the distortion waveform will quickly show whether 60-Hz or 120-Hz hum voltage may be present.

Conclusion

Although the harmonic-distortion meter is the basic instrument for measurement of audio distortion, the os-

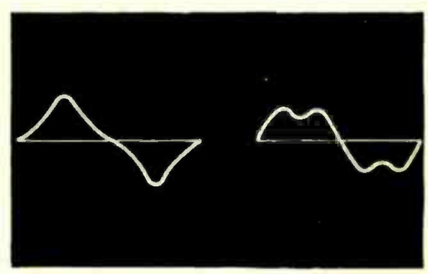
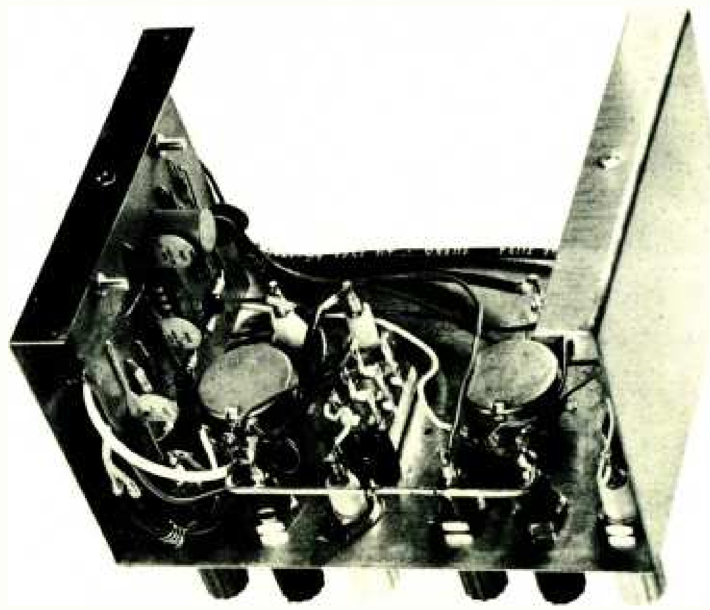
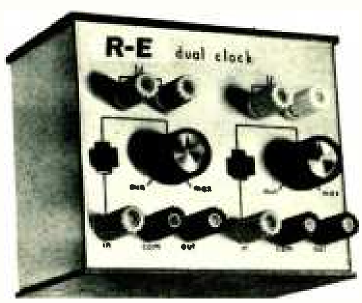


FIG. 16—THESE TWO distortion waveforms are alike except for relative phase relations.

cilloscope is a useful supplementary instrument. When an HD meter is not available, a scope can be used for qualitative and even for rough quantitative analysis of distortion. The most useful approach is to display an input-output Lissajous pattern. To obtain meaningful results, both the vertical and the horizontal amplifiers of the scope should have hi-fi characteristics. A scope is also useful for checking harmonic-distortion products in audio circuits when used with an harmonic-distortion meter. **R-E**

Universal dual signal source for audio testing, digital logic, electronic music synthesis, SWL and ham BFO'S, panic alarms, sirens, birdcalls, calibrators, signal generators, squawkers, etc. . . .





Solid-State Dual-Clock Generator

by DON LANCASTER

HERE'S A UNIVERSAL SHORTPROOF DUAL oscillator that virtually anyone in electronics can use and easily afford. Snap on a capacitor and out comes a stable, buffered, 3-volt high symmetrical square wave of any frequency you want from once every ten seconds up to 30 MHz. If you want, you can knob tune the frequency over a 3.5 to 1 range with a single capacitor, or voltage control the thing with an external 3- to 5-volt dc control voltage.

The output directly drives TTL, RTL, DTL, or low-threshold MOS integrated circuits, and with a good power supply, the frequency is stable enough for music synthesis and metronome work. A speaker can be driven directly by the output to useful volume levels. If you need more stability, just replace the capacitor with a crystal from 3 to 30 MHz and you have a crystal-controlled source.

You can use just one of the clocks, use both clocks separately, or you can let the one clock control the other one, useful for sirens, two-tone alarms, toneburst testing, etc. Hams and SWL's might like to put a crystal calibrator on one half and a bfo on the other.

Cost and complexity? A single $2.40 integrated circuit does the whole job, helped along with two optional 25¢ transistors. You provide the power supply—either 5 volts from a regulated bench source or 4.5 to 6 volts worth of D cells.

Construction hints

The schematic is in Fig. 1. The heart of the circuit is IC1, a dual buffered TTL astable multivibrator. The multi's frequency is controlled by an external capacitor along with a control voltage input. For no frequency adjustment, you clamp the control voltage to +5. For pot control, you run it to a pot that lets the voltage run from +2.5 to +5. Or for external use, you bring out the voltage control directly.

Note that there are three supply voltages and three ground connections that must be made to the IC. B+ to the oscillators must be R-C decoupled to prevent interaction between both circuit halves. The oscillators *cannot* be gated by applying and removing B+ because of a sneak path through from the voltage control input. Thus, to electronically gate (or turn on and off) the oscillator, you break the ground side to the oscillator. This is done optionally by transistors Q1 and Q2. If you don't need gating, just replace these transistors with a solid ground connection. +2 to +5 volts at the GATE terminal turns ON the clock. Ground shuts it off.

A small printed circuit simplifies assembly. You can make your own using the layout guide of Fig. 2, along with the mechanical and layout guides of Figs. 3 and 4. Be sure to observe the code notch and dot when inserting the IC and use a low-wattage iron and fine solder during assembly.

The printed circuit mounts on the side of a small case, with each clock's input, output, and capacitor binding posts going on the top, along with a frequency-adjust pot. Since this is a 30-MHz device and circuit, lead routing can be critical and cause noise and interaction problems. To solve these problems, use short pieces of coax (miniature 50-ohm RG-174 is ideal) to reach the capacitor binding posts. Use one piece of coax for each binding post and ground the coax only at the printed-circuit end. Also, use a sturdy No. 12 or

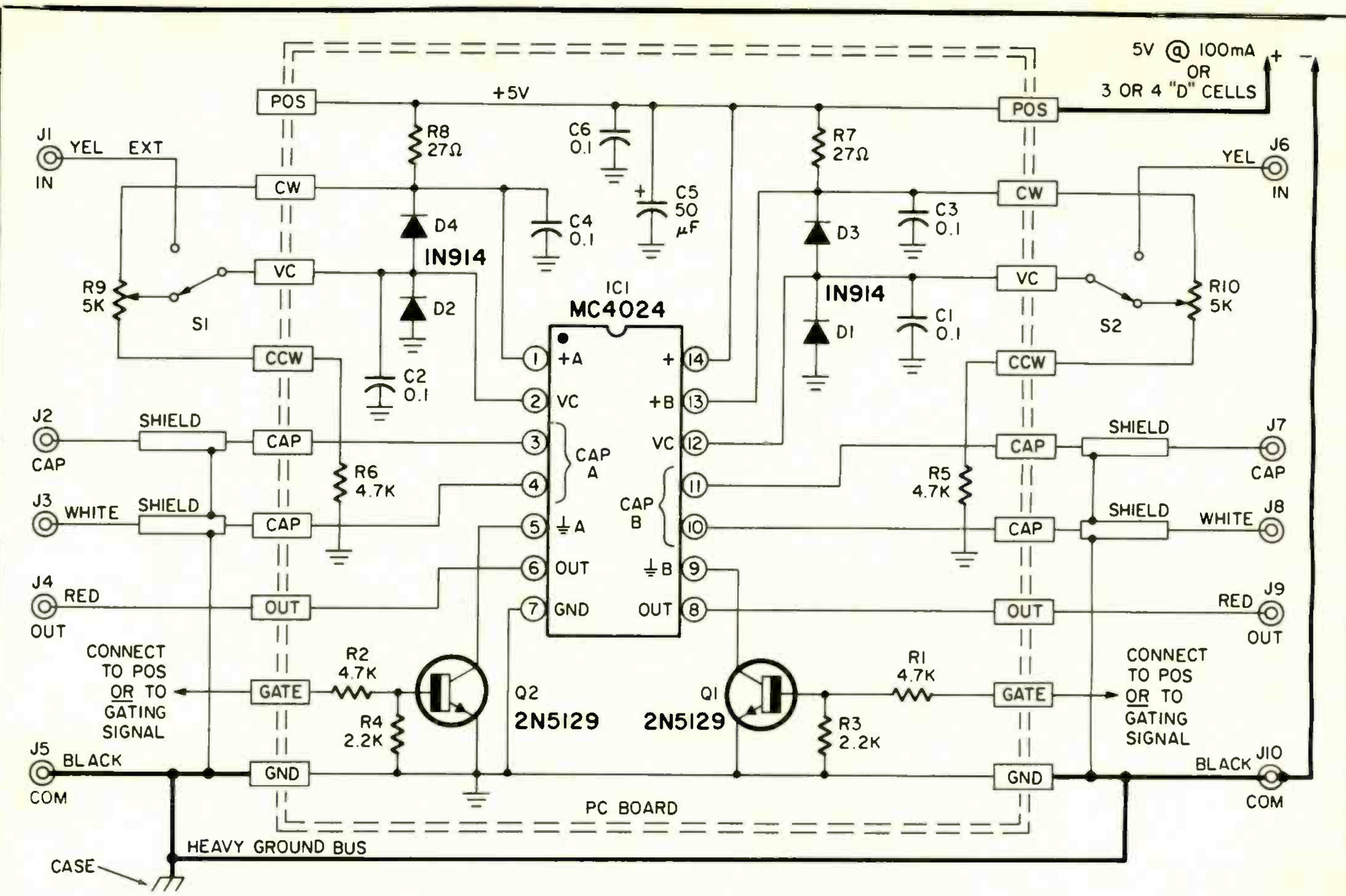


FIG. 1—COMPLETE SCHEMATIC of the dual clock. It's a versatile dual-output signal generator that has a thousand and one uses around the shop. And you can build it around a single IC and a pair of low-cost diodes.

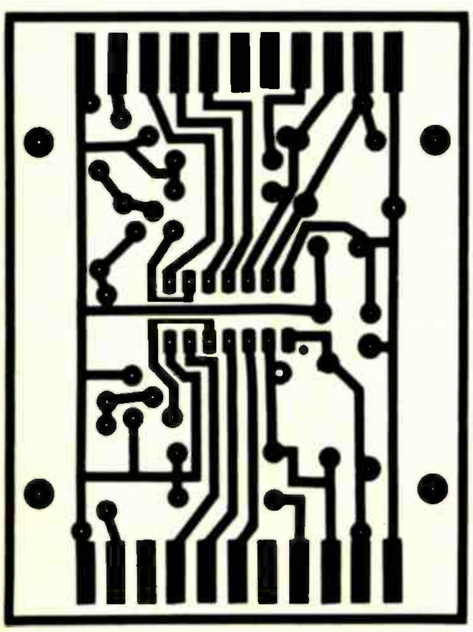


FIG. 2—FULL SIZE PATTERN for the dual-clock circuit board.

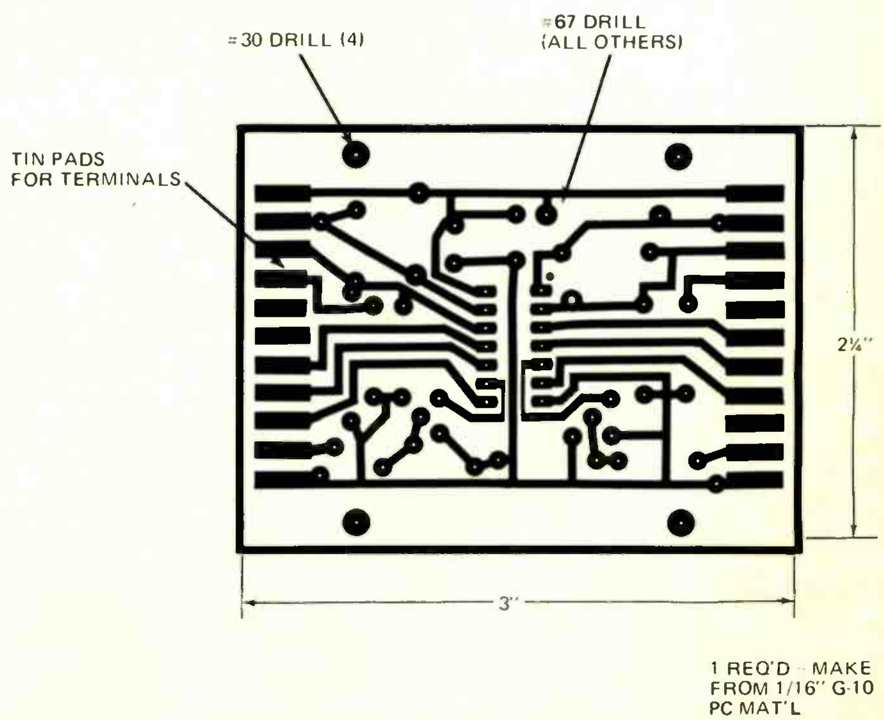


FIG. 3—DRILLING GUIDE shows proper hole sizes for board.

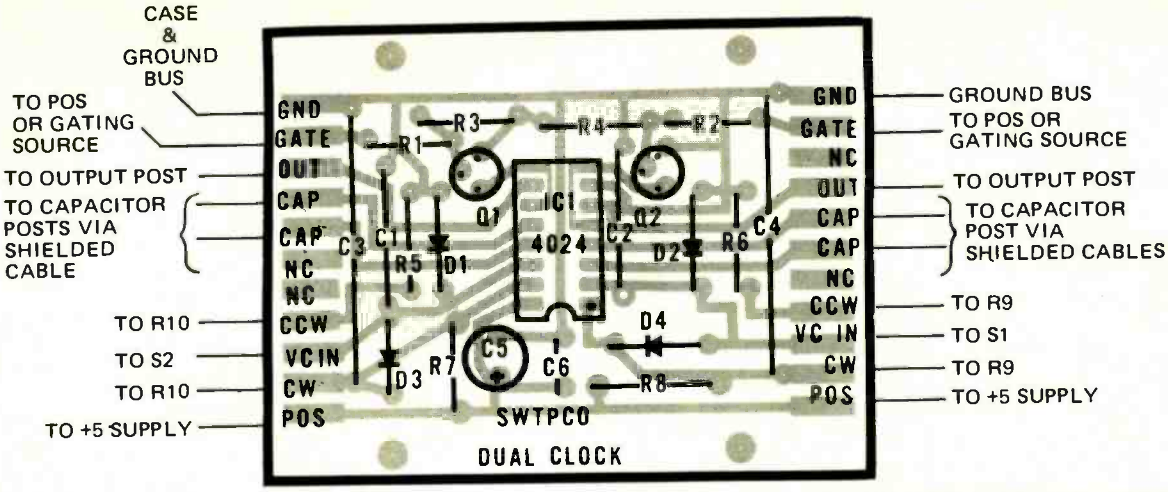


FIG. 4—PARTS LAYOUT to follow when wiring your dual-clock circuit.

R1, R2, R5, R6—4700 ohms, ¼ watt
R3, R4—2200 ohms, ¼ watt
R7, R8—27 ohms, ¼ watt
R9, R10—5000 ohms, linear pot
C1, C2, C3, C4, C6—0.1 μF, 10 volts, disc ceramic
C5—50 μF, 6 volts, electrolytic
D1, D2, D3, D4—1N914 silicon diode
IC1—MC4024 or MC4324
Q1, Q2—2N5129
S1, S2 spdt slide switch
J1 thru J10—5 way binding posts, 4 white, 2 each red, yellow, and black
MISC: PC Board, 2¼" x 3"; case; mounting feet (4); push-on knobs (2); RG-174 or other miniature shielded wire, 2 feet; hookup wire; PC board mounting hardware; ground bus; solder, ground lug to fit J5.

NOTE: The following items are available from Southwest Technical Products, 219 West Rhapsody, San Antonio, Texas, 78216:
Integrated Circuit IC1 MC4024, $2.40.
Etched and Drilled PC Board No. 176B, $1.80.
Complete kit of all parts including prepunched and prefinished case and complete assembly instructions No. 176-C, $8.30.

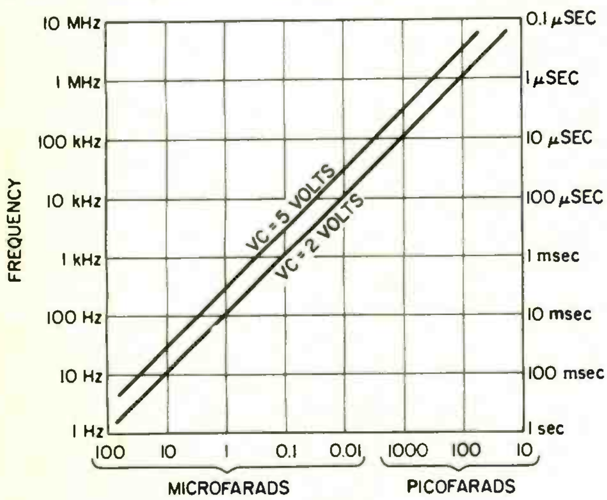


FIG. 5—OUTPUT CAPACITOR selection is simplified by using this little chart.

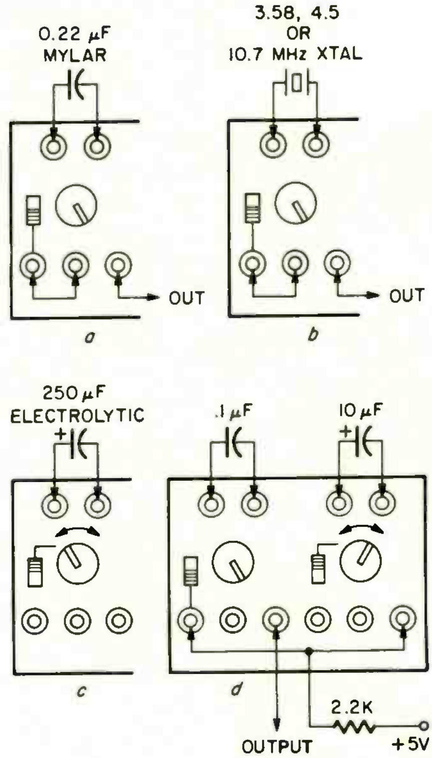


FIG. 6—FOUR APPLICATIONS for the dual clock, a—1 kHz test oscillator, b—crystal clock or marker generator, c—1 pps metronome or clock source, d—two-tone alarm.

No. 14 ground bus, made from a piece of house wiring. When lead dress is right, both oscillators should run over their entire range without any interaction, pulling, or noise problems.

If desired, a small 5-volt power supply may be added to the bottom of the case. It should be regulated if extreme frequency stability is needed.

Operation

To use one of the clocks, apply 5 volts, make the gate input positive by 2.5 to 5 volts, use the internal pot, and snap a capacitor in place. The frequency is determined by the graph of Fig. 5. For instance, a 0.1-μF Mylar capacitor should give you a range of 1200 Hz to 4500 Hz.

Some practical circuits are shown in Fig. 6. A 1-kHz square wave generator (Fig. 6-a). A 3.58, 4.5, or 10.7-Mhz crystal oscillator for color, sound TV or FM work (Fig. 6-b). Crystals below 3 MHz may be used, but some capacitive padding is sometimes needed for stable operation. You can go down to 100 kHz if you custom-fit the padding to the particular crystal in use. A one pulse-per-second timer or metronome (Fig. 6-c). A two-tone audio alarm that puts out a commanding TWEEE-DELLL TWEEE-DELLL note (Fig. 6-d). To allow one clock to control the other, or anytime you want a full five volts output, add a 2,200- or a 470-ohm resistor between the driving output and +5 volts. You might like to do this internally.

To gate one clock with the other, remove the gate input from POS and connect it to the other output. This gives you a gated oscillator or a tone burst generator. Or, add a big electrolytic and a charging resistor to the VC INPUT to get a siren or FM signal source.

There are many options available to you. If you want, bring the GATE inputs out to binding posts and add permanent output pull-up resistors. Or to cut costs, if you're never going to use an outside world signal, leave off protecting diodes D1 thru D4. You'll find lots of ways to customize this **Radio-Electronics** dual clock to your own uses. **R-E**

ALL ABOUT ELECTROLYTICS

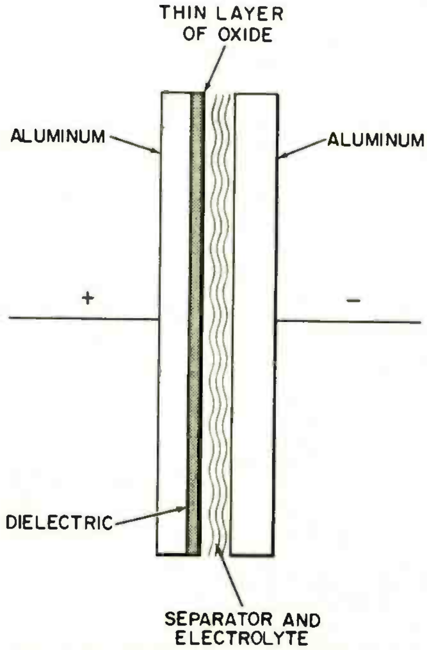


FIG. 1—ELECTROLYTIC CAPACITOR PLATES greatly enlarged. The very thin layer of oxide is the dielectric.

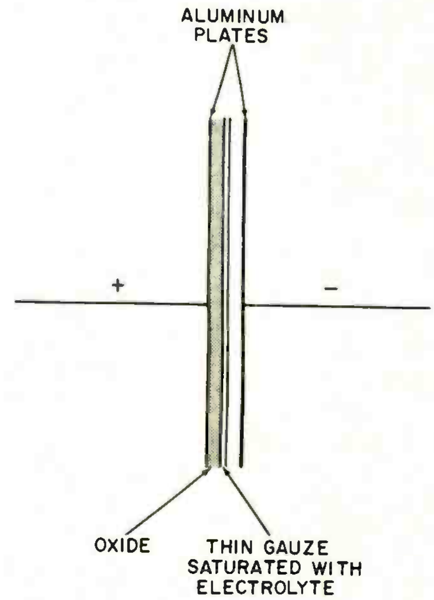


FIG. 2—BASIC CONSTRUCTION of all dry electrolytic capacitors follows this pattern. There are two sheets of aluminum foil with electrolyte between them. The sandwich is then rolled up to form the capacitor.

THE MODERN ELECTROLYTIC CAPACITOR is one of the "main parts" in electronic circuits today. Their major use is still power-supply filtering, but electrolytics are also used for bypassing and signal-coupling, especially in solid-state circuits.

They can also cause some of the weirdest troubles imaginable! So, let's take a long look at these things—how they're made, how they're used, and most important of all to the service technician and experimenter, how to test them.

We'll show you at least one guaranteed-*infallible* test for an electrolytic! They are not hard to test if you know how they work and how they act when they don't work.

How electrolytics are made

We don't have time to go into a detailed explanation of the design of an electrolytic capacitor. You don't have to build them—all you have to know is what size to buy and use.

All capacitors have two plates. Capacitance depends on the size of these plates, and the spacing between them, and the dielectric between them. An electrolytic capacitor is made of two sheets of aluminum. This metal has a peculiar yet useful property—it oxidizes very rapidly. Clean a piece, and without special precautions, it's covered with a thin layer of aluminum oxide before you can say Jack Robinson. Remember this oxide layer!

The original electrolytics were wet types. A corkscrew-shaped electrode was mounted in a can, filled with a solution of borax, etc. A forming voltage, dc, was applied and the oxide layer formed on the positive electrode, the corkscrew. The can was negative. The oxide layer, about 10^{-5} cm thick is the negative plate! Since it is very close to the metal, the result is a very high capacitance per sq. inch. The electrolyte liquid and the other metal plate, or the can, is used only to make electrical contact to the outside of the oxide layer (Fig. 1)!

The wet types, like all electronic components, had disadvantages and advantages. One big advantage was their ability to arc between the plates, and then heal. (The paper capacitors used during that period would not do this. When they broke down, that was it.) The disadvantage was large size. An 8-μF wet electrolytic had a diameter of about 2.5 inches and were 3 to 4 inches high. Also, they had to be kept right-side up, to assure proper venting of the electrolytic capacitor.

Eventually, the wet electrolytic was replaced by the present dry electrolytic types. These aren't any more dry than a dry battery is. The liquid electrolyte is still used, but in a different form. To make one like this, two very thin sheets of aluminum foil (2-3 mils thick) are rolled up, with a porous separator between them. This is saturated with the electrolyte in a paste form. The roll is sealed into aluminum cans. One end of the can has an insulator with a terminal, which is the positive plate, except in specially-built units (Fig. 2).

The first dry electrolytics used smooth foils. They got what was then an amazing amount of capacitance into a very small can. Manufacturers kept looking for ways to increase capacitance without increasing size, and they found it. The surface area of the plates determined the capacitance. So the surface of the plates was etched enough to make it rough (Fig. 3). The roughness increased the effective surface area, and the capacitance increased.

Making an electrolytic

Assembling an electrolytic capacitor is a fascinating process. Two sheets of perfectly clean aluminum foil, with the saturated separator between, are rolled up to form a cylinder. The sheets are usually offset slightly; and aluminum tabs are spot-welded to each foil for the connections (Fig. 4). This assembly is sealed into the can and the tabs are welded to the terminals.

In this condition, the thing would have a certain amount of capacitance, but it would be small and the leakage would be high. You could say that it is not a capacitor, yet.

To make an electrolytic out of it, a dc forming voltage is applied. The forming voltage determines the working voltage of the finished capacitor! The positive voltage is connected to the in-

The modern electrolytic capacitor is not the simple device it seems. Take a look at how it is made and how it may fail.

by EUGENE CUNNINGHAM

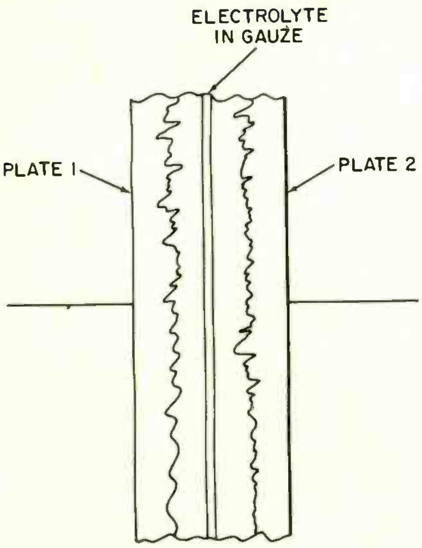


FIG. 3—ETCHING THE SURFACE of the aluminum sheets that form the plates of the "dry" electrolytic capacitor, in effect, increased the surface area of these plates. This, in turn, increases the capacitance, permitting a larger-value capacitor in the same size case. A simple but effective technique.

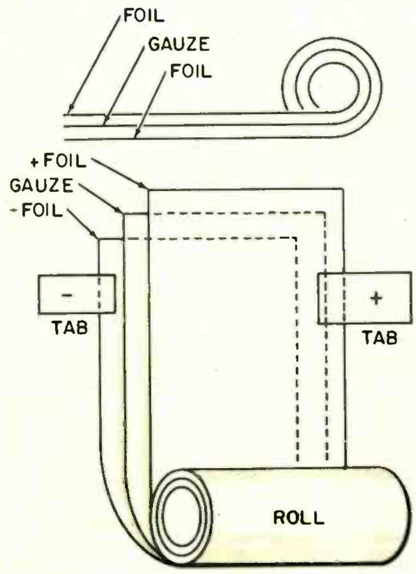


FIG. 4—TYPICAL CONSTRUCTION of a dry electrolytic. You can see how the two foils, with the electrolytic between them, are slightly offset. This simple offset makes it possible to have the connecting tabs located so they come out at opposite ends of the assembled capacitor.

sulated terminal, the + terminal of the capacitor. This causes the oxide layer to form on the positive plate. The thickness of the oxide layer determines the capacitance of the unit, also its safe working voltage. For low-voltage capacitors, a very thin layer is formed, and the capacitance is greater. (Plates spaced closer.) The oxide layer could be said to be plated on the surface of the positive plate.

These capacitors, in all standard types, are definitely polarized. The positive terminal must be connected to a positive voltage. If they are reversed, the current-flow through the electrolyte will actually dissolve the oxide layer into the electrolyte and the capacitor will conduct dc. So you can't use it backwards.

There are specially built "nonpolarized" electrolytics for use on ac. But practically all of the ones we find in electronic circuits, though, will be dc electrolytics. Unless they are a special type, the insulated terminal will always be positive and the can negative.

Remember those little tabs which make the contact; we'll be seeing them later!

Leakage current

Because of their peculiar construction, all electrolytic capacitors permit some leakage. With the proper polarity, in good grade capacitors, this is very small. We used to have a rule on this; "one tenth mill per mike". (0.1 mA/μF). The new models have a leakage much lower than this. They have to! Otherwise, leakage current through a 4,000-μF capacitor would be something like 400 mA.

Leakage current is measured by applying the rated dc working voltage to the capacitor, and reading the current on a milliammeter. Practically all of the better capacitor testers can make this test. If the applied voltage is reversed, a much greater leakage current will flow, and the capacitor will be destroyed.

You can verify this for yourself with an ohmmeter. Connect the positive lead to the + terminal, and the negative to the –. You'll see a fairly high resistance. Reverse the ohmmeter leads, and you'll see a very low resistance, even with the very low voltage applied by the ohmmeter battery. (Very much like the effect you get when checking a semiconductor diode!)

If the forward leakage current is too high, it will generate heat, inside the electrolytic. So if you find a warm or hot electrolytic in a power-supply circuit, and there is no source of heat nearby, *look out!* This one is probably on the verge of failing! If the leakage current is high enough, it can even cause steam to form, and the pressure will break the seal and blow off the electrolyte. Whereupon, the capacitor opens. (In some of the older wet types, steam pressure has been known to make the can explode and shoot itself through the top of the cabinet like a tiny rocket!)

High power factor

Excessive leakage is part of the cause of one of the most annoying faults in an electrolytic capacitor—high power factor. It reduces the capacitance only a little bit, but it sharply reduces the filtering efficiency. As simply as I can put it, it's about the same as connecting a good sized resistor *in series* with the capacitor.

All good capacitor testers can measure power factor. This is done with a bridge circuit. As a rough rule of thumb, units which read higher than about 15% power factor should be eyed with deep suspicion! High power-factor capacitors can cause some of those weird reactions I mentioned before. We'll get to a reliable test for this in a minute.

What are they used for?

What do we do with electrolytics? Everything. Their principal use in the early sets was power-supply filtering. However, in modern sets, especially solid-state models, you'll find them used as bypass and coupling capacitors too. We need to know what they do, how they do it, and the typical fault-reactions we see when they aren't doing it.

Power-supply filtering

In all ac-powered equipment, the basic power supply is the 117-volt ac line. This is stepped up or down to the proper voltage, rectified, and must then be filtered to a "pure dc". If you're Brit-

ALL ABOUT ELECTROLYTICS

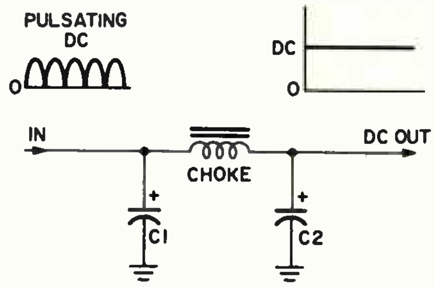


FIG. 5—FILTER CIRCUIT for removing the ripple (ac component) from pulsating dc from the rectifier output.

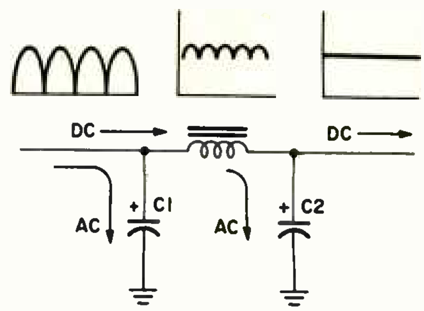


FIG. 6—AC GOES TO GROUND through the filter capacitors. Dc goes on through the circuit.

ish, this is "smoothing". The basic circuit used in practically all filters is in Fig. 5. It works because of the useful property of a capacitor to pass ac and block dc.

The rectifier output of all power supplies includes ripple. This is the sinewaves of ac that we fed to the rectifier—actually a "pulsating dc" as in Fig. 5. If we think of this as "dc with an ac component" it may be easier. Our filter circuit works something like the diagram of Fig. 6.

The ac component is passed to ground, through the first and second filter capacitors, while the dc component goes on through the choke. We come out of the filter with fairly good dc.

This is a "π-section filter"—so-named because it looks like the Greek letter π. Here, C1 is the input filter and C2 the output filter. Remember these names. They'll come up later on. Each one has a different fault-reaction to help us find the trouble.

Dc power supply troubles

Rule one: The *one circuit* in a set that is *common* to *all* of the others is the dc power supply. Any faults in it will show up in *all stages.*

Here's the second one: The *resistance* of the dc power supply, as measured to ground with an ohmmeter, must be *very high*. The *impedance* of the dc power supply must be *absolutely zero*, or very close to it.

If the dc resistance is too low, the circuit draws too much leakage current, and the transformer gets hot, the rectifiers blow, etc. This kind of problem can usually be solved with an ohmmeter, and/or a voltmeter. Low resistance here is usually caused by shorted or leaky electrolytic or paper capacitors. To find the cause, look for the last resistor in the string that's too hot, and then find the shorted capacitor on the load side of it!

How do we make the impedance of the dc power supply so low? With big electrolytic capacitors connected from the dc supply lines directly to a common ground. All of these capacitors can be considered as being connected in parallel across the dc supply lines. So their capacitances add. Four 80-μF capacitors gives us a total of 320 μF.

Why is this such a big deal? We need pure dc for the power supply, of course, but this is not the only important function of these capacitors. They are also bypasses. Here's a very important fact: remember it. *The dc power supply acts as a common ground-return for every signal-handling stage in the set!* (See Fig. 7).

The dc power supply is fed up the lines to operate the amplifiers. In all amplifiers, the signal is developed across a "load impedance". After the signal has passed through this impedance, and done its work, we have to get rid of it! It must be bypassed quickly to ground.

Since the only way we can do this is to bypass it to ground through a big capacitor, here's where those big electrolytics in the dc power supply come in handy. As you can see in Fig. 7, the total impedance of the power supply to ground, at all frequencies from 60 Hz on up, must be as close to absolutely zero as we can make it. Signal-return currents from every stage in the set flow through it; 60/120-Hz ripple, 60-Hz vertical sweep, 15,750-Hz horizontal sweep, video, audio, color, etc. You name it, we've got it in there somewhere.

If you have zero impedance to ground, no matter how many currents you have flowing through it, you won't develop very much voltage drop across it. And that's what we must have.

What would happen if we *didn't?* What if we had what some of the books call *non-zero impedance to ground?* In other words, one of our electrolytic capacitors has opened, or lost capacitance, and as a result, the impedance of our dc power supply is now greater than zero. Now we have some resistance in our return circuit. In Fig. 7, we had zero, so we had zero voltage drop across it. Now we have something like Fig. 8. We have a resistance in series with our signal currents and we do have a voltage drop across it.

Now we've got signals of all kinds flowing *back and forth* on our dc power supply lines. Since the dc power supply is common to all stages, some of these are going to be fed back into other stages. What does feedback cause, with the right phase? Yes sir! Oscillation. (Incidentally, it can also modulate the other signal.

Notice that we didn't even bother to label each stage in Fig. 8. It makes no difference at all which stage is feeding back into which! In all cases, this causes trouble (and that starts with "T" and rhymes with "E" and that stands for *electrolytics!*) I can make a firm statement here; counting all the cases of this type of trouble that I have ever run into, at least 99% of them have been caused by faulty electrolytics.

Fortunately, there are several ways to pin down this problem. One requires only the well-calibrated eyeball, and the other calls for an instrument that should be used in all service shops. This one gives you an infallible test for this. We'll get to them very soon.

Symptom analysis

Right now let's warm up by talking about one of the most important things in all kinds of electronics repair work—the analysis. Diagnosing the cause of a fault is the hard part. The actual repair takes very little time. So if you learn to recognize the usually obvious symptoms of electrolytic capacitor faults, it can speed your work tremendously.

The failure of an electrolytic capacitor in any kind of circuit will give you a definite indication. If it's shorted, this is easy. Up the ohmmeter and at 'em. In the simple half-wave or full-wave power supply, an open capacitor in the filter input will make the dc voltage drop to about ½ of its normal value or less (C1 in Fig. 6).

So if we find the dc supply voltage is low, and the rectifiers, etc. all in good shape, and no obvious overloads or hot resistors, etc.—the first thing to look for is an open input filter capacitor. You can check for it by simply bridging a good capacitor across the input filter. If

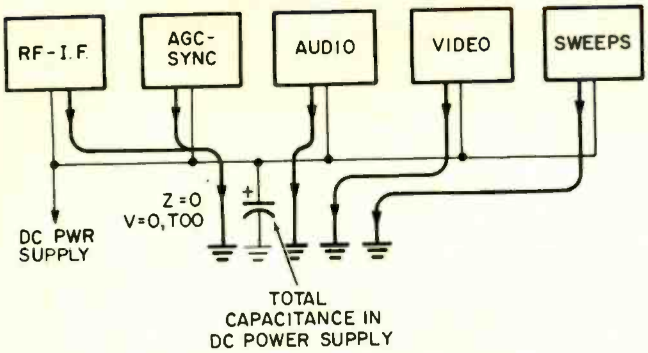


FIG. 7—DC POWER SUPPLY circuit for any set. This also acts as signal-return path for all stages.

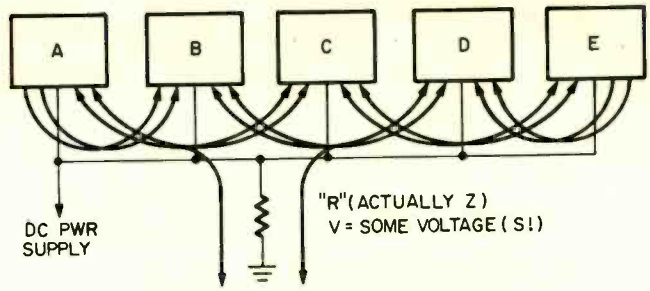


FIG. 8—SAME SIGNAL-RETURN path as in Fig. 7, but now we have non-zero-impedance, and look at that mess of feedback paths.

the dc voltage jumps back to normal, you've found the trouble. Needless to say, this applies to *tube circuits only*. Don't do this in transistor circuits with power on. The resulting surge can damage transistors.

Audio problems

In all audio amplifiers oscillation is a common symptom of electrolytic failure. It is usually caused by a unit that has opened or developed a high power factor. As a result, there is a feedback path through the power supply, and away we go. This kind of oscillation can be anything from a high-pitched squeal to a very low-frequency plop, plop sound, which used to be called motorboating.

Once again, an open capacitor is at fault, so you can bridge a good one across any suspected unit and see if it stops the trouble. Remember, only in tube sets with the power on. Turn the power off in solid-state sets before bridging and back on only with the bridge capacitor in place. Follow the same power-off procedure to remove the bridge capacitor.

By the way, this kind of trouble can develop even in battery-powered amplifiers, radios, etc. The basic cause is the same; non-zero impedance to ground in the power supply. You'll find a good-sized electrolytic capacitor connected across the dc supply lines to hold this impedance to the lowest possible level. Same basic symptoms; oscillation, etc. A weak battery can cause similar symptoms so check the battery in battery-powered sets first.

Black & white TV set troubles

You can have the same kind of power-supply troubles in black & white TV's. Dc voltages low, oscillation in audio, and so on. Now you can see some of the symptoms, though. In sets with a full-wave rectifier, an open input filter capacitor can allow the ripple to reach high levels, and reduce the dc voltage as well. So you get a symptom looking something like Fig. 9.

Note the BASIC CHARACTERISTICS: raster reduced in width; two dark "hum-bars" showing on the raster, and the edges of the raster pulled in. You see two hum-bars because the basic ripple frequency in full-wave dc supplies is 120 Hz, and the vertical sweep is 60 Hz. If this set had a half-wave rectifier in the dc supply, the ripple frequency would be 60 Hz, and you'd see only one hum-bar.

This is one of the very few places where you can be led up the garden path by the symptoms. A heater-cathode short in any tube with a cathode resistor can cause the same single-hum-bar symptom. Even the rf amplifier can do it. (Our infallible tester will catch this; wait just a minute!)

All TV sets

Remember the multiple feedback paths shown in Fig. 8? Here is our MVS (Most Valuable Symptom). Any fault in this common-ground-return path will cause multiple symptoms. So if you see any TV set with several different symptoms all at the same time, look for a bad filter capacitor! Almost certainly open, or high power-factor.

Why is this? Because, by the nature of things, other part-failures in TV circuits will affect only one thing; video, audio, sweep, etc. Dead tube, open resistor, shorted paper capacitor, etc. Sets which have multiple symptoms are almost certain to have a common cause, and here we are again; the dc power supply and its electrolytics.

This does not refer to something like a "no raster" complaint, that could be a shorted rectifier, fuse, etc. If you do have a raster, but (for a typical example) you have very poor horizontal and vertical sync, bending, shading of the picture, smeared color, oscillations visible in the picture, and so on, go straight for the dc power supply and start checking electrolytics. Dc voltages in these cases will offer very little help. You need the Infallible Test Instrument; I told you we'd get to it.

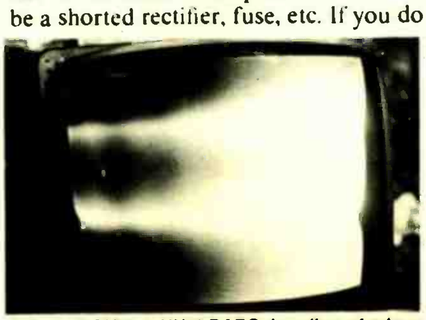


FIG. 9—DOUBLE HUM BARS, bending of edges of raster, narrow raster—all symptoms of electrolytic capacitor trouble.

The Infallible Test Instrument

The best test for any kind of electronic equipment is actual operation in the circuit where it's supposed to work. If we can get an accurate reading on how well the thing is working, without having to take it out for an external test, this is far more useful (and a heck of a lot faster). The capacitor-tester is very useful, necessary, and you should have one. There will be times when you need it, for reading leakage, capacitance, power-factor, etc.

However, you have one instrument on your bench that is a simple, fast, and *absolutely infallible indicator* of this kind of trouble. It is the oscilloscope. With one quick jab of the probe, you can tell whether any electrolytic capacitor is doing what it's supposed to—in-circuit and in operation.

How-come? What? Well, go back a few paragraphs, and see what I said about what an electrolytic capacitor is supposed to do. It is supposed to *remove all signals* from the dc power supply lines. So to find out if it is doing the job, just touch the scope-probe to the terminal of any electrolytic capacitor; if you see anything, there's a bad (open) capacitor in there! The scope responds only to ac signals! (In this case; you can use a dc scope, but put a blocking capacitor in series, making it an ac scope).

If we see any ac floating around on the dc supply lines, we have trouble. The impedance of the power supply should be so low that you should *never* be able to see any signal; just a nice straight line. You do not have to calibrate the scope, or set the sweep to any particular frequency! Just set the verti-

(continued on page 84)

R-E's Service Clinic

practice what I preach!

Keep your scope handy, use it wisely. It's a friend that will never let you down

JACK DARR
SERVICE EDITOR

AT REGULAR INTERVALS I EMBARRASS myself by NOT doing what I keep telling others to do! A really good example of "Don't do as I do, do as I say!" There is one redeeming feature, though. I get to write up my mistakes and sell 'em, much to the envy of some friends. Herewith, the history of one of these.

The victim was an RCA CTC-38 color set. It had some dandy symptoms (all intermittent, of course): Horizontal pull, loss of sync, color smear, and a few more. It was brought in by a friend who had been working on it for a couple of days. He claimed that it acted up at home, but sat on his bench and played perfectly. (Normal, huh?) So, we set it up, hooked it to the test jig, and started in.

He was right; it did play very well. Voltage checks showed nothing unusual; the agc tube plate showed a normal reaction with and without signal. However, the agc control showed a rather odd effect. Instead of going smoothly from whiteout to blackout, it had a sort of "hump in the middle" kind of action. Agc voltages seemed to be very close. I tried to override the agc voltage with my bias box, without success. Checking the schematic showed why: my old box went only to 20 volts, and this one needed considerably more than that. So, "Oh, well. We'll do without it." (Mistake No. 1.)

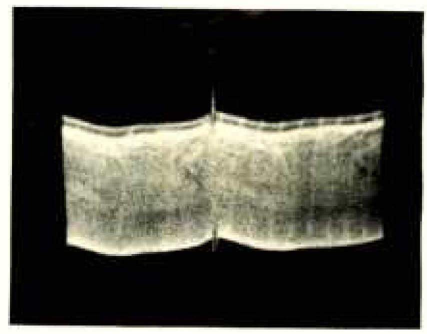
At about this point in the proceedings, I accidentally found that the thing was *mechanically* intermittent. You could push on the bottom of the PC board, at certain places, and make the symptoms appear and disappear. Oh, ho! This is going to be easy. Cold solder joint. After about 15 to 20 minutes of pushing, tapping, bending and hammering on it, I decided that it was not going to be all that easy. Everything I *touched* made it cut in and out!

A close visual examination of the bottom of the PC board showed no obvious bad solder joints. So, I got down the shotgun; I resoldered all of the joints in the area that seemed to be the most sensitive. This helped—just as much as anything I'd done so far—or, not at all.

Quite a few fruitless voltage measurements and hammer-tests later, I finally did what I should have, long before this. I got out the scope. Nothing in the way of excess ripple on the dc voltage supply lines; symptoms in or out. Keying pulse on agc tube plate clean, plenty of amplitude. So, there went that one. Signal on agc tube grid, woops! Here's something that isn't right! All bent up and badly distorted.

Back to the video detector output; signal there OK when board was pushed down, very badly distorted when board pushed up to make the symptom show up. Ah, ha! This trouble is NOT in the sync, etc. where I'd been looking for it. It's farther back, in the i.f. or tuner. (At this point, I am now beginning to show signs of having a normal mentality.)

Changing to the crystal-detector probe, I followed the signal back through the i.f., to the 1st i.f. input.



Hmm. Signal clean at that point, distorted when board pushed. Tuner trouble? No. Oh, oh. What *controls* the i.f.? The agc. So, how about the agc line? (Right at this point, I'm looking pretty good. About time, too!)

Going back to the low-cap probe, I scoped the agc line. Oh, wow! With the symptoms out, clean. With the symptom in, the dangedest mess of stuff you ever saw. The scope photo shows what this pattern looked like. This is just a *little* out of the ordinary! The agc line should have nothing but pure dc on it. Not this mess of horizontal and vertical pulses, at about 5.0 volts p-p.

After I stopped hitting myself on the head with the rubber hammer kept on the bench for this purpose the real nature of the trouble dawned on me. There are all sorts of pulses and things

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, 200 Park Ave. South, New York 10003.

THIS IS WHAT THE BRAIN found on the agc line, when it went looking for it! 5.0 volts p-p of assorted mess, on the i.f. agc!

on the agc line, at its "beginning". What parts are used to take them out? Bypass capacitors. (Boy! How complicated can you get?) What would happen if one of these bypass capacitors was **open**? I'd have exactly the same kind of mess on the agc line that I had just seen. Ergo, the intermittent that I had been fruitlessly chasing for so long was now identified. It was one of the three agc bypass capacitors. Had to be. (Now, you're beginning to think.)

Locating these capacitors, and checking them carefully showed that C251, a .001-μF capacitor directly connected to the emitter of the agc transistor, had a **VERY** bad ground connection. This joint just happened to be under a couple of wires on the bottom of the PC board, and I hadn't seen it. When it opened, being right on the agc input to the i.f., it allowed all of those pulses to be applied to the i.f. bases. There, they caused the mother and father of all feedbacks, and I got all of those different symptoms at the same time.

The moral of this is very simple. When I stopped using my muscles—pushing and hammering on the board, and began using my head—to make a logical *analysis* of the symptoms, I could trace the fault back through the circuits to the point where it *began*. Then, everything cleared up in a hurry! Total elapsed time, using second method, not more than 10 minutes; time wasted using first method, about two hours.

So, **STOP** and **THINK**. You **KNOW** how these things work, and "what causes certain reactions". If you'll make a few logical tests, and then interpret the results correctly, you'll get along a lot better, and be embarrassed much less frequently! **R-E**

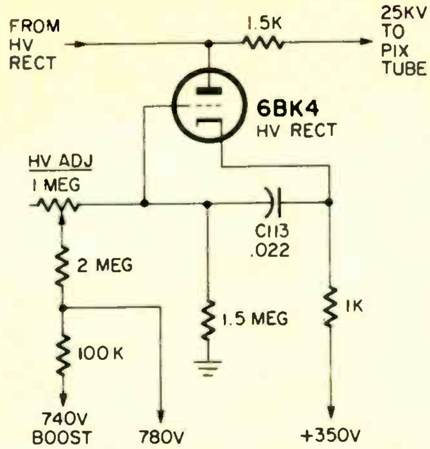
Reader Questions

NOT ENOUGH HIGH-VOLTAGE

I've problems with a Zenith 25NC38. The high-voltage rectifier tube gets red hot and I can only read about 9-10 kV of high voltage. After some fiddling around, I pulled the cap off the 6BK4 high-voltage regulator; the high voltage shot up to 30 kV, and the high-voltage rectifier tube cooled off.

Voltage on grid and cathode of the 6BK4 reads +290 volts. Boost voltage reads +600 volts. I've checked everything I can think of in the 6BK4 circuit, no results. Where is it?—J.L., Elizabeth, N.J.

You're there, keep looking! The fact that you can get up to 30 kV with



the regulator tube out of the circuit, and only 10 kV with it in proves one thing. That regulator tube is drawing a heck of a lot more current than it's supposed to. (It doesn't take much, either, with a plate voltage of 25,000 volts. Check the *maximum* rated current of a 6BK4 in the tube manual. It's a whopping big *1.5 mA!*)

You have the key voltage reading—you said that *both* grid and cathode of the 6BK4 were at +290 volts. If you read this from cathode to grid, you'd notice that the tube actually has *zero-bias* on it! Same voltage on grid and cathode. Going back to the tube-man-

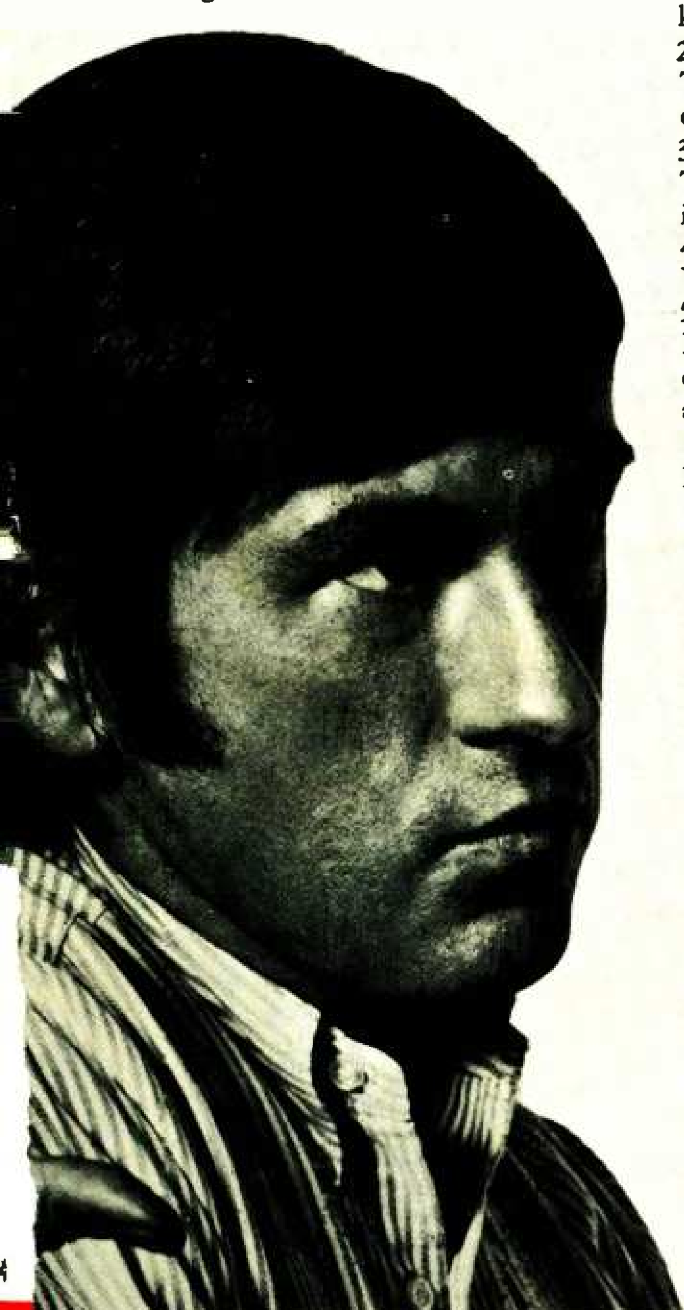
(continued on page 68)


Does your mother-in

law call you a meatball?

Does your boss?
Maybe even your wife? On payday.
Know what? If you have read this far, you are not meatball material. Because meatballs don't face the present, the future, the facts. They stay put. Dreaming and talking. And today, more than ever staying put means falling behind. Pretty tragic in a time when people with specific aptitudes are so necessary in so many interesting fields.

Today huge industries depend on people with electronics training.



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READER QUESTION

(continued from page 63)

ual again, at zero bias, the tube draws a fat 2.8 mA, or more than double the maximum rated plate current.

Normal bias on this tube must be about -15 volts. This holds the current down to not more than 1.0 mA. In actual operation, this is set by the two resistors in the grid circuit, 1.0 megohm variable (HV ADJUST) and the fixed 1.5 megohm to ground. This goes back to the *boost* voltage through a 2-megohm resistor. The cathode is fixed at B+ voltage through the 1000-ohm resistor to the damper plate.

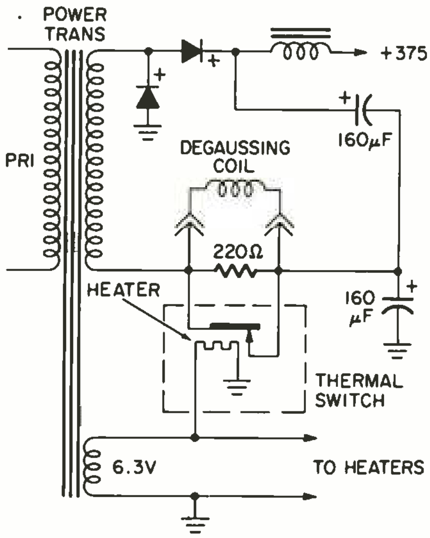
Normal operation should be at about a -15 volts, or less than 1.0 mA current with the pix tube screen dark. Check these resistors. One of them may be off; or C113, the .022μF may be shorted.

RASTER RIPPLE, RAINBOW BARS

I've a bad 120-Hz ripple in the raster of this Motorola 918 color chassis. Two horizontal bars, about an inch wide, roll slowly up through the picture. At the point where the bar is at any moment, there's a color rainbow! Follows the bar up. The sides of the raster pull in and wrinkle, and this too follows the bars.

The silly part is that it does not do this on my test jig! All filter capacitors, which I suspected at first, check perfectly good and the picture is clear; no ripple at all. I smell a resistor burning somewhere, but I haven't found it yet.—R.G., Cove, Ark.

When you took the chassis out of the cabinet, you "moved" everything



that could normally cause this, with one exception. The degaussing coil. I'm pretty sure that you'll find the thermal switch either open or burned up so that it doesn't make contact (See diagram).

In normal operation this switch is open at turn-on leaving the degaussing coil in the circuit. It is a tiny thermal switch with a heating element in the filament circuit. It should *close* after a short time, shorting the degausser. It it doesn't, the coil is left in-circuit, and is carrying a hefty ripple pulse and quite a bit of dc. It is causing the 120-Hz bars and the rainbows.

There is a 220-ohm 2-watt resistor connected across the degaussing coil. It is on the front of the chassis at the degaussing coil plug. If the set is operated with the degaussing coil unplugged, the B+ circuit is completed through this resistor, which should be shorted by the thermal switch. If the switch is open, the resistor carries all the current and burns up. That's the one you're smelling. Replace the thermal switch and check the coil. It may have been heated up and shorted.

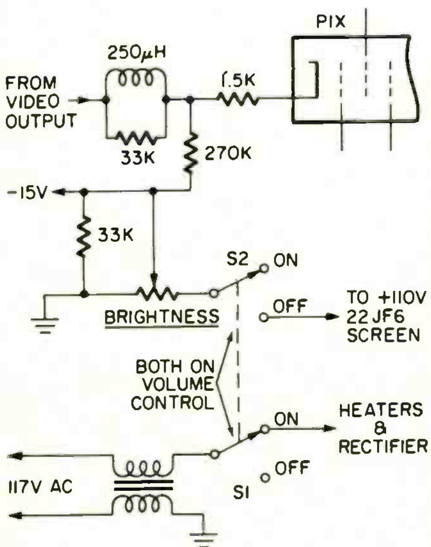
REPLACEMENT SWITCH

The on-off switch on this RCA KCS-160 is damaged. I'd like to replace it with one of the push-pull types. Don't find a listing for a replacement.—J.F., Media, Pa.

This is a special, dual switch (see diagram). S1 is the regular on-off switch in the ac input. However, S2 is a completely *separate* switch. It is connected to the ungrounded end of the brightness control and to a +110-volt dc source at the 22JF6 screen grid.

This is a "spot-killer" switch; it turns on when the ac line switch is turned *off*. This puts the +110 volts dc on the brightness control and the picture tube cathode, thus discharging the hv quickly and killing the spot.

As far as I know, no one makes an



exact duplicate. RCA part number is 119191. In an emergency, you can use any stock 1-megohm volume control with an spst switch and leave the spot-killer circuit open. With an aluminized picture tube it doesn't do much good anyhow!

APPLIANCE CLINIC

(continued from page 24)

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an open. If C1 is shorted, you won't be able to get enough gate voltage on the trigger diode. So, the thing would stay off at all times. If C1 was open or leaky, the chances are that it would either refuse to work or operate erratically. If either the trigger diode or the Triac shorts, the light will stay on all the time. (I'm not sure, but I believe that a shorted trigger diode would destroy the Triac, from breakdown due to excessive gate voltage. Depends on the resistance "after the short."

The photocell causes little trouble: if you suspect it, check it with an ohmmeter. Dark, it should have a very high resistance. Shine a flashlight on it and the resistance should go away down. If it'll do this, it's OK.

This particular Triac and several others in the same series are built in a TO-5 transistor case. Looks like a transistor but isn't. Check the number in any good Transistor Guide to make sure.

JACK DARR
SERVICE EDITOR

new products

More information on new products is available from the manufacturers of items identified by a Reader Service number. Use the Reader Service Card on page 101 and circle the numbers of the new products on which you would like further information. Detach and mail the postage-paid card.

BURGLAR ALARM SYSTEM, *Watchdog,* do-it-yourself kit. Low-cost system is easy to install. Comes with eight-inch diameter bell that is activated by solid-state control circuitry. Three sets of magnetic weatherproof switches, on-off key switch, door cord, wood screws, 100 feet of plastic-

coated wire and illustrated installation drawing are included. Designed to sound local audible alarm to scare off intruders, the system is powered by 12-volt dc battery. $49.95.—**Crime Detection Systems, Inc.,** P.O. Box 790, Dept. A-89, Pearland, Texas 77581.

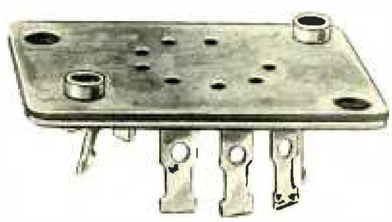
Circle 31 on reader service card

MAGNETIC TAPES, *UD-C-60, UD-C-90.* Blank cassette tapes in sixty- and ninety-minute lengths. Feature wide dynamic range, high output, low-noise characteristics. These are ferric-oxide coated tapes

that are intended to be used in existing cassette recorders without any need for readjusting the bias setting.—**Maxell Corp. of America,** 501 Fifth Ave., New York, N.Y. 10017.

Circle 32 on reader service card

TRANSISTOR SOCKET for new 8 lead *TO-3* case. Molded nylon top wafer with two integral .060 high insulating shoulder mountings. Eight spring brass cadmium plated pin contacts and two steel cadmium plated mounting lugs with 6-20



formed threads that will accept a No. 6 metal tapping screw.—**Keystone Electronics Corp.,** 49 Bleecker St., New York, N.Y. 10012.

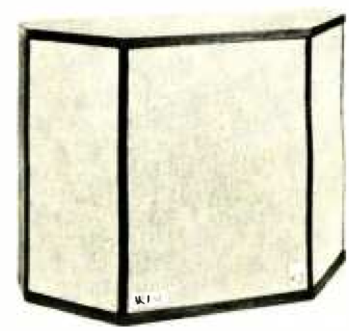
Circle 33 on reader service card

AUDIO AMPLIFIERS, *Sanken Series S-1000A.* A 50-watt hybrid IC for audio amplifier applications. Delivers 50 watts into an 8-ohm load. Harmonic distortion is 0.5%. An application note showing how to

use the hybrid IC to build a stereo amplifier is available.—**Airpax Electronics, Int'l. Div.,** P.O. Box 8488, Fort Lauderdale, Fla. 33310.

Circle 34 on reader service card

SPEAKER SYSTEM, *LST,* designed specifically for professional applications as a broadcast and recording monitor or on a medium-power sound reinforcement system requiring maximum accuracy. Offers six different energy profiles, repeatable at the turn of a switch. Low harmonic distortion; wide dispersion of midrange and high frequencies; multiple drivers to handle power levels significantly higher than speakers for home use. Uses one 12-inch acoustic suspension woofer, four 1½-inch midrange hemispherical domes, and four ¾-inch high-frequency hemispherical



domes.—**Acoustic Research, Inc.,** 24 Thorndike St., Cambridge, Mass. 02141.

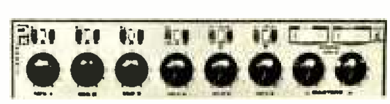
Circle 35 on reader service card

REMOTE CONTROL, *Whistle Switch.* Wireless sound command device turns TV, lights, appliances on and off. Plugs into any 117-volt standard household outlet, then plug any home appliance up to

300 watts capacity into the *Whistle Switch.* Comes with both squeeze-bulb and mouth whistle to activate the device. Possible uses include: security device for turning on lights in dark areas, to a convenience for bedridden or convalescent persons. $14.95.—**Signal Science, Inc.,** Box 413, 140 Lowland St., Holliston, Mass. 01746.

Circle 36 on reader service card

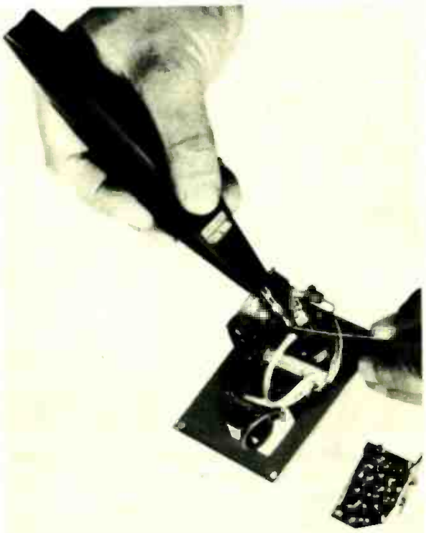
STEREO MIXER KIT, *Prokit SM-6.* All plug-in IC's minimize servicing and troubleshooting problems. Kit forms profes-



sional system for remote or studio recording, and sound reinforcement mixing. Will mix up to six signals simultaneously. Any input can be switched between line or microphone function. Inputs 5 and 6 can be switched to function as RIAA phono preamps. Input 5 is permanently assigned to output A, input 6 to output B. Other four inputs can be switch-assigned to either output or both at the same time. Microphone preamps can be switched into either high- or low-gain mode. Accessory packages available. $229.00.—**Gately Electronics,** 57 W. Hillcrest Ave., Havertown, Pa. 19083.

Circle 37 on reader service card

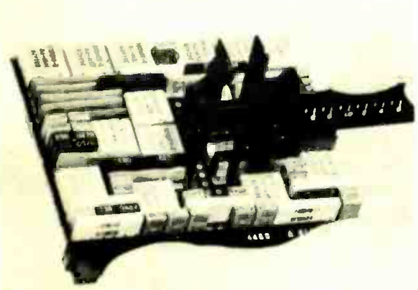
PORTABLE SOLDERING IRON, *Iso-Tip,* cordless rechargeable iron is designed for hobbyist, service technicians, engineers. Construction prevents ac leakage from damaging delicate electronic components. Mimimizes problems caused by



high heat transfer. Tip capacity up to 60 joints per charge; reaches soldering temperature in five seconds; performance equivalent up to 50 watts. Uses nickel cadmium batteries. Overnight recharging. $19.95.—**Wahl Clipper Corp.,** 2902 Locust St., Sterling, Ill. 61081.

Circle 38 on reader service card

COMPONENT FORMING & MEASURING SYSTEM, *ConForm I,* fits in palm of the hand. Designed to make leads conform to proper hole-to-hole spacing for all axial lead components while compensating for lead thickness, stress relief loops and MIL



Spec's. Also bends all sizes and shapes of axial lead components for horizontal and vertical mounting with or without stress relief loops. Device straightens transistor leads and provides gauging for cutting leads to suit board thickness and lead length requirements. $8.95.—**Pace, Inc.,** 9329 Fraser St., Silver Spring, Md. 20910.

Circle 39 on reader service card

PATTERN GENERATOR, *model LCG-384.* A digital-clock binary system assures quality test patterns and is among the prin-

cipal features of this mini-portable color-bar pattern generator. Powered by four 1.5V pen-lite batteries (6V total) and ac adaptable, this generator fits into a tool caddy. The *LCG-384* provides 8 patterns including the gated rainbow for testing NTSC color sets. It has two push-button selectable TV channel frequencies, offers full protection against ambient temperature and line voltage changes and is supplied with two battery compartments, carrying case and strap. The unit weighs 2 lbs. $109.50.—**Leader Instruments Corp.,** 37-27-27th St., Long Island City, N.Y. 11101.

Circle 40 on reader service card

INDOOR TV/FM ANTENNA AMPLIFIERS, *Color Caster Plus series* designed to make signals from a single antenna strong enough to serve every TV and FM receiver in homes, apartment houses, and motels.

The amplifiers feature dual-diode input circuits protecting them from lighting induced voltages at the antenna terminals. Model *TA-84* amplifies all uhf, vhf and FM signals, provides four 300-ohm outputs from a single 300-ohm input, $40.75. Model *TAC-84* is similar, except it is a 75-ohm unit for use with coaxial cable, and particularly applicable wherever interference is a problem, $49.95. *TA-246*, $31.50. *TA-81*, $46.50.—**Jerrold Electronics Corp.**, 401 Walnut St., Philadelphia, Pa. 19105.

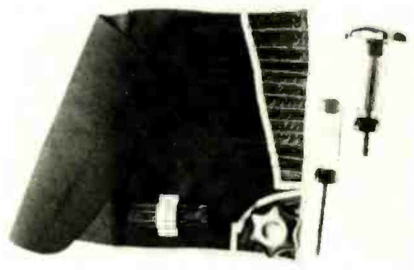
Circle 41 on reader service card

ADHESIVE, *Permabond*. Industrial-strength adhesive for repair and maintenance. Liquid requires no solvents, catalysts, or heat treatments and bonds all hard surface materials to themselves and to each other, including rubber, glass, porcelain, wood, ceramics, metal and most plastics. Water and weatherproof, solvent-free and non-toxic, *Permabond* is useful to repair autos, cameras, radio and TV cabinets, switches and knobs, sporting goods, motors, lab apparatus, etc.

—**Oneida Electronic Mfg. Co.**, 843 N. Cottage St., Meadville, Pa. 16335.

Circle 42 on reader service card

RATCHET SCREWDRIVER SET, *Palm-Grip*. Change drivers in the common handle of this screwdriver set which comes with two sizes of Slot drivers, two sizes of Phillips drivers, and 10 sizes of



Hex drivers in standard increments. Handy, durable pouch included.—**J. Mills Tool & Mfg. Co., Inc.**, 1444 South 27th St., Phoenix, Ariz. 85034.

Circle 43 on reader service card

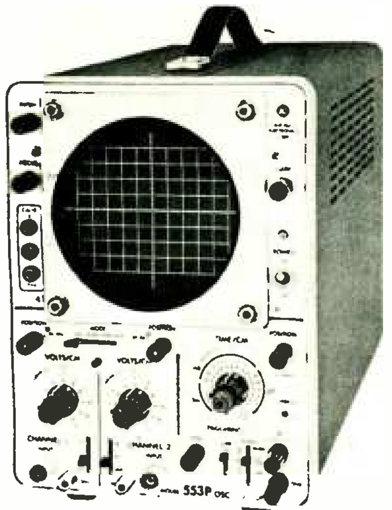
EMERGENCY MONITOR, *CB-9*. Monitors emergency channel 9 or any alternate channel. Full receiver with squelch and volume control, sensitivity 0.5 µV. Crystal supplied for monitoring channel 9; any other channel or Citizen or business band between

25 and 30 MHz may be monitoried on alternate swith by adding plug-in crystal for appropriate frequency. $39.95.—**PACE Div., Pathcom Inc.**, 24049 S. Frampton Ave., Harbor City, Calif. 90710.

Circle 44 on reader service card

OSCILLOSCOPE, *model 553P*. 5" CRT has all solid-state circuitry, dual-trace trigger scope is suited for measurement and waveform monitoring applications. With two identical channel operations, the *553P* contains a vertical differential dc amplifier that produces a bandwidth of dc to 10 MHz. with a voltage accuracy of ±3%. The system displays either channel sepa-

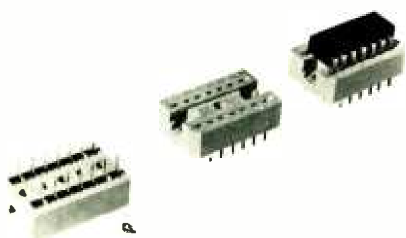
Circle 62 on reader service card



rately, alternates between channels, or choppers between channels. $538.00.—**Kikusui Electronics Corp.**, 200 Park Avenue, New York, N.Y. 10017.

Circle 45 on reader service card

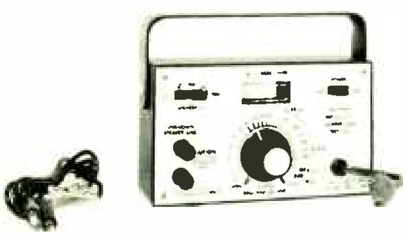
D.I.P. SOCKETS. Fourteen contact D.I.P. sockets designed with a low profile of 0.218 in. to provide high-density packaging. Large tapered entry channels aid IC insertion and reduce lead damage. Dual-leaf wiping contacts, accepting round or



flat leads, insure low contact resistance and high reliability. Body design features mounting points for hexagon bolts or nuts, and standoffs provide an air gap between socket and board.—**Vero Electronics, Inc.**, 171 Bridge Road, Hauppauge, N.Y. 11787.

Circle 46 on reader service card

SPEAKER LINE TESTER, *model LTS-1*, is a self-contained ac powered direct reading instrument designed to determine the wattage requirement of any 25- or 70-volt speaker line up to 200 watts, the wattage drawn by a speaker with a 25- or 70-volt



transformer, and the impedance of a speaker voice coil. It tests speaker lines, speaker with transformer, and the speaker voice coils for shorts and opens. $34.75.—**Trutone Electronics, Inc.**, 14660 Raymer St., Van Nuys, Calif. 91405. **R-E**

Circle 47 on reader service card

new literature

All booklets, catalogs, charts, data sheets and other literature listed here with a Reader Service number are free for the asking. Turn to the Reader Service card on page 101 and circle the numbers of the items you want. Then mail the postage-paid card.

ELECTRONIC CHEMICALS CATALOG, *No. 7172*. Among the products described are tuner sprays, circuit coolers, insulating sprays, lubricants, tape head and record cleaners, glues and cements, solder, and spray paints. The 12-page catalog is complete with descriptions, applications, tables and pricing for all products.—**Chemtronics Inc.**, 1260 Ralph Ave., Brooklyn, N.Y. 11236.

Circle 48 on reader service card

RADIAL HORN LITERATURE, *Model RH-500*. Information on an indoor and outdoor radial horn for use in stadiums, auditoriums, transportation terminals and industrial plants is now available. Describes the weatherproof horn designed for high intensity audio in the middle and upper range of the spectrum.—**Atlas Sound,** 10 Pomeroy Road, Parsippany, N.J. 07054.

Circle 49 on reader service card

CONNECTOR & SWITCH CATALOG, *No. 7FOM*. 24 pages in full color, illustrating IC terminal sockets, connectors and terminals, relay sockets, phono sockets, lighted pushbutton switches, and various tools for hand and production assembly and extraction of components.—**Waldom Electronics, Inc.**, 4625 W. 53rd St., Chicago, Ill. 60632.

Circle 50 on reader service card

SCIENCE & OPTICS, *Catalog No. 721*. 4,000 unusual items for hobbyists, experimenters, craft enthusiasts, students, gardeners and workshop buffs. Fully illustrated book lists tools, puzzles, games, rockets, microscopes, telescopes, binoculars, photographic attachments, black-light equipment, and unique lighting equipment.—**Edmund Scientific Co.,** 380 Edscorp Bldg., Barrington, N.J. 08007. **R-E**

Circle 51 on reader service card

more ways to use your tape recorder

by BYRON G. WELS

ONCE UPON A TIME YOU BOUGHT A tape recorder. You took it home, showed it to the family, and let them all take turns making recordings. You smiled as they heard their own voices coming back to them, and then you put the recorder away.

Now we're going to try to interest you in using that tape recorder once again, and maybe make you take it out and try a few new useful and/or amusing little applications. Who knows? You might even leave it out this time!

Play a musical instrument?

If so, you can have a ball with a tape recorder. To begin with, you need a pickup microphone, available from most mail-order houses, for everything from accordions and guitars through harmonicas and saxophones! Connect an appropriate unit to your instrument, plug it into the tape recorder, and you're all set. Record the melody on track one, playing it straight. Then, using sound-on-sound, record a harmony line or chord accompaniment on track two. Using sound-on-sound, put both voices on track one, and then add another voice

TAPE-RECORDER FUN can be listening to earlier performance while taping sound-on-sound.

to track two. I've had a lot of fun with this, using my guitar. After recording melody and a chord accompaniment, try slowing the machine to 3¾-inch speed, and record a tremolo accompaniment an octave lower. Then add this to the first track, at the 7½-ips speed. It comes out sounding like a mandolin, and the total effect is astounding. You don't play a musical instrument? Try using your own voice, monitoring track one with earphones while you record track two, and sing a harmony figure. You can make yourself sound like a choral group!

". . .Veddy Intderesstink. . ."

Invite a friend or two over, and without their knowledge, make a good, long recording of a conversation. Make sure you get lots of words of all types. Make the recording at 7½ ips. Then cut the words apart. Carefully place them in envelopes, adding duplicates as you get them. Then mark the envelope so you know what words are in each. Now you can actually write a script, and splice the words together so that, in their own voices, your friends are saying entirely different things. With practice, you will learn how to select inflections properly too, making the tape much more realistic.

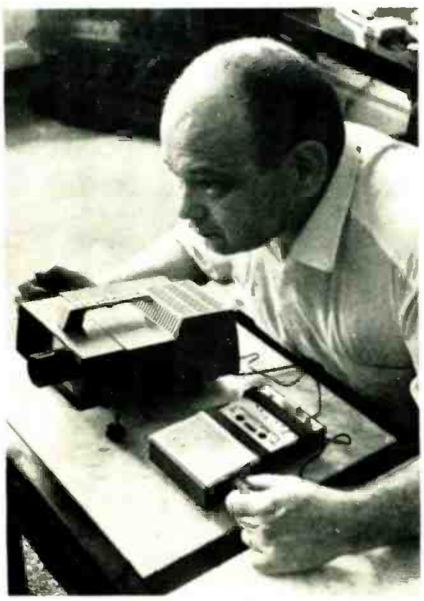
Automatic sound-slide shows

Got an automatic slide projector? Good! Make a sensing element by attaching two brass standoffs to a piece of plastic about 1 inch by ½ inch, and cementing the plastic base to your tape deck so it is in the path of the tape as it goes to the take-up reel. The back of the tape must be in contact with both posts at all times. Connect a piece of ac line cord to each post, and connect the other end of the cord to the slide projector's remote switch socket. Now arrange your slides, and project the first one on a screen. Record your comments (maybe even some background music and sound effects) on the tape. When you're finished, apply a bit of aluminum sensing tape to the back of the recording tape. When the sensing tape shorts the two posts, the projector will switch to the next slide.

Next time you have people over, plug the slide projector into the tape recorder, and sit back and enjoy the show with your guests!

"Hello. Hi. Who's this? . . ."

You've heard the bit, and are probably very well aware of it. You telephone a friend, and he says, "Hello". Then you say, "Hello". He says, "Who's this", and so it goes. Get a telephone pickup and connect it to your phone and tape recorder. Start recording all your telephone conversations. After each one, play them back. You aren't trying to "bug" anybody—you're trying to learn how to



AUTOMATIC SLIDE SHOWS are easy when you use a tape recorder to do the hard part.

Circle 66 on reader service card

use a telephone properly. Before long, you'll find yourself making a call, and when the other party says, "Hello", you'll answer, "This is John Smith; may I speak to Mr. Jones, please?" Your phone efficiency factor will zoom. In fact, you will soon lose patience with people who are not efficient on the telephone, and it won't take long at all.

Do-it-yourself language lab

Start out with a packet of 5 x 7 file cards. Mark them at the bottom so that, with the card resting on your tape deck, a pair of marks on the card will indicate the level of the tape. Now, using rubber cement and a razor blade, apply a strip of recording tape at the bottom of each card. When they have all dried, write a word in English on each card. Set your machine to RECORD, and feed the card into the head gap, until the capstan and capstan idler grab the card and pull it through. As it passes through, speak the same word in the foreign language into the mike.

To use this device, look at the card, and try to remember the foreign equivalent for the word. To check yourself, slip it into the head with the machine on PLAY, and you'll hear the foreign word coming out the speaker!

Record a TV program

Maybe you can't record the video portion of a TV program, but there's nothing to stop you from picking off the audio portion! Unfortunately, with the relatively poor fidelity one gets from today's television set, you'll be better off to slightly modify the television receiver first. Do this by adding a jack to the back of the chassis and connecting the jack across the volume control. Plug in your tape recorder, and make sure you set the recording level before the program starts. The quality of filmed programs is usually pretty poor, but you can do great on live or taped shows, and usually, the sound is worth saving, too. (Better add blocking capacitors—about .05 μF, 600 volts) to each side of the jack for isolation if your TV is a transformerless type.

"Hello CQ, Calling CQ. . ."

Three times three, three times. That's the way you're supposed to initiate a CQ. A lot of hams lately have taken to using a tape-recorded CQ, as it saves a lot of time and trouble. Simply record a good one, and either play it through your microphone, or plug the tape recorder's output directly into the mike jack (provided the impedances aren't too far off). There's a good chance here for the CW operator, too. Use a relay in place of the speaker on the recorder, and record your CQ in CW. The audio from the recorder's amplifier will key the relay, which in turn will key the transmitter.

Living greeting cards

We all know that tape-respondence isn't new. Families, separated by many miles, often keep in touch with one another via reels of tape—after all, the spoken word is far more satisfying than written letters. But have you thought about making taped greeting cards? The youngsters especially like these "tapes with a theme."

Got any more good ideas on how to use a tape recorder? Got some special technique of your own? Jot it on a postcard and mail it to Tape Ideas Editor, RADIO-ELECTRONICS, 200 Park Ave. South, New York, N.Y. 10003. We'll pick out the best of those we receive and publish them at some future date for all our readers to enjoy. **R-E**

audio switching systems

In a search for versatility, I have devised a switching system, so that various parts of an audio system can be operated, without having to plug and unplug the separate parts, or having to turn on more equipment than is necessary. In effect, this unit combines a hi-fi system and an intercom system.

Many of you know that a simple way to feed a signal from a self-contained unit, such as a shortwave receiver, into a high-impedance input of a recorder or amplifier, is to take off the signal across the receiver voice coil and feed it to the input. This is convenient for recording, but suppose you just want to listen to the receiver at some remote point. Why amplify the voice-coil output, since it is all ready to feed a speaker? That is where this unit will come in handy.

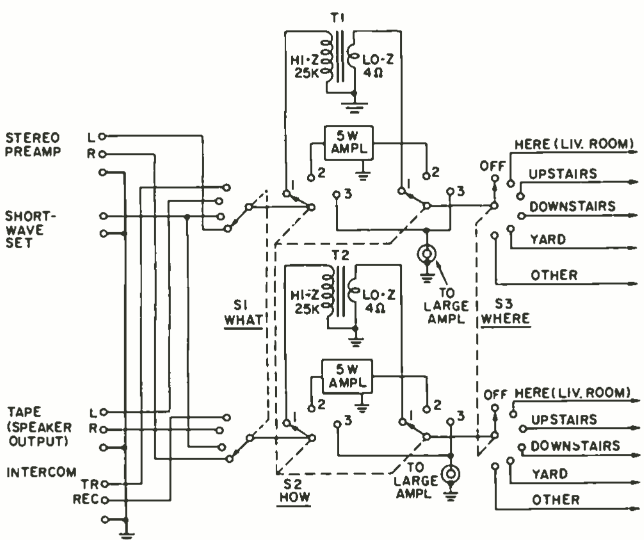
The coupling unit consists of 3 switches, which I have labeled WHAT, HOW and WHERE. The WHAT switch selects the program originator such as tuner, tape, etc. which can be high impedance or low impedance. The HOW switch selects the volume level at which the program is to be reproduced. The WHERE switch selects the location where the program will be heard.

A little explanation may be needed about the HOW switch. It has three positions. Position 1 connects a high-impedance program source to a step-down transformer (Stancor A3327 or equal), to operate a speaker directly, without amplification as a low-level background source. If you have 1 to 2 volts at a high-impedance level you can do this. I found this very adequate if the ambient noise level is low.

Position 2 connects the inputs to 5-watt amplifiers for stereo, more serious listening or where there may be higher background noises.

Position 3 has two uses. If the input is low impedance (4, 8 or 16 ohms) to start with, you can send it on to the speakers directly through position 3 and leave the amplifiers off. Position 3 also feeds the signal to the right and left channels of a large stereo amplifier (in the living room).

I did not make any provision for a dummy load on the 5-watt amplifiers. This can be done by making S2 a 5-pole switch (both amplifiers using a common dummy load). For my purposes, I found miniature zip cord (2 cond. 24 GA stranded) obtainable from Lafayette, ideal for running between the unit and the remote speakers.—*Fred Butterfield*



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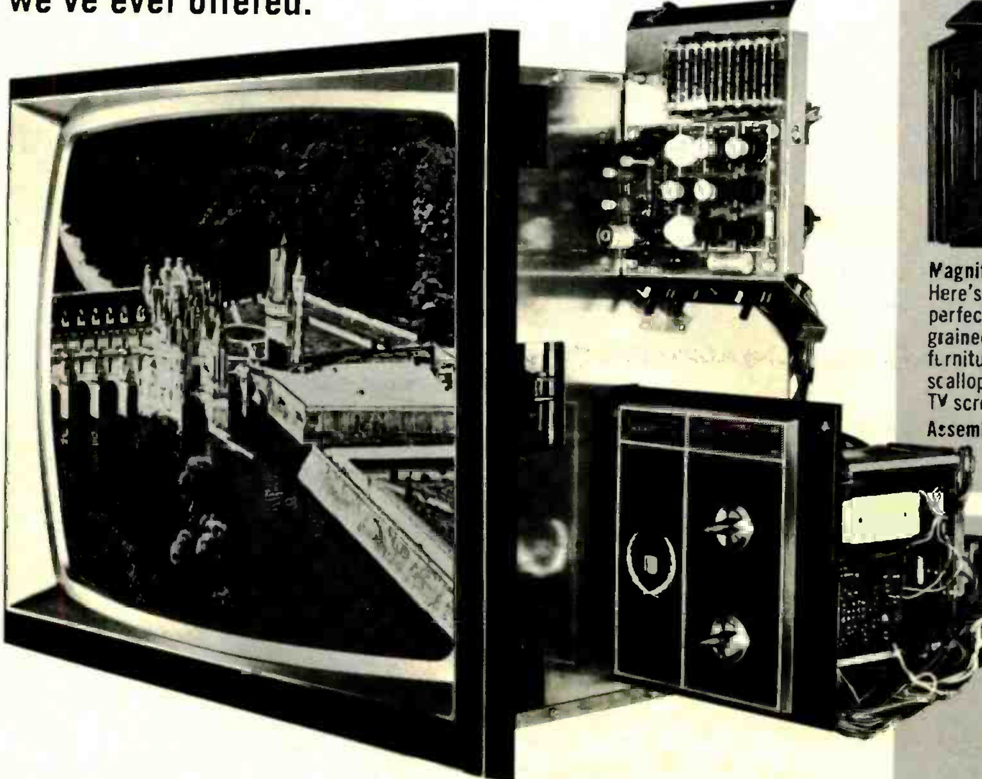
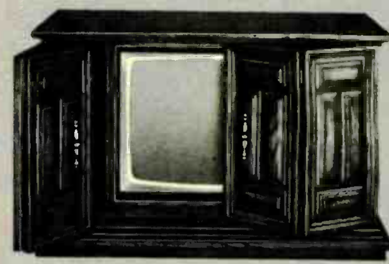
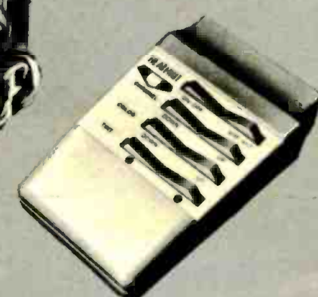




Magnificent Mediterranean Console. Here's the finest TV cabinet we offer, a perfect choice for a GR-900. Has deep-grained pecan veneers on hand-rubbed furniture grade hardwood solids. Two scalloped double-hinged doors hide the TV screen when not in use.

Assembled GRA-405-25, 100 lbs. 179.95*



Wireless Remote for your GR-900. The ultimate in armchair viewing. Gives you eight-function across-the-room control of on/off, three preset volume levels, power tuning (up or down), color, tint, UHF/VHF channel selection. Also activates Custom Wall Mount doors.

Kit GRA-900-6, 6 lbs. 79.95*

The new Heathkit GR-900 25V Color TV has UHF/VHF detent tuning & varactor UHF tuner, angular tint control – more features than any other color TV kit! Better performance than any other set.

UHF/VHF detent power tuning. Push a button and you scan the channels in either direction with detent action locking in on VHF channels 2-13 and any 12 preselected UHF stations. A pushbutton selects either UHF or VHF mode, and a lighted dial indicates tuner position. And you can have full remote-control selection too for just a few dollars more.

New voltage-controlled varactor UHF tuner and specially designed VHF tuner with MOS Field Effect Transistor contribute to better fringe-area reception, increased sensitivity.

New angular tint control. A switch now gives you either "normal" or "wide angle" color demodulation to reduce tint and flesh tone change when changing stations and when programs change. Other deluxe features include "instant on" operation with override for conventional on/off operation; automatic fine tuning; adjustable tone control, and an output for playing TV audio through your stereo hi/fi system.

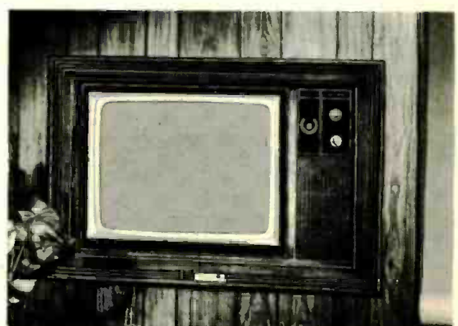
Exclusive Heath MTX-5 ultra-rectangular tube. It's the largest color screen you can buy anywhere, with a full 25 inch meas. diag., 315 sq. in. viewing area. You see virtually everything the station transmits, in the corners and at the sides. The specially etched face plate cuts glare, and reflection, increases contrast without sacrificing brightness, and each dot is projected through a matrix screen to stand out crisply against a solid black background.

Modular solid-state circuitry. Plug-in circuit boards and plug-in transistors make assembly, adjustment and servicing easy. There are 46 transistors, 57 diodes and four ICs – making this one of the most reliable sets we've ever designed.

Other features include automatic chroma control, adjustable video peaking, adjustable noise limiting and gated AGC.

Exclusive Heath self-service built-ins. Your Heathkit GR-900 includes built-in dot generator, tilt-out convergence panel for set-up and periodic adjustments. A handy volt-ohm meter included in the circuitry helps you check your work during assembly, and can be used in conjunction with the manual for any servicing. Like all Heathkit color TVs, the GR-900 gives you complete installation flexibility. There are four beautiful Heath cabinets to choose from plus the new built-in electronic wall mount with hide-away tambour doors. Or you can custom install your GR-900. We think you'll agree, the GR-900 is truly the most impressive color receiver we've ever offered.

Kit GR-900, TV less cabinet, 125 lbs. 599.95*



New Custom Wall Mount. Touch a button on the frame or on your Heathkit Remote Control unit and the folding tambour doors open to reveal your color TV. Kit includes everything needed to build your Heathkit GR-371MX or GR-900 into a wall.

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Here's a five-inch triggered sweep scope at a price you can't afford to pass up. Has DC-10 MHz response, calibrated attenuator, 50 ns sweep rate with magnification, AC-DC coupling, 50 mV sensitivity. It's the ideal instrument for general service and design work...and its quality design, easy assembly, simple operation and self-service capability make the Heathkit IO-103 one of the greatest scope values on the market today. Order one for your shack, shop, lab or classroom, now.

Kit IO-103, 37 lbs. 229.95*

The most powerful and sensitive stereo receiver they've ever tested.

Heathkit AR-1500 AM/FM/FM-Stereo Receiver — ranked by independent experts as the best ever. Here's 180 watts dynamic music power, 90 watts per channel into 8 ohms, 120 watts per channel into 4 ohms. Less than 0.1% intermod distortion, less than 0.25% harmonic distortion. FM selectivity greater than 90 dB, outstanding phase linearity, separation, and low distortion result from two computer-designed 5-pole LC filters. A 4-gang 6-tuned circuit front end offers rock-solid stability, 1.8 uV sensitivity, 1.5 dB capture ratio and 100 dB image and IF rejection. Automatic FM squelch is both noise and deviation activated, fully adjustable for sensitivity.

The AM section, overlooked in most receivers, boasts two dual-gate MOSFETS in the RF and Mixer stages, one J-FET in the oscillator, 12-pole LC filter in the IF, and broad-band detector for good overload characteristics, proper AGC action, no IF alignment and high-fidelity performance. The AR-1500 is an easy kit to build, ten plug-in circuit boards, two wiring harnesses and extensive use of pre-cut wiring with installed clip connectors make assembly fun. Built-in test circuitry uses the signal meter to make resistance and voltage checks as you go. Other features include Black Magic panel lighting that hides the dial markings when the set is not in use; flywheel tuning; pushbutton function controls; outputs for two separate speaker systems, bi-amplification, oscilloscope monitoring of FM multipath; inputs for phono, tape, tape monitor and auxiliary sources — all with individual level controls. The AR-1500 is the critics choice, and with no reservations, the best stereo receiver we've ever designed.

Kit AR-1500, less cabinet, 42 lbs. 379.95*
ARA-1500-1, walnut cabinet, 6 lbs. 24.95*

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Circle 100 on reader service card

AC circuits nomogram

by A. K. QUINN

The graph on the facing page makes it easy to solve series and parallel circuits containing resistance and reactance. It's simple to use and gives results well within normal parts tolerances.

The conventional way to solve the circuit of Fig. 1, when the reactance of C is known, takes many steps. One way would be the solving equations like

$$Z = \sqrt{X^2XR^2}$$

which requires squaring and square root. Another would be to draw vectors and either measure phase angles with a protractor or look up values in trig tables.

Consider the circuit in Fig. 1. Assume we want to find the voltages across C and R, the current, the impedance, the phase angle, and the power factor. The graph, plus some Ohm's-law arithmetic, will give us all those quantities.

Here's how to go about it.

1. Divide the reactance by the resistance. For our example, this would be 7,000/10,000, or 0.7.
2. Locate 0.7 on the left-hand vertical axis. A straightedge laid **straight** across the graph at this point shows that 0.7 corresponds to a *phase angle* of 35°.
3. The straightedge cuts scale A at about 0.58. Multiply this by the applied voltage 200 volts times 0.58 gives us 116 volts. This is the *voltage across C*.
4. The corresponding point on scale B is 0.82. Multiply this by 200 volts and we get *164* volts across R. Scale B also gives the *power factor, 0.82*.
5. Ohm's law gives us the value of *current* as E_R/R, or 164/10,000, or 16.4 mA.
6. Impedance is 200 volts/16.4 mA or 12,200 ohms.

Series R-C-L circuits

These circuits are even simpler. Look at Fig. 2.

1. Subtract X_C from X_L
2. X/R gives the vertical axis index, as with the last example.
3. Scale B value gives a multiplier for E_R
4. Current is E_R/R
5. E_C is I times X_C
6. E_L is I times X_L
7. E_L is I times X_L
8. Z is E_A/I

60 − 40 = 20 (X)
20/20 = 1 (Index)
0.71 (Multiplier)
E_R = 0.71 × 100 = 71V
I = 71/20 = 3.5 amps
E_C = 3.5 × 40 = 140V
E_L = 3.5 × 60 = 210V
Z = 100/3.5 = 2.9 ohms.

Parallel ac circuits

For these circuits, procedure varies, because now we are looking for different things. We know the voltage across the components, but we want to find the current through each component, the total current, the impedance, phase angle and power factor. (See Fig. 3.)

1. Find the current through each com-

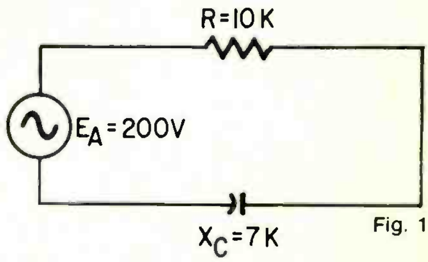


Fig. 1

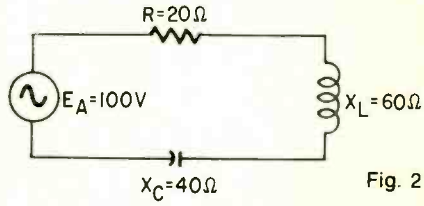


Fig. 2

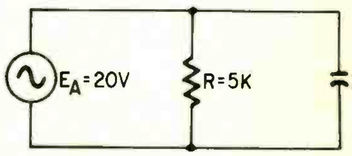


Fig. 3

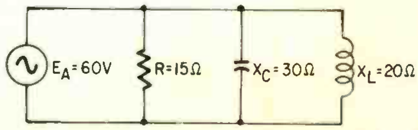


Fig. 4

The math for ac circuits is generally tedious and boring. This nomogram speeds the solutions to R-C, R-L and R-C-L networks.

ponent by dividing the applied voltage by the resistance or reactance.

$I_C = E_A/X_C = 20/10{,}000$, or 2 mA.
$I_R = E_A/R = 20/5{,}000$, or 4 mA.

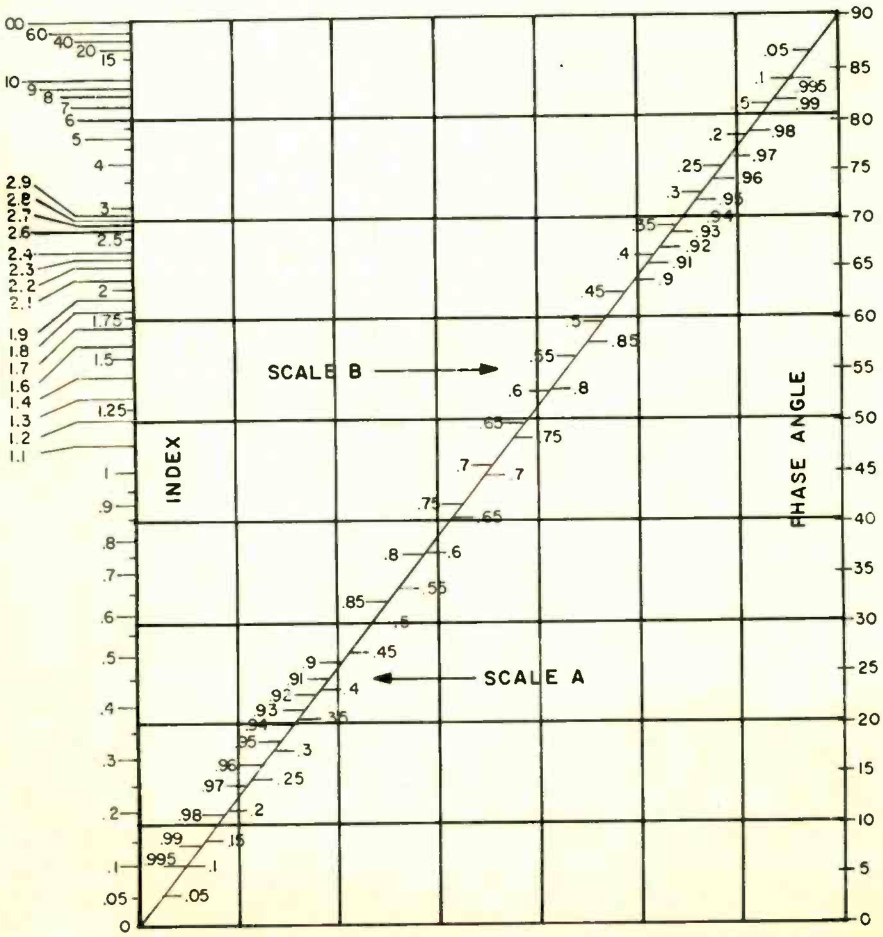
2. Divide R by X_C. $5{,}000/10{,}000 = 0.5$. This is the index, or left vertical axis value. It corresponds to a phase angle of 26°.
3. A straightedge at 0.5 cuts scale B at 0.90. This is the power factor.
4. Now divide I_R by 0.9 to get the total current (I_T). For example, I_T will be 4 mA/.9, or 4.5 mA.
5. Impedance is E_A/I_T, or 20V/4.5 mA, or 4.450 ohms.

Parallel RCL circuits

This type of circuit is shown in Fig. 4.
1. I_R, I_C, and I_L are found by Ohm's law. $60/15 = 4$ amps. $60/30 = 2$ amps. $60/20 = 3$ amps.
2. $I_L - I_C$ gives 1 amp, which we will call I_X.
3. I_X/I_R gives us our vertical index value. $1/4 = 0.25$
4. Read scale-B value as 0.97 (power factor). Phase angle is 14°.
5. I_R/ (scale-B value) gives I_T. $4/0.97 = 4.13$ amps.
6. E_A/I_T gives impedance. $60/4.13 = 14.5$ ohms.

You'll note that in all the applications, scale B is associated with resistive voltage or current. Scale A is associated with *reactive* voltage or current. Knowing that makes it easier to find and use the right scale.

The graph is not absolutely precise, yet it yields solutions well within practical tolerances, and is easier to use than other approaches that rely on vectors, square roots or trig tables. **R-E**



new books

RCA TRANSISTOR, THYRISTOR & DIODE MANUAL (Technical Series SC-15). RCA Solid State Div., Somerville, N. J. 08876. 5 x 8 in., 768 pages. Soft cover. $2.50.

This, the latest edition of the RCA semiconductor manual, has been expanded and updated to cover the latest developments in solid-state technology and application. Too, the technical data has been regrouped according to product type (small-signal bipolar transistors, MOS transistors, low- and medium-frequency power transistors, rf power transistors, etc.) to facilitate selection of the optimum device for a particular application. An index to specific devices is included.

The Circuits Section includes several new additions and the circuits carried over from previous editions have been modified and updated to reflect current practices in circuit design and applications.—*RFS*

SERVICING ELECTRIC ORGANS, 1969 from TAB Books, Blue Ridge Summit, Penna. 17214. By Max H. Applebaum and Donald A. John. 8½ x 11 in. 160 pp. Bound in simulated leatherette. $7.95.

This book is a handy reference for those interested in repairing and tuning electronic organs. It covers actual technical aspects of organs, presents a history of the organ as a musical instrument, and the way the organ basically functions, for better understanding of the possibilities of what could go wrong. The section on troubleshooting hints is heavily illustrated to show organ troubles and their causes.

There is a separate 36-page fold-out section of typical organ schematics. Step-by-step tuning methods, which do not require previous musical knowledge, are also detailed.—JW

ENGINEERING CIRCUIT ANALYSIS, by William H. Hayt, Jr. and Jack E. Kemmerly. McGraw-Hill Book Co., 330 W. 42nd St., New York, N.Y. 10036. 6½ x 9½ in., 653 pp. Hardcover, $15.50.

Intended for use as text for a first course in electrical engineering. The concepts covered include the resistive circuit, natural response and complete response to dc excitation of the simpler RL, RC, and RLC circuits, frequency domain, complex-frequency, magnetic coupling, and transform methods in circuit analysis.—*MCL*

BASIC ELECTRONICS PROBLEMS SOLVED, by Donad A. Smith. Tab Books, Blue Ridge Summit, Pa. 17214, 192 pp. 5½ x 8½ in. $7.95 hardbound, $4.95 clothbound.

Answers basic electronics problems dealing with solid-state and tube-type circuits. Concentrates on problem solving giving detailed explanations with answers. Starts with simple problems, then goes on to dc circuits, semiconductors and power supplies, all the way through the use of the slide rule.—JW

RCA SHUTS DOWN SERVICEAMERICA

December 31, 1971 was the last day of business for RCA's ServiceAmerica operation. Established in three test markets (Philadelphia, San Francisco, and Miami), ServiceAmerica was to repair all makes of tv sets and other home-entertainment equipment. RCA stated that its results in the test markets did not justify the investment of manpower and other resources needed to expand ServiceAmerica nationally.

laser experiment

Coherence is one of the prime characteristics of laser light. Try this experiment

Consider an ideal elementary sinusoidal wave form. The characteristics of this wave are its amplitude A (its height above the zero line) and its wavelength λ (the distance from wave peak to wave peak). In this case, the amplitude varies with time in a constant sinusoidal manner and with the maximum remaining the same. The wavelength also remains constant, as the wave propagates (Fig. 1).

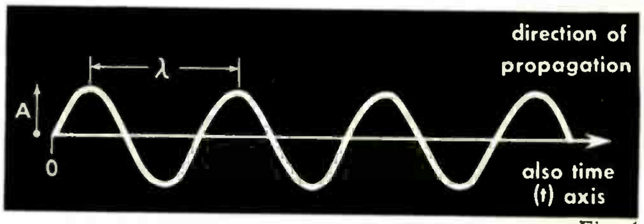


Fig. 1

Temporal coherence

The definition of coherence involves two or more waves rather than just one. Consider two waves, one superimposed over the other on the same line of propagation. (Figure 2 shows the two waves with the super-imposition modified for clarity.)

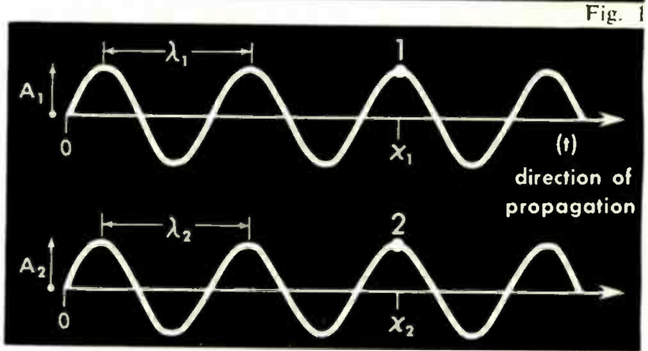


Fig. 2

First, disregard the amplitudes of the points and consider points *only* with respect to the direction of propagation.

During a time t, each of the two waves advances down the line of propagation to a wave peak, point 1 on wave A_1 and point 2 on wave A_2. They are traveling at the same speed and have the same wavelength and, if allowed to continue, the wave peaks will occur at the same places all the way down the line. These waves are said to be in phase and coherent. This particular coherence, that is, with respect to time, is called temporal coherence.

With this in mind, we can now define coherence. Two or more waves are said to be coherent if the "phase difference" between two pairs of points, one on each wave, *remains constant*. If our example, where the waves are in phase, the phase difference is zero throughout and thus constant.

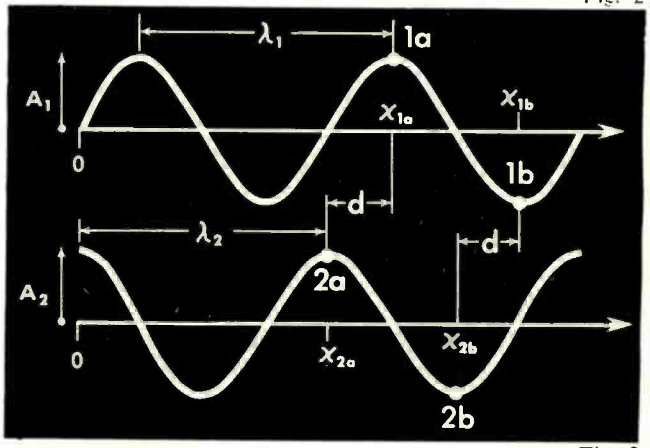


Fig. 3

Figure 3 shows a slightly different situation. In this case, one wave "lags" the other slightly, but the waves are still temporally coherent because the sets of points remain at constant distance d apart along the line of propagation. They are not in phase but have a constant phase difference.

Interference

Up to this point, the amplitude of the waves being discussed has been ignored to stress other factors.

Consider two waves superimposed on each other along the same line of propagation. It is well known that as a wave moves through a media, it propagates a disturbance along the direction of propagation. The amount of disturbance depends on the amplitude of the wave. When the amplitude is positive (i.e. when a peak is formed or the wave point is moving up), it is termed positive disturbance. Alternately, when the amplitude is negative, it is termed negative disturbance.

If two waves are superimposed on one another along the same line of propagation, the amplitudes add. If there are two positive amplitudes, they total to a greater positive amplitude. Two negative amplitudes follow the same formula, adding to a greater negative amplitude. If, however, a negative amplitude is paired with a positive, the difference between the two is found for the total amplitude.

The interaction of two waves as described above is called *interference. Constructive interference* results from adding two wave amplitudes of the same sign (+ or —) (see Fig. 4A). *Destructive interference* results from adding two amplitudes of different signs (Fig. 4B).

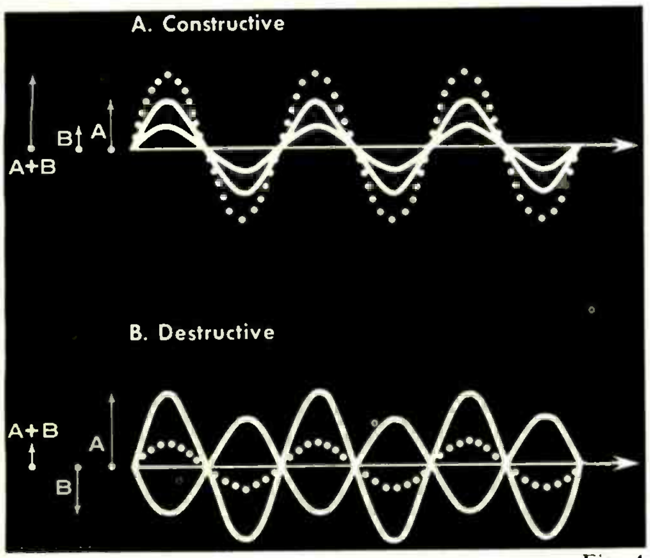


Fig. 4

Lateral coherence

Consider two waves traveling along the parallel lines of propagation, with equal amplitudes, wave lengths, and in phase (Fig. 5). Pick two points, one on each wave, and note

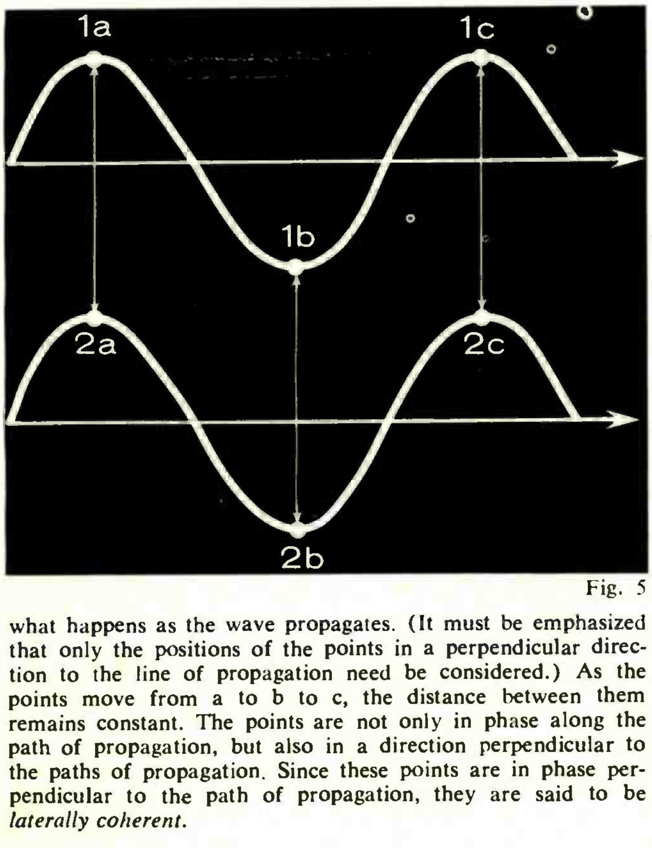


Fig. 5

what happens as the wave propagates. (It must be emphasized that only the positions of the points in a perpendicular direction to the line of propagation need be considered.) As the points move from a to b to c, the distance between them remains constant. The points are not only in phase along the path of propagation, but also in a direction perpendicular to the paths of propagation. Since these points are in phase perpendicular to the path of propagation, they are said to be *laterally coherent*.

Spatial coherence

The discussion has been limited thus far to a two-dimensional representation. However, light waves are three-dimensional, and the concept of coherence must be expanded to cover such a system.

The transition is simple. Temporal coherence remains the same along the direction of propagation as does lateral coherence, but now lateral coherence is allowed to relate to any direction perpendicular to the line of propagation.

The result of combining these two concepts, lateral and temporal coherence, produces what is called spatial coherence in which two or more points are in phase a) along the direction of propagation (temporal); and b) along *any* direction perpendicular to the direction of propagation (lateral) (See Fig. 6).

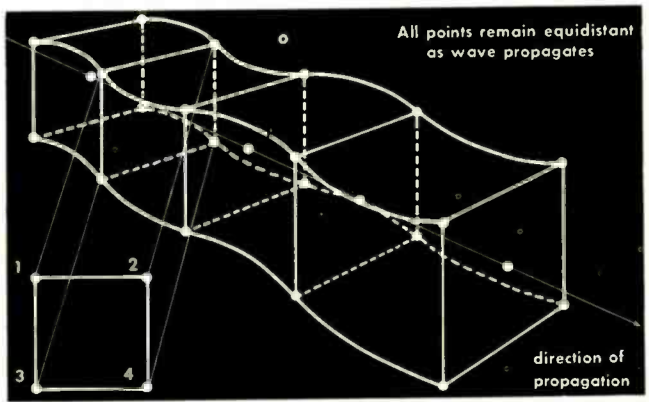


Fig. 6

Importance of coherence

One of the most startling consequences of coherent light was totally unexpected until the phenomenon was viewed for the first time during the operation of a continuous wave laser. This phenomenon is, of course, the speckled image produced when the highly coherent laser light is scattered from a semi-smooth diffuse reflector. Here we see diffraction and phase interference effects on a scale never attained before with visible light. What we see is really a stationary diffraction pattern in space resulting from the scattering of the coherent light by the diffuse reflector and the subsequent interference of the coherent wave trains with each other. The effect is enhanced by the high coherence so that the pattern extends to dimensions visible to the human eye. **R-E**

LIQUID CRYSTAL

(continued from page 36)

treat them with respect! Don't get any on your hands, eyes, or mouth. Clean up thoroughly when finished, and keep the chemicals away from children. Avoid getting any fumes (highly unlikely) in your eyes or mouth. In short—in spite of the fact that liquid crystal chemicals appear harmless—treat them as dangerous chemicals. Better safe than sorry.

Before you start your display work, get as much printed information as you can, starting with manufacturer's literature from Tables I and II. Then read *Dynamic Scattering: A New Electrooptic Effect in Certain Classes of Nematic Liquid Crystals* by Heilmeier, et al., in the July 1968 *Proceedings of the IEEE*, Vol 56, no 7, pp 1162-1171. You might also find pages 2146-2148 (December 1968) of interest, as well as pages 34-38 (January 1969) of volume 57. For more information beyond this, check the *Engineering Index* in your local library under *Crystals, Liquid.* This will generate a hundred or so papers, some of which you'll be able to pin down. Remember that nematic liquid crystals are most often the ones used in displays, while half the papers will deal only with thermal effects and cholesteric materials. **R-E**

TRANSISTOR TESTING IS A CINCH

(continued from page 39)

sistor now shows good. No leakage, and npn (and, as you can see in Fig. 4-c, the "almost-standard" TO-5 basing or E-B-C counting clockwise around from the locator lug on the case.)

There was evidently too much shunt resistance somewhere to let the transistor test good in-circuit. This was in a little "gadget" I had picked up; I thought the transistors were good, and this one was.

In another test, on an all-channel TV booster, there was a definite suspicion that the transistor was bad. (I don't know what made me think that; maybe because it had been hit by lightning, and wouldn't work!) At any rate, there were a lot of low-resistance things hooked across the transistor; baluns, small resistors, and so on. Resistance readings were way off. However, I did note that the ohmmeter showed no diode-effect between base and emitter.

I took the transistor out and checked it on the tester, no good. The ohmmeter showed that the base-emitter junction was open. The collector-emitter junction still showed a diode-effect. From the low resistance indicated, this note that the ohmmeter showed no the ohmmeter was on the emitter. So, this was a pnp. I did note that what I was using as the collector lead was connected to the case.

The assumption turned out to be correct. Plugging the booster in, and checking the open-circuit dc voltage from the power supply showed 25 volts. So I chose a pnp germanium transistor, collector-voltage rating of 35 V, 800 MHz high-frequency cutoff, and tried it. It worked.

So even if the transistor is a complete stranger, with one junction completely open, you can still use these tests to get enough data to make a ball-park diagnosis of what it was, and select a replacement that has a chance of working. As a matter of fact, if you turn out to be wrong (as demonstrated by the indisputable fact that the thing *won't* work!), it doesn't seem to do any harm to a modern junction transistor to be installed *backward*.

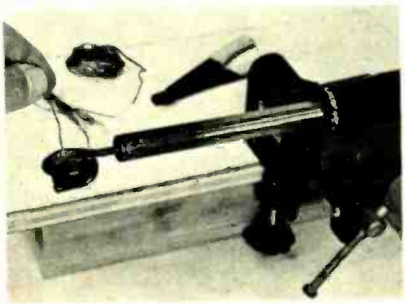
Summation: I have only one suggestion now. Be sure to *try* these tests yourself, with your own equipment, and compare results. At first, use new (checked) transistors, and keep notes. Watch for the peculiar reactions of the two types of bipolar transistors, and remember them. I believe this will be very helpful!

Possibly some of you have your own methods of identifying and testing unknown transistors. If so, I'd like to hear from you. Perhaps we can get together and develop a "standard" test. **R-E**

try this one

MINI SOLDER POT HEATS IN MINUTES

How many times have you wished for a ready hot solder pot at hand as you tinned a dozen or so wires one at a time with an iron? Here is a miniature solder pot that fits into a regular soldering iron that heats up, ready to use, in only a few minutes.



The solder cup is an end cap for ½-inch rigid copper tubing around which a copper wire is bent, as shown, forming a circle slightly smaller than the diameter of the end cap.

After forming the wire and checking for a tight fit thoroughly clean it and the outside wall of the cup with steel wool or sandpaper. As the iron heats up for the first time apply solder to the copper wire and it will flow between the wire and the cup.

The wire used to support the cup should be soft copper (preferably solid) of the same diameter as the soldering-iron tip it replaces. A No. 2 or 3 wire is about right for a ¼-inch tip.

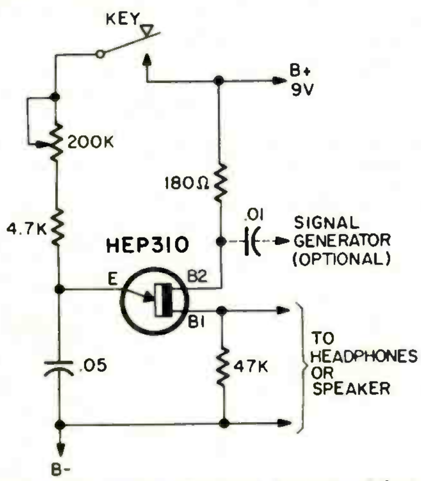
With care lightly shake the iron (wear safety glasses!) to get rid of excess solder. What's left will form a near perfect heat transfer, hot or cold, insuring a quick warm up of the solder that now can be put in the pot.

For safety and to free both hands, use a bench stand or a small vise to hold the iron. This is a case where an ounce of prevention, by way of the stand, is well worth a pound of trouble that the lead on the loose would surely be.—*Gene Cabot* **R-E**

If electrolytic capacitors are your nemesis, you won't want to miss the article starting on page 58. It's called "All About electrolytics," and once you've read it you shouldn't have any questions left.

audio signal generator

PARTS LIST
1 HEP 310 or 2N5871 unijunction transistor
1 180 ohms, ½ watt, 10% resistor
1 200,000-ohm potentiometer
1 47,000 ohms, ½ watt, 10% resistor
1 0.5-μF, 25-volt capacitor
1 Key (for code practice)
1 Set headphones (or speaker)
1 0.01-μF, 25-volt capacitor (optional, needed only for signal generator)
1 9-volt battery



A unijunction relaxation oscillator can be used for many purposes simply by changing a few components, as illustrated by this one-transistor project. It can generate an audio signal for troubleshooting amplifiers or for practicing code. The frequency is adjustable and the oscillator can be used with headphone or speaker. The signal generator output provides a pulse output with high harmonic content. For a clarinet-like sound, take the output signal from the emitter of the unijunction transistor. **R-E**

EQUIPMENT REPORT

(continued from page 84

(C7, L3, C8, C9) and only the lower difference-frequency signals are passed. The first af amplifier feeds through the volume control to three cascaded af voltage amplifiers. The receiver's selectivity (2 kHz at -6-dB points) is quite adequate for most amateur communications.

Two paralleled diodes protect the mixer transistor against possible damage by very strong rf signals and induced voltage from electrical storms.

The ANTENNA TUNE control tunes L2 on 80 and 40 meters. On 20 15, L1 is switched across L2 to low the effective inductance of the antenna circuit and permit it to be tuned to the higher frequencies.

The oscillator circuit is rather unusual. On 80 meters L5 and L6 are in series and the main tuning capacitor is between ground and the oscillator emitter. The buffer, an emitter follower, feeds the signal to the mixer. On 40 meters, only L5 is tuned and the MAIN TUNE capacitor is moved to a capacitive tap to provide the correct bandspread tuning for that band and the ones above it. When receiving on 20 and 15 meters, the oscillator tunes from 7.0 to 7.3 MHz and the multiplier is cut into the circuit to double or triple the oscillator frequency as needed.

Ten-Tec has a set of three PC modules (VO-1 oscillator, MX-1 mixer and AA-1 audio oscillator that can be interconnected to make a receiver similar to the RX-10. By adding to this, the TX-1 crystal oscillator and 2-watt rf amplifier module, you will have a low-power ham-band transceiver.

SPECIFICATIONS

Frequency range: 3.5–4.0 MHz
7.0–7.3 MHz
14.0–14.6 MHz
21.0–21.9 MHz

Modes of operation: USB, LSB, AM, CW

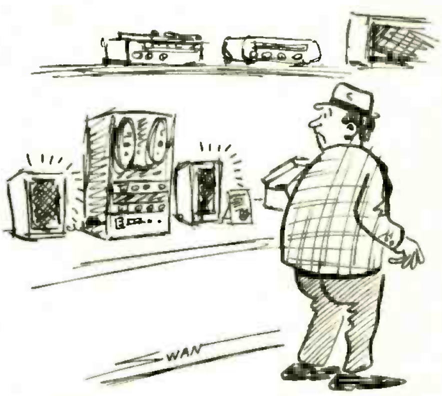
Sensitivity: Less than 1 μV for readable signal

Stability: Less than 100 Hz drift, no warm-up

Audio output: 3 volts across 1000 ohms

Antenna Impedance: 50–70 ohms unbalanced

Selectivity: 2 kHz at -6 dB points



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technotes

SONY KV-1710

Residual buzz in this color set is caused by hum or noise in the deflection circuit. After replacing the SC board, use the following procedure to eliminate the buzz:

1. Move the grounding point of the GRY/WHT shielded wire connected between the volume control and terminals 12 and 13 on the SC board as shown in Fig. 1.

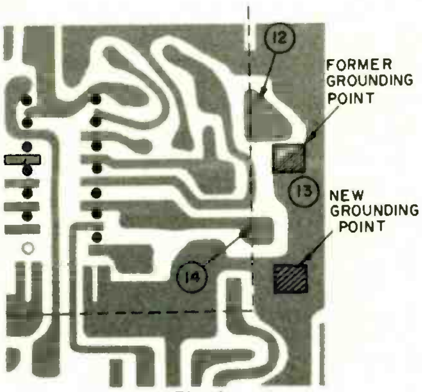

Fig. 1

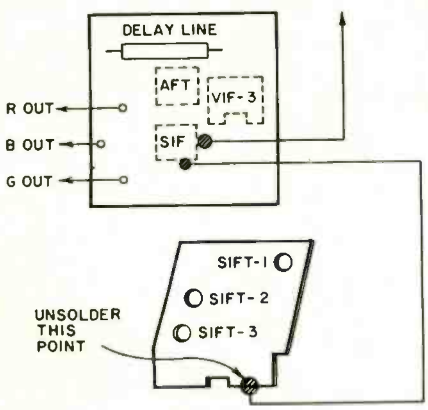

Fig. 2

2. Unsolder the single ground point for the SIF shield case as shown in Fig. 2.—*Sony Service Supplement*

RCA CTC 46 SERIES

The output impedance of the MAN sound output module is relatively high (32–35 ohms) compared to other current color chassis. When bench servicing is required, make certain a lower impedance (4–8 ohms) test speaker is *not* used since this can result in damage to the MAN module components.—*RCA Service Information*

3CU3 HV RECTIFIER

Some late Magnavox color TV chassis use a 3CU3 high-voltage rectifier tube and a 3A3 should never be tried as a substitute. The 3CU3, a directly heated type, has a posted filament design that prevents the possibility of a broken filament from contacting the tube anode. The 3A3 does not provide this protection.

The 3CU3 has a faster warm-up time and receivers using it may display the picture before the automatic degaussing action is completed. **DO NOT** use a 3A3 to delay the picture and thus conceal the degaussing action.—*Magnavox Service News Letter*

LINEARITY CONTROL REPLACEMENT

When a vertical linearity control (usually a wire-wound pot) burns out an exact replacement may not be available. While an ordinary wire-wound pot may be substituted I've found that a 3-watt fixed wire-wound resistor may be used. The resistance required for good linearity can be found by substituting. The height control can be used to fill the screen vertically.

I used this scheme in an RCA KCS146 b-w chassis.—*Paul Galluzzi*

Do you know what liquid-crystals are all about? If not turn back to page 33 right now and read Don Lancaster's article on Liquid Crystal Displays. It opens the door to a whole new corner of electronic devices.

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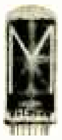

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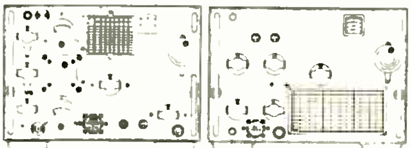

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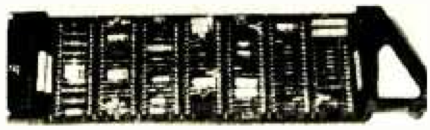

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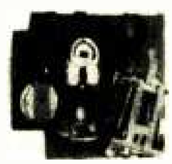

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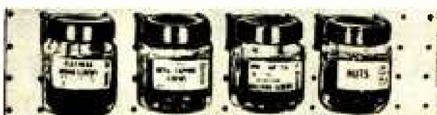

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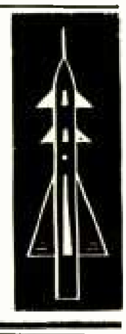

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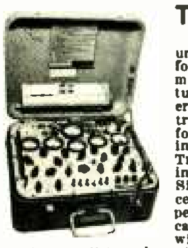

For portable use. Gov't. surplus unit used to test and measure performance capacities, and to determine rejection limits for electron tubes used in receivers, low powered transmitters and other electronic equipment. Has provisions for checking tubes up to 9 pins including Acorn, Noval, 7 Pin Trans. etc. Meters 2½" for reading Fil., Grid, Plate, Screen, Signal and transconductance (percent quality) which is 10,000 ohms per volt. All the important tests can be made on this unit. Also it will test tubes under actual operating conditions by setting the proper voltages on the meters. Power Req.: 115 volts, 60 cycle. Size: 17¾" x 16¼" x 8½". Wt.: 45 lbs. Prices: Used, serviceable: $55.00 Checked: $65.00

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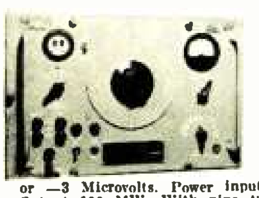

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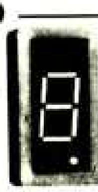

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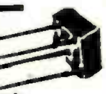

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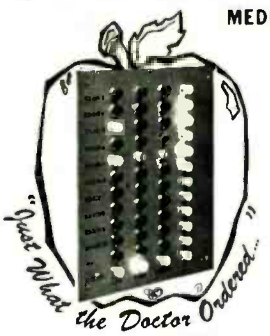

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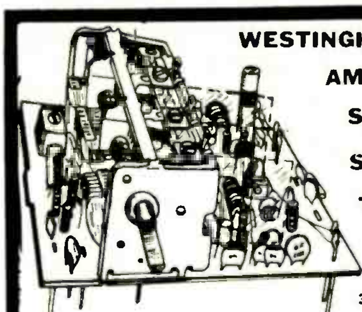

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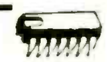

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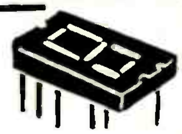

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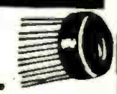

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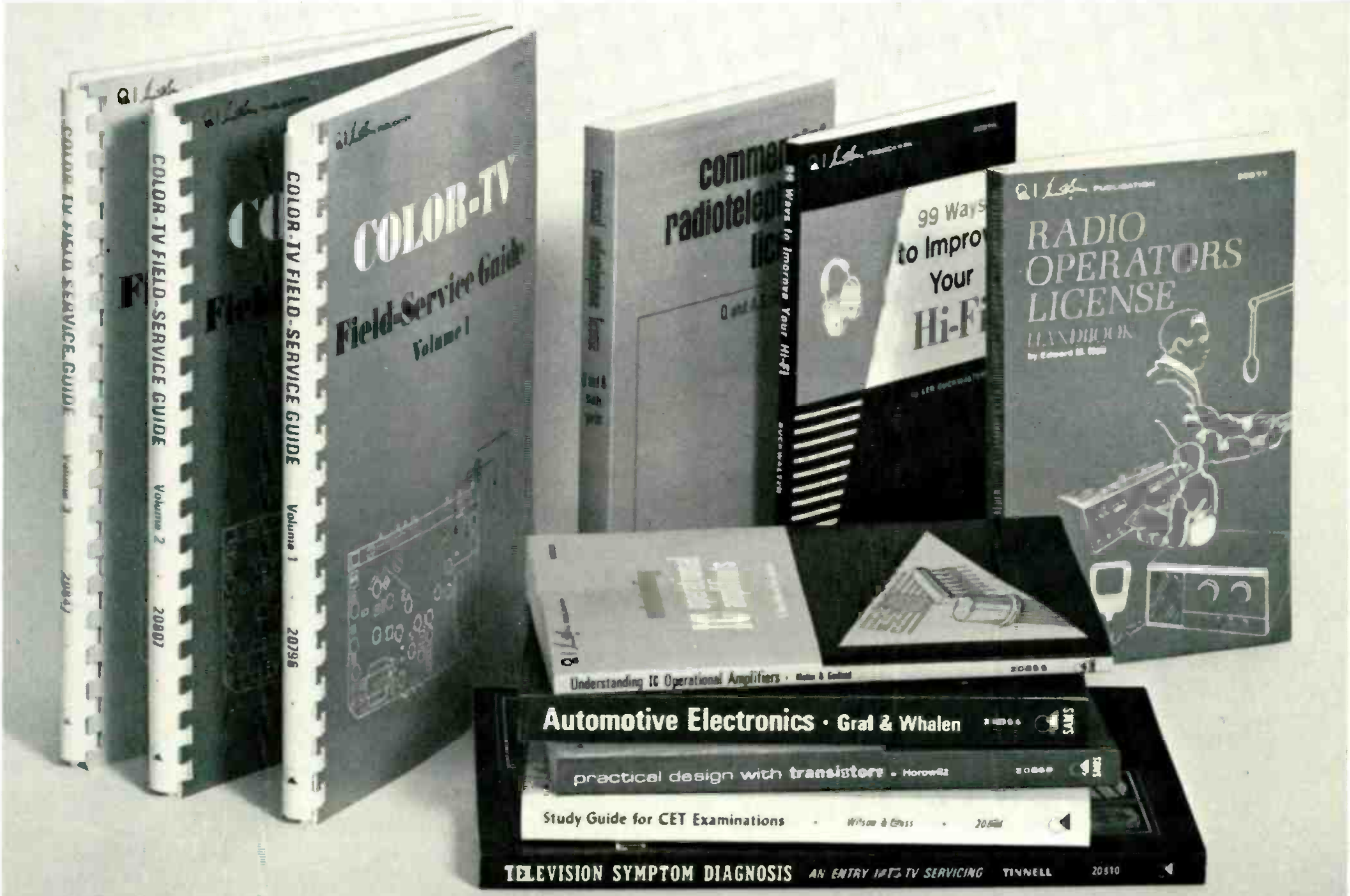

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RE-022

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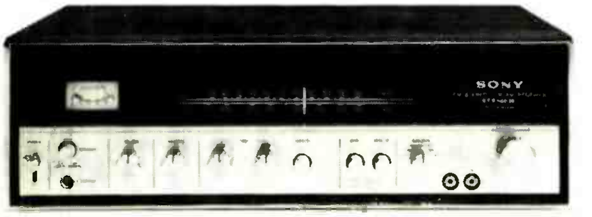

*IHF standard constant supply method.

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