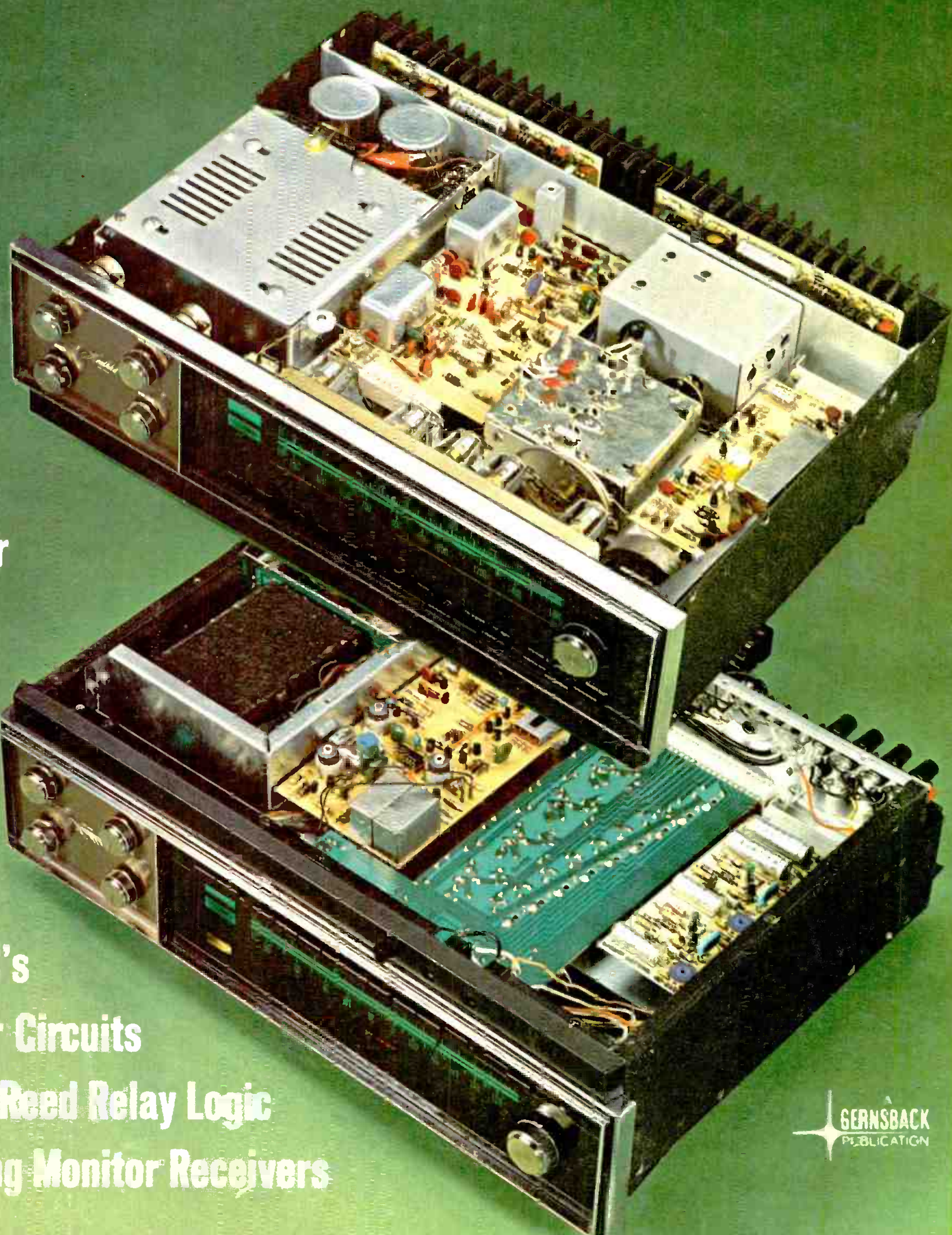
60¢ ■ DEC. 1971

Radio-Electronics

FOR MEN WITH IDEAS IN ELECTRONICS

R-E BUILDS HEATH AR-1500 STEREO RECEIVER

Top-quality kit has many exciting features



BUILD

Don Lancaster's Tic-Tac-Tronix Game Computer

Liquid-Crystal Wattmeter

Windshield Wiper Pause Control

Sonic Cleaner

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Today's Linear IC's

Class-A Amplifier Circuits

Troubleshooting Reed Relay Logic

All About Scanning Monitor Receivers

GERNSBACK PUBLICATION

Technically, our new SQ four-channel system has 4 basic advantages.

Sony SQ.

A new stereo/quadraphonic system, delivers four distinct sound channels from a compatible SQ record.

It also offers four distinct advantages over all the other four-channel "matrix" systems.

Advantage #1:
Greatest stereo separation, front and rear.

Your present stereo system probably can maintain 40 db or so of separation between left and right channels. Maintaining this full left-to-right separation, in both the front *and* rear pairs of channels, is one of the major achievements of the SQ system.

Advantage #2:
Simple logic that lets soloists stay soloists.

When a single instrument is playing, all you want to hear is that instrument, even in four-channel. A pure matrix decoder—even the matrix at the heart of SQ—can't reproduce a solo instrument without a softer, phantom soloist in other channels. But by adding a logic circuit, these phantom signals can be diminished or eliminated, sharpening your sense of the soloist's position.

So far, though, only Sony's SQD-1000 and SQA-200 decoders have this logic enhancement. Because SQ's unique encoding (which shows up on records as a double-helical modulation of the groove) makes simple logic circuits practical.

Advantage #3:
Total omnidirectional fidelity.

A musician plays no softer when he's behind you or to one side. With SQ he doesn't sound as if he did. No matter where in the 360° quadraphonic circle the musician sits, he will be heard at exactly the same volume as if he were sitting in front of you. And that's true whether you're listening to the SQ record in four-channel or just playing it on a stereo system without an SQ decoder.

Advantage #4:
Equipment by Sony.

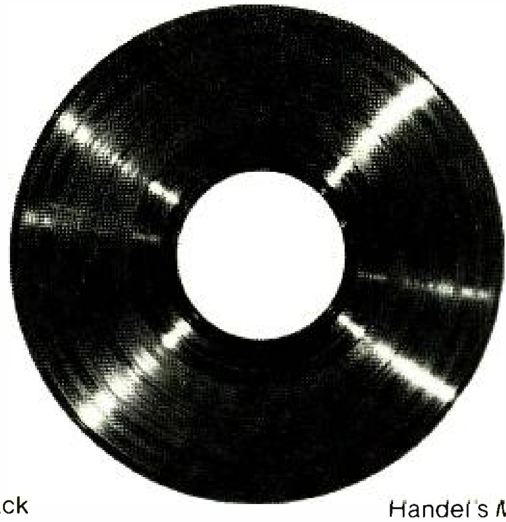
Sony offers you a choice of two SQ adapters. For the more demanding, there's a new SQD-1000 decoder. Its logic circuit enhances front-back separation by up to 6 db, so that front-center soloists (or rear ones, for that matter), stand out more clearly. The SQD-1000 lets you listen to four-channel sound from SQ records, or to discrete four-channel tapes on auxiliary players. It also lets you listen to normal stereo, or to stereo broadcasts and recordings enhanced with SQ ambience. Just plug the SQD-1000 into your tape monitor jacks (the SQD-1000 has its own), and add your choice of rear-channel amplifier and speakers.

If you want to get into SQ with a more modest investment, add Sony's new SQA-200 SQ decoder/amplifier to your system. It has all the SQD-1000's features (except the four-channel master volume control). But because the SQA-200 has a stereo amplifier built in, it saves you the expense of an extra amplifier for your rear channels.

Hear SQ at your Sony dealer. Or write Sony Corporation of America, 47-47 Van Dam Street, Long Island City, N.Y. 11101.

New SONY® SQ

Musically, it's starting out with 52.



Columbia Records

Popular

Lynn Anderson, *Rose Garden*
Blood, Sweat and Tears II
Johnny Cash at San Quentin
Chase
Ray Conniff, *Love Story*
Al Cooper, Mike Bloomfield & Steve Stills, *Supersession*
Miles Davis, *Bitches Brew*
Bob Dylan, *Nashville Skyline*
Percy Faith, *Romeo and Juliet*
Funny Girl, Original Sound Track
Janis Joplin, *Pearl*
Kris Kristofferson, *Silver-Tongued Devil and I*
Johnny Mathis, *You've Got a Friend*
Jim Nabors, *Help Me Make It Through The Night*
No, No, Nanette, Original Cast
Poco, Deliverin'
Ray Price, *For the Good Times*
Raiders, *Indian Reservation*
Santana, *Abraxas*
Sly and the Family Stone, *Greatest Hits*
Ray Stevens, *Greatest Hits*
Barbara Streisand, *Stoney End*
Ten Years After, *A Space in Time*
Andy Williams, *Love Story*
Tammy Wynette, *We Sure Can Love Each Other*

Classical

Bach, *Switched-On Bach* (Carlos)
Bernstein, *Mass* (Bernstein, Original Kennedy Center Cast)
R. Strauss, *Also Sprach Zarathustra* (Bernstein, N.Y. Philharmonic)
Morton Subotnick, *Touch*
Verdi, *Requiem* (Bernstein, Arroyo, Veasey, Domingo, Raimondi, London Symphony)

Vanguard Records

Popular

Joan Baez, *Blessed are...*
Larry Coryell, *At the Village Gate*
Country Joe and the Fish, *From Haight-Ashbury to Woodstock (2 LP)*
Buffy Sainte-Marie, *Moonshot*

Classical

"P.D.Q. Bach," *The Stoned Guest* (Schickele)
Berlioz, *Requiem* (Abravanel, Utah)
Handel's *Messiah* (Price, Minton, Young, Diaz, Somary, English Chamber Orch.)
Handel, *Messiah highlights*
Mahler, *Symphony No. 3* (Abravanel, Utah)
Mozart, *Divertimenti* K287/138 (Blum, English Chamber Orch).
Tchaikovsky *Symphony No. 4* (Stokowski, American Symphony)
Tchaikovsky, *Serenade Op. 48;* Prokofiev, *Classical Symphony;* Arensky, *Variations* (Somary, English Chamber Orch.)
The Virtuoso Trumpet of Martin Berinbaum (Somary, English Chamber Orch).

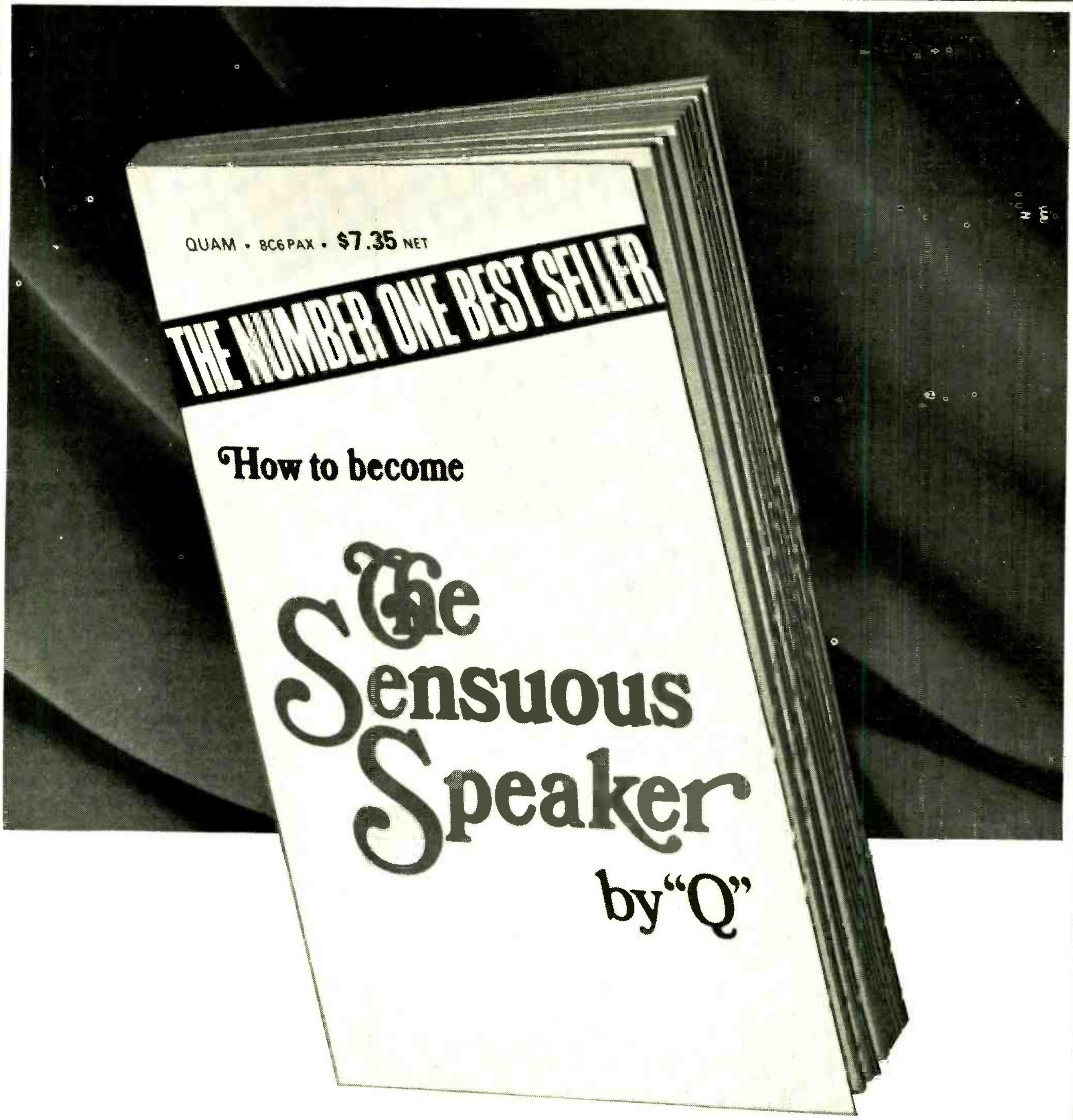
Ampex Records

Popular

Anita Kerr Singers *Grow to Know Me*
Anita Kerr Singers with Royal Philharmonic, *A Christmas Story*
Bob Hinkle, *Ollie Moggus*
Melting Pot, *Fire Burn and Cauldron Bubble*
Mason Profit, *Last Night I had the Strangest Dream*
Purlie, Original Cast
Cris Williamson
Rome Philharmonic, *Classical Movie Themes*

four-channel record system

Circle 1 on reader service card



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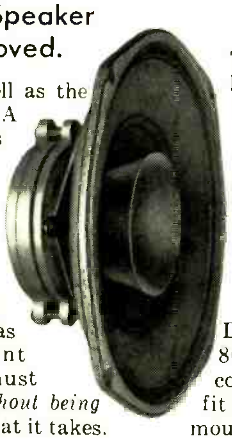

But few manage it as well as the Quam Model 8C6PAX. A jillion of these speakers have already been installed in factories, offices, restaurants, and other locations. What's the secret of success? It's the Sensuous Sound!

The Quam 8C6PAX *knows* that music often has to compete with inherent situational sounds. It must manage to be *audible without being obtrusive.* It has to have what it takes.

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Don't try to be too deep. The 8C6PAX has just the right shallow construction. At three inches, it can fit almost anywhere. Transformer mounting facilities add to its appeal.

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Circle 2 on reader service card

Radio-Electronics
FOR MEN WITH IDEAS IN ELECTRONICS

December 1971

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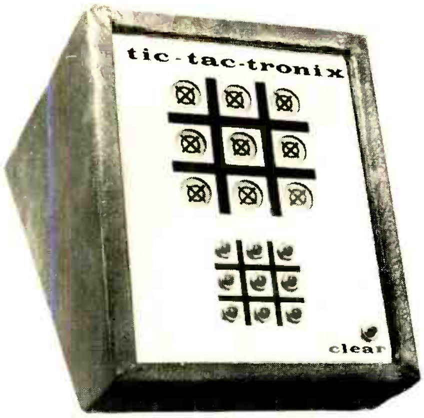

TIC-TAC-TRONIX is a hard-wired game computer that is a champion tic-tac-toe player. In fact it can't be beat. . . we think. see page 32

SCANNING MONITOR RECEIVERS watch the emergency bands automatically, and lock onto incoming signals. . . . see page 58

TEST CAPACITORS for leaky or shorted units. Build this basic checker. . . . see page 60

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looking ahead

Color video disc

The full-color version of the video disc developed jointly by Germany's A.E.G. Telefunken and Britain's Decca was warmly received in its first demonstration at the Berlin Radio and Television Exhibition. Observers generally agreed that the color quality was excellent and the picture produced was completely satisfactory for home viewing. The video disc's developers are now shooting for a marketing date some time in 1973. The concept of the disc has been changed somewhat since a black-and-white version was demonstrated in the United States in fall 1970. Plans for a 15-minute disc have been scrapped. Instead, the discs will have a five-minute playing time, with a rapid-change system to permit the playing of up to 12 discs consecutively with virtually no interruption.

The discs are about eight inches in diameter. The simplest type of player, targeted at about $200 retail, will be slot-loaded. The record, in its jacket, is pushed into a "mail slot," is played, reloaded into its jacket and automatically ejected. The automatic changer, to cost about $400, will accommodate discs loaded into a special cartridge, somewhat similar to a slide magazine. It will have two turntables and two pickups—while one disc is playing, the next one is being deposited on the air-suspension turntable to continue the performance with only a fraction of a second's lapse.

The video disc uses a simplified color system based partially on redundancy of information in the television picture. For low-frequency sections of the picture (up to about 1 MHz), the color is line-sequential—one line of red information, one of blue and one of green, and so on. This information is stored and redistributed on each line. The higher-frequency portions of the picture are reproduced unaltered. To accommodate all of the world's television standards, only two versions of each disc will be required—one for 525 lines, spinning at 1800 rpm, the other for 625, at 1500 rpm. The electronics in the disc-player will convert the color to the system for which it is designed—NTSC, PAL or SECAM—to be fed into the antenna terminals of a standard color set.

FCC & videocassettes

With all the publicity about the coming age of the videocassette player/recorder, it was inevitable that the FCC would get into the act. Through its power to control interference-causing rf radiation, the Commission has proposed establishing a new category of product known as a "Class I TV device"—any non-broadcast device which produces an rf carrier modulated by a television signal. Typical Class I TV devices would be VTR's, cameras and videoplayers which are designed to feed a TV signal into the antenna terminals of a standard TV set. CATV systems, covered by separate rules, are not included.

The FCC proposed a maximum output voltage of 2000-μV rms for devices designed to feed into a 300-ohm antenna connection on a TV set. In addition, it proposed limits for spurious radiation from these devices. The practical effect of the Commission's proposal has been a dead halt in legal distribution of any devices (VTR's, cameras, etc.) designed to be fed to a TV set's antenna terminals. Many of these devices have output voltages of 1V or more. The FCC has offered to grant waivers of its rules to permit marketing of such devices if its laboratory finds in tests that they come within the proposed limits. At press time, the only such device which had passed the FCC test was the Motorola-built EVR cartridge film player. Most manufacturers in the VTR and videocassette field are expected to urge higher limits on the grounds that the proposal would result in an unsatisfactory picture.

The FCC, for its part, wants assurance that videoplayers won't act as transmitters, feeding backwards through master antenna systems, radiating through apartment walls, and generally disrupting neighborhood television reception. The practical result of the new proceeding will be a temporary halt in most plans for videoplayer systems until final and official government specifications are worked out.

Rentertainment

With cable TV seemingly on the brink of an explosive expansion, television receiver manufacturers have been devoting increasing attention to the question of just how they fit into the cable age (Looking Ahead, **Radio-Electronics** Sept. 1971). In the prime CATV territory of hilly western Pennsylvania, Philco-Ford is currently engaged in a special test project which could go nationwide. It's called "Rentertainment"—which just about describes it. The test area is Greensburg. Jeanette, Irwin and Latrobe, served by a major cable system. Philco has adapted one of its ruggedized hotel-motel color television receivers, a 19-inch table model. for cable reception (75-ohm input, improved adjacent-channel interference rejection) and has established a factory-operated set leasing operation there. The theory apparently is that people pay by the month for CATV service—why not pay by the month for the receiver, too?

In this pilot operation, Philco is charging $14.95 monthly rental for a color receiver—available to cable subscribers only. The customer doesn't sign a long-term agreement—the TV is removed any time he requests it. Philco's big lure is service. Its ads promise: "Never a service charge . . . because you rent the set and if something goes wrong the set is replaced quickly—at no charge." The service is performed by Philco's own technicians. If the results of the test are encouraging, Philco plans further rental operations in other cable-TV areas and eventually perhaps a nationwide Rentertainment franchise operation.

Satellite telecasting

The first direct satellite-to-receiver telecasting is now tentatively scheduled to occur in mid-1973 in the Rocky Mountain area. The experiment is to be a joint effort of NASA and the HEW Department, to transmit educational television to 500 community receivers in schools, public broadcast stations, cable systems and other locations. The Federation of Rocky Mountain States, which is coordinating the experiment, notes that there is nothing to prevent any individual from acquiring a parabolic antenna-converter at $150 to $200 and picking up the direct broadcasts. The transmissions will be at 2500 MHz. After a year's use over the Rockies, the satellite is scheduled to be moved into stationary orbit over India, where it will provide direct broadcasting of educational material to community TV sets there. Future plans depend on the results of these tests.

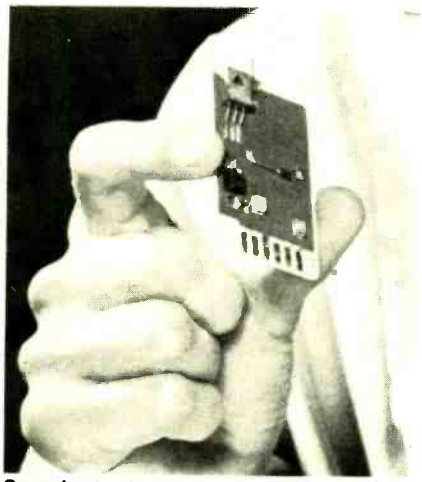
DAVID LACHENBRUCH
CONTRIBUTING EDITOR

new & timely

Ceramic circuit modules

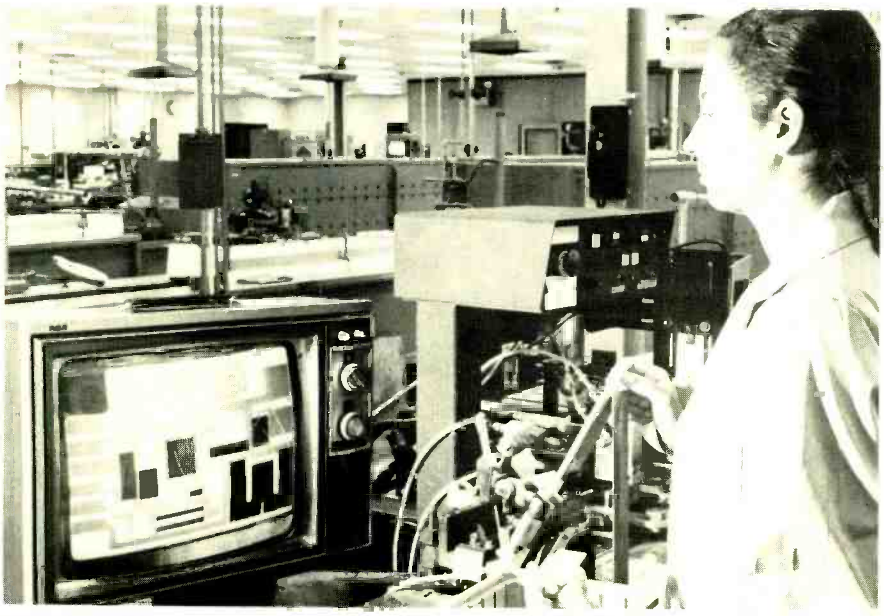
RCA Consumer Electronics division in Indiana, exhibited its new production facility for manufacturing thick-film ceramic circuit modules now being used in their solid-state TV sets and stereo phonographs.

The ceramic circuit modules are hard alumina ceramic wafers containing resistors, capacitors and transistors. Those



Ceramic circuit module.

currently in use measure 1.4 x 2" and are 1/16" thick. They are more rugged and durable than vacuum tube circuits, and create less heat, a prime cause of failure in electronic equipment. Their small size gives designers greater flexibility to create new product designs.



Enlargement of small circuit modules printed on ceramic wafers.

At the ceramic circuits plant RCA starts from scratch, combining basic raw materials to get the desired mix to cast alumina substrate sheets from which individual ceramic units are punched out and kiln fired. Capacitors and resistors are screen printed on the substrate, and discrete components mounted prior to encapsulation of the entire modules in resin epoxy. A computer-directed laser beam handles the precise trimming required on the printed resistors.

Robert A. Schieber of RCA states "we expect . . . to be producing color TV sets in which a major portion of the circuitry will be on ceramic modules." The advantages of the modules permit the circuits to be designed to last longer, be more reliable and cost less for power to operate over the total production lifetime, explained RCA's Barton Kreuzer. He continued, "because the modules lend themselves to a high degree of automation during manufacture, they are also being counted on to hold the line on production costs while raising product performance."

Sensory prosthesis

The National Institute of Neurological Diseases and Stroke, National Institutes of Health, has awarded contracts for specific experimental studies to determine the feasibility of a prosthesis for the blind. It has been known for some time that electrical stimulation of portions of the brain concerned with vision can produce sensations of light even in blind people. If such stimulation could be derived from an array of light sensors or a TV camera, a prosthesis for reading and mobility becomes possible.

To determine the biological feasibility, potential electrode materials have been implanted in animals. The long-term effects of the materials and electrical stimulation on the brain are being studied as well as the stability of the materials. Other studies in animals and in humans undergoing neurosurgical procedures for their own benefit include determining the optimum electrode configuration, the effects of changes in the stimulus parameters, and the evaluation of various visual areas of the brain as potential sites for stimulation.

About two years will be needed to complete these studies and decide whether to proceed with hardware development.

The results of these studies will also be applied to current neurosurgical techniques, such as brain and spinal cord stimulation for relief of intractable pain, prevention of epileptic seizures and the treatment of certain kinds of psychoses. In the future, they may also become useful in developing other forms of neural control, such as an auditory prosthesis for the deaf and direct nervous system control of artificial limbs.

Microwave CATV system

Laser Link Corporation, in its latest presentation to the FCC, has requested that broad enough bandwidths be assigned for local distribution of inter-city long-haul microwave signals which would take full advantage of the company's new equipment capabilities. The newly developed TV transmission system has already been tested and demonstrated in the millimeter microwave range of 17–19 GHz and 38–40 GHz which the FCC is considering allocating for this type of service.

The Laser Link system will be used by twenty CATV operators. It permits transmission of up to 18 separate TV channels on a single carrier. Using the FCC type accepted transmitting equipment the CATV operators can now send 12 channels over the air simultaneously.

A single transmitter can send the programs to receivers up to twenty miles distant without any cable, as well as in 21 different directions. The system may be applied to urban, suburban, or rural areas. The delay and expense of digging

(continued on page 12)

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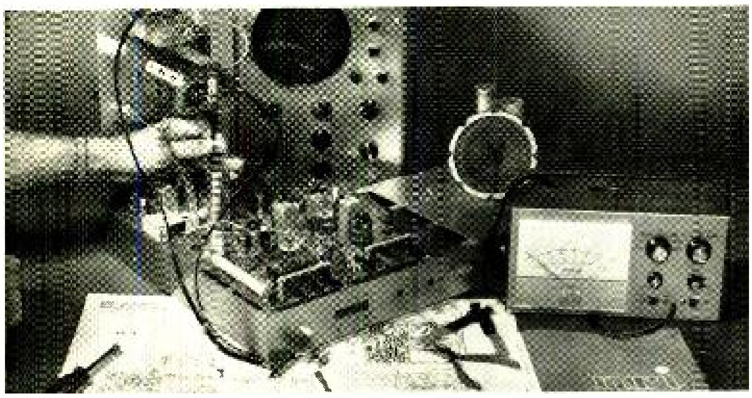

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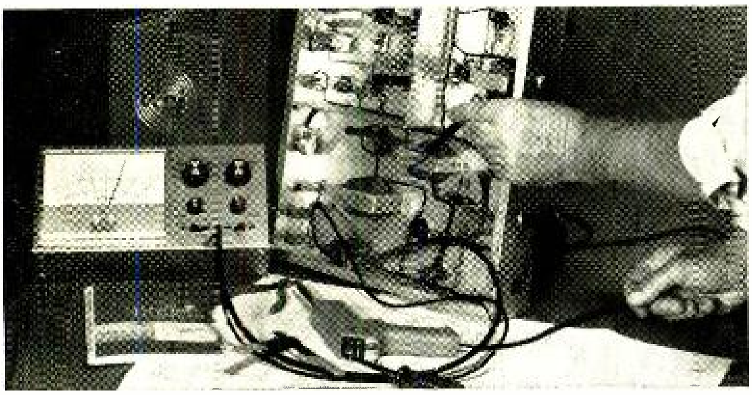

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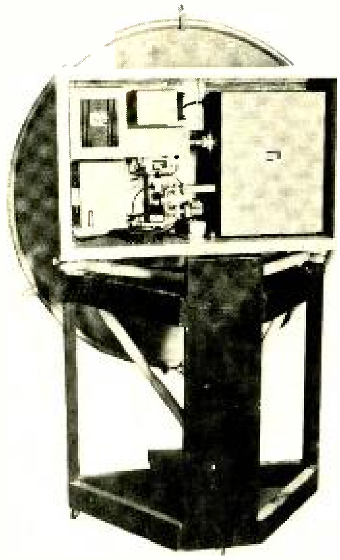
new & timely (continued from page 6)

trenches for cable is eliminated.

Laser Link's specially designed equipment transmits on 12.7–12.95 GHz. The transmitter at the head end and the receivers at various points are compact and mounted on the antenna itself. Through a special patented process, the signal need not be "down-converted" to video level, reprocessed and then transmitted to the user. Instead, the signal is



Laser Link wideband modulator/transmitter package mounted directly on the rear of a parabolic antenna. Set up for laboratory demonstration purposes, the unit is supported by a wooden dolly.

immediately fed into the cable serving the subscribers as it is received at a nearby antenna.

Ira Kamen, president of the corporation, believes that, if the FCC decides affirmatively, it would be on of the most important actions in the electronics field in recent years.

Dolby FM broadcast

The first publicly scheduled transmissions encoded by the Dolby noise reduction system were broadcast on Chicago FM station WFMT. The reduction in background noise which the system produces at the receiver is said to be comparable to that obtained by increasing transmitter power five to ten times.

These recent field tests involved a group of listeners located at various distances from the station's transmitter. Their receivers were equipped with special Dolby System adapters enabling them to hear the test broadcasts without the background noise which normally affects FM reception when the listener is distant from the station. The questionnaires returned after the field test indicated an enthusiastic acceptance of the idea even on the part of listeners who were not equipped with Dolby decoders.

Electronics imports

The Electronic Industries Association recently completed a study showing the impact of electronic products imports, especially from Japan, on the US market. The figures reveal that, in 1970, imports accounted for 37% of all TV sets, 63% of phonographs, 92% of radios and 96% of tape recorders.

The trade association also discovered that 31% of all TV picture tubes, 35% of all electron-receiving tubes, 49% of all resistors, 64% of capacitors, 73% of loudspeakers, and 90% of transformers all were imported.

Holocamera

A lightweight, portable holography camera has been developed by scientists at Hughes Aircraft Labs, who foresee many valuable applications for the device in industry, medicine, dentistry, archeology and teaching. Dr. Donald H. Close, who headed the project, shows inner workings of the holocamera which he described as the first practical portable device for recording holograms.

(continued on page 14)

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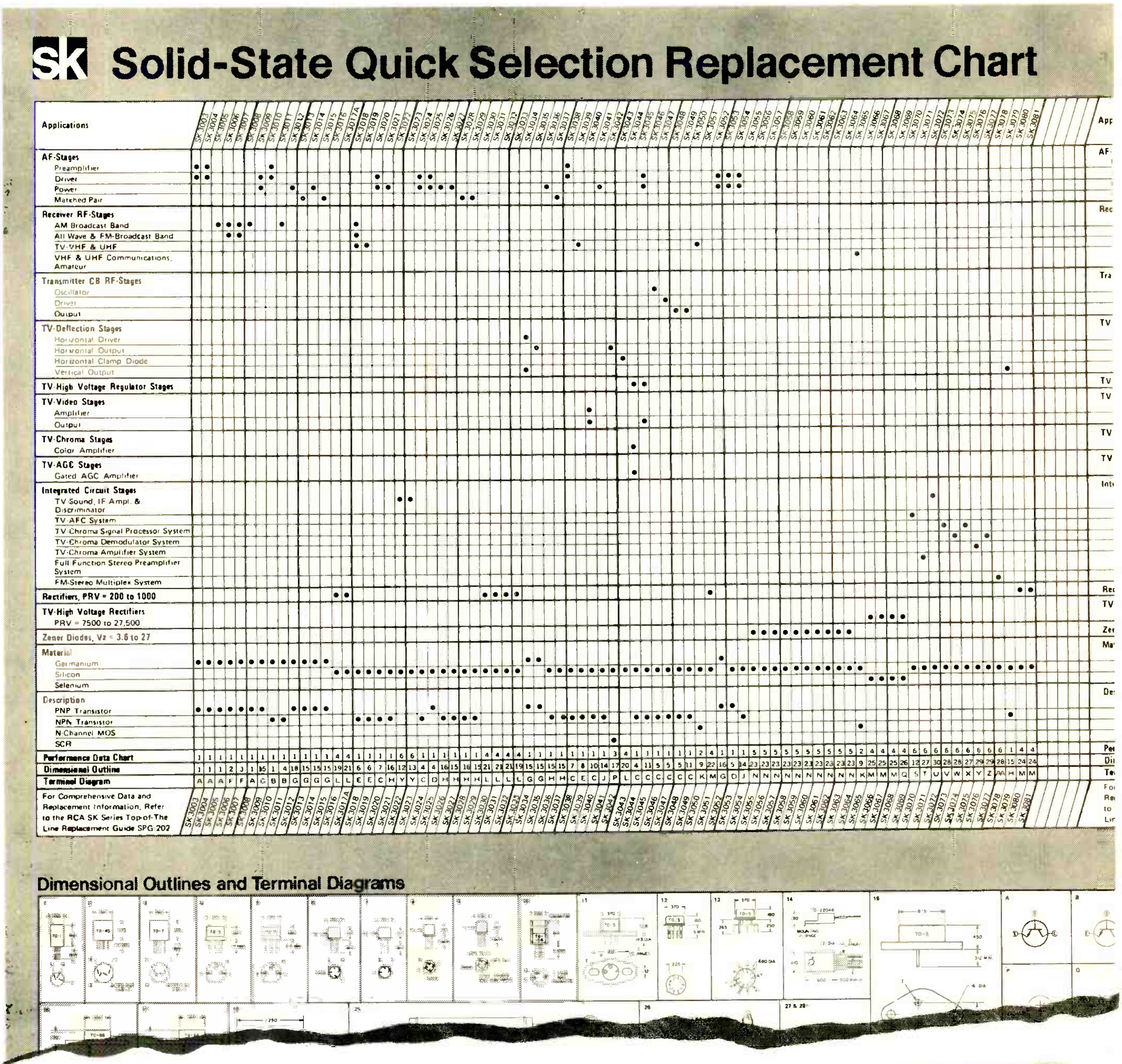
Find SK replacements fast with the new RCA SK Wall Chart



A brand new expanded, king-size SK Quick Selection Wall Chart which shows you the correct SK replacement when the device to be replaced cannot be identified is now available from your local RCA distributor.

Keying all RCA SK types to applications, and showing terminal diagrams and performance data charts, this 23" x 35" chart is just what you need for fast SK replacement.

Also available is the new edition of RCA's SK Series Top-of-the-Line Replacement Guide which shows how only 79 RCA SK devices can replace more that 20,000 OEM solid state devices in radios, TV's, stereos, tape equipment and other home entertainment equipment.

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All RCA SK types are accurately cross-referenced with industry types in this updated Replacement Guide which you can use to advantage on every service call. See your local RCA distributor for both the SK Quick Selection Wall Chart (1L1367) and the SK Replacement Guide (SPG-202L). They work hand in hand to make your replacement job faster and easier.

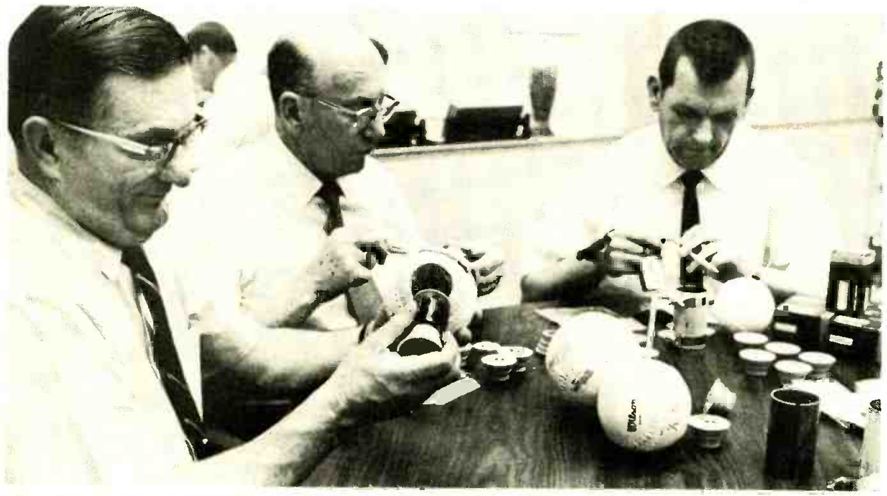
RCA | Electronic Components | Harrison, N. J. 07029

RCA

new & timely (continued from page 12)

Baseballs sound off

Western Electric Telephone Pioneers and volunteers are shown here assembling Audio Ball kits consisting of a regulation softball with a shockproof signaling unit embedded inside it. The ball emits high-pitched beeps, enabling blind children to find it. The kits will be sent to other chapters of the Telephone Pioneers experiencing difficulty in obtaining parts.



Too many engineers

The National Science Foundation, in an intensive study, has projected an oversupply of between 18,000 and 66,000 scientists and engineers with doctorates by 1980. Although only science and engineering fields were studied in detail, it is projected that 'too many' doctoral degree holders in the social sciences, in life sciences, and in mathematics, will also be true.

Apollo 15 in-flight TV camera

A hand-held Westinghouse color television camera of the type used in previous Apollo lunar missions was used again in Apollo 15 during the flight to and from the moon to capture the space walk.

The camera is designed and built for the vacuum and extreme thermal conditions found on the moon's surface. It has the recently perfected "burnproof" EBS (electron bombarded silicon) tube, with a silicon diode array target that prevents tube damage from high intensity light.

Ham hears robbers by-play

A radio ham in London tuned in on a bank robbery—the thieves were talking among themselves on walkie-talkies. Although the ham reported his discovery to the police, Scotland Yard was unable to trace which bank was being robbed until nearly 34 hours had passed. Later, the Post Office, which operates radio-detector vans, criticized Scotland Yard for failure to ask for help until after the robbers' transmissions had stopped. An estimated $1,235,000 or more in jewelry and other valuables was missing from the raided safe deposit boxes.

The ham taped the entire dialog and gave it to the police. R-E

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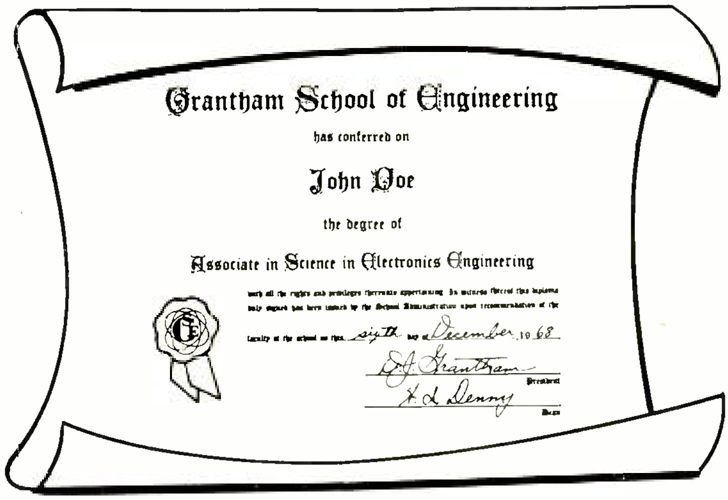

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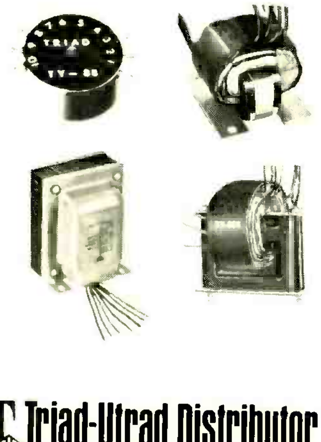
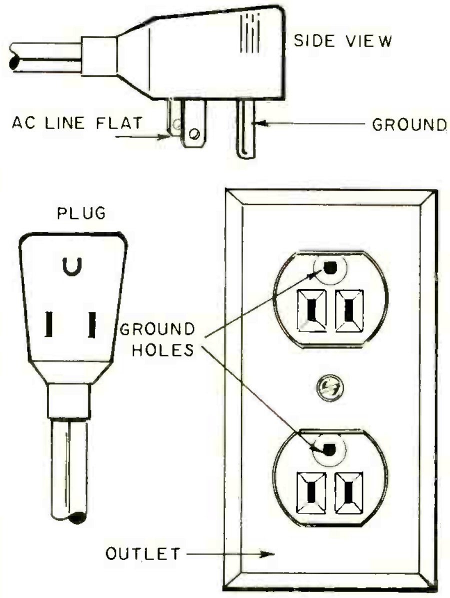


appliance clinic

WE HEAR A LOT ABOUT SAFETY AND "Consumerism" these days. This is nothing new! This is just the same old "Customer Relations" that we've all worked on so hard for the past many years. They're just making more noise about it lately. Safety, of course, is what those of us who are still here have been observing all along! However, they have come up with some new ideas, and some of them are pretty darn good; especially those that really protect the "consumer" spelled Customer, who pays us!

A great many appliances have metal cases, trim, and so on. So, it is easy to see that a short or leakage from the ac line to the case could do one of two things—make the whole case **hot** to any grounded object, or ground it. A 50–50 chance, depending on where the short is and how the thing is plugged in. These aren't nearly good enough odds for the protection of our customers! Since "any grounded object" includes such things as sink faucets and even cement floors when they're a little damp, we've got a very dangerous situation. So, let's do something about it.



They're starting to use a new system which will give us **positive** protection against internal electrical leakages and shorts. This is the "Third Wire," with a three-wire line cord, and a *separate* pin on the plug which does nothing but ground the case of the appliance. The diagram shows one of these; you've all seen them by now.

Let's look at some figures that will shock you (and perhaps keep some of your customers from a different kind). Even a very minute *leakage* from a hot wire inside an appliance, to the metal case, can cause a shock hazard. Do you know how much current it takes to kill? **Ten milliamperes!** This figure comes from an authoritative article in the June 1971 issue of *IEEE Spectrum*, by Mr. Ralph H. Lee, a Fellow of IEEE and a member of the National Electrical Safety Code Grounding Committee. Its title is "Electrical Safety in Industrial Plants." Well worth reading, and in some cases, frightening.

Think of that figure for a little longer. Ten mills! A No. 47 pilot light draws **fifteen times** that much current! We all touch hot wires at regular intervals. We jump and sometimes use regrettable language, but remember, we are professionals. We automatically keep that one hand clear, etc. If we don't, we're apt to be ex-professionals and maybe ex-people. The housewife who is using these appliances isn't a professional. She is almost certain to touch an appliance with one hand and a faucet with the other. To make it worse, her hands are very apt to be damp!

This is the best possible condition for a severe shock. Damp skin has very low resistance. Also, the "circuit" is the most dangerous one you can find; up one arm, across the chest (and through the heart) and down the other arm. Ten milliamperes is the paralysis threshold. If the victim's hands happen to be closed around the object, she can't let go. Her muscles contract, and she grips the thing more tightly (reducing the resistance even more!) At 30 mA, the breathing-control centers are paralyzed and that's it. Fibrillation of the heart sets in, and this is the worst cause of death from shock.

So it's up to us, as professional workers in either electronics or electrical wiring, to make sure that these safety devices are safe and properly connected. They should be *checked* every time anything electrical is serviced. This doesn't take long. A quick ohmmeter check between the third pin of the plug and the case, which should show zero ohms, and a check from both of the line pins to the case, which should show infinity.

For an even more definite check,

(continued on page 81)

letters

Reader Improves Photographer's Test Meter

Marshall Lincoln's "Photographer's Test Meter" article in the October 1971 issue of **Radio-Electronics** looks like a handy instrument. Might I suggest some slight changes to enhance the device?

The schematic shows that only *one* 1500-ohm resistor is necessary. Add an 820-ohm resistor in the ohms circuit to limit the maximum meter current to less than 2 mA when the ohms zero pot is at minimum. Change the pot to a value of 1000 ohms. This will allow ample zero range when the battery voltage is 1.0 to 1.5 volts.

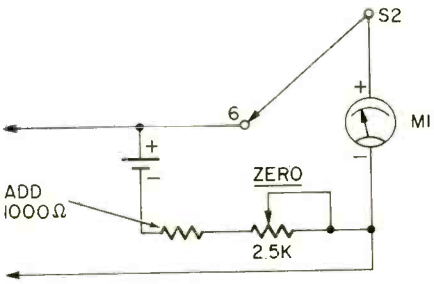
If the meter movement is of good quality, and the user inclined to be somewhat absentminded (!), add meter protection diodes and perhaps even a fuse.

I enjoy reading your magazine a great deal and hope you will keep up the excellent quality of your articles and projects.

GEORGE D. EASTMAN
Aloha, Oregon

Extra Protection For Photographer's Test Meter

When I studied the circuit diagram for the Photographer's Test Meter in the October 1971 issue of **Radio-Electronics,** I saw that position six of the switch would consist of a closed loop (meter M1, pot R7 and the 1.5-volt battery) which could burn out the meter if the potentiometer was set at too low resistance.



If you add a resistor of about 1000 ohms between the potentiometer and battery as in my diagram you would prevent meter burnout.

I hope this helps some of your readers when they build the project.

ARTHUR A. AALTO
Concord, Mass.

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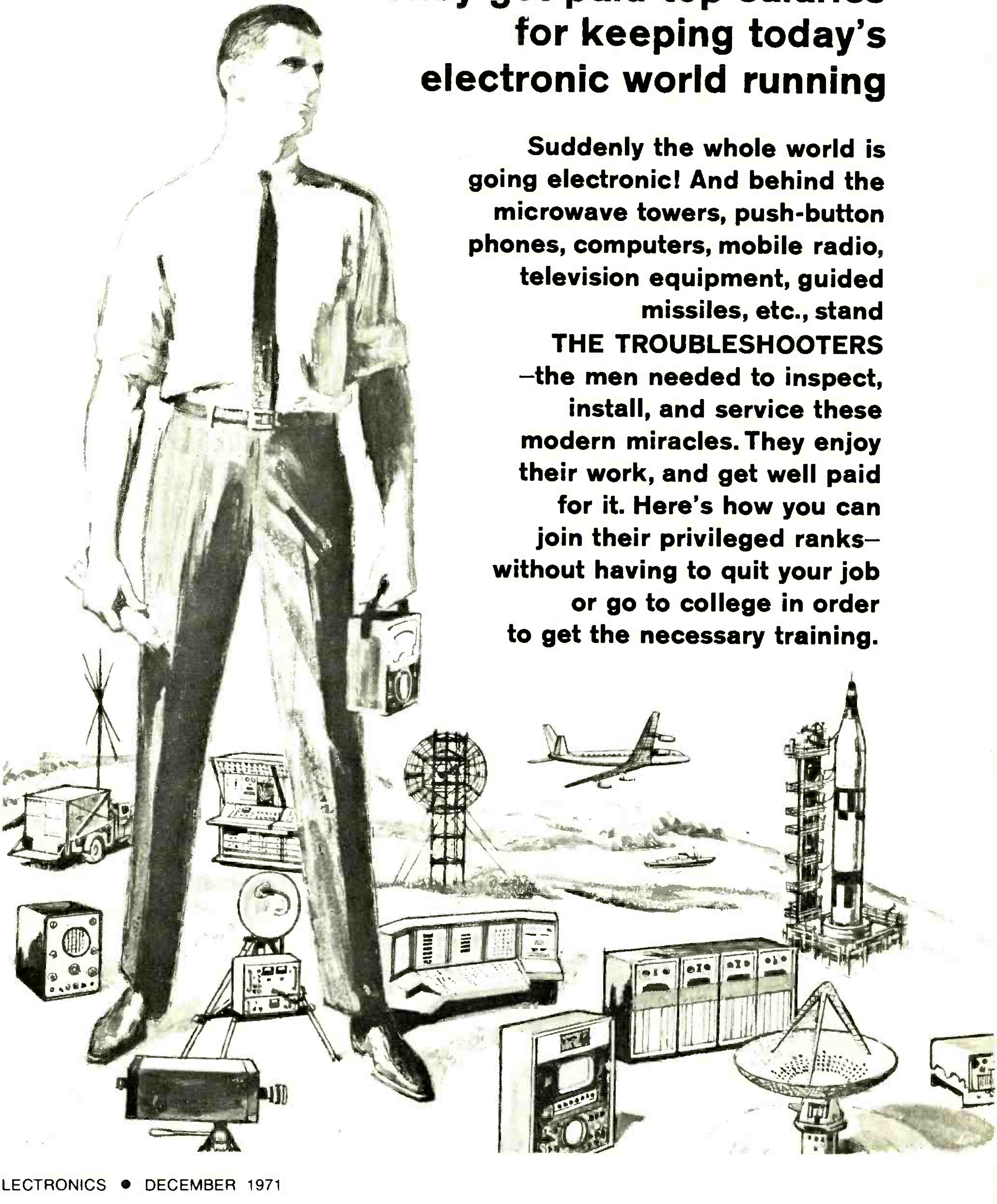

JUST THINK how much in demand you would be if you could prevent a TV station from going off the air by repairing a transmitter...keep a whole assembly line moving by fixing automated production controls...prevent a bank, an airline, or your government from making serious mistakes by servicing a computer.

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

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4-CHANNEL STEREO
another new system

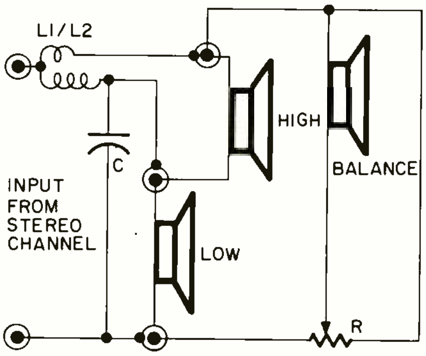
Synthesized sound turns two stereo channels into 4-channel surround sound

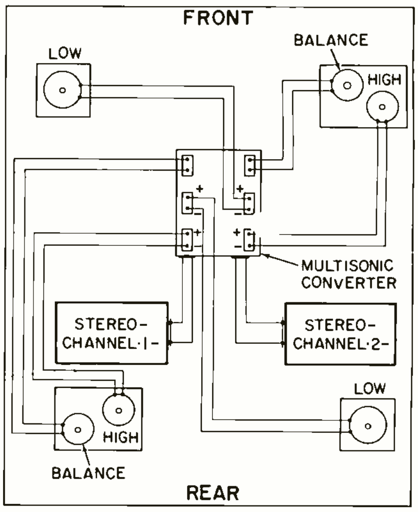
ONE OF THE NEWEST 4-CHANNEL SYSTEMS to come down the pike is the Iras Multisonic. This, like most of the existing 4-channel systems is a synthesizer; it is not a discrete 4-channel playback system. However, it most definitely delivers a pleasing 4-channel effect from just about all 2-channel material.

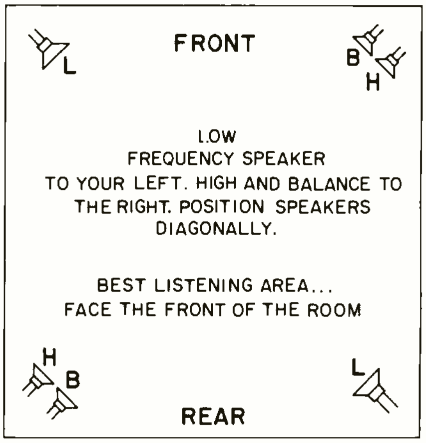
Fig. 1 shows the basic wiring of the Iras Multisonic Converter. You will note how the sound fed to the converter from one channel amplifier of a stereo is divided into three separate elements.

The HIGH and LOW speakers are placed in one enclosure and have a frequency crossover at about 1500 Hz. The BALANCE speaker goes in the diagonally opposite corner of the room and should be a midrange unit that will avoid excessive bass emphasis. The balance control permits shifting the apparent positions of the BALANCE speaker with respect to the other speakers.

FIG. 1—(left) WIRING OF ONE CHANNEL of converter. Two similar channels are built into the unit.
FIG. 2—(below) HOW THE CONVERTER is wired to the speakers in the room.
FIG. 3—(bottom) LISTENING ROOM setup when using Iras system.







L-LOW FREQUENCY "WOOFER"
H-HIGH FREQUENCY TWEETER
B-MIDDLE RANGE BALANCE

The complete Iras converter includes two identical channels like the one in Fig. 1. They are connected as in Fig. 2. If phase reversal is considered desirable, it can be easily added by connecting a reversing switch across the stereo amplifier output.

According to Mr. Ira, "the listener should make no effort to balance the output from the stereo amplifiers. In fact, the system should be operated in an unbalanced condition to give the predominant bass emphasis to the low-frequency speaker located in the left front corner of the room (see Fig. 3)."

Mr. Ira further states "It is important to remember that my system may violate all or most of the widely accepted rules of speaker positioning and phasing, interconnection and balance. We are trying to avoid the sound-coming-out-of-a-hole-in-the-box effect of the normal stereo system. The sounds made by musical instruments do not normally come out of a hole on a box." **R-E**

SYMPTOM no color

No-color is a common complaint from TV set owners. There are several symptoms and a great many causes Here are stories of a few such cases.

by ART MARGOLIS

THE UNFORTUNATE CHARACTERISTIC of a symptom of **no color** is the trouble could be hidden anywhere in the color pathway from the antenna head to the output of the color amplifiers. This includes the antenna system, tuner, i.f. strip, video detector, burst amplifier, 3.58-MHz area and the bandpass amplifier. The first step with this trouble is an analysis and test to boil down the actual circuit area.

This can be a lot easier said than done. The antenna and tuner can give similar indications and fool you into thinking one is bad while the other is really the culprit. The i.f.-detector area is fraught with inconsistencies and can produce false clues. The color oscillator can be defective in varying degrees making the trouble hard to pinpoint. The bandpass amplifier can show perfect voltages yet still be not working.

I'll tell you about some recent **no color** jobs I had to show you what I mean.

Case of the crazy fine tuner

For some reason complications always occur during deliveries of large jobs to cranky people. This case was no exception. The TV was a 23-inch color Magnavox with a new picture tube. As I checked it out with the customer breathing heavily over my shoulder I noticed the fine tuner was misadjusted on channel seven. I pressed it in and adjusted it for best color. Then let the fine tuner's spring push it out into place. As the knob snapped forward the color disappeared. An excellent black and white picture remained.

I checked the other channels. They were displaying color fine. I switched back to seven. While I held the channel selector in, color was perfect. As soon as I let it out the color disappeared.

I tried a bunch of different settings to no avail. Color would not appear on seven unless the fine tuning knob was held in. The customer said. "I would think with a new picture tube you'd get color on all the stations."

I asked. "Was it this way before?"

"Of course, but with the new picture tube I would think you'd have it perfect."

I shrugged, disconnected the antenna wire and pulled the TV away from the wall. Then I took off the back of the TV and pulled the tuner. I looked over the fine tuning mechanism carefully. It seemed fine. I lubed all the moving parts and tightened all the contacts especially the channel seven strip. Then with the tuner still out I turned on the TV again. I put my finger on the antenna terminals and a colorful channel seven appeared. Good.

I reinstalled the tuner, pushed the TV back against the wall and reattached the antenna. Then I turned on the TV.

The customer said, "That didn't help, there is still no color on seven." I looked, she was right.

I thought, wait a minute and disconnected the antenna. I placed my finger on the terminals. The customer said. "That's it, now you have color."

The trouble was in the antenna! The fine tuning phenomena was a false lead. Evidently my hand was acting as an antenna when I held the fine-tuning knob in.

I looked over the antenna. It was a 72-ohm coax installation with a little 72- to 300-ohm matching transformer for termination. I removed the impedance-matcher and attached the coax directly. All three channels including seven came in perfectly! Evidently the transformer had narrow bandpass characteristics, enough to attenuate channel seven's color subcarrier.

The TV is in a prime signal area so the mismatch of the coax to the tuner is inconsequential. The customer said. "I knew a new color picture tube should make the TV perfect."

The confusing sound caper

A do-it-your-selfer was in the shop one morning and said to me, "Do you remember me?" I nodded. He had been in the previous day, had tested some tubes and bought a few.

He continued. "I had no sound on my color set. I checked the sound tubes and bought some new ones. Sure enough the sound came back but now I have no color."

I asked. "Do you want to test the color tubes?"

He answered plaintively. "No, that's over my head, would you come out?"

I took his name and other vital statistics.

That afternoon I arrived at his

house. He had an RCA 23-inch color. There was no real color but the skies had a tinge of blue to them and the performers had a slight flesh tone. Also there was considerable 920-KHz beat in the scenes.

I turned to an unused channel and began manipulating the color killer. Color snow appeared in force. That meant the color circuits were cleared as the trouble maker. If there had been no color snow, just black and white snow, I would have known the trouble was in the color areas.

This way I knew I had an antenna-rf-i.f. search to conduct.

I took my color bar generator and attached it directly to the antenna terminals. At 100 percent modulation the bars appeared on the picture tube face all washed out instead of vivid. This cleared the antenna system.

Then I inspected the TV picture closely. There was no trace of snow with the generator on. That cleared the tuner. If there is snow the tuner is usually at fault. When there is no snow at this point the i.f. strip becomes the main suspect.

I felt the lit i.f. tubes. They were all hot and evidently drawing plate current, not lukewarm with only heater current going through them. As a "make sure" test though I replaced the i.f. tubes one at a time, but there was no change. I left the third i.f. tube in though because tapping it revealed loose elements.

I turned on the audio note on my generator. The washed out color bars filled up with a 920-KHz beat. The do-it-yourself was watching me and nodding approval.

I figured since there is so much 920-KHz in the picture it wouldn't hurt to touch up the sound reject and 41.25-MHz sound carrier trap. I took out my diddle stick and rocked the 41.25-MHz sound carrier trap. It seemed to be set fine and didn't reduce the appearance of 920-KHz at all.

Then I reached for my tiny screwdriver and made a pass at the miniature sound reject pot mounted near the third i.f.

He said, "Hold on, what are you doing?"

"Adjusting the sound reject pot."

"But the sound is perfect!"

"Of course, it has nothing to do with the audio circuits. It is there strictly to suppress the sound carrier from getting into the video." I pointed at the herringbone 920-KHz pattern on the screen. "This 41.25-MHz trap is also there for the same reason."

He groaned. I adjusted the pot, the 920 KHz disappeared and the colors hove into view as vivid and as beautiful as you please.

He said, "I thought that was a buzz control and turned it for what I thought was minimum buzz."

The hidden barber pole

There is a large 21-inch Muntz color TV in the barber shop I frequent. Last time I went for a haircut, Ralph said to me, "Art, guess what?"

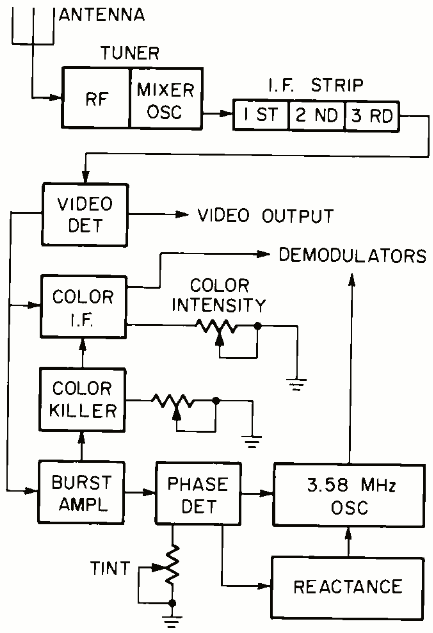


FIG. 1—NO COLOR CAN BE CAUSED by problems anywhere from the antenna to the demodulator input.

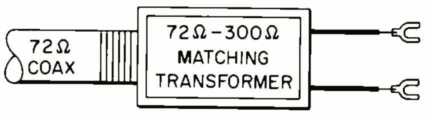


FIG. 2—ANTENNA MATCHING TRANSFORMER can be tuned so sharply, that it will exclude color.

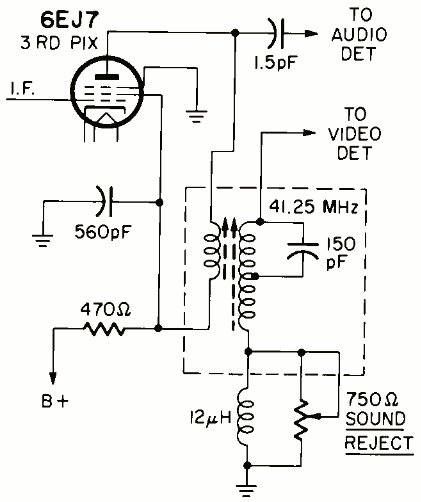


FIG. 3—MISADJUSTED SOUND REJECT potentiometer can kill color as well as cause 920-kHz on the screen.

I answered, "I'd never guess."

He said, "You're right again, the TV needs fixing."

"What's the problem?"

"There's no color."

"All right, if you don't scalp me too bad I'll look at it."

I could feel a couple of stray hairs scratching my neck as I bent behind the TV. There was no problem seeing the screen in all the mirrors. There was no color at all. I adjusted the color killer. There was no color to the picture till, oops, I saw some color whirl by. There was a bit of color but it was way out of color sync. That told me immediately the antenna, rf, i.f. and bandpass amplifier were good. The trouble was in the color sync area, which included the burst amplifier, 3.58-MHz oscillator, reactance circuit, and color phase detector.

There were at least ten sets of rainbows from top to bottom of the screen. That meant a high frequency error. My first step was to see if the oscillator could run at its prescribed 3.58-MHz.

I took my clip lead with the alligator clips on it and shorted the reactance control grid to ground at the test point sticking up from the printed circuit board. Then I took my diddle stick and began adjusting the plate coil of the reactance tube.

I kept on tuning. The colors on the screen shifted a bit more or less but turning the coil many turns brought me no closer to zero beat.

That meant the oscillator circuit was the troublemaker. I took out a 3.58-MHz crystal and went to work. In about ten minutes I had a new crystal installed.

I was in luck. The frequency really shifted in the zero-beat direction. I adjusted the plate coil again and the colors fell into place and then moved ever so slightly.

I removed the jumper short and the colors locked in solidly. The picture was beautiful.

Ralph said, "Do you know what those moving colors remind me of?"

I said, "You tell me."

He said, "It looked like a barber pole."

I laughed, "Well, how about that?"

True case of no color

A customer took advantage of our BRING IN service by carrying in a 21-inch color Motorola table model. I put it on the bench and began checking it out.

The symptom was no color. I adjusted the color killer on an unused channel and there was no color snow, just black and white snow. That meant the trouble was in the color circuits. Since there was no barber pole effect on the TV programming, the trouble was probably not in the color sync circuits. Since there was a good monochrome picture the trouble was not in the color demodulator or difference amplifiers. If it had been there, the condition would have been incorrect colors.

I settled down in the bandpass amplifiers or as they are called in this TV, the color i.f.'s.

My first step was a quick check of the dc operating voltages. The plate, screen, cathode and control grid of the 2nd color i.f. all read exactly what the schematic called for, for a black and white picture. The control grid had a cutoff voltage of minus 10 as it should be, with the corresponding high plate and screen voltages.

I touched down on the first color i.f. The plate, cathode and control grid of the triode section of the 6DX8 tube all read correctly. No quick check clues anywhere to be found.

I took my color bar generator and attached it to the antenna terminals, and turned on bars with about 100 percent modulation. Then I turned on my wide-band scope, attached a low-capacitance probe and began to take pictures.

The cathode of the first color i.f. showed about 12 volts peak-to-peak for the color spikes on the horizontal sweep rate. I crossed over an RC network in the cathode and the same good picture appeared. Then I crossed over a peaking coil into one end of the color intensity control and all was still good. Next I tried the center tap of the control. The picture attenuated down to about 3 volts peak-to-peak, but it was still pure color spikes and exactly what the schematic called for.

I crossed over another peaking coil and what do you know? The scope picture disappeared into a straight line.

I read the peaking coil resistance in circuit. Instead of 1.4 ohms, it was open! As a make sure check I shorted the peaking coil. A beautiful picture in color came on.

I didn't have the exact replacement so I took a 1-megohm resistor and wound a few turns of fine wire onto it till it read about one and a half ohms. Then I installed it.

The customer paid me and left the shop with his bring-in job. **R-E**

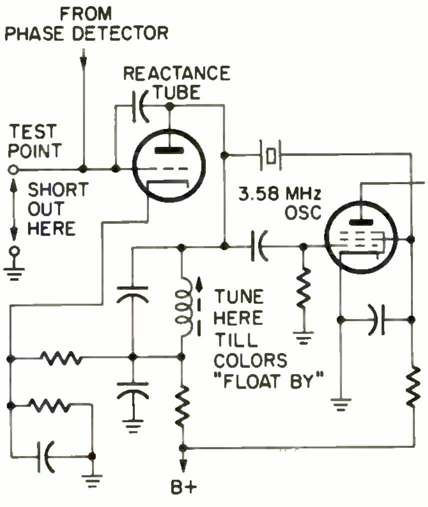


FIG. 4—QUICK WAY TO CHECK color oscillator frequency is to short the reactance input and tune reactance plate coil.

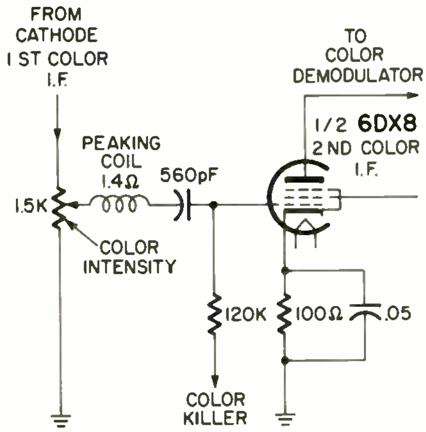


FIG. 5—OPEN SERIES PEAKING COIL killed the color in this Motorola color chassis.

High-Impedance Voltmeter

Figure 1 shows how an FET operational amplifier can be used for construction of a voltmeter with an input impedance in the order of 500,000 megohms. The unit can be used for insulation measurements, for testing of capacitor leakage, testing of purity of distilled water, etc.

Resistance measurements in 1–500-megohm range: Given the circuit shown in Figure 2

$$R_x = R_0 \cdot (1-d)/d.$$

where d = ratio of measured voltage with R_x inserted and R_x shorted. R_0 is the resistor selected with switch S1 (100 megohms, 10 megohms, 1 megohm, or 100,000 ohms). **Capacitor Leakage** resistance measurements (> 500 megohms): To measure capacitor leakage a charged capacitor can be connected to the input terminals of the meter (Fig. 3). Switch S1 is then left in the open position. Assuming t = time in seconds till voltage drops to ½ of the starting value and C in microfarads, the capacitor leakage resistance

$$R_x = [(1.44 \times t)/C] \times \text{megohms}$$

Use as millivoltmeter: The circuit can also be used as an ac-dc millivoltmeter. The voltage gain of the circuit can be set with the rotary switch S2 to 1, 5, 10, 50 or 100 with the given resistance values. The Philbrick QFT-5 operational amplifier is $14 in unit quantities.—*C. R. Lewart* **R-E**

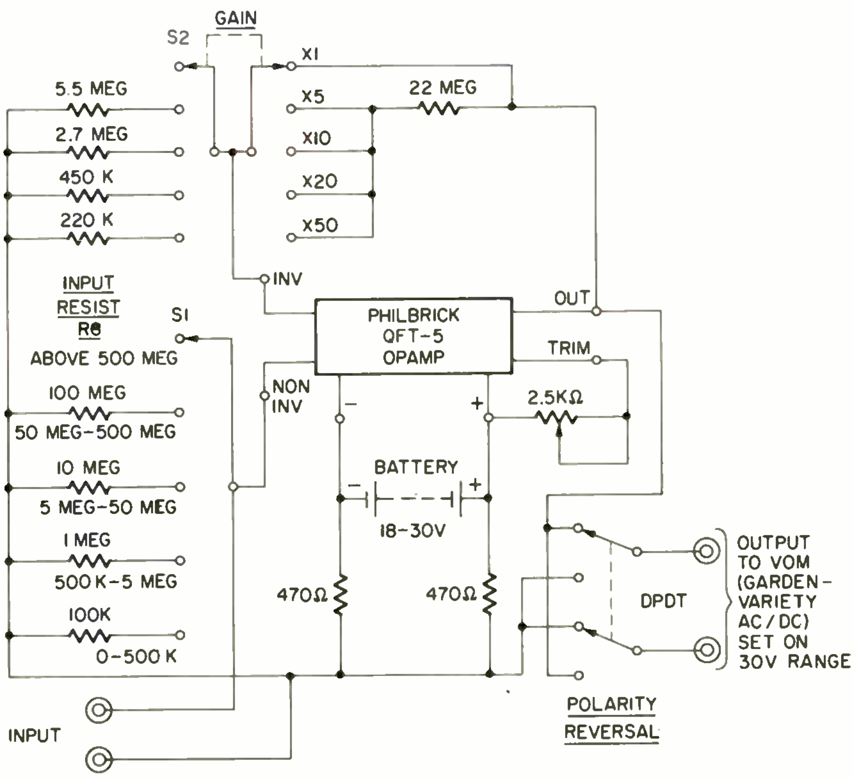


FIG. 1

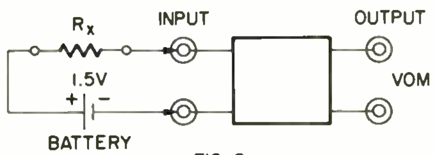


FIG. 2

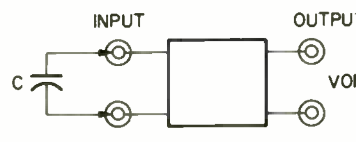
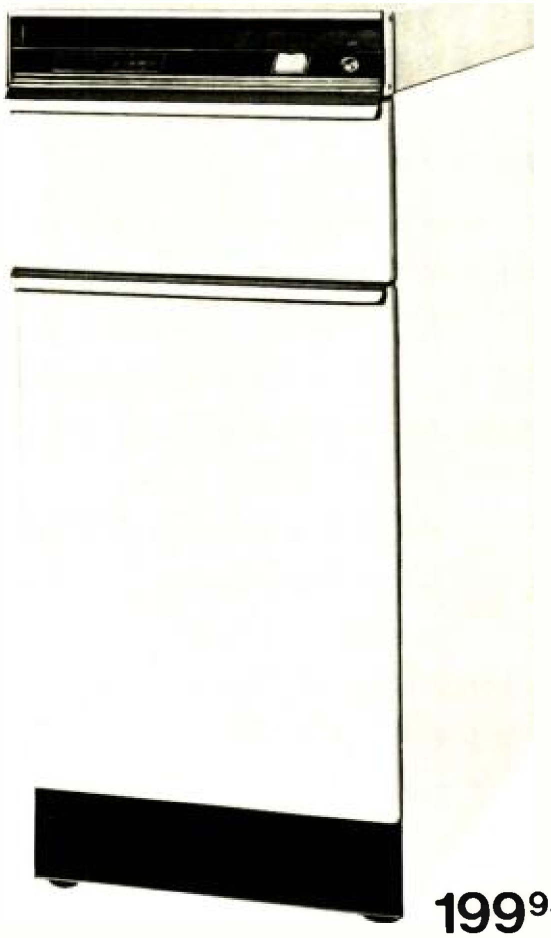


FIG. 3

for every age, every hobby!

New Heathkit "Minimizer" kitchen waste compactor...



Today's most modern refuse handling method in easy-to assemble kit form! Now you can own the most exciting k tchen appliance on the market for less than you'd pay for any other comparable compactor. The Heathkit Minimizer lets Mom throw out the unsightly waste baskets and garbage cans for the latest in clean, convenient, odor-free disposal. The Minimize· handles all normal household trash — food wastes, glass and plastic containers, tin cans, wrappings, boxes, floor sweepings, light bulbs, etc. The packing ram descends with 2,000-lb. force to reduce refuse to almost ¼ of its original size, packaging the material in a strong disposable bag — one bag holds an entire week's trash for a family of four! When the bag's full, Mom simply folds over the top and removes a neat, dry package for normal rubbish pickup. And the Minimizer deodorizes the contents each time the drawer is opened and closed. The sanitation man will love Minimizer, too!

Simple, safe operation! To use, Mom merely inserts a Minimizer plastic-lined bag in the drawer and starts the compacting cycle. In less than a minute the ram forces down the trash, returns to its normal position, and the Minimizer shuts itself off. For maximum safety, the Minimizer uses a key lock switch and an interlock which automatically turns unit off if drawer is not fully closed or is accidentally opened during cycling. Your Heathkit Minimizer can be built-in under the kitchen counter or le!t free-standing. Its bright white enamel finish with marble-tone vinyl-clad top complements any decor. And you can build it yourself in 6 to 10 hours. Has long-life ⅓ hp motor, plugs into 110-120 VAC conventional household outlet. Kit includes 5 plastic-lined bags, one 9 oz. aerosol can of deodorant. Minimizer measures 34⅜" H x 15" W x 25½" D.

Kit GU-1800, 203 lbs. **199.95***
GUA-1800-1, 15 plastic-lined bags, 5 lbs. **4.99***

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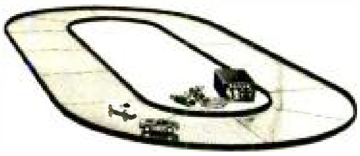
129.95*



You race up to 4 GT cars — each with independent acceleration, deceleration and steering! Make all the maneuvers of real high-speed drivers. You can even turn around completely and backtrack. Kit includes track sections for 8'x4' oval, power transformer, 2 cars and controllers.

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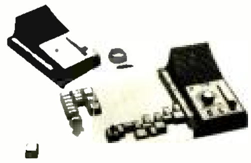

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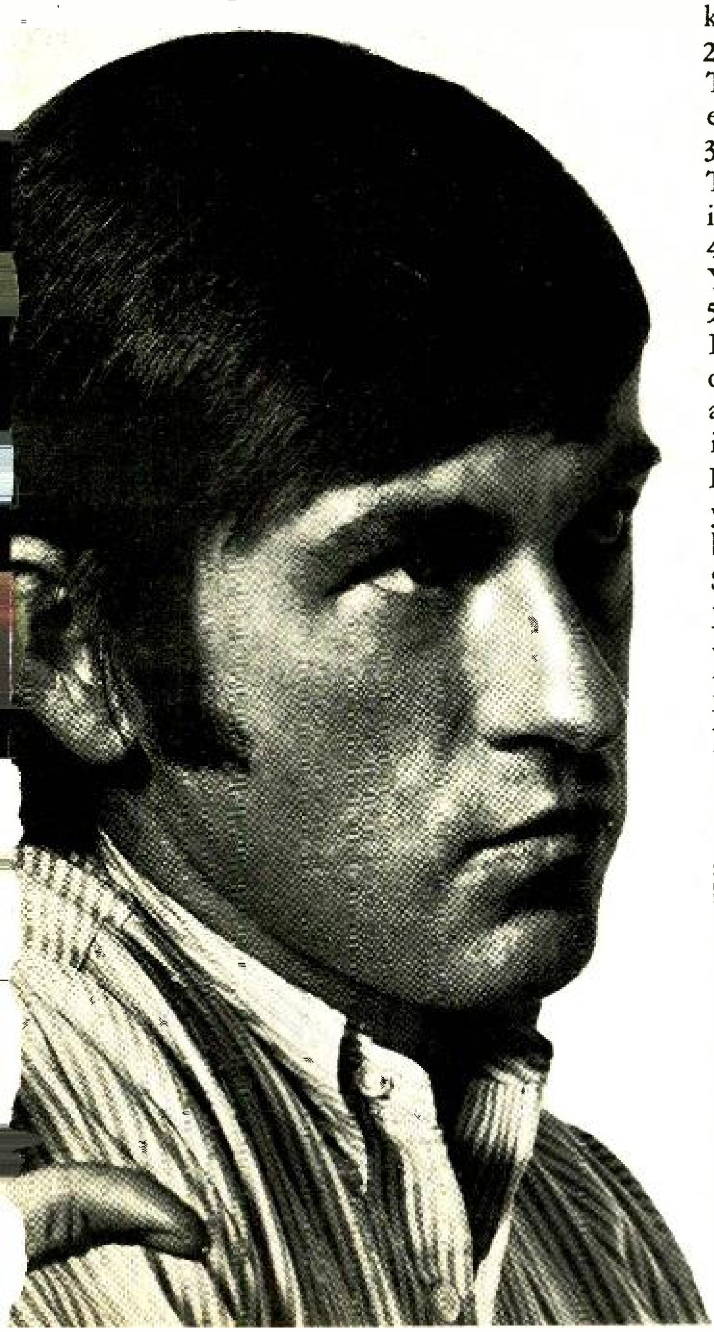

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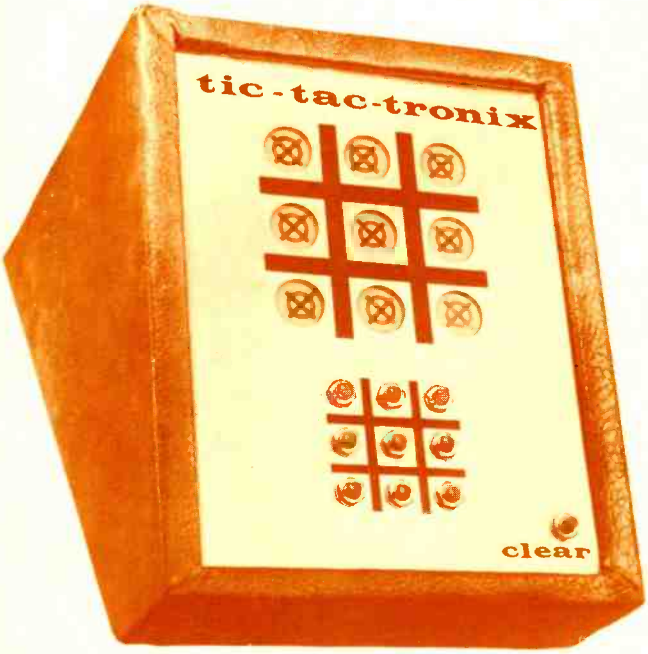
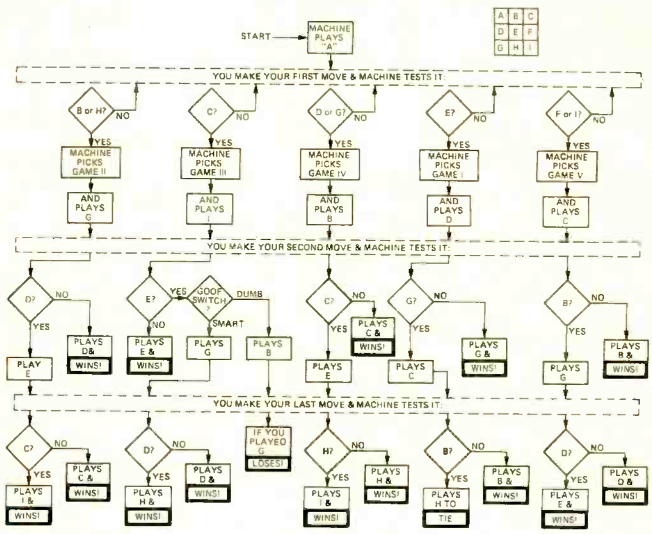
can you beat TIC-TAC-TRONIX?

If you follow the plans and don't cheat when playing you'll never beat Tic-Tac-Tronix





by DON LANCASTER

IF YOU'RE LOOKING FOR A REALLY ADVANCED digital computer project or a sure-fire attention getter for an exhibit, promotion, or display, TIC-TAC-TRONIX is for you.

Tic-Tac-Tronix is a compact, special-purpose digital computer programmed to play an unbeatable game of Tic-Tac-Toe against all comers—unbeatable *unless* you have flipped the hidden GOOF SWITCH. Then, you or anyone who knows the secret can indeed beat the machine. You can build this all-solid-state project for around $45.

The program

Any digital computer follows a predetermined set of rules by way of a series of sequential steps. The rules are often called *algorithms,* and the steps by which these rules are obeyed are called *program steps.* Tic-Tac-Tronix is a permanently programmed computer that has been taught the Tic-Tac-Toe strategy by means of fixed internal connections. This is also called a *hard-wired* or a *fixed* program. One exception is provided in Tic-Tac-Tronix where the GOOF SWITCH is brought out to let you as a programmer choose one of two programs, a beatable one and an unbeatable one. The sequential thought processes or *flow chart* of the machine is in Fig. 1 (at top of this page).

Each square of the Tic-Tac-Toe board is identified by a letter; **A** through **I.** The game begins by the machine playing square **A.** You then make a move and the computer recognizes that you have played and *tests* to find out where you played. As a result of the testing, the machine first picks one of five *strategies* or *program branches*, and then answers your move. The machine then awaits your second move, after which it again tests and plays either to win immediately or to set up a potential win on the next move. The machine always sets up a "critical square" situation and tests that square on its next move to see if you played on it. The third move is similar to the second, and the computer usually wins on the third move. Further moves are ignored by the computer.

Although it takes the computer only a few billionths of a second to move each time, a two-second time delay is introduced after each move, for effect, to let the computer "think things over". With the goof switch in the SMART position, the computer *always* wins if you play anything but the middle square (**E**) on your first move. Even then, it can win if you are careless.

Suppose you try to beat the computer by playing the lower righthand corner (**I**). The game begins with the computer playing **A** followed by your **I** response. The computer tests, sees that you played **I,** picks strategy **V,** and plays **C.**

On the next move, if you haven't played **B,** the machine does and wins. If you have played **B,** the machine plays **G,** letting it win next move either **A-D-G** or **C-E-G.** On your next move, the computer tests square **D.** If you played here, the computer plays **E** and wins. If not, it plays **D** and wins. The strategies for the other moves are similarly based.

For variety, all possible winning forks have been set up in the computer, including three corners; two corners and the middle; and one corner, the middle, and an adjacent side. Should you answer with the middle square **E,** the computer decides on a defensive strategy and forces you to block its moves.

The goof switch tampers with strategy **III** if it is set to the DUMB position. This gives the machine one wrong move, allowing the player to win.

Tic-Tac-Tronix circuitry

The circuit is made up of five IC's, 31 transistors, and a resistor-diode computer array. The block diagram of the

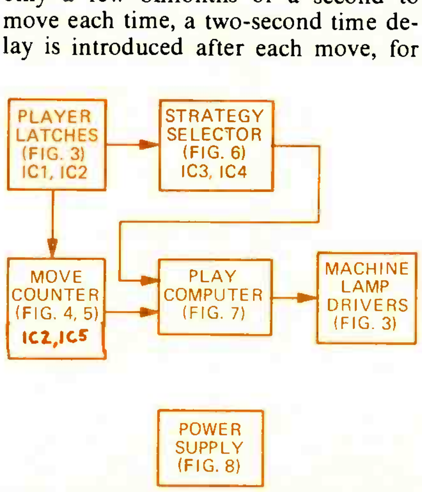
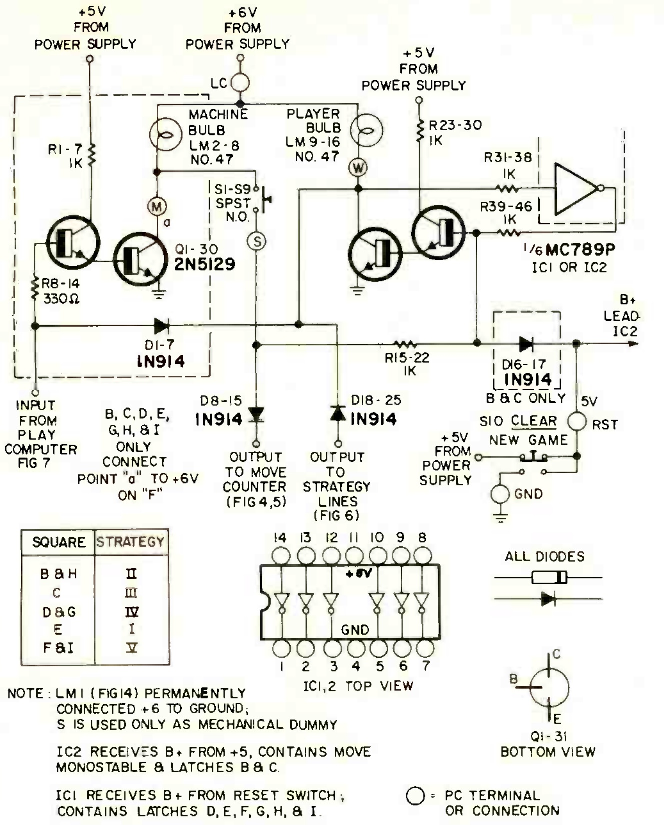
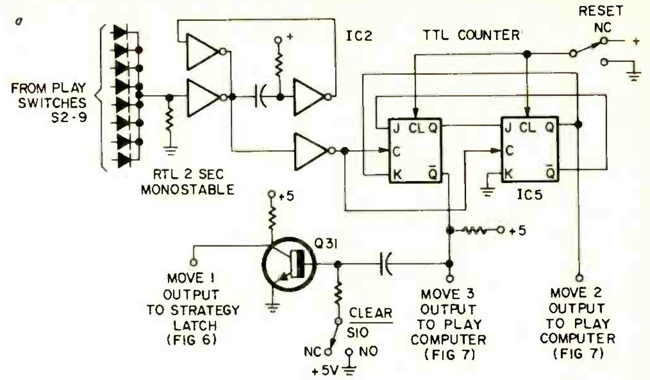


FIG. 2—BLOCK DIAGRAM OF TIC-TAC-TRONIX. Schematics of sections in Figs. 3 to 8.





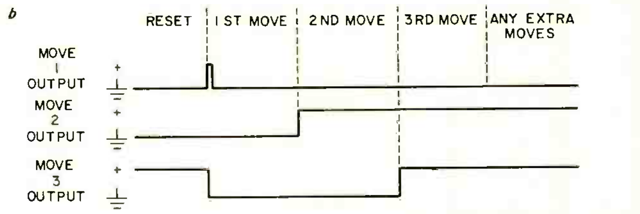
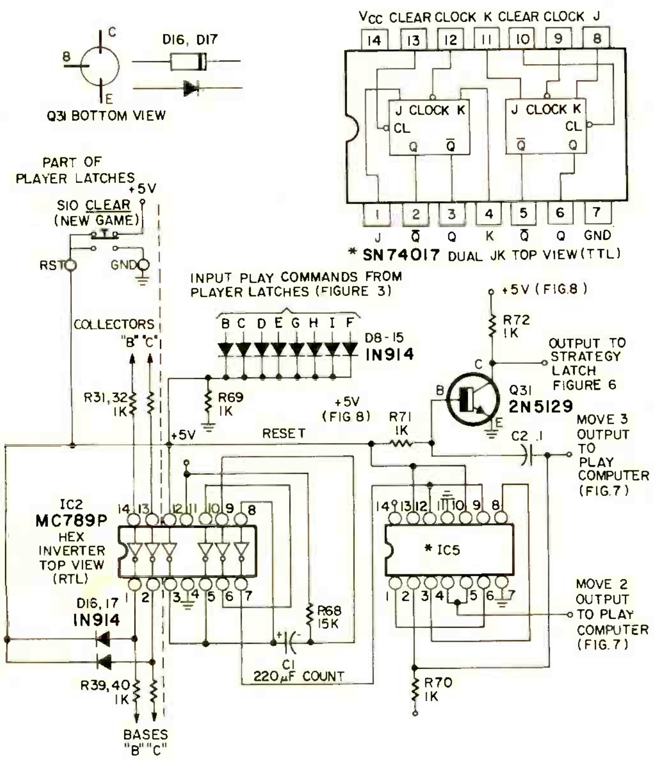
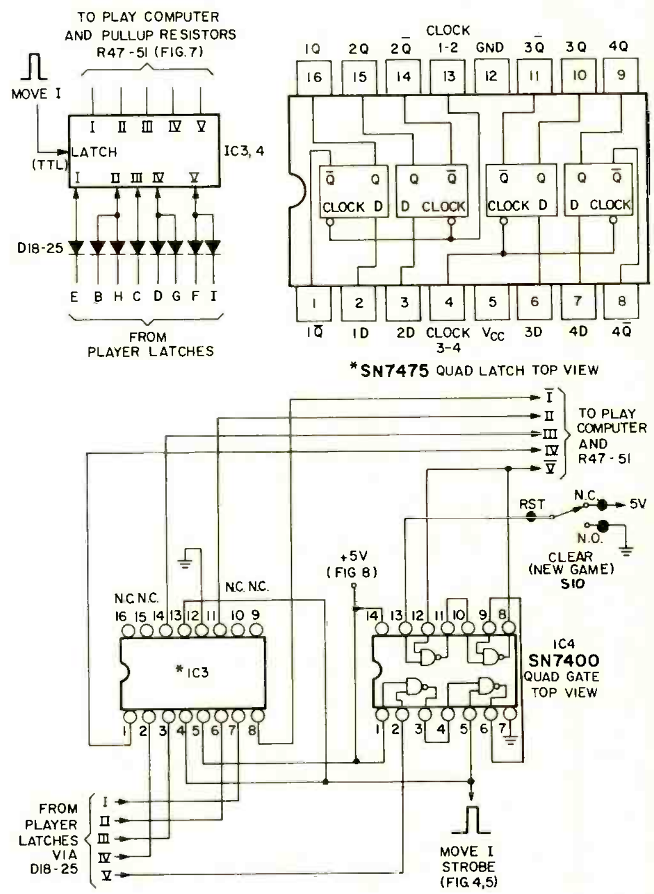


FIG. 3 (top left)—PLAYER LATCHES and machine drivers light proper lamps. FIGS. 4 and 5 (above and lower left)—LOGIC AND SCHEMATIC diagrams of the move counter which keeps track of game's progress. FIG. 6 (below)—STRATEGY SELECTOR picks and holds one of five possible strategies based on prior player moves.



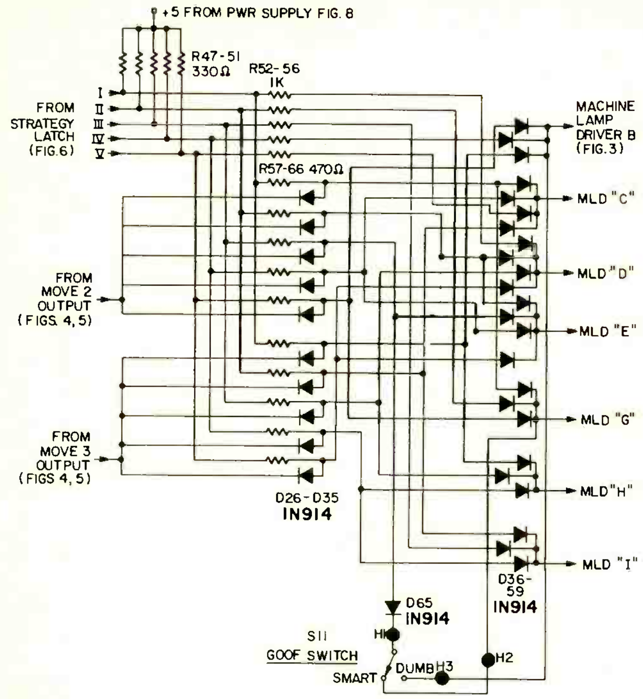


circuit is shown in Fig. 2, while the schematic is in Figs. 3 through 8, broken up into modular chunks.

The player latches and machine drivers are shown in Fig. 3. A player's move shows up as a lit blue pilot lamp; the machine's by a lit red lamp. These two illuminate a red X and a blue 0 in each display cubicle, resulting either in a black X on a blue background, or a black 0 on a red background.

Player latches are needed for squares **B** through **H**. *Machine drivers are not needed at* **A** and **F** since **A** is permanantly lit and since square **F** never has to be played by the machine.

Each player latch consists of a set-reset flip-flop using an integrated circuit inverter and a Darlington lamp driver. Pushing a valid select pushbutton sets the flip-flop and lights the bulb. It also delivers a play pulse to the move counter via one of diodes D8 through D15. The pushbutton is interlocked



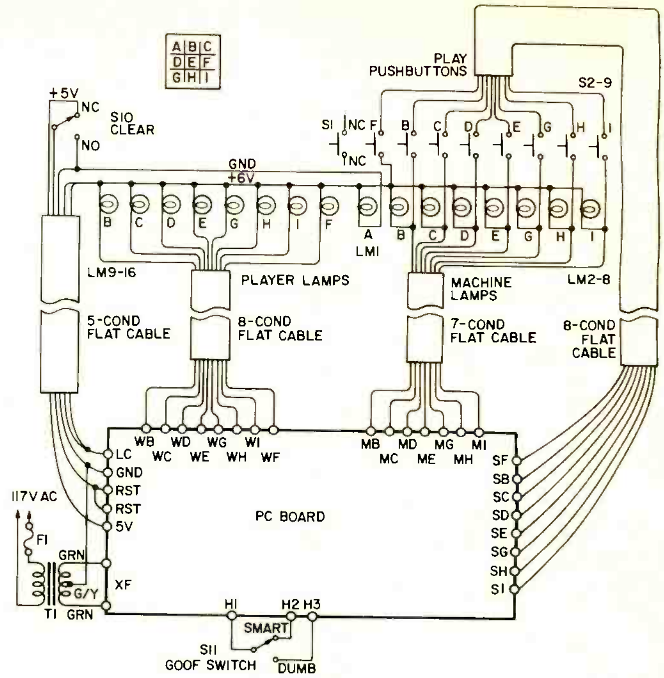


FIG. 7 (top left)—PLAY COMPUTER is DTL array used as the brain-center of the game. Three diode-resistor networks determine moves. FIG. 14 (above)—WIRING DIAGRAM shows how multi-lead cables are used to simplify the wiring and as an aid when troubleshooting.

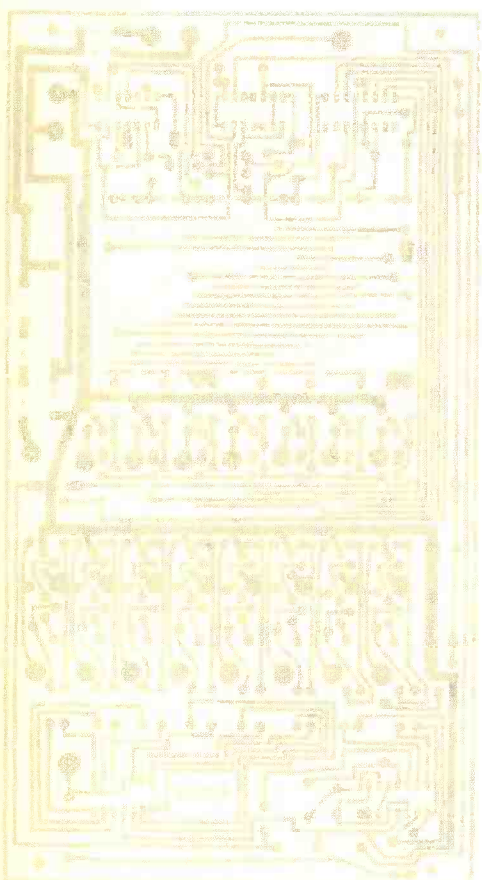


FIG. 9—FOIL PATTERN OF COMPUTER BOARD is reproduced here exactly half-size so you can make your own if you desire.

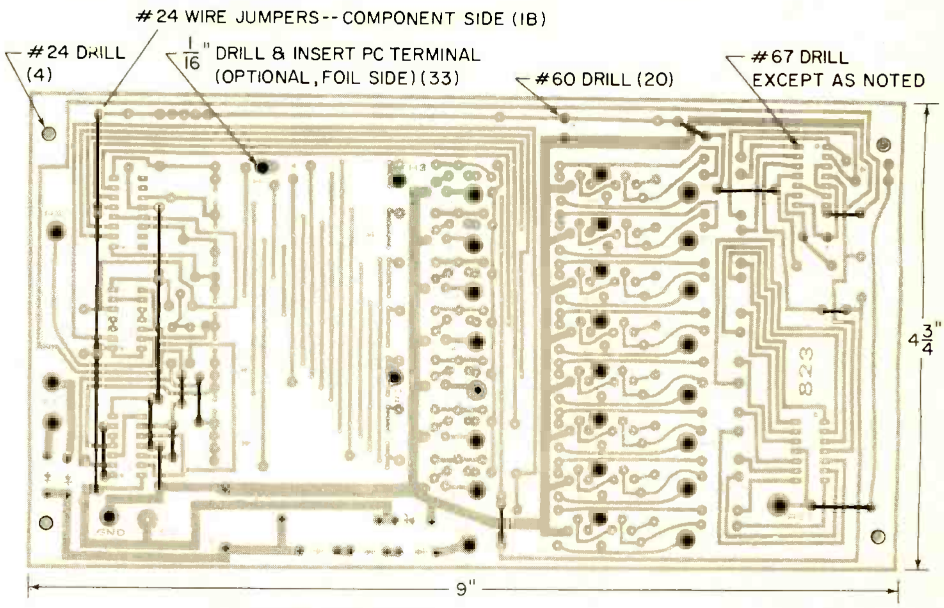


FIG. 10 (middle right)—DRILLING GUIDE shows hole sizes and the location of jumpers to be installed on component-side of the board.

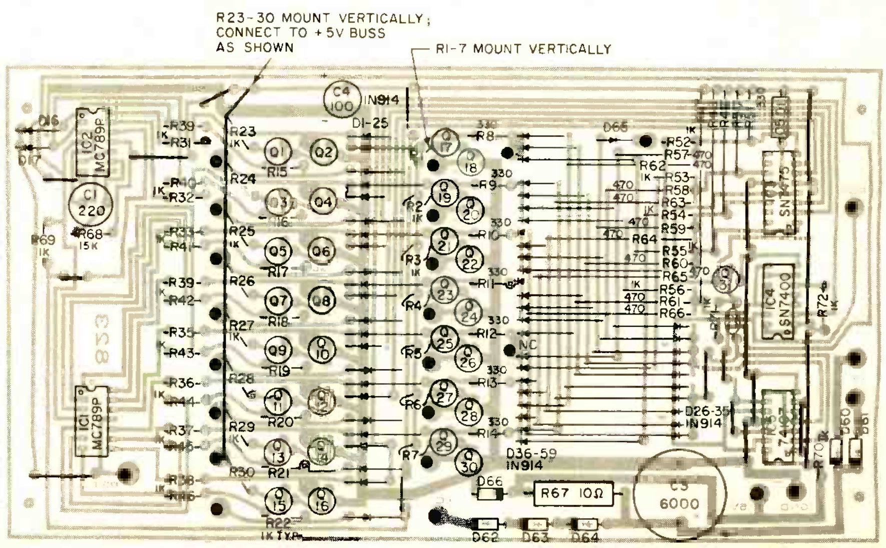


FIG. 11 (right)—COMPONENT LAYOUT shows the position of all parts. Use small iron, thin low-temperature solder and extreme care.

with the machine bulb so that the player can't cheat and attempt to play on top of a square the machine has already used. If the machine bulb is lit, no voltage is available for the pushbutton and it won't set the player latch or advance the move counter.

Diodes D18 through D25 provide a reference of what square has been played. This information is later used by the strategy latch when it has to pick a game strategy after the first move.

The player latches must be reset for each new game. This is done either by removing the inverter supply voltage or by shunting Darlington current with diodes D16 and D17, depending on the particular player latch being reset. S10 is the reset (CLEAR) switch. It does several things. It resets the player latches; it resets the move counter; and it loads a "no play" strategy into the strategy selector.

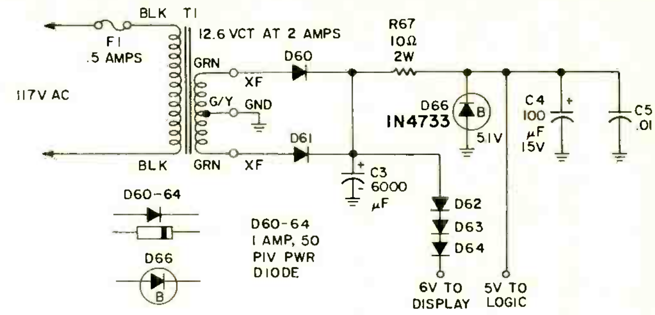
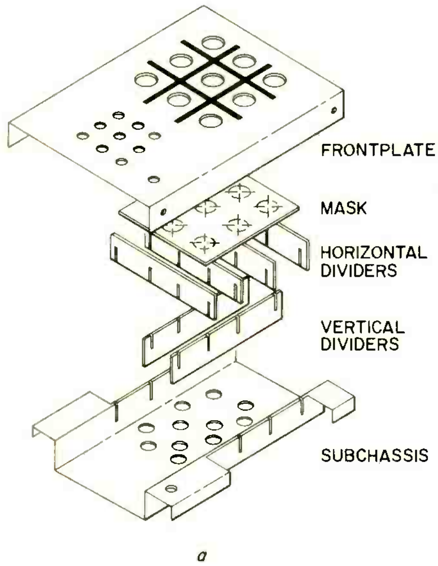
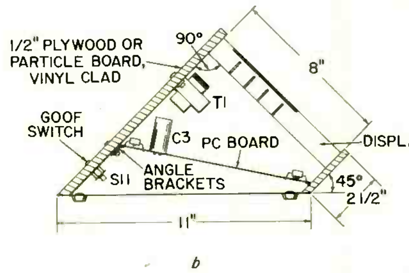
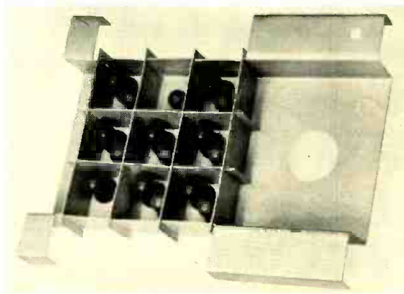


FIG. 8—POWER SUPPLY delivers 5 volts regulated to solid-state devices and 6 volts dc to the lamps.







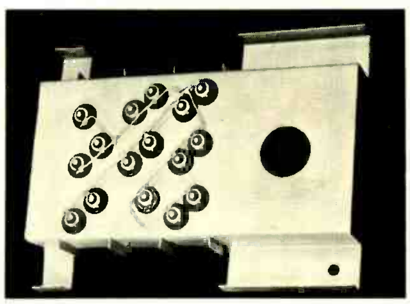


FIG. 12—DISPLAY ASSEMBLY construction is shown in drawings (a and b) and in the photographs above.

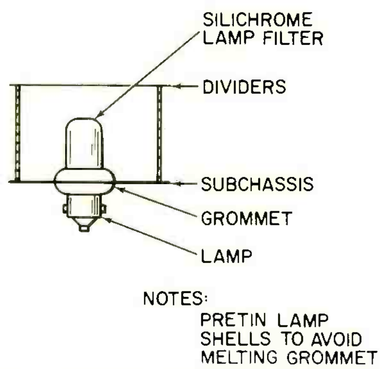


FIG. 13—HOW DISPLAY LAMPS ARE MOUNTED. Pre-tin lamp shells for low-heat soldering.

PARTS LIST

R1 thru R7, R15 thru R46, R52 thru R56, R69 thru R72—1000 ohms, ¼ watt (48 total)
R8 thru R14, R47 thru R51—330 ohms, ¼ watt (12 total)
R57 thru R66—470 ohms, ¼ watt
R67—10 ohms, 2 watts
R68—15,000 ohms, ¼ watt

C1—220 μF, 6-volt electrolytic
C2—0.1 μF, 10-volt disc ceramic
C3—6000 μF, 10-volt electrolytic
C4—100 μF, 6-volt Electrolytic
C5—0.01 μF, mylar

D1 thru D59, D65—1N914 or equal (60 total)
D60 thru D64—1 amp, 50 piv, silicon power diode
D66—1N4733, 1-watt Zener diode, 5.1 volts

F1—0.5-amp fuse & holder

IC1, IC2—MC789P MRTL Hex Inverter
IC3—SN475 or MC7475 Quad Latch TTL
IC4—SN7400 or MC7400 Quad Gate TTL
IC5—SN74107 dual JK flip-flop TTL

LM1 thru LM16—No. 47 pilot light; 6.3 volts, 150 mA

Q1 thru Q31—2N5129

S1 thru S9—spst pushbutton
S10—spdt pushbutton
S11—spdt slide

T1—filament transformer: primary, 117 Vac; secondary, 12.6 Vct, 2 amps

Miscellaneous: PC Board (see text and Figs. 9, 10, 11): No. 24 wire jumpers; PC terminals (33; optional): flat cable or wiring harness (see Fig. 12); subchassis assembly; ⅜" ID grommets (16); Silichrome lamp filters APM Hexseal No. 1813/27-R5 RED (8) and No. 1813/27-B1 BLUE (8); front viewing filter kit; front panel; vinyl-clad case; line cord and strain relief: switch hardware; misc hardware; wire; solder; lacing twine.

NOTE: The following items are available from Southwest Technical Products, 219 W. Rhapsody, San Antonio, Texas, 78216:
Printed Circuit Board Etched & Drilled
No. PC-962 $8.65
Set of all listed electronic parts and hardware less display assembly & cabinet
No. 962K $42.25
Postage & Insurance additional. Shipping weight: 3 lbs, 5 oz.

The machine drivers do not have to latch as they are continuously driven by the play computer. They are also Darlington lamp drivers. If the input from the play computer is made positive, the lamps light. A new game starts when the reset switch returns the play computer and the strategy selector to an all-outputs-low condition.

Diodes D1 through D7 serve an important function. They are the way the computer tests to see if a square is occupied. If the player lamp is lit, the diode robs the machine driver of its base current and prevents the computer from playing on top of the player.

The machine keeps track of the moves with the move counter, shown logically in Fig. 4 and schematically in Fig. 5. The move counter is made up of a 2-second delay monostable IC2, a four-state counter IC5, and a strategy select pulser Q31.

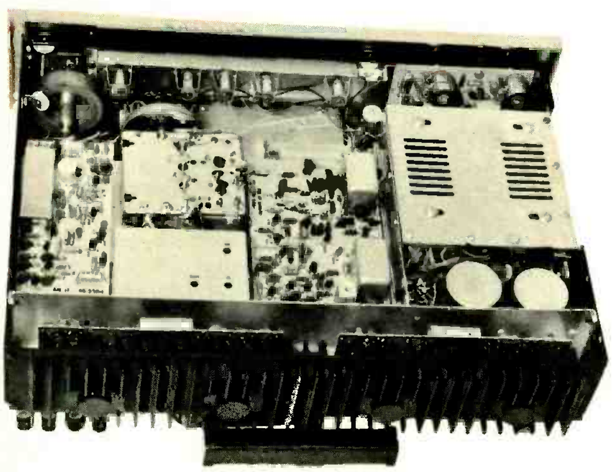
Depressing any valid play pushbutton trips the monostable in IC2 and provides a two-second delay. At the end of the two-second delay, the move counter advances one state. The move counter starts out in a reset condition. On the first move, the strategy-selector is pulsed by half-monostable Q31, while both the move-2 and move-3 logic lines are grounded, preventing any premature move-2 and move-3 plays. On the next play, the move-2 line is allowed to go positive and the second play moves are made. On the next play, the move-3 line is released and allowed to go positive, completing the play. The

(continued on page 78)

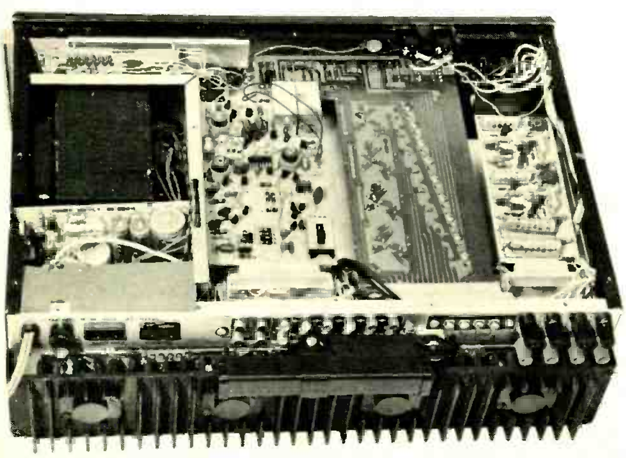
Great new solid-state stereo receiver kit matches the demands of the most golden of golden ears. Listen to one soon

R-E BUILDS HEATH AR-1500 STEREO RECEIVER

by CHESTER H. LAWRENCE



TOP REAR VIEW of Heath AR-1500. FM and AM i.f. boards and power supply filter capacitors are visible.



UNDER CHASSIS look shows input pre-amp, multiplex, phono preamp and power-supply circuit boards.

THERE'S A NEW TOP-OF-THE-LINE stereo receiver being made by Heath. It's the AR-1500, and it is intended to replace the older AR-15.

As you know, the original, the AR-15, has been widely acclaimed as one of the very best stereo-receivers that has ever been made. Therefore, it's hard to imagine that anyone has gone ahead and built a better one. But spec for spec, the AR-1500 is ahead of the AR-15.

As you grow to expect from any Heath kit, there are no special problems in assembling the kit, provided you do follow the construction manual closely and don't rush the soldering. Bad solder joints are still the number one problem builders have with kits.

So rather than spend a lot of space talking about building the kit, let's look at some of the features that make the AR-1500 a great receiver.

Built-in scope amplifier

While hooking up your speakers to an AR-1500 you'll probably notice a pair of rear-panel terminals marked SCOPE. These two terminals are connected to horizontal and vertical scope amplifiers built right into the receiver. The full circuit of the scope amplifier is on page 38.

Why is this so important? These outputs make it possible to easily monitor FM multipath, tuning, and signal strength with a scope. Start off by connecting the scope to the receiver as shown. The waveform you now see is quite important. Eight typical patterns that you might expect to see are shown at the far right.

With the receiver tuned to a station delivering a monophonic signal with 100% modulation you'll see the pattern at **a,** if the receiver is perfectly tuned.

The waveform at **b** is what you get if a stereo station (or test generator connected to the receiver antenna terminals) is transmitting a 19-kHz pilot signal only.

A station transmitting stereo, at near 100% modulation, and with a near-perfect signal, will produce the waveform shown at **c.**

But the real value comes in when you examine the remaining five waveforms. The first four of them **(d, e, f, g)** indicate reception of an FM stereo broadcast with various types of multipath interference. Waveform **h** shows a rapidly fluctuating signal strength. The upshot: you can easily position your antenna for minimum multipath reception and be sure you are doing it right. A quick glance at the scope screen tells you good or bad, without question.

Built-in test meter

Also built into the AR-1500 is a little front-panel meter that serves a dual purpose. It's carefully disguised as a signal-strength meter in the finished unit, but by unfolding a pair of test leads (a permanent built-in feature) you now have a device that permits you to check out all transistors and diodes in the AR-1500.

You can also use the same meter to check capacitors, provided their capacitance is 50-μF or smaller. Just flip the two slide switches to turn the signal meter into a simple ohmmeter or voltmeter. Incidentally, this meter is also used to check out the assembled circuit boards before inserting them into the receiver chassis. The complete circuit of the meter is shown on page 38.

Plug-in boards

A group of 10 individual circuit boards both speed assembly and ease troubleshooting, should repairs become necessary. There's an FM tuner (fully preassembled and aligned) and an AM rf circuit. Field-effect transistors are used in both circuits where they deliver excellent sensitivity and large signal-handling capability. The FM tuner in the AR-1500 incorporates afc. The AR-15 does not offer this feature.

The i.f. strips, both AM and FM, use inductance-capacitance (L-C) filters to increase selectivity and stereo separation. And perhaps even more important, these filters *never* require alignment. Also, the FM i.f. strip includes three ICs.

The other circuit boards include the phono preamp, control circuits, output amplifier (two of these), power supply, input preamp and multiplex. The multiplex circuit also includes one IC that contains all the circuitry for the decoder. Most of the boards plug-in and out on pivoting connectors to simplify in-circuit testing. There's even an extender circuit board which lets you lift the circuit boards away from the receiver for even easier access.

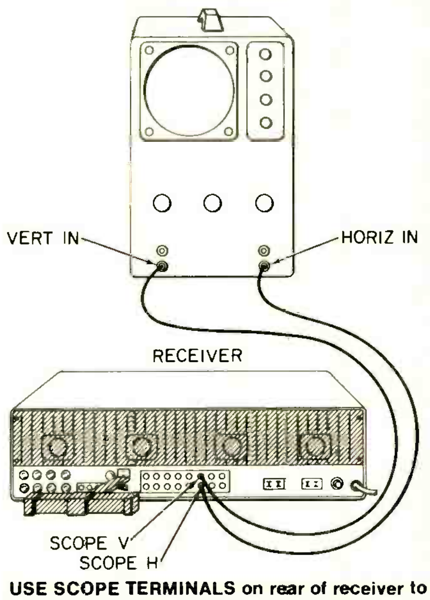
A multitude of front-panel controls makes the AR-1500 an extremely easy to use unit, with all the flexibility anyone might want. To start off, there's a bank of 14 pushbutton switches. They control power on and off, speaker selection, input source selection, operating modes, and tone-loudness. One of the mode selectors (FM STEREO) lets you tune across the FM dial and receive stereo broadcasts only: mono programs are muted. The (TONE FLAT) switch when depressed takes the bass and treble controls out of the circuit and switches in a flat response. This is great if you want to compare your personally compensated response to actual flat response without twisting the controls. It also permits leaving tone controls set for phono, yet takes them out for tape or radio playback.

There are also two front-panel meters—signal and tune. TUNE meter operates only when FM or FM stereo signals are being received. The SIGNAL meter operates for AM, FM or FM stereo reception and shows the relative strength of the received signal.

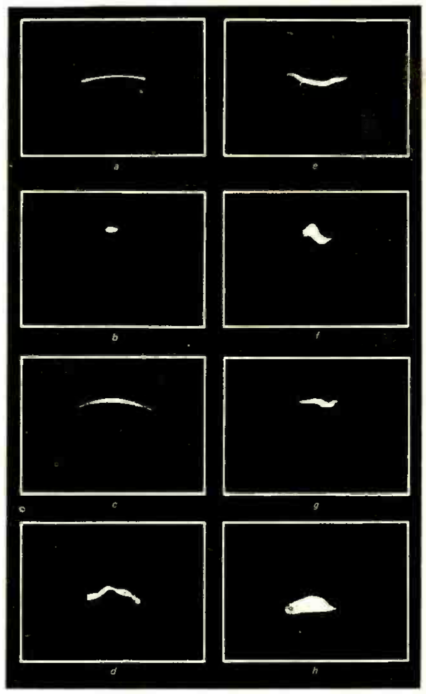
Then there are conventional controls—volume, treble, bass, balance, tuning and squelch. The tuning knob is used for both AM and FM. Two separate headphone jacks complete the front panel. Output signals are fed to both jacks at all times, regardless of the speaker switch positions.

AR-1500 tests

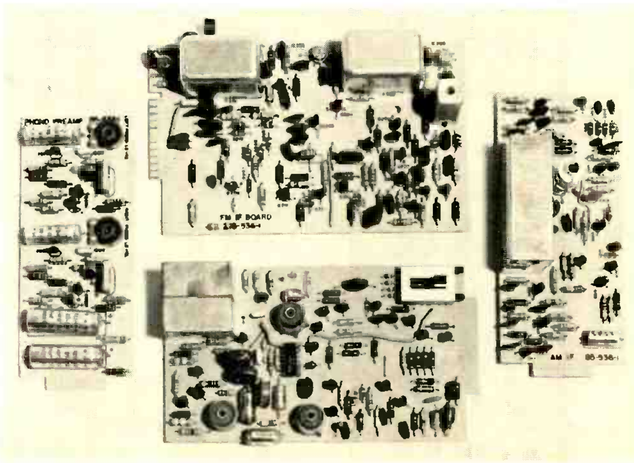
The assembled receiver was tested in a Manhattan apartment about one mile from the Empire State Building, which houses most of the major FM



USE SCOPE TERMINALS on rear of receiver to monitor FM multipath, and other signals.



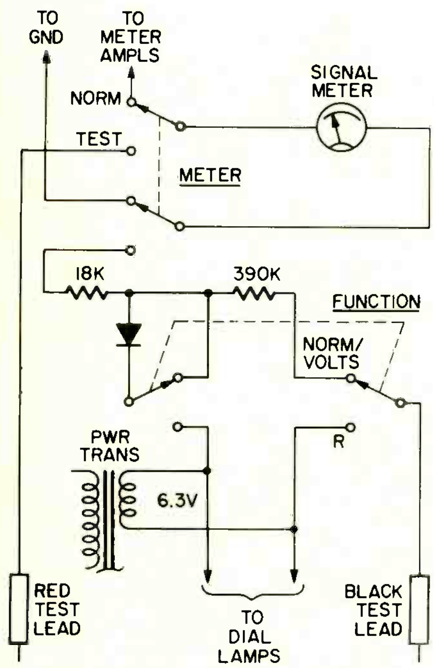
TYPICAL WAVEFORMS from scope output. a—perfect mono. b—19-kHz pilot only. c—near perfect stereo. d, e, f, g,—multipath distortion. h—rapidly varying signal strength.



PLUG-IN circuit boards are used in many AR-1500 circuits. Four of them are shown here. Top—FM i.f. Bottom—multiplex. Right—AM i.f. Left—Phono preamp.

transmitters in New York City. The location was the eleventh floor of a steel building and it was not possible to use a regular outdoor antenna. Instead, a folded dipole made up of twinlead was tacked on the outside window ledge. This window faced away from the Empire State Building.

The FM tuner section was given an A-B test with an AJ-15 tuner, the FM tuner version of the AR-15, which the AR-1500 replaces. The AJ-15 is one of the top FM tuners available. The AR-1500's FM selectivity is rated a little



TWO SLIDE SWITCHES turn signal meter into either simple ohmmeter or voltmeter for testing receiver circuits.

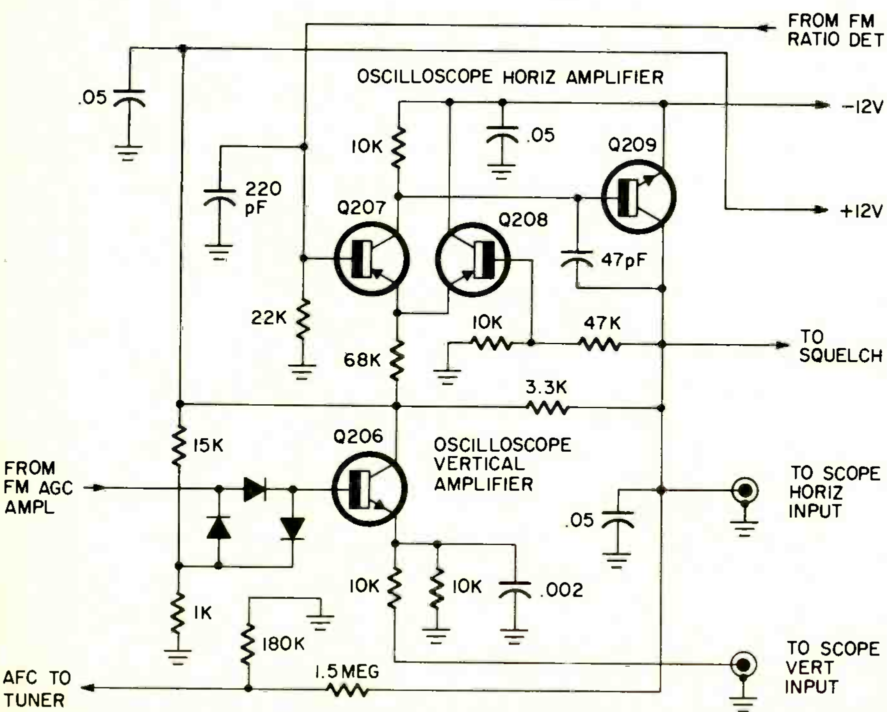
better than the AJ-15–AR-15; sensitivity of both is the same. Intermodulation distortion of the AR-1500 FM tuner is 0.1% versus 0.5% for the AJ-15–AR-15.

FM reception was excellent on most local stations, although there was some problem with multipath distortion because of the simple antenna. A number of suburban low-power stations came in as well. Some had sufficient strength to give completely noise-free reception.

Unlike most solid state FM receivers tested in this location (including the AJ-15), there was no difficulty with overloading or cross modulation on any of the stronger stations located on the Empire State Building. Apparently Heath has overcome this problem very nicely in the AR-1500. Selectivity was exceptionally good, as expected. Due to the distribution of FM stations it was not possible to compare the two tuners when receiving transmitters on adjacent channels. All stations received were separated by at least one channel. In this situation the two units performed equally well.

The receiver was tested with four-ohm speakers (AR-3A's). With this type of a load, the amplifiers are rated to deliver 100 watts per channel (continuous sine wave) with less than 0.1% intermodulation distortion. The unit easily met the specifications. The sound was what you would expect with a system of this caliber. In other words, there was no audible distortion at any listening level that could be tolerated in a living room of 15 ft. x 30 ft.

The AR-1500 is indeed an outstanding performer. **R-E**



THESE OSCILLOSCOPE AMPLIFIERS are built into the receiver. Scope connection terminals are mounted on receiver's rear apron.

SPECIFICATIONS

TUNER: FM SECTION (Monophonic)

Freq. response .... ±1 dB, 20 to 15,000
Sensitivity .... 1.8 μV*
Selectivity .... 90 dB*
Image/rejection ..... 100 dB*
I.f. rejection .... 100 dB*
Capture ratio .... 1.5 dB*
AM suppression ..... 50 dB*
HD .... 0.5% or less*
Hum and noise .... 60 dB
Spurious rejection.. 100 dB

TUNER: FM SECTION (Stereophonic)

Channel separation 40 dB or greater at midfrequencies
35 dB at 50 Hz
25 dB at 10 kHz
20 dB at 15 kHz
Freq. response .... ±1 dB, 20 to 15,000
HD .... 0.5% at 1000 Hz with 100% modulation
19 kHz & 38 kHz suppression .... 55 dB or greater
SCA suppression ... 55 dB

TUNER: AM SECTION

Sensitivity .... 50 μV with external input
300 μV per meter with radiated input
Selectivity .... 20 dB at 10 kHz
60 dB at 20 kHz
Image rejection ...... 70 dB at 600 kHz
50 dB at 1400 kHz
I.f.rejection .... 70 dB at 600 kHz
HD .... Less than 2%*
Hum and noise .... 40 dB*

AMPLIFIER (per channel)

Dynamic power output (music power rating) .... 90 watts (8-ohm load)*
120 watts (4-ohms)*
50 watts (16-ohms)*
Continuous power output .... 60 watts (8-ohm load)*
100 watts (4-ohms)*
40 watts (16-ohms)*
Power bandwidth for constant 0.25% THD......... Less than 8 Hz to greater than 30 kHz*
Frequency response (1 watt)................ –1 dB, 7 Hz to 80 kHz
–3 dB, less than 5 Hz to 120 kHz
HD .... less than 0.25% from 20 Hz to 20 kHz at 60 W output
IM distortion .... Less than 0.1% at 60 W output using 60, 6000 Hz mixed 4:1
Less than 0.1% at 1W output
Damping factor ...... Greater than 60
Hum & Noise .... Phono (10 mV ref) –63 dB
Tape and aux (0.25 V ref) –75 dB
Channel separation Phono—55 dB
Tape & aux—55 dB

Troubleshooting reed-relay logic

Here's how to locate the trouble fast when reed-relay logic circuits start causing trouble

by DON BLACKLOCK

THE INDUSTRIAL ELECTRONIC TECHNICIAN NOW FACES AN INcreasing complexity of control circuits in the equipment he is called upon to service. Today's equipment is becoming more automatic, and demanding increased complexity of control circuits—this must be considered as logic. Some form of logic has always existed, even in the simplest of control circuits, but no one bothered to call it logic.

Now, the basic logic functions of AND, OR, FLIP-FLOP, and INVERTER appear in industrial equipment, not in digital form of transistor circuit elements, but more often, relay logic. Highly sophisticated machines like numerically controlled machine tools use transistor logic and are serviced generally by factory trained technicians. However, a much larger amount of equipment, in process control area, particularly, make extensive use of relay logic. This type equipment is most often serviced by an industrial technician. With continued increase of automatic equipment a general service technician may even be called upon to service a Parking Lot Attendant—Automatic Variety.

Some elements of a hypothetical process control system are shown in Fig. 1. Signals from interlock, materials and mechanical status sections are combined to produce the "GO" signals to the power control. All inputs must be "GO", before power is turned on. This combining of signals is the logic function AND.

The trend today is to use reed relays for logic applications. Reed relays offer several advantages over conventional relays. Possibly the most important factor is high reliability.

Because the contacts are sealed in a glass capsule, they are protected from environmental contamination. The seal alone provides high reliability. Reed relays can be made very sensitive and operate from low drive voltage or current. They can be driven by solid-state devices; the low drive required is well suited for this.

A very attractive feature to the equipment designer is that reed relays can be mounted on PC boards, resulting in low vertical profile. A maximum number of relay cards may then be mounted in a standard card file. This capability of high-density packaging leads to increased application of reed-relay logic in new equipment.

To service reed-relay logic, the professional technician must have a thorough understanding of two things—the reed relay and basic logic functions.

Although the reed relay has been available for some time, its primary use has been in aero-space and data processing applications. Logic functions are one of the basic principles in the computer/data processing industry, an area where the general technician has little opportunity to find out "What's new in the field."

The skilled workman on the job must understand his tools. So too, reed relays and logic functions are the tools the technician uses to service industrial control equipment. Using these new tools, the industrial or general service technician can tackle control circuits with confidence, without losing time.

The reed relay

The reed relay's heart is the reed capsule (Fig. 2). The reed unit is a simple device. Two thin metal leafs or reeds are sealed within a glass capsule. They are cantilever supported so their free ends overlap and are separated by a small gap. The reeds are magnetic metal, plated with diffused gold or rhodium to reduce contact resistance. The sealed capsule, which is filled with inert gas, prevents contamination of the contacts and provides high reliability. The reed capsule appears simple, but it is a precision unit with very close tolerances maintained in manufacture.

To close the contacts, an external magnetic field must be applied—the reeds provide a flux path concentrating lines of

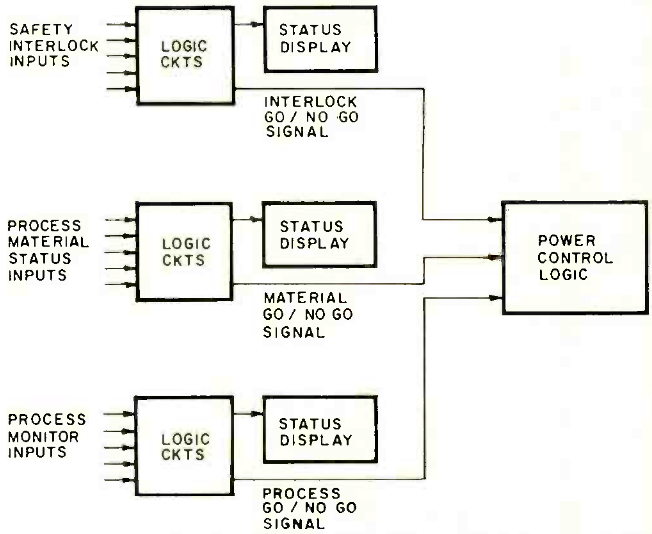


FIG. 1—HYPOTHETICAL PROCESS-CONTROL SYSTEM. Logic circuits must ok all conditions before power can be applied.

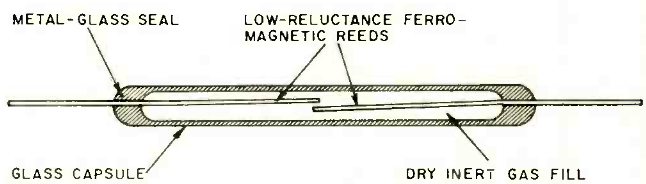
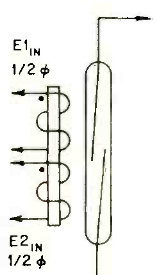
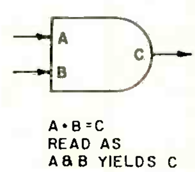


FIG. 2—REED-RELAY CAPSULE slips into core of spool on which drive coil is wound. Magnetic field pulls reeds together.



AND TRUTH TABLE

$E1_{IN}$	$E2_{IN}$	OUT
F	F	F
T	F	F
F	T	F
T	T	T

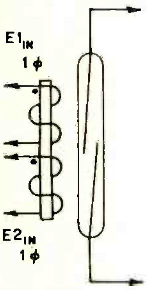


a b c

FIG. 3—DUAL-COIL REED RELAY used as a 2-input AND gate (a). Its logic truth table and symbol are at (b) and (c) respectively.

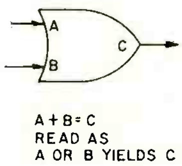
force along the reeds. When flux density is maximum across the gap, the ends of the reeds assume opposite magnetic polarity and attract each other. When this attraction overcomes the reeds' rigidity, they come together making electrical contact. With the reeds in contact, a lower flux can maintain the contact, providing a pull-in drop-out differential as with conventional relays. A second contact can be added to the capsule to provide spdt (Form C) switching.

The reed capsule must have a drive coil to become a functioning relay. Here again, the reed relay differs from the



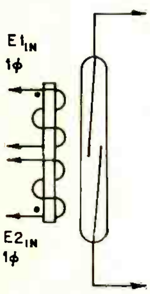
OR TRUTH TABLE

$E1_{IN}$	$E2_{IN}$	OUT
F	F	F
T	F	T
F	T	T
T	T	T



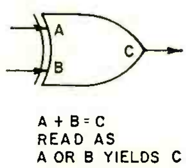
a b c

FIG. 4—REED-RELAY OR GATE (a) closes when either coil is driven. Truth table (b) shows operation; (c) is the logic symbol.



X-OR TRUTH TABLE

$E1_{IN}$	$E2_{IN}$	OUT
F	F	F
T	F	T
F	T	T
T	T	F



a b c

FIG. 5—EXCLUSIVE-OR ARRANGEMENT (a) has coils with opposing fields for truth table (b). X-OR symbol is at (c).

conventional relay. First, the physical shape of the coil is cylindrical, with a hollow center. The reed capsule is inserted in the center enclosed by the coil. When two or more capsules are driven by the same coil, it is wound on an elliptical bobbin with the capsules inserted side by side. Relays with as many as five capsules are not uncommon.

Another difference is the number of windings in the coil. For logic use the coil will have two or more isolated windings. Each winding serves as a logic input.

Now the relay is assembled into a compact flat unit with the rather delicate capsule enclosed and protected by the coil. The finished unit can take a variety of shaps. Typically sealed in a metal (magnetic shielding) case, all leads extend out one of the long sides. This enables easy mounting directly on PC boards.

Another popular form is unsealed. The coil has end plates that connect to the reed capsule while holding the capsule positioned within the coil. The end plates have lugs on common edges for direct PC mounting. Another possible arrangement is the sealed plug-in unit.

Basic reed relay logic

Logic circuits are possibly some of the simplest circuits to handle from the technician's point of view. In simple terms, the circuits perform like switches. Because the circuits have only two conditions, ON or OFF, problems of distortions, or similar problems are not encountered. Inputs, and outputs are one of two voltage levels. Any other voltage is a faulty condition. Circuit problems will be discussed later. We must first define each logic function, and also, how the logic functions can be handled by reed relays.

Logic AND

The AND circuit is like a coincidence circuit because all inputs must be ON to get an output. If one input is OFF the output will be OFF, (the number of inputs may range from two to five or more). More inputs are handled by using additional AND gates, then combining or ANDing all outputs. This is called fan-in. A two input AND gate, its truth table and logic symbol are shown in Fig. 3.

Depending upon design of the reed relay, a specific amount of magnetic flux is needed to make the contact is close. This is referred to as one flux unit (symbol ϕ). The two coil windings (Fig. 3) are designed to provice ½ϕ each at

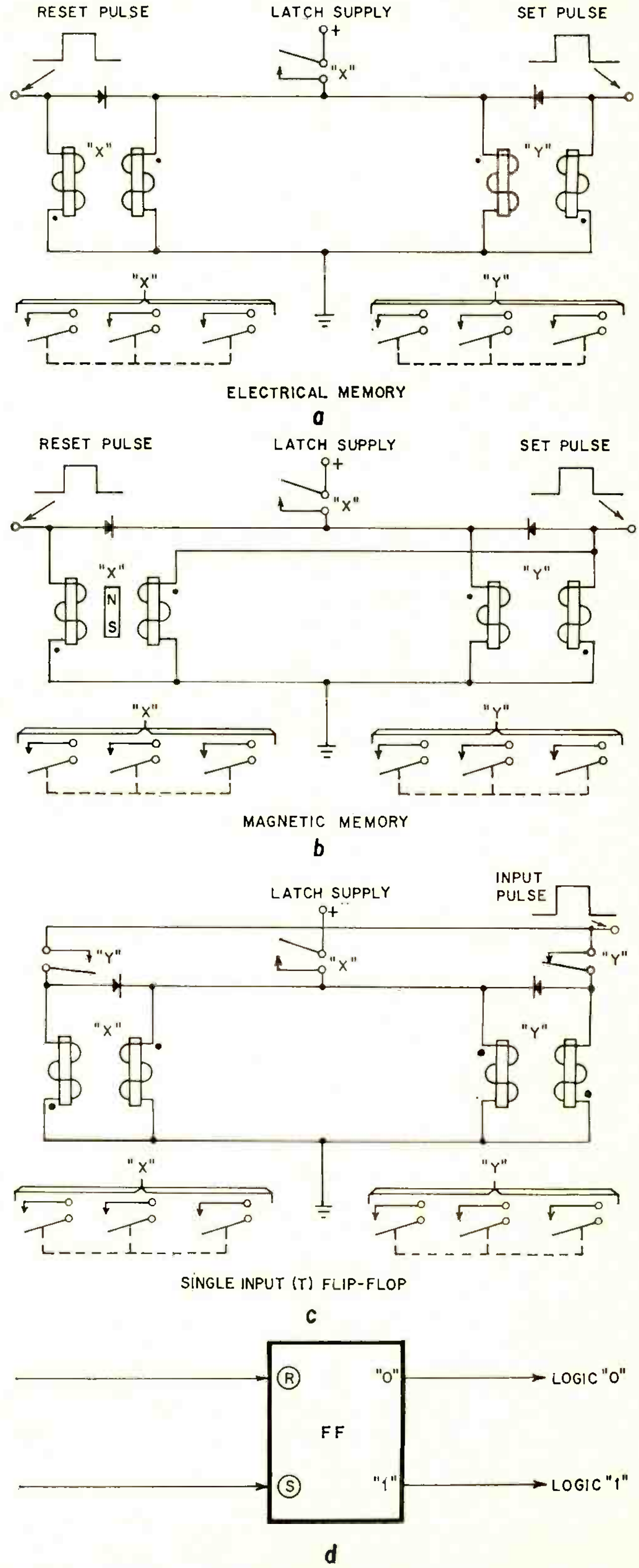


FIG. 6—COMMON LOGIC CIRCUITS USING REED RELAYS. Four different arrangements are shown here.

GLOSSARY OF LOGIC TERMS

AND gate: A circuit with one output and many inputs. The output is energized when and only when *all* inputs are energized. A coincidence gate.

Binary coded decimal (BD): A system of representing digital numbers. Each decimal number is represented by four binary digits (bits).

Binary counter: A network composed of flip-flops that count the number of input pulses in the radix or Base 2.

"Bi-Stable": see flip-flop

Clock: The controlling circuits to effect transfer or operations to be performed at a given time.

Clock Pulse: The electrical signal to the equipment that allows operations to take place.

Clock Rate: The number of pulses per second supplied by the clock.

Flip-Flop: A device or circuit with two stable states. The circuit remains in either state until the application of a signal causes it to change. The flip-flop is also called: "bi-stable", "bi-stable multivibrator", "two state" and "toggle".

Gate: A circuit with one output and many inputs, designed so that the output is energized when certain input conditions are met. See "AND gate", "OR gate", "NOR gate", "NAND gate", and "Logic boards."

Logic: A class of circuits, principally "gates" which produce an output only when prescribed input conditions are fulfilled. A functional grouping of the above type of circuits.

Logic boards: A device that contains a circuit that may be used as a gate.

Logic operations: Non-arithmetical operations such as selecting, sorting, comparing, matching, etc.

NAND Gate: An "AND" gate that inverts the signal .

"NOR" Gate: An "OR" gate that inverts the signal.

"OR" Gate: A circuit with one output and many inputs that energizes the output when one or more inputs exist.

Ring Counter: A network what presents a unique state (output) for each input pulse. A device used for counting input pulses. A device used to provide a digital count of sequential pulses. A device used to divide the rate of incoming pulses.

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operating voltage. Thus, both coils must be energerized to cause contact closure. A three-input AND gate requires three coils, each coil providing ⅓ϕ (four-input, four coils, etc.). However, the number of inputs that can be accommodated this way is limited. The limit is reached when the flux supplied by one input coil is less than the pull-in/drop-out differential. In this case, losing one input would not cause the output to change.

OR gate

The next logic function is the OR gate or circuit. A two-input OR gate, truth table and logic symbol are in Fig. 4. The circuit is similar to basic AND with one exception. Instead of ½ϕ flux unit, each coil receives one full flux unit of drive for contact closure.

A modification of the basic OR gate is shown in Fig. 5, termed exclusive OR(X-OR) gate.

In this circuit the drive coils are connected to produce opposing magnetic fields. Therefore, when both inputs are ON, the output will be OFF. The X-OR circuit eliminates the ambiguity which can result with the conventional OR circuit. Sometimes the exclusive OR circuit is called a comparator.

Flip-flop

The flip-flop is an extremely versatile circuit. It provides the basic form for many types of counters used in industrial contols. The types of counters are binary, binary-coded decimal or bi-directional. One common application is step-by-step control programmers. The reed relay flip-flop has the advantage in providing multiple outputs and complete input-output isolation.

Basic operations of two types of flip-flops will be outlined next—first, two input (R-S)—second, modification of R-S flip-flop (single input or "T" flip-flop).

The R-S flip-flop circuit is comprised of two double-wound reed relays connected as in Fig. 6-a. Fig. 6-b is an R-S circuit using magnetic memory. Please note, their operation is identical; however, the magnetic memory's one set of contacts, (x in Fig. 6) remains closed when power is removed.

The doubde-wound coils are labeled X and Y for easier identification. The coils of each relay are diode-coupled and wired in opposition to produce zero flux when both coils are energized. In electrical memory, one coil of each relay is connected to an "X" reed contact for latching. The presence of a SET-input signal energerizes both coils of "Y", but only one coil of "X" will make the "X" reed contacts operate. When the SET pulse ends, one "Y" coil is de-energized. The other one remains energized through the "X" latch, allowing the "Y" reed contacts to operate. In electric memory FF, applying the RESET input energizes both "X" coils, releasing the "X" reed contacts. With *magnetic* memory FF the RE-SET input energizes the "X" release coil, dropping out the "X" reed contacts. In either type of memory, one "Y" coil remains energized through the "X" diode, causing the "Y" reed contacts to stay closed until the reset input is ended. Then the "Y" contacts release and the circuit is prepared to re-cycle.

The single input of "T" FLIP-FLOP is in Fig. 6-c. It has normally open and normally closed contacts. These contacts are used to alternately steer the single input pulse to the SET and RE-SET inputs.

The preceding discussion outlines the basic operation of relay flip-flops. The exact timing relationship of input-output and electrical interconnection depends on how the "FF" circuit is used.

The last logic function we will cover is the INVERTER. It is used to change the level of a signal; an ON state to OFF. This logic function is normally used to make input or output of the control unit compatible with its external equipment. The INVERTER can be a separate circuit or can be part of a standard gate. The logic function of the INVERTER is handled by normally closed contacts.

When the INVERTER function is a part of the gate circuit, the name is changed, adding the letter N to the gate name. An AND gate which inverts becomes a NAND gate; OR gate becomes NOR gate. Its logic symbol is changed by adding a small circle at the output line.

Common malfunctions

Although we are primarily concerned with reed relays, the industrial technician often runs into older equipment with conventional relays. Such relays, of course, are prone to the same ills as any exposed relay.

The reed relay, thanks to its sealed reed capsule is unconcerned with two of the most common problems of other relays—dirty and tarnished contacts. However, reed relays are very sensitive to contact pitting. With the small contact area of the reeds and little wiping action, very little pitting can be tolerated. As with any switching contact, pitting is caused by arcing that occurs when the contacts open. This arcing is caused by back voltage from inductive loads.

Pitting or erosion of reed contacts has a considerable effect upon contact resistance. For example, a reed relay in a dry circuit can expect to last through 5×10^8 operations. The same unit with a rated load (resistive) can expect life of 5×10^6 operations. Both life ratings are based on a 2-ohm contact resistance end-point. Typical initial resistance is 50 to 100 milliohms.

When reed relays switch inductive loads, i.e., other relay coils, proper load suppression is a must. While selecting the suppressor is the responsibility of the equipment designer, the technician must insure that these devices continue to operate. He should check them regularly.

The next most common problem with reed relays is contact welding. This is commonly caused by switching too high a current. The reed relay contact can carry more current than it can switch (i.e., switch 1.5 amps, carry 6 amps). Welding is prevented by operating the relay within its ratings. If the technician finds welded contacts, he can assume they are caused by a fault external to the relay. He thoroughly checks down-stream from the relay to determine and correct the cause of excessive current.

Reed-relay coils have a very low electrical failure rate; but it does happen occasionally. The most common problem is physical damage to the coil.

Repairing reed relays

Repairability of the reed relay depends on the construction of the unit. The sealed or "potted" unit, for all practical purposes, cannot be repaired. Servicing the sealed unit is limited to "remove and replace". With little difficulty, the unsealed units can usually be repaired. The faulty reed is repaired as a unit. If required, the coil can be replaced.

Be cautious when attempting reed-relay repairs. The reed capsule is glass and fragile. The glass-to-metal seal where the reeds enter is prone to breakage. The seal can be easily broken by mechanical stress. Prevent any side thrust on the leads in the area of the seal.

When the technician replaces a relay coil with multiple windings, he must follow the phasing of the windings. The coil leads are color-coded to indicate start and finish. Replacements are wired exactly as "the original."

Also, at this time, each protective device is checked and replaced if found faulty. Since these are solid-state devices, be careful while soldering or de-soldering.

Removing PC board mounted relays presents a problem, because numerous connections (as many as 12) must be broken at one time.

From past experience, I recommend using a vacuum-type de-soldering iron. Several types are available.

High speed reed relays

Some logic applications require a relay that has no contact bounce. To eliminate this bounce, high-speed mercury-wetted relays are used.

Typical construction of a mercury-wetted reed capsule is in Fig. 7-a. The most obvious addition is a small pool of mercury. The reeds' surface is also treated so it will be wetted by the mercury by capillary action.

You can see the mercury film as the reeds start to open in Fig. 7-b. Surface tension causes a thin bridge of mercury to stretch across the opening reed gap. This occurs either when the relay is de-energized or when the reeds attempt to open, due to bounce.

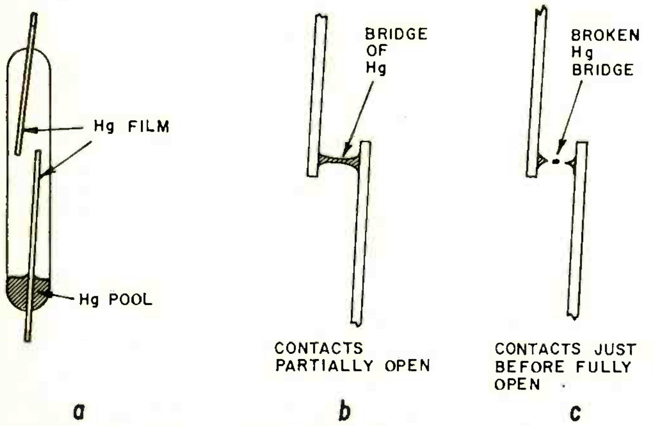


FIG. 7—MERCURY-WETTED REED RELAY (a) has mercury bridge (b) to maintain contact until contacts are fully open (c).

The reed action just before the reeds are fully opened is in Fig. 7-c. When surface tension can no longer maintain the mercury bridge, it snaps!

The droplet of mercury falls back to the reservoir while the remainder is pulled back on to each reed. Capilliary action still maintains the film on the reeds. This action provides high-speed bounceless operation.

Unfortunately, we do not get something for nothing. Adding mercury to the reed capsule makes the relay position sensitive. The unit must be mounted with its long axis vertical. The mercury reservoir is at the bottom. If placed on its side or upside down the unit will act as a mercury switch.

The technician should remember two precautions in handling a high-speed relay. When first installed, a spare relay does not function properly unless stored in operating position. It can take from less than one hour to several hours for the proper mercury film thickness to form. Until the right thickness is reached, the relay may not open when energized. When the technician removes the relay for testing, he must keep it vertical at all times.

Which logic element

There is no real problem in troubleshooting a relay logic element because the relay logic element is simple and easy to service. However, when the industrial technician is called upon to repair a piece of equipment, he is presented with one commonplace problem—finding the one logic element that has failed out of 100 logic elements. One basic question, he must ask himself, "How do I find the relay failure? No universal plan can be used to troubleshoot logic; however certain facts are there. Since, logic has only two states (ON and OFF) he loses no time in deciding if a test result is correct. He knows there are no "almost right" signals.

No large amounts of test equipment are needed to service relay logic, usually, only a "Jumper Lead," to simulate relay operation and a voltmeter to monitor outputs. In fact, a low-voltage testlight can be substituted for the meter.

All logic operations must follow a definite sequence. This sequence is already built into the equipment. For the equipment to operate this sequence must be complete.

The technician must study all available manuals and diagrams for the equipment he is repairing. Then he can devise his troubleshooting plan. His more complex equipment has a status display indicating the conditions of certain blocks of the logic. These displays are handy for locating the general area of trouble. Simpler equipment will not have built-in aids and the technician must examine his diagrams and select his own indicators.

The technician reasons, "If I check one relay, find it "operated," I can be sure all logic up to that point is functioning." Another valuable help in solving the problem is to sketch simplified diagrams of the logic, showing the basic relay chains.

Technician aids

The best technician's key for attaining logic knowledge is equipment manuals and diagrams (vital interconnection information) for the basic logic circuits. Without this information, servicing the equipment is severely handicapped, if not downright impossible.

Simpler logic equipment is laborious to circuit trace, but the newer complex units are literally impossible to circuit trace because the interconnect wiring is wired point-to-point on the PC connectors.

Many a "poor" technician happens to find himself in a dilemma such as facing twelve connectors, and twenty pins on the back of a 10-inch box. Of course, this perplexity is nearly impossible to circuit trace.

The technician who services a piece of equipment on a regular basis will find it worth his while to acquire his own set of manuals and diagrams. The general service technician who occasionally services industrial equipment should obtain and keep copies of the diagrams, at least. The experienced technician never assumes a certain manual is available when he needs it. He knows that somehow manuals have a "strange habit." They seem to sneak into someone's private tech-library and disappear forever.

Conclusion

The industrial or general service technician who understands logic principles shouldn't hesitate to accept a job of repairing control equipment. There is no real mystery about logic as used in control. Only a comprehensive knowledge of the basic logic functions and equipment manuals can give our technicians "a gentle push" into this field. **R-E**

Build a Liquid-Crystal Wattmeter

A new approach to an rf wattmeter design for checking and tuning low-power vhf amateur and Citizens band transmitters

by JOHN POTTER SHIELDS

IF YOU ARE LIKE ME, YOU WANT TO check the rf power output from your CB or ham rig regularly to make certain that the transmitter is still delivering maximum output power. Aging tubes and components can result in a gradual reduction of power output—robbing you of the performance originally designed into your unit.

There are several methods of gauging the relative power output from your rig. Perhaps the most common is to simply connect a small light bulb to the output terminals of the rig. Noting the apparent brightness of the bulb will give a rough indication of the rig's power output. Unfortunately, this scheme leaves much to be desired. For one thing, the resistance of the light bulb is nowhere near the nominal 52-ohm output impedance of most transmitters. Also, it's difficult to judge the relative brightness of the bulb accurately; it may be considerably brighter than when the same bulb is energized from the 120-volt power line.

The other common approach is to connect an rf wattmeter to the output terminals of the transmitter. This will assure quite accurate readings. However, the cost of an even relatively accurate wattmeter is not low.

Searching about for a simple solution to this problem I came across an item marketed by the Edmund Scientific Co. which I thought might just fill the bill. Known as Liquid Crystals, the material is available in several forms. The one of particular interest to me was in the form of a thin plastic sheet in which the Liquid Crystal material is imbedded. Liquid Crystals have the unique ability of changing color when subjected to temperature change. For example, if you place a piece of the Liquid Crystal plastic on the palm of your hand, the heat from your hand will cause the plastic next to your fingers and palm to change color due to the heat radiated from them. As you can see, the material is extremely sensitive to temperature change. It was this extreme color-temperature sensitivity of the Liquid Crystal plastic that led to the development of this little rf Wattmeter.

Circuit description

Let's take a look at Fig. 1. It shows the schematic of the liquid crystal rf wattmeter. Parallel-connected resistors, R1, R2, R3, and R4 form the load for the transmitter. Each of these resistors is a 200-ohm, 2-watter. So we wind up with a total load resistance of 50 ohms. The power dissipation of the four resistors will be eight watts—more than enough for the CB rig or small vhf ham transmitter.

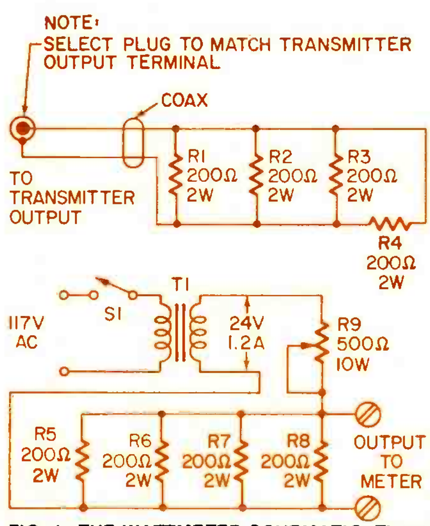


FIG. 1—THE WATTMETER SCHEMATIC. There are two parts—the load resistor at the top and the indicating section at the bottom.

The second portion of the watt-meter consists of four more parallel-connected 200-ohm resistors. The ends of this parallel-resistor combination are connected in series with potentiometer R9 and the secondary of the 24-volt filament transformer, T1. Cement a square of Liquid Crystal plastic to the tops of R1, R2, R3, and R4. The square should be large enough to cover the tops of all four resistors. Similarly, cement a second piece of Liquid Crystal plastic to the tops of R5, R6, R7, and R8. A glance at the sketch, Fig. 2, will make things clear.

The various components of the liquid crystal rf wattmeter are assembled on the top of a small metal chassis. Parts placement is shown in Fig. 2.

Operation

Now let's put the liquid crystal rf wattmeter to work. First, connect the cable from the load resistors (R1, R2, R3, and R4) to the output connector of your rig, and hook a multimeter to the unit's "output voltage" terminals. Most vom's have an ac volts range. Select the 0 to 50-volt range, or any range close to this general voltage. Next, with R9 set at its maximum resistance range, connect the unit's line cord to a source of 117 volts, ac, and place power switch S1 in the ON position. Fire up the transmitter; tune for maximum rf power output, and after waiting for a few seconds, note the color of the Liquid Crystal plastic on top of the load resistors. Finally, adjust R9 until the color of the Liquid Crystal plastic on the top of R5, R6, R7, and R8 matches that of the plastic on the top of

PARTS LIST

R1, R2, R3, R4, R5, R6, R7, R8—200 ohms, 2 watts
R9—potentiometer 500 ohms, 10 watts, wirewound
Liquid Crystal Plastic—Edmund Scientific Co. Stock No. 71, 140
T1—24-volt 1.2 amp filament transformer (Allied Electronics No. 273-1480 or equal)
S1-s.p.s.t. toggle switch

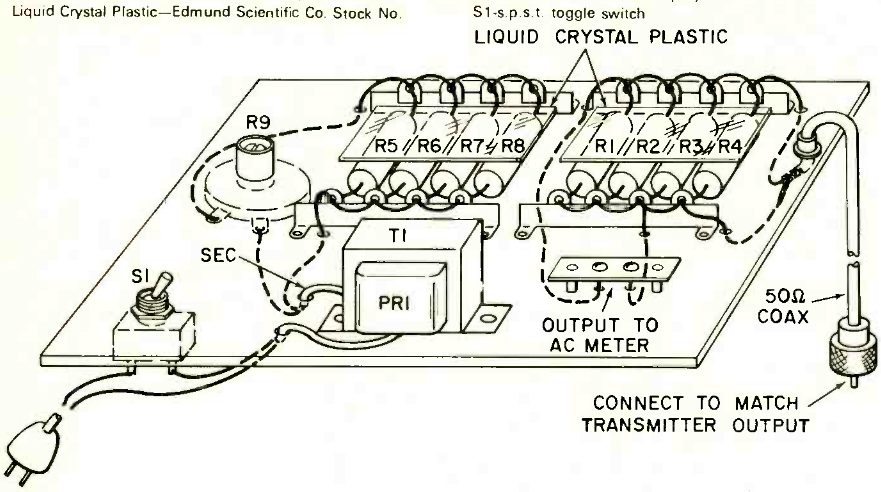


FIG. 2—HOW THE WATTMETER IS PUT TOGETHER. Note that the terminal strip for the meter is connected across R8 as in Fig. 1, not across the rf load (R1–R4 in parallel).

the load resistors. When colors match, equal current is flowing through both sets of resistors.

Now, by noting the meter reading and using a bit of Ohm's Law, we can determine the amount of power dissipated in the load resistors. Using $P = E^2/R$ to calculate the power, let's say that the meter indicates that 10 volts is developed across the output terminals. Our power will then be:

$$P = \frac{E^2}{R} = \frac{10^2}{50} = \frac{100}{50} = 2 \text{ watts}$$

So you see, that's all there is to it. Why not build a Liquid Crystal RF Wattmeter yourself? The small amount of time and expense will be more than justified. **R-E**

The TV Scope

The scope on the blink, an old-timer shows a young bench-hand a clever scheme for making a TV set trace its own i.f. response curve.

by EGON STRAUSS

"Charlie, Charlie." The voice of Mac, the young repairman sounded excited.

Charlie Lightspot, owner of Lightspot's TV and Hi-Fi Service was not too pleased with this fact. He already had quite a few problems on his mind: there was the custom stereo installation downtown that had a few bugs in it, and his main help, Frank, was there. Charlie had to take care of the shop with Mac, the young and eager, but still unexperienced repairman as his only help.

Right now Mac was trying to repair Mrs. Brown's TV, brought in by its owner for a general overhaul.

"What seems to be the problem, Mac," asked Charlie.

"I'm trying to align the i.f. strip in Mrs. Brown's Zenith. Guess what happened? The scope went dead."

"That's all we need," said Charlie. "Well, Mac, this requires some fast thinking. Let's sit down and analyze the situation."

While sipping hot coffee, Charlie asked about the progress Mac had made on the job, and was told the only thing remaining was the i.f. alignment and a final check.

"Well, all we really need now is a scope to align the set so we can get it back to Mrs. Brown," said Charlie.

"But we don't have a working scope here," observed Mac.

"Quite true, my friend, but let's try to find one—fast," said his boss. "You know, Mac, a TV receiver has much in common with a scope. All the basics are there. Let me show you." Charlie took his note pad and made a rough sketch of the scope (Fig. 1).

"Look, Mac," he said. "Here you have the basic ingredients. The CRT with its power supply, both low and high voltage, the four main controls: brightness, focus, horizontal and vertical centering, the horizontal timebase and the vertical signal amplifier. Compare this with the circuit of this TV set. Let's try to use these basic elements in the receiver to observe the i.f. response curve on the receiver screen."

"It's a wonderful idea," answered Mac, "but won't it be complicated to change all the chassis connections to get this response curve on the screen?".

"Well, Mac, maybe the changes aren't so big as you'd think. Let's go to work."

Under Charlie's direction, Mac changed the following connections in the partial circuit diagram in Fig. 2. He disconnected C27 from the cathode pin of the CRT, and using a clip lead, connected this capacitor to the grid of vertical output tube V10-b. He also disconnected C48 and C45 from this tube. Then he disconnected both horizontal yoke coils and their center tap from the horizontal sweep transformer. One of the outside cables of the horizontal coils was connected to ground and the other to the 6.3-volt power transformer winding.

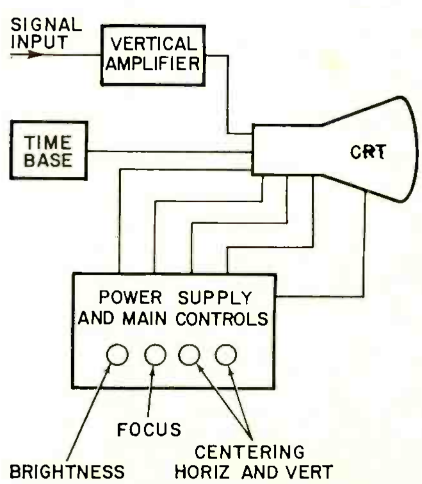


FIG. 1—THE BASIC OSCILLOSCOPE has lots in common with a televison receiver.

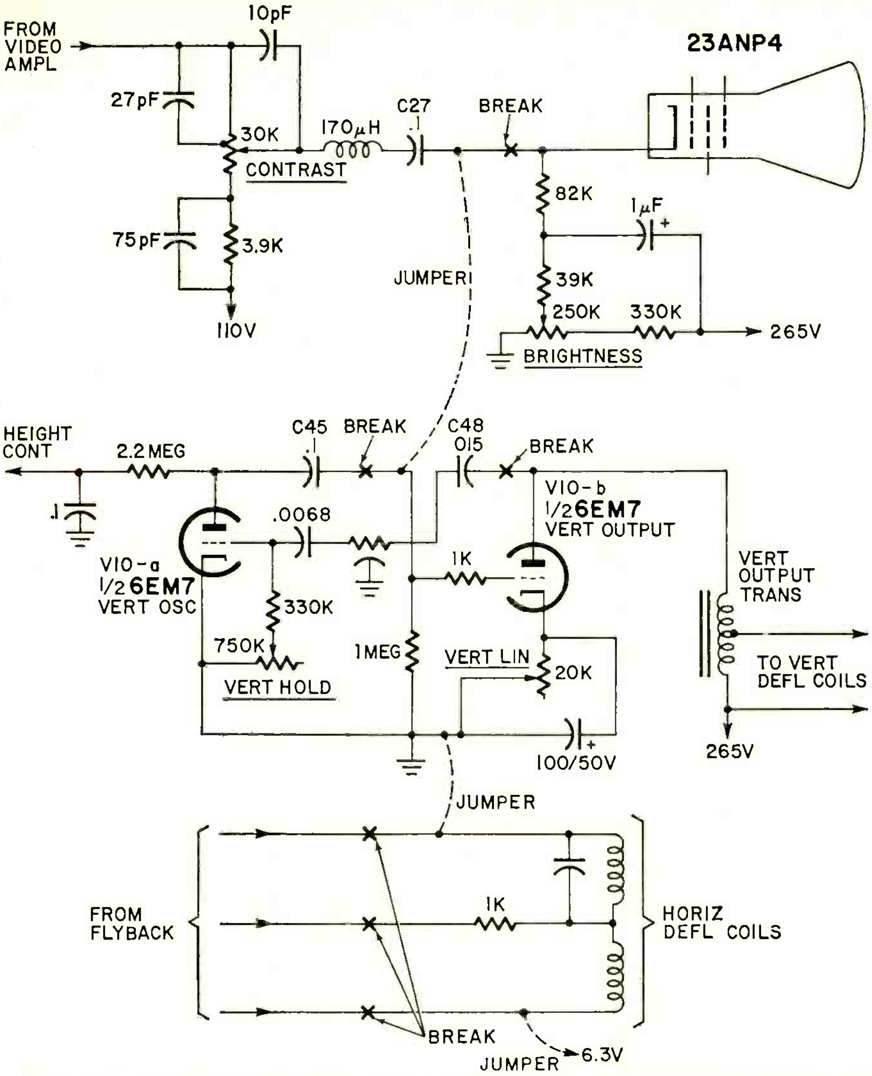


FIG. 2—HOW TO MAKE A TV RECEIVER PLOT ITS OWN RESPONSE CURVE. Detected video signal drives the vertical output while the horizontal deflection comes from 6 volts ac.

At this point Mac said: "Don't you think this is a very low voltage for a horizontal sweep on a 23-inch picture tube?"

"Well, Mac," answered Charlie, "don't forget that with magnetic deflection it's not the voltage that counts but the current. Also remember that at 60 Hz the inductance of the yoke winding isn't important, it's the current limiting factor—about 22 ohms resistance—which is. If we make a very rough calculation we have to take the peak-to-peak voltage of 6.3 volts, which is approximately 17.5 volts, and divide it by the ohmic resistance. This give us almost 0.8 amps, plenty of sweep current for a horizontal deflection coil."

"You're right, Charlie, and that means we should see a horizontal line on the screen if we don't apply any other signal."

"Correct, Mac," was the reply. "Let's try it out."

They connected the receiver and soon had the horizontal line. They turned down the brightness control to avoid burning the screen.

Charlie connected his TV sweep generator output cable to the i.f. input of the tuner and after a few turns of the sweep generator controls (frequency, amplitude, sweep width and phase) the response curve of the receiver appeared on its own screen.

When the alignment job was finished, Charlie said, "Now Mac, put all the connections back and let's do the final touchup."

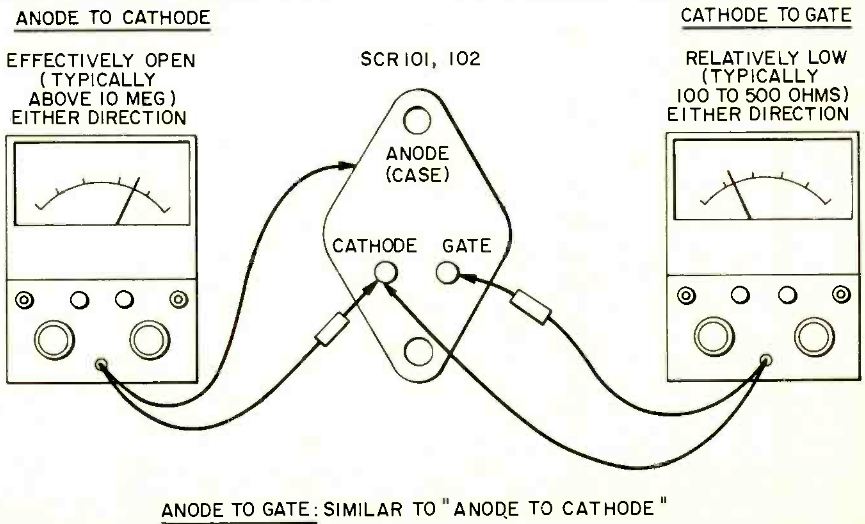
"Charlie, this scopeless alignment method saved us quite a bit of trouble. Don't you think other people in the trade could be interested? **R-E**

Ohmmeter Checks SCRs

The SCR sweep system has proven to be quite reliable. However, when failures do occur many technicians are at a loss as to how to check silicon controlled rectifiers. Several elaborate methods of testing SCR's have been devised. However, the following is adequate for television servicing.

If the sweep circuit troubleshooting procedure indicates the possibility of a defective SCR, substitution with a known good device is the best test method. If a known good SCR is not available, an ohmmeter check will give a reasonable evaluation of the device. This is true since generally speaking, a good SCR in the *off* state will block current flow and show a high resistance anode-to-cathode reading and, when test leads are reversed, a high cathode-anode resistance. A shorted device will not block current and shows low resistance readings anode to cathode, either direction. Gating problems, as far as the device itself is concerned, are practically nil in this type SCR.

The drawing shows the test setups and the normal ohmmeter readings between elements.—RCA Tips



Build a SONIC CLEANER

Get small parts bright and clean with a little detergent and this easy-to-build sonic cleaner. It's a one-evening job

by HAROLD PALLATZ

THIS EASILY BUILT SONIC CLEANER scrubs small parts clean and bright. It operates on the same basis as the ultrasonic cleaners used in industrial and government laboratories. Essentially, a solution (such as water and a detergent) is made to vibrate or move in short high-speed strokes, resulting in a scrubbing action. This action penetrates the smallest crevices and otherwise inaccessible areas.

The heart of our sonic cleaner is an Ashworth sound reproducer. This is a special type of speaker that has a metal disk in place of a speaker cone. By attaching the disk center to a wall or side of a car, it turns the whole area into a speaker. It is powered by any radio, phonograph or audio amplifier. It can normally handle 35 watts without noticeable distortion. You can apply as much as 75 watts, if you don't care what the music sounds like.

Construction

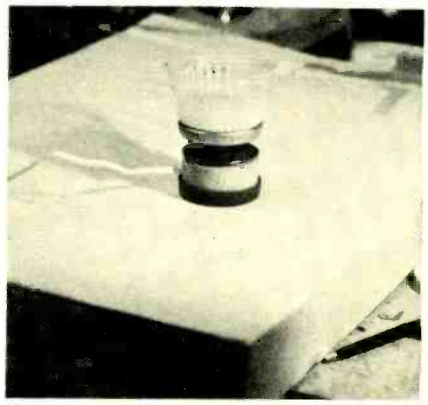
A piece of ½" to 1" dowel is carefully screwed onto the center welded wood screw of the reproducer. Drill a small hole (No. 30 drill size) in the dowel first and grasp the sides of the disk to prevent ripping it loose from its rubber mounts. The dowel need only be ½" long. Cement a metal bottle cap to the top of the dowel. (Our cap was 2¼" diameter with ¼" sides). A light-weight plastic cup (bottom is 2" diameter) holds 2 ounces of cleaning solution, and is simply placed on the cap. If large amounts of power are applied, you will have to glue the plastic cup onto the cap to keep it from falling off while cleaning.

Operation

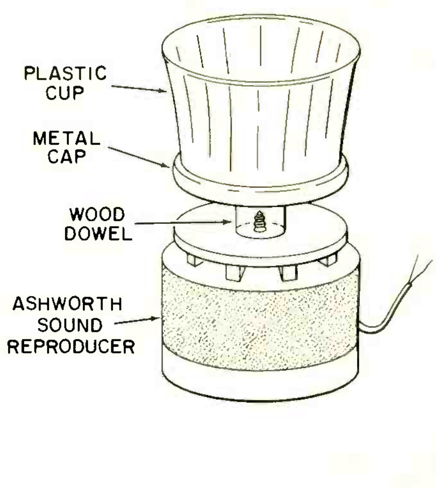
With the reproducer attached in place of the loudspeaker (it matches 4, 8 or 16 ohms) to an audio amplifier output, feed the input of the amplifier with signals from records, tape, radio or better yet a audio oscillator. You will notice the plastic cup will move with the signal. Add cleaning solution (you can use soap and water for a start) and the small parts to be cleaned. The size, weight and type of dirt will determine the amount of time necessary to complete the cleaning.

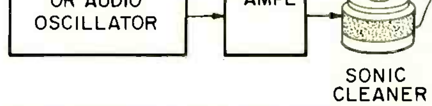
I used an audio oscillator and it was interesting to watch the wave patterns on the surface of the solution vary as the frequency was changed. For maximum effect the highest frequencies should be used. Commercial cleaners, which are very much more efficient, operate at some 90 kHz (90,000 cycles). The higher the frequency the better the scrubbing action. However, our reproducer efficiency falls off rapidly beyond the audio range. So do not expect the same efficient operation as the more complex ultrasonic models.

Parts that will rust or corrode require cleaning solutions other than water. Dry cleaning fluid will work. Xylol and Freon are also useful. Don't put your fingers into the solution while the high power is on. Doctors report that some dangers may exist. This, of course, would be much reduced with our sonic cleaner (compared to the effects with ultrasonic cleaners), but take the precaution anyway. **R-E**



COMPLETED SONIC CLEANER should look like the one in the photo.





A SONIC CLEANER is easy to build. This diagram contains complete construction details and should be followed closely.

PARTS LIST

- Ashworth Sound Reproducer, (Available from Ashworth Foundry Div., Reliance Electric Mfg. Co., P.O. Box 841, New Albany, Miss., 38652, $9.95)
- Dowel, approx. ½" long x ½" diameter
- Metal Bottle Cap, approx. 2¼" diameter with ¼" sides
- Plastic Cup, (can be drinking cup or cookie cup)
- Glue, Duco, Elmer's or Ambroid

Radio Operated Fire Alarm System

How electronics speeds fire alarms to the station house

by BURTON BERNARD

The first municipal fire alarm system was put into operation in Boston in 1852. Its 45 hand-cranked street alarm boxes were interconnected by telegraph cable. For the next 114 years, every municipal fire alarm system required overhead or buried cables to transmit the alarm signal.

Today, many municipal fire alarm systems are wireless. New, radio-operated, fire alarm call-boxes are replacing the older, telegraph or telephone type, cable systems. Each new call-box is a completely self-contained radio transmitter eliminating the need for costly or breakable transmission and power cables.

In 1966, Fire District number 11 of King County, Washington installed the first wireless fire alarm system in the United States. Now, practically every new fire alarm system being installed, or planned, is wireless because of economics, simplicity of operation and ease of expansion.

A typical radio fire alarm system consists of a fire alarm communications center (Fig. 1) and strategically located fire alarm call-boxes. Large cities may have, in addition, substation call-boxes and retransmission equipment.

Each radio fire alarm system must be FCC approved. Public Safety frequencies are available in the 72–76, 150- and 450-Mhz bands. All present operating radio fire alarm systems operate at, or near, 72 Mhz. Power output is limited to one watt.

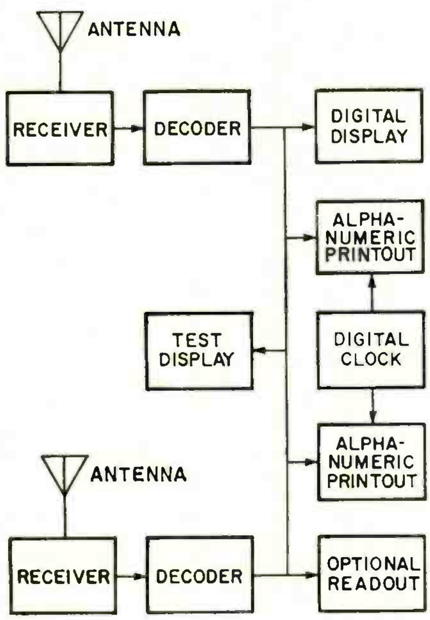


Fig. 1—FIRE-ALARM communications center is shown in this basic schematic. Note that a back-up receiver is included.

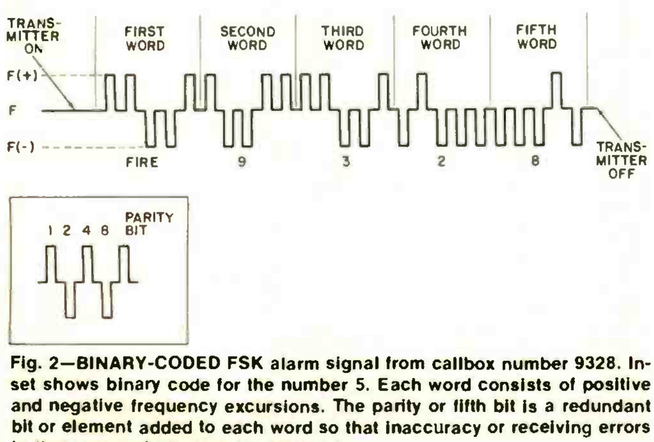


Fig. 2—BINARY-CODED FSK alarm signal from callbox number 9328. Inset shows binary code for the number 5. Each word consists of positive and negative frequency excursions. The parity or fifth bit is a redundant bit or element added to each word so that inaccuracy or receiving errors in that group of bits can be detected.

To operate one of the new call-boxes, the user simply presses a conveniently located button. Some call-boxes require that a piece of glass be broken to gain access to the button. Once the button is pressed, an emergency signal is transmitted to the alarm communications center and immediately informs the dispatcher of the problem and location.

The transmitted signal is pulse coded by frequency-shift-keying (FSK), a form of frequency modulation that is relatively free from static and other forms of interference. Each transmission (or round) consists of a series of binary 'words' (Fig. 2). Each 'word' contains five pulses (or bits). The first four pulses make up the 'word' and the last pulse is used as a parity bit for verification at the receiver.

The first 'word' identifies the type of message being sent (ie; fire, test, etc.): the next 3 or 4 'words' identify the location of the call-box. Each transmission (round) lasts about one second. All fire signals are automatically transmitted three times (three rounds).

A mercury switch inside the call-box is used as a TAMPER/KNOCKDOWN switch. It is activated whenever the call-box is tilted more than five degrees.

Each call-box contains a rechargable battery that operates, without charging, for at least six months. Some systems use solar-cells to trickle-charge the batteries during daylight hours, eliminating the need for battery replacement every six months.

All radio fire alarm call-boxes test themselves at least once a day. The call-box is automatically triggered by a battery-operated clock and sends a test signal to the alarm communications center. A special readout at the communications center displays and stores each test signal so that the dispatcher can tell at a glance if any of the call-boxes have failed during the past 24 hours.

Battery voltage is measured every time the call-box transmits a signal. If the battery voltage falls below 85% of its rated value (usually 12 volts), a special pulse is transmitted with the normal signal to advise the alarm communications center of a weak battery. Weak batteries must continue to operate for at least 15 days before replacement is absolutely necessary, according to the *National Fire Prevention Association Standards for Municipal Fire Alarm Systems.*

Inside the call boxes

The radio call-boxes are all solid state and designed to operate for at least 25 years. Each call-box requires its own non-directional antenna and transmits its signal for about 25 miles.

The receiver at the alarm communications center contains a decoder unit to check and verify every signal received at the call-box frequency. The signal is stored until the decoder is satisfied that the signal received contained the proper number of binary 'words' and that each 'word' contained the correct number of pulses as verified by the parity bit. Only upon proper verification will the decoder release its information to the digital display and paper printout. Signal verification takes less than one second.

An alpha-numeric recorder prints every message received with date, time, location and nature of call. Two complete message receiving systems (Fig. 1) usually operate simultaneously to increase system reliability.

Up to 1,000 different call-boxes may be identified with a three-digit identification system (10,000 for a four-digit system). In addition, up to 16 different messages may be identified including POLICE and AMBULANCE as well as FIRE, TEST and TAMPER/KNOCKDOWN. Local, or remote, alarms such as building fire alarm systems, sprinkler systems and smoke or heat detectors may also be transmitted through the radio call-boxes.

Call-box frequencies can be coordinated to eliminate any possibility of interference from neighboring communities. Nearby fire districts using the same frequency may code their call-box identification numbers to correspond to their own community. A four-digit identification system may have ten fire districts using 1,000 call-boxes each without any duplication of identification number.

One feature about the radio call-box is that if any box should fail, it has no affect on the balance of the system. Also, since no cables or external power is required, radio call-boxes may be installed anywhere within the fire district. Additional radio call-boxes may be added at anytime without addition or modification to the alarm communications center receiving equipment. **R-E**

STEREO

how to design your own solid-state audio amplifier

How to design a practical class-A audio amplifier

by MANNIE HOROWITZ*

Our task is to design an audio amplifier capable of delivering 5 watts to a 3.2-ohm loudspeaker load. The design will be based on material presented in previous articles. The transistor available is the 2N3055. Use it. Outline a step by step procedure.

1. Draw a workable circuit. In order to keep the dc current out of the speaker winding, an output transformer should be used. For improved thermal stability use a resistor in the emitter to provide dc feedback. If desired, bypass it with a capacitor to prevent ac degeneration and the reduction of power reaching the loudspeaker. A valid circuit arrangement is shown in Fig. 1.

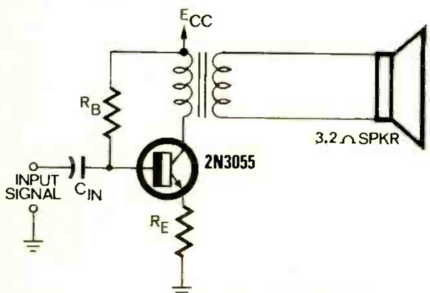


FIG. 1—CLASS-A POWER AMPLIFIER. Constants for this simple, but practical circuit are calculated in the text.

2. Determine the actual power the amplifier must deliver. Although 5 watts is desired at the speaker, the 2N3055 must deliver more than this due to losses in the output transformer. Assuming 75% transformer efficiency, the power available from the 2N3055 across the primary of the transformer must be at least 5/0.75 = 6.66 watts.

3. Choose V_{CEA}, the voltage at which the ac load line crosses the horizontal axis. (See Fig. 9 in the previous installment.) The maximum voltage that may safely be applied between the collector and emitter of a transistor varies with the size of resistor placed between the base and emitter. Breakdown voltages are specified on data sheets for different resistor values. There is no resistor used in the circuit in Fig. 1. Then the BV_{CEO} rating applies. BV_{CEO} is the voltage that may be applied between the collector and emitter of the transistor without destroying the device, when there is no resistor between the base and emitter. BV_{CEO} is the breakdown voltage when the current flowing through the device is very small. As the collector current increases, the BV_{CEO} breakdown voltage is reduced to a more or less constant value, V_{CEO}(sus), referred to as the sustaining voltage. For the 2N3055, V_{CEO} (sus) is 60 volts. V_{CEA} should be equal to or less than 60 volts. Taking various factors into consideration, such as peak voltages due to the primary inductance of the transformer, the possibility of getting transistors at reduced prices when BV_{CEO}(sus) is low, the economy of a low-voltage power supply, etc., choose V_{CEA} at 25 volts.

4. Calculate the power the transistor must dissipate. Because it must deliver 6.65 watts, the device must be capable of dissipating at least 2 x 6.66 watts = 13.3 watts. The 2N3055 is capable of dissipating 115 watts at room temperature so this 13.3 watts should be no problem. In fact, add 25% to the required dissipation capability to accommodate limitation of current and voltage swings on the load line as well as signal power losses across the emitter resistor. The required dissipation capability should be 13.3 + .25 (13.3) = 16.6 watts.

5. Determine points on the P_{CEM} parabola and draw a line from V_{CEA} = 25 volts to the I_C axis touching the parabola at one point. Several points on the parabola are

at V_{CE} = 25 volts, I_C = 16.6 watts/25 volts = 0.66 amperes
at V_{CE} = 20 volts, I_C = 16.6 watts/20 volts = 0.83 amperes
at V_{CE} = 15 volts, I_C = 16.6 watts/15 volts = 1.11 amperes
at V_{CE} = 10 volts, I_C = 16.6 watts/10 volts = 1.66 amperes
at V_{CE} = 5 volts, I_C = 16.6 watts/5 volts = 3.32 amperes
at V_{CE} = 2 volts, I_C = 16.6 watts/2 volts = 8.3 amperes

Draw the parabola using the data just calculated. See Fig. 2. Starting from the

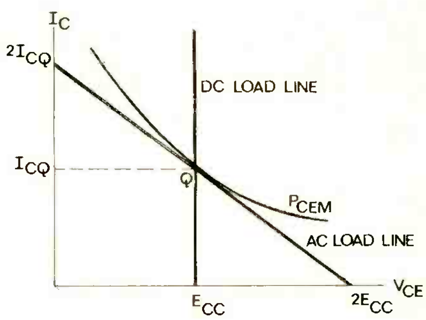


FIG. 2—LOAD LINES and power-limiting curve for the amplifier we are designing.

selected V_{CEA} = 25 volt on the V_{CE} axis, draw an ac load line tangent to the parabola at $V_{CEA}/2$ = 12.5 volts and I_{CQ} = 16.6 watts/12.5 volts = 1.33 amperes. It will intersect the I_C current axis at $2I_{CQ}$ = 2.66 amperes. The dc load line will also intersect the P_{CEM} curve at Q.

6. In Fig. 1, the voltage across R_E should be between 0.5 and 1 volt. As the quiescent current has been chosen at 1.33 amperes, R_E may assume any value between 0.5 volts/1.33 amperes = 0.375 ohms and 1 volt/1.33 amperes = 0.75 ohms. Choose a relatively "standard" 0.56 ohm 10% resistor. The power the resistor must be capable of dissipating is $I_{CQ}^2 R_E = (1.33)^2(0.56) = 1$ watt. Use a 2 watt component for safety reasons.

7. The ac resistance seen by the transistor is equal to the reciprocal of the slope of the ac load line, or $V_{CEA}/2I_{CQ}$ = 25/2.66 = 9.4 ohms.

*Chief Project Engineer EICO Electronic Instrument Co. Inc.

8. The dc load line is determined by the supply voltage E_{CC}, the dc resistor in the emitter circuit, and the resistance of the primary winding of the output transformer. We know that R_E is 0.56 ohms. Choose a transformer so that the sum of R_E and the resistance in the transformer winding will be small—let us say about 1.5 ohms. The slope of the reciprocal of the dc load line is equal to this resistance, so that $1.5 = (E_{CC} - V_{CQ})/I_{CQ} = (E_{CC} - 12.5)/1.33$ (for V_{CQ}, when set at the center of the load line in this problem, is equal to $V_{CEA}/2$). E_{CC} must then be 14.5 volts. Plot this point on the V_{CE} axis. Draw a line connecting the 14.5 volt point on the horizontal axis with Q on the ac load line. This is the dc load line.

9. The total ac resistance in the collector circuit is equal to the sum of the primary resistance of the transformer (1.5 ohms–0.56 ohms = 0.94 ohms), the 0.56 ohm resistor in the emitter, and the resistance R_L' reflected from the secondary into the primary winding due to the 3.2 ohm speaker in the secondary. If the resistance of the secondary winding is not small compared to the 3.2-ohm load, R_L' is due to the reflection of the sum of the speaker resistance plus the resistance of the secondary winding. In step 7, it was determined that the total ac resistance the transistor must see is 9.4 ohms. Thus the reflected resistance into the primary of the transformer is 9.4 ohms–0.56 ohms–0.94 ohms = 7.9 ohms.

10. The impedance ratio of the transformer is 7.9 ohms:3.2 ohms. As this is equal to the square of the turns ratio, of $7.9/3.2 = (N_P/N_S)^2$ where N_P is the number of turns in the primary winding and N_S is the number of turns in the secondary, the turns ratio from the primary to the secondary must be about 1.6:1.

11. Check if sufficient power can be delivered to the load. The transistor characteristics set limits to the possible output current and voltage swings. At the one end, the saturation voltage of the transformer is stated at 1.1 volt at 4 amperes. Since our maximum current is 2.66 amperes, the saturation voltage is somewhat less. Let us assume that the minimum voltage across the transistor due to saturation is 0.75 volts. Let us also assume a 1 volt loss in swing at the other end of the load line due to leakage current limits. Thus, the signal voltage swing is limited to 25–0.75–1 = 23.25 volts. The power the transistor can deliver is $(23.25 \text{ volts})^2/8(9.4) = 7.2$ watts.

The ac power developed across the emitter resistor is $(2I_{CQ})^2 R_E/8 = (2.66)^2(0.56/8 = 0.5$ watts.

The total power left to be across the output transformer is 7.2–0.5 = 6.7 watts. If the transformer is 75% efficient, the power reaching the load is 0.75(6.7) = 5 watts.

12. The emitter resistance is 0.56 ohms. When reflected into the base circuit, it appears as a dc resistor equal to the beta of the transistor multiplied by R_E. The dc beta curve, reproduced in Fig. 3, shows the average beta is about

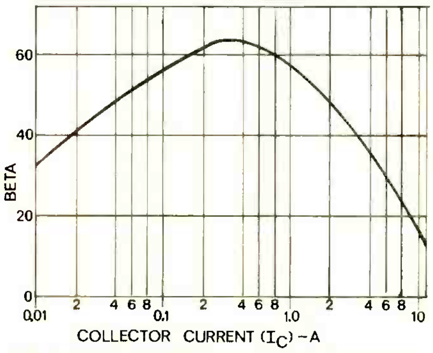


FIG. 3—BETA CURVE shows how dc beta varies with collector current when V_{CE} is 4 volts.

50 when $I_{CQ} = 1.33$ amperes. Thus the resistance at the input is 0.56 x 50 = 28 ohm.

13. The quiescent base current, I_B must be $I_{CQ}/\beta = 1.33A/50 = 0.027$ amperes.

14. Using the data from steps 12 and 13, we can calculate R_B, for $E_{CC} = I_B(R_B + \beta R_E) = 12.5 = 0.027(R_B = 28$ ohms). R_B is equal to 435 ohms. Use the standard 470 ohm resistor. The power dissipated by R_B is $I_B^2 R_B = (0.027)^2(470) = 0.34$ watts. A ½ watt resistor can be used here although a 1-watt component is more desirable.

15. The ac resistance reflected into the base circuit from the emitter circuit is $\beta(R_E + r_e)$, where r_e is the ac emitter resistance of the transistor. In step 12, the dc emitter resistance was ignored, for it is negligible. However, the ac emitter resistance was specified as equal to $26/I_Q$ in a previous article, where I_Q is expressed in milliamperes. In this problem, r_e will be very small if calculated from the formula. In reality, it is seldom less than 1 ohm. We will assume it to be 1 ohm.

The ac emitter resistance reflected into the base circuit is then 50(0.56 + 1) = 78 ohms. (It is assumed that the ac beta is equal to the dc beta).

The input impedance is essentially this 78 ohms in parallel with the 470 ohm resistor calculated in step 14, or 67 ohms. If this amplifier is designed to have a good frequency response down to 20 Hz, C_{IN} must be at least equal to 1/6.28(67) (20) = 120 μF. This assumes that the input signal has zero impedance. Calculations of this type will be elaborated upon under the topic of audio filters in a future article.

DISTORTION

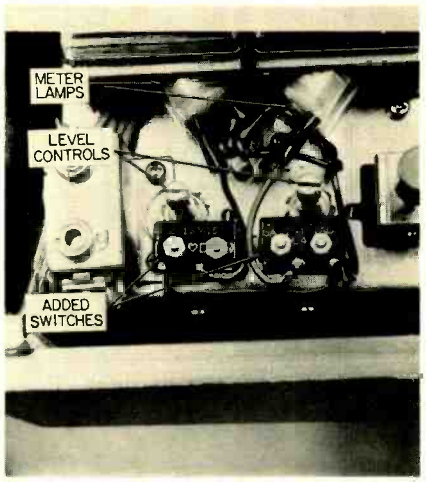
In the problem, the transistor will deliver 5 watts only if the collector current and voltage will swing over its maximum capabilities. Because of nonlinearity of the collector characteristics, it is most desirable to limit the swing to the minimum. This is especially true near the saturation voltage lines as well as near the I_{CEO} curve where $I_B = 0$. A good rule of thumb is to make the minimum collector voltage equal to three times the saturation voltage. Subtract another 2 volts due to the leakage current.

The above solution to the problem is marginal. In the laboratory, it will probably be found that more power output capability is necessary and improved circuit efficiency measures should be considered. Some of these measures can be to bypass the 0.56 ohm emitter resistor with a large capacitor, to use a more efficient output transformer, to increase E_{CC}, etc. These considerations are important here, as well as in the next article dealing with class B and class AB power amplifiers.

This concludes the discussion on class-A power amplifier fundamentals. But, before going on to class-AB and B amplifiers, we are going to design a practical class-A power amplifier. Watch for it in the next installment. **R-E**

SONY 350 RECORDER

In this recorder, both VU meters light up whenever the RECORD button is pushed. This occurs even though one or both RECORD LEVEL controls is turned all the way off. Needless to say, this is very confusing, especially when making a monaural recording.



ADD TWO SWITCHES as shown in photo to Sony 350 tape recorder to prevent both VU meters from lighting when making a monaural recording.

One way to correct the problem is to mount a pair of subminiature snapaction switches on a small metal bracket near the RECORD LEVEL controls, as shown in the photo. Adjust each switch so its plunger rests in a flat spot filed on the shaft when the control is rotated fully counterclockwise. Connect the common and normally open contacts in series with each VU meter lamp so that it illuminates only when its respective RECORD LEVEL control is rotated away from the off position.—*Donald R. Hicke*

Inside linear ICs

practical applications of transistor arrays

Here are two IC amplifiers you can build with a CA3018. See how you can build on these ideas.

by WALTER G. JUNG

The biasing techniques used with monolithic transistors is unique, but at the same time, simplicity itself. To see just what we mean by this, take a look at Fig. 1. We know that our matched IC transistors will have very close current gains and V_{be}'s within a millivolt for the same collector currents. These factors are used in Fig. 1 to predictably bias transistor Q2 at the same current as Q1. You can analyze the operation as follows.

The current (I_1) in R1 is composed of 3 components; the bulk of it is I_{C1}, and the other 2 components are I_{B1} and I_{B2}. Since these two transistors have current gains of 100, I_{C1} is the dominant current in R1 as both I_{B1} and I_{B2} are 1/100 of its value. It is therefore reasonable that we call these two components negligible and call $I_1 = I_{C1}$.

Q1 and Q2 are identical due to their matched monolithic characteristics. Since they receive the same base voltage (the voltage developed across Q1) the current in both transistors will be the same. This holds true within 5% if the currrent gains of the transistors are 40 or greater (which is true for all the array transistors).

Now note also that if the V_{be} of Q1 is *small* with respect to supply voltage V_{cc} the current I_1 will be almost solely determined by R1. This makes the current relatively independent of temperature variations in Q1's V_{be} with typical supply voltages of 10 volts or more.

So we can set the current in Q1 and Q2 by selecting a single resistor, R1. Since the current in R2 is the same as R1, making R2 one half the value of R1 will cause it to drop one half the voltage. And since R1 drops nearly the full supply voltages, R2 will drop one half of this, or ½ V_{cc}. The unique thing is that E_o will be equal to ½ V_{cc} for all values of V_{cc}! This automatically biases E_o for maximum voltage swing, and this is determined by the *ratio* of R2 to R1, not their absolute values.

You can make an ultra simple amplifier out of this matched transistor combination simply by modulating the bias applied to Q2. This can be done in two ways, transformer coupling (Fig. 2) or direct current addition as in Fig. 3.

The transformer method offers very high voltage gain (46 dB with values shown) and maximum simplicity. This little circuit as shown could make a general-purpose low-level audio amplifier with a minimum of parts. Use a transformer with a secondary dc resistance of 50 ohms or less (higher dc resistances will upset the current balance between Q1 and Q2). You can even use a step-up transformer and get more gain, as the Z_{in} (input impedance) of the amplifier itself is about 7000 ohms. The output impedance is the collector resistor, or 22,000 ohms so if you want to drive any kind of a load you'll need a buffer stage. This is easily done in the CA3018 by using the Darlington pair (Q3–Q4) to drop the output impedance to 25 ohms. Then with this circuit you could even drive a 70-ohm speaker and make yourself a one-chip intercom!

The transformer-coupled circuit

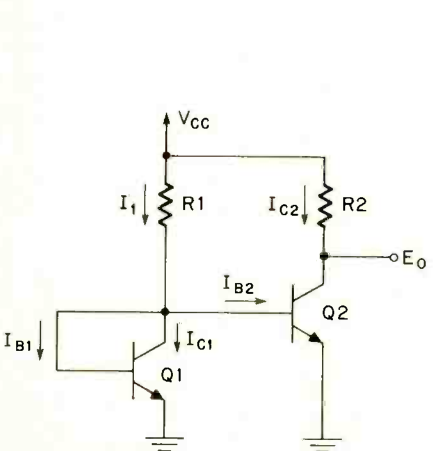


FIG. 1—A BIASING TECHNIQUE using matched monolithic transistors. When R1 is twice R2, output voltage E_o is half V_{CC} for all supply voltage levels.

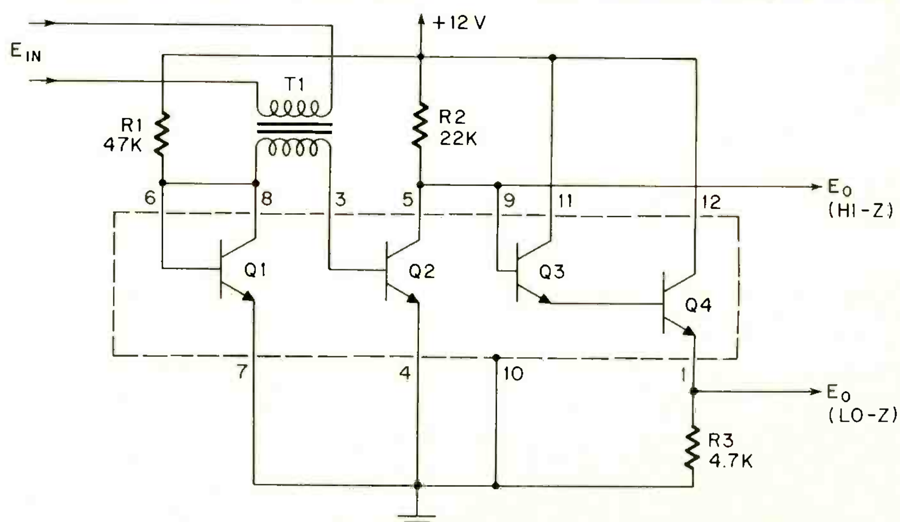


FIG. 2—MATCHED TRANSISTORS in a transformer-coupled amplifier. Pin numbers shown are for the CA3018; T1 is an audio line-to-line or step-up transformer.

TABLE I: Monolithic IC Transistor Array Specifications

Specification and Condition(s)	RCA CA3018 Min	typ	max	RCA CA3018A Min	typ	max	RCA CA3045*/CA3046 Min	typ	max	RCA CA3086 Min	typ	max	SILICONIX SI3045AK Min	typ	max	SILICON GENERAL SG3821 Min	typ	max
BV_{CEO}: $I_C = 1mA$ unit: volts	15	24		15	24		15	24		15	24		15	24		25^1	30^1	
BV_{CBO}: $I_C = 10\mu A$ unit: volts	20	60		30	60		20	60		20	60		20	60		40	60	
BV_{EBO}: $I_E = 10\mu A$ unit: volts	5	7		5	7		5	7		5	7		5	7		5	6.2	
$V_{CE(SAT)}$: $I_C = 10mA$, $I_B = 1mA$ unit: volts		0.23	—		0.23	0.5		0.23	—		0.23	—		0.23			0.5	—
h_{FE} @ $V_{CE} = 3v, I_C$ 10mA	—	100	—	50	100		—	100	—	—	100	—	—	100	—		80^2	
1mA	30	100	—	60	100		40	100	—	40	100	—	40	100	—	50^2	100^2	400^2
10µA	—	54	—	30	54		—	54	—	—	54	—	—	54	—		80^2	
$\|V_{BE1}-V_{BE2}\|$ @ $V_{CE} = 3v$, $I_C = 1mA$ unit: millivolts		0.48	5		0.48	2		0.45	5	—	—	—		0.45	5		0.5^2	5^2
$\frac{\|V_{BE1}-V_{BE2}\|}{\Delta T}$ @ $V_{CE} = 3v$, $I_C = 1mA$ unit: µV/°c	—	10	—	—	10	—	—	1.1	—	—	—	—	—	1.1	—	—	—	—
$\|I_{B1}-I_{B2}\|$ @ $V_{CE} = 3v$, $I_C = 1mA$ unit: µA		—	—		—	—		0.3	2	—	—	—		0.3	2		0.4^2	4^2
$\frac{h_{FE1}}{h_{FE2}}$ @ $\frac{V_{CE} = 3v}{I_C = 1mA}$	.9	.97		.9	.97		See figure 4			—	—	—	—	—	—	—	—	—
f_T @ $V_{CE} = 3v$, $I_C = 3mA$ unit MHz	300	500		300	500		300	550			550		300	550			950^3	

*CA3045 —55 to 125°c, CA3046 for 0 to 85°c. [1]@ $I_C = 100\mu A$ [2]@ $V_{CE} = 5v$ [3]@$V_{CE} = 5v$, $I_C = 3mA$

does not offer low distortion (although tolerable at a low level) because, in this case, Q2 is driven in a G_m mode (voltage in, current out) which is not the best from a distortion standpoint. But is a quick and dirty way to get maximum gain in a single stage.

If you want to clean up the linearity, try the current-modulation scheme of Figure 3. This method sums in an ac current through R_{in} with the dc bias in Q1, and in so doing modulates the base voltage applied to Q2. Q1 automatically develops a base voltage for Q2 proportional to this modulation current. And, since Q2 is matched it develops a corresponding current in its collector circuit. In this manner the input signal current is transferred to the output of Q2. This circuit inherently has current gain of *one*, so you cannot get out more current than you put in. But you can get current gain through the Q3–Q4 Darlington pair, and you get voltage gain proportional to the ratio of R2 to R_{in}. Since Q1 is a low-impedance summing junction, you can mix 2 or more inputs with very low cross coupling. This circuit works best if the input current is small in relation to the bias current in Q1. The dc blocking capacitors C1 and C2 should be chosen to be equal in reactance to R_{in} at the desired low-frequency 3-db point, as the input impedance is essentially the value of R_{in}.

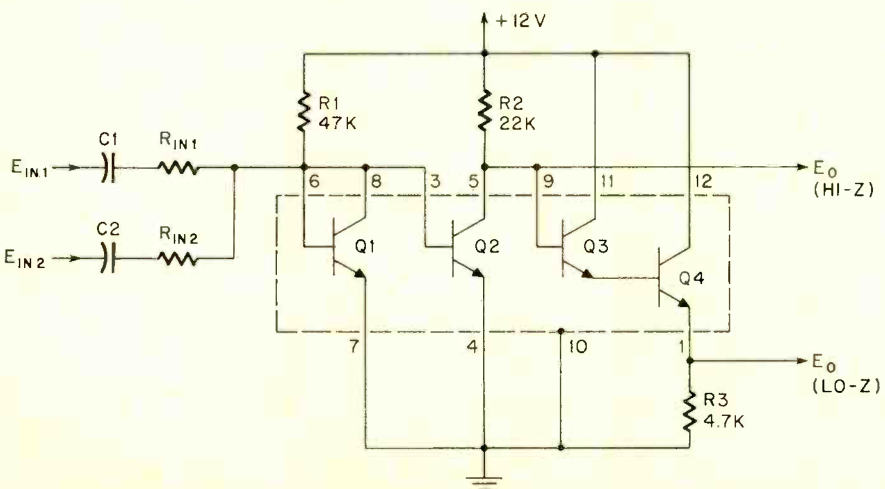


FIG. 3—DIRECT COUPLING in af amplifier using transistor array. Voltage gain is approximately $R2/R_{in}$. Input impedance approximates R_{in} when R_{in} is much greater than the input (diode) impedance of Q1. With values shown, Z_o1 is about 100 ohms.

These two simple amplifier ideas are examples of what can be done with the most basic of IC biasing. Used to advantage, array transistors can do some very interesting things. Next month we'll go further into biasing techniques based on this fundamental idea and see how it can be developed into a variety of useful circuits—all using these same IC arrays in a multiplicity of hookups. **R-E**

WINDSHIELD WIPER PAUSE CONTROL

Most versions of this popular device won't work in late-model cars. Here is one that will.

by PAUL SCHULTZ

MANY ARTICLES HAVE BEEN PUBlished on building and using automobile windshield wiper "variable rate" or "pause" controllers. These devices provide a way to activate an automobile windshield wiper automatically at a predetermined rate to avoid excessive "dry" wiping of the windshield during periods of light drizzle and snow or occasional misting or spatter from adjacent traffic. This eliminates the necessity of turning the wipers on and off every few seconds to avoid irritating wiper scrape and possible windshield scratches. Some new cars offer this as a built-in option.

The majority of these units use a unijunction transistor oscillator to trigger an SCR with timed pulses, which turn on the windshield wiper for one complete cycle and then repeats again at a rate set by the operator.

A typical circuit is shown in Fig 1. This arrangement is simple, efficient and does the job well; but does not work for all cars. This circuit will not work on many late-model General Motors (GM) that use self-reversing motors to park the wiper blades in a recessed or depressed position. This happens because the type of controller in Fig. 1 is turned off by the short-circuit which appears across the SCR after the windshield wiper motor has been activated and the wiper cam-driven switch has "taken over" control of the motor. Remember, the SCR latches on positively and will not turn off unless conduction is stopped in some way. The wiper cam-driven switch does this by shorting out the SCR. Now the SCR is in a nonconducting state until once again activated by the next UJT pulse. The GM type wiper assemblies mentioned above have a combination relay and latching mechanism to control the motor. This type of arrangement will *not* turn off the SCR and when used with the circuit shown in Fig. 1, allows the wiper to run continuously, since the SCR remains latched on.

A new circuit

The circuit to be described was developed to overcome this problem. The basic UJT circuit is retained. However, the medium-current SCR is replaced by two low-current SCR's and a miniature 12-volt relay plus a few minor components. Fig. 2 shows the circuit of the revised controller. To get away from the self-latching action of the original single SCR, two small SCR's are used in a flip-flop arrangement which is triggered by pulses from the UJT. The relay, controlled by SCR2, is driven on by the first pulse, off by the second, and so forth. Thus, the switching cycle of the relay is entirely independent of the wiper cam-driven switch. The pulse rate is determined by R1, R2, R3 & C1. Note that one set of relay contacts is used to switch circuit components to obtain the proper on and off timing intervals.

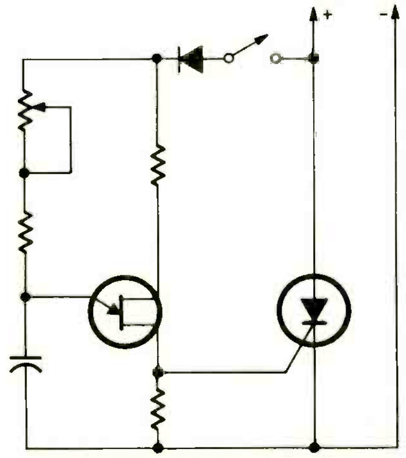


FIG. 1—BASIC WIPER-PAUSE CONTROL. This circuit won't work on many new cars.

The relay switching works as follows: When the unit is turned on by closing switch S1, the wiper motor is immediately activated when the ground circuit through the normally closed contact of the relay is completed. After a short delay, the UJT fires and activates the relay which, in turn, breaks the ground circuit to the wiper. By this time, the latching mechanism of the wiper has taken over and the wiper continues to run until the end of its normal single sweep, at which time it parks the blades and turns off. The relay remains energized, holding open the ground connection to the wiper for a length of time determined by the setting of R3.

Note that R1 is switched into the circuit to determine the length of the "on" interval while the combination of R2 and R3 are switched to provide the variable "off" interval. The value of these resistors was very carefully selected to provide a 1½-second "on" interval and a variable 1 to 30 second "off" interval (time computed after wiper blades are in park position).

The flip-flop action of the two SCR's is made possible by selecting the value of the SCR1 load resistor (R6) in combination with the SCR2 load (relay dc resistance) and C1 so as to create a bistable condition which will not permit SCR1 to latch on properly. Since the UJT pulse is applied to the gates of both SCR's simultaneously, SCR2 is allowed to latch on and off alternately through the combined charge and discharge action of C1 and the bistable loading of SCR1.

In the revised circuit (Fig. 2), the current load of the wiper motor is carried by the relay contacts. Therefore, smaller SCR's can be used. However, it is recommended that the small stud-mount types such as 2N1771A, 2N1772A, TI40A4, etc., be used rather than the miniature T05 types. The stud-mount types are sturdier and will hold up more reliably where there is a possibility of line transients overloading components in the circuit. Heat sinks are not required since current flow and the duty cycle are low. The 12-volt relay should have a contact rating of at least 2 amperes.

A dpst switch is used to control the 12-volt plus and ground supply simultaneously. This is required to provide complete electrical isolation of the unit in view of the peculiar internal wiring of the wiper relay latching assembly. This means that all circuit components which are normally grounded must be insulated from ground with suitable mounts. In my model, all components were mounted on a small phenolic terminal board. C4 is a non-polarized unit. Do not attempt to substitute an electrolytic. However, you can use two 1-μF capacitors connected in series, back to back.

By using miniature components wherever possible, this device will fit into a small metal box or enclosure, permitting installation under your car's instrument panel at a convenient position for the driver. I used a 3½ x 2 x 1½-in. seamless aluminum cover removed from a relay assembly. This provided a neat and sturdy enclosure, although suitable standard boxes would have sufficed. Point-to-point wiring was used. However, printed circuitry can be used instead and a diagram of a circuit board is shown. Further space can be saved by using a standard volume control type switch mounted integrally with R3. However, this will require resetting the pulse rate control each time the unit is switched on unless you use a control with a push-pull switch. A miniature lamp holder with a colored lens provides an on-off indication.

The 12-volt plus terminal should be connected to any convenient tie point that is controlled by the ignition switch. Make a good ground connection to the negative 12-volt terminal. Connect the relay output contact to the wiper unit wire or terminal which activates the motor when grounded. Do this at either the wiper assembly or the wiper switch. If a wiring diagram is not available, the proper terminal can be easily located in just a few minutes by trial and error.

I constructed and installed this controller about one year ago. Performance has been excellent and reliable with no operating problems. Once used, most drivers will wonder how they got along without it. **R-E**

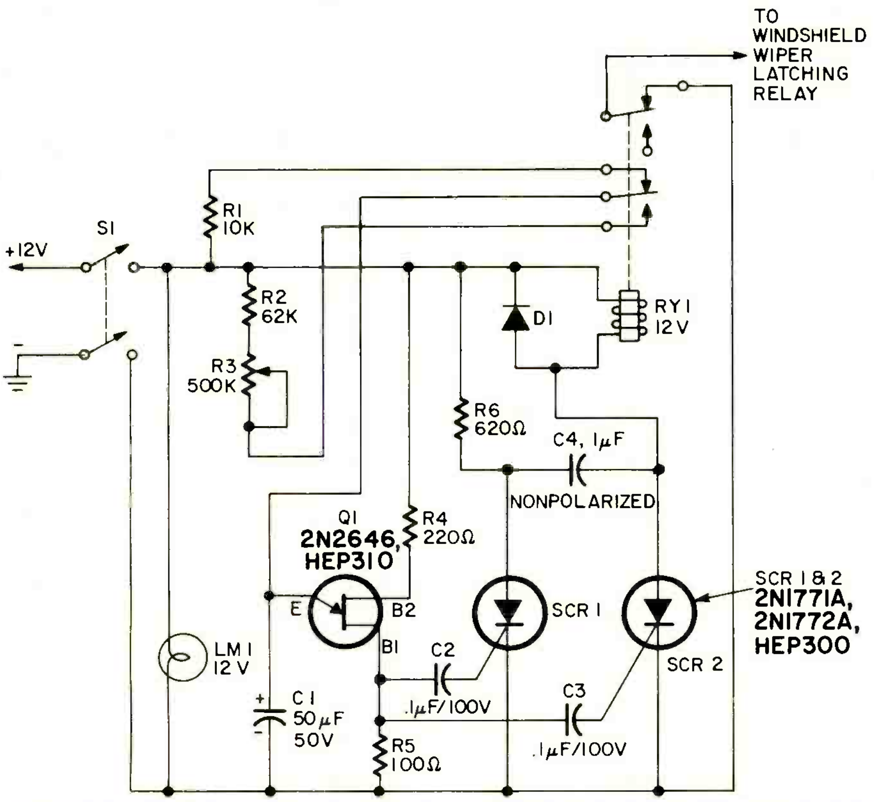


FIG. 2—IMPROVED WINDSHIELD-WIPER PAUSE CONTROL. Its complexity is dictated by the design of the wiper motor and circuitry used in late-model cars. The UJT drives SCR flip-flop.

PARTS LIST

R1—10,000 ohms
R2—62,000 ohms
R3—potentiometer, 500,000 ohms
R4—220 ohms
R5—100 ohms
R6—620 ohms
C1—50 μF, 50 V, electrolytic
C2, C3—0.1 μF
C4—1 μF, non polarized
Q1—2N2646, HEP310 or equal
SCR1, SCR2—2N1771A, 2N1772A, HEP300 or equal
RY1—dpdt, 12 V miniature with 2-amp contacts
S1—dpst toggle (could be push-pull switch on R3)
LM1—12 V miniature panel lamp

All fixed resistors ½-watt, 10% unless otherwise stated

Using Tape Recorders

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.

Maybe a month or so later, you took it out again during a party. Once or twice you tried to use it for dictating letters for the office, but your secretary didn't like transcribing the tape. You put it back in the closet.

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!

Mary had a little what?

At your next party ask each of your guests to write a child's nursery rhyme on a slip of paper. Then invite them one at a time, into another room, out of earshot of the other guests. The first one in reads the first line of his, the next one the second line of his, and so on, until you've finished one rhyme. When you play these back, you get some very startling results! Just make sure that there are no youngsters around, nursery rhymes or not!

Talking cookbook

Next time the lady of the house tries to follow a recipe, suggest that she first read the recipe into a tape recorder. Then all she has to do is play it back and follow the directions. That first reading will give her a good idea of what's going on, and it's a lot easier to follow step-by-step instructions when they're spoken like that. The alternative, trying to juggle an open cookbook makes things an awful lot harder.

". . . and turn left at . . ."

Keep a portable tape recorder handy in the car the next time you have to ask for directions. Record the directions as they're given to you, and you won't have to remember them while you drive. Simply play back as you go.

In the darkroom

Working with a new process or new chemicals in the darkroom? With the lights out, you can hardly refer to the directions, can you? I solve this problem by recording all pertinent information on a portable tape recorder. In the dark, I simply play back what I need to know, as I need it.

Train on this 315 sq. in. picture color TV and get the skills that mean a high-paying career!

Solid-State – the newest development

Count on NTS training to always feature the latest electronic equipment.

Now included in two exciting NTS color TV courses, this set is the largest, most advanced color television made. Guided by the NTS "Lab-Project Method" of combining professional kits and easy-to-follow lessons, you build this color TV step by step – learning TV Servicing as you go! NTS has successfully trained thousands of men at home for rewarding careers as electronics technicians. Prepare for the great opportunity fields of TV-Radio Servicing, Computers, Communications, and Automation.

This solid-state color set contains: 45 transistors, 55 diodes, 2 silicon controlled rectifiers, and 4 advanced Integrated Circuits representing an additional 46 transistors and 21 diodes. The first solid-state color TV this large – yours to keep! It features Automatic Fine Tuning; "Instant On"; an Ultra-Rectangular Screen (25 in. diagonal measurement) that lets you see the complete transmitted image for the first time – a full 315 square inches; exclusive built-in Self Servicing features which eliminate the need to buy costly test equipment; exclusive design Solid-State VHF Tuner with an MOS Field Effect Transistor; 3-stage Solid-State IF; Automatic Chroma Control; Adjustable Noise Limiting and Gate Automatic Gain Control; High Resolution Circuitry; Matrix Picture Tube; and a specially formulated Etched Face Plate that eliminates unwanted glare, and heightens contrast. Colors are more vivid, fresh tones more natural, and the picture is sharper than ever before. By training on this unique color TV, you'll gain the most up-to-date skills possible in TV Servicing!

Other valuable equipment you build and keep includes an AM SW Radio, Solid-State Radio, FET Volt-Ohmmeter, and Electronic-Tube Tester. All included in your tuition. You learn troubleshooting, hi-fi, multiplex systems, stereo, and color TV servicing. Step right into a technician's job at top pay or open a business of your own! For complete details on *all* NTS electronics courses, mail the coupon today for the full-color NTS Catalog. No obligation. No salesman will call.

All About Scanning Monitor Receivers

These receivers feature tuning circuits that seek and lock-in on desired channels. Here is how they work.

by ROBERT F. SCOTT
TECHNICAL EDITOR

THE ROBYN HI-BANDER Model 100 scans 8 channels between 144 and 174 MHz (including 2-meter ham band). Has dual-speed scan and lamp-dimmer switch.

SCANNING-TYPE MONITOR RECEIVERS are the latest development in vhf/uhf FM communications. They are made by several manufacturers and are, basically, receivers that continuously scan or "signal-seek" across a number of crystal-controlled communications channels; stopping and locking in on any active channel and then resuming scanning at the end of the transmission.

Receivers are generally available in 4- and 8-channel models covering the vhf low band (30-50 MHz), vhf high band (144-174 MHz) or the 450-470-MHz uhf band. Some models, the Regency Hi/Lo Monitor Scanners for example, cover any mixture of eight channels in the vhf high and low bands.

Most sets operate from 117 volts ac and 12 volts dc. Front-panel pushbutton switches are usually provided for selecting the channels to be scanned and panel lamps to show the channel being received. A MANUAL switch is used to tune in a particular channel and to disable the scanner circuit.

The channel-select feature enables the operator to listen only to those channels he wants to monitor at a given time. For example, a volunteer fireman may monitor the channels of his local fire company and the companies in adjacent towns while excluding Police, Special Emergency, Public Service and other transmission channels that the receiver is capable of receiving. At other times, he may want to monitor just the base and mobile channels of his local company.

Some sets, like the Sonar Auto-Scan models, include such additional features as "priority channel" and "carrier delay". Priority channel permits the operator to listen to a particular channel to the exclusion of all others, only when a signal is being transmitted on the selected priority channel. (At any given time and in any particular area, there is always one channel that is more important than the others).

Regardless of which channel (other than the priority channel) is being received at a given instant, the receiver samples the priority channel for 40 milliseconds every 2 seconds. If the receiver finds a signal on the priority channel, it locks in on that channel and excludes all others that may be active at the time.

Carrier delay keeps the receiver locked-in to an active channel for a few seconds after a transmission ends so the operator can hear any possible reply.

Some of the scanner circuits are rather elaborate and may have more active components than are used in the rf, i.f. and af circuits in the receiver.

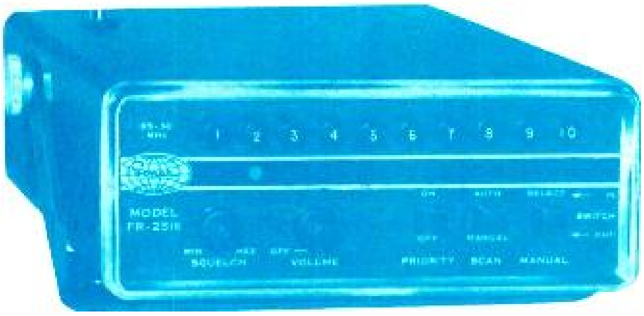
To give you an idea of the workings of automatic scanners, we'll discuss one of the simpler circuits. The schematic shows scanning circuitry in the Regency model TMR-4L Monitoradio covering four channels in the low vhf band.

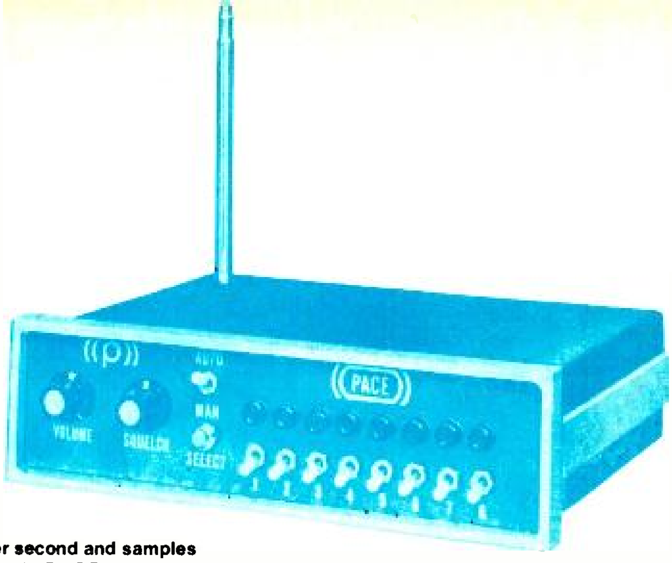
Transistor Q10 is the first local oscillator in a double-conversion superhet circuit. Electronic switching selects the crystals which operate in the third-overtone mode. The oscillator frequency beats with the incoming signal to develop a 10.7-MHz first i.f. at the output of the mixer.

The heart of the scanner is an emitter-coupled multivibrator (Q8 and Q9) operating at about 15 Hz. When the SCAN-MANUAL switch is in the SCAN position the multivibrator is turned on and off by Q7, a squelch-controlled electronic switch.

When no signal is being received the audio is squelched and Q7 is biased to cutoff, allowing operating bias to reach Q8. The multivibrator starts and continues to operate until a signal is received and then cuts off.

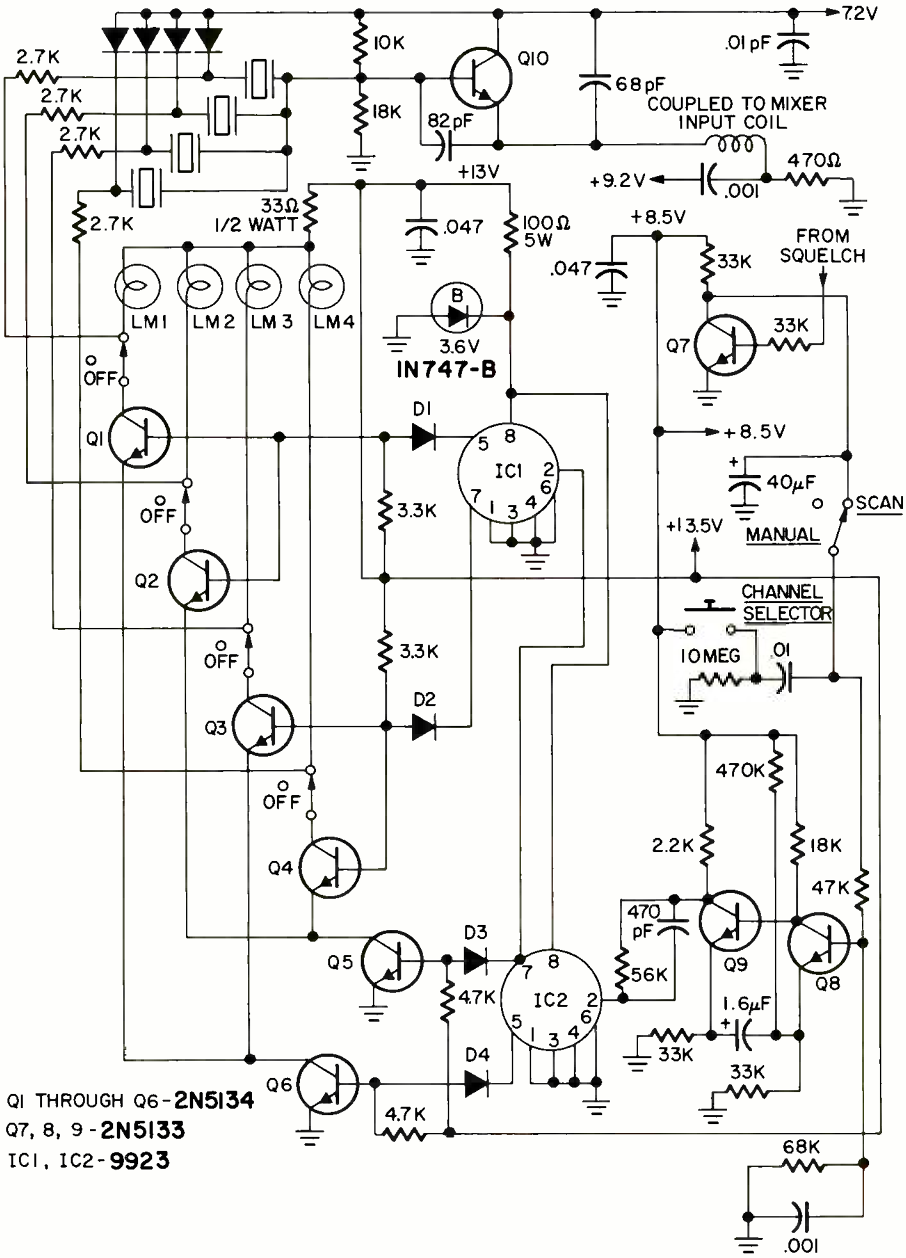
Integrated circuits IC1 and IC2 are J-K flip-flops with outputs taken from pins 5 and 7. When either output terminal is high, the other is low. The states of pins 5 and 7 reverse each time a





SONAR 10-CHANNEL LOW-BAND RECEIVER (above) scans 20 channels per second and samples priority channel every 2 seconds for 40 msec. Manual selection scans slower. PACE SCAN 202-HL (top right) tunes 8 channels between 25 and 512 MHz. The set, by Pathcom, has ceramic filters for good adjacent-channel rejection; 12-volt dc and 117-volt ac supplies. JOHNSON'S DUO-SCAN FM MONITOR (at right) covers 8 channels in 30-50- and 150-174-MHz bands. Receiver is double superhet and operates from 11-16 volts dc and 117 volts ac.

SCANNING CIRCUIT USED IN THE REGENCY TMR-4L MONITORADIO. Scanning in other makes and models is similar. Channels are keyed on in sequence by coupled flip-flops.



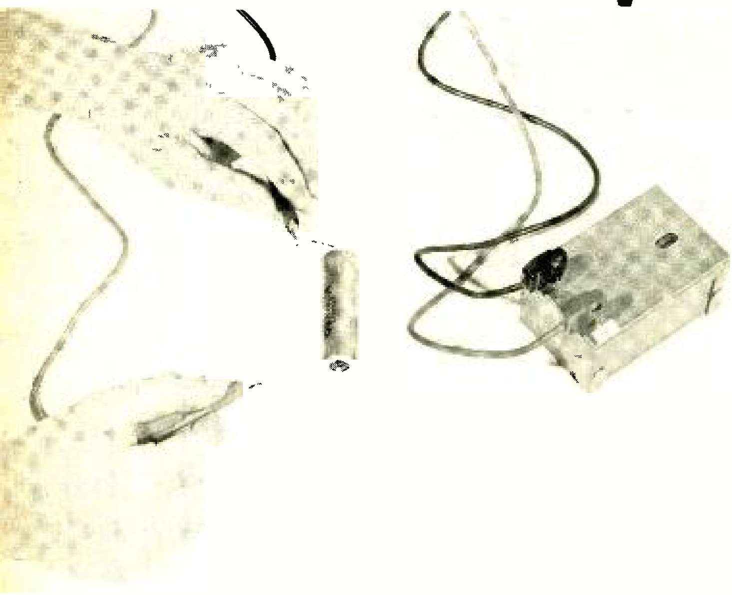
negative-going pulse is applied to the control terminal (pin 2). For example, if we start with pin 5 high and pin 7 low, the first negative-going pulse switches pin 5 low and pin 7 high. The next negative pulse reverses the states again. Note that IC1's control terminal (pin 2) is tied to pin 7 of IC2.

The output pulse from the collector of Q9 is applied to pin 2 of IC2; therefore IC2's outputs switch states at *half* the rate of multivibrator Q8-Q9. The output from pin 5 of IC2 is connected through switching diode D4 to the base of Q6 which is connected in series with Q1 and Q3, the switching or control transistors for channels 1 and 3. Similarly, pin 7 of IC2 is connected through D3 and Q5 to Q2 and Q4, controlling channels 2 and 4.

As we noted, IC1 is toggled by the output from pin 7 of IC2. Output pin 5 of IC1 is connected through switching diode D1 to the bases of Q1 and Q2. Likewise, pin 7 is tied to the bases of Q3 and Q4. Since IC2 operates at *half* the multivibrator frequency and, in turn toggles IC1, the latter operates at *one-fourth* the multivibrator frequency. Thus transistors Q1-Q4 are turned on and off in sequence by the grounding of their emitters through Q5 and Q6 and

(continued on page 75)

Test Capacitors Fast



Capacitor checkers are essential to electronic servicing. This inexpensive, take-along tester spots many defective parts and checks continuity too.

by HENRY LINTON

TESTING CAPACITORS is easy with a simple go-no-go neon-type tester.

This capacitor tester is a rapid aid in isolating troubles in faulty capacitors and is an indispensable tool for the television service technician, ham and hobby enthusiast. There are no complex settings or dial readings to interpret. The tester checks paper, mica, Mylar and electrolytic capacitors in the range of .001 to 100 μF. A good-bad (go/no-go) visual indication of the capacitors' worth is easily observed on a neon lamp.

The circuit (see schematic) is quite simple and the completed instrument is small enough to be carried in your jacket pocket or tube caddy and weighs approximately 7 ounces. It costs less than $5.00 to construct.

Defective capacitors are often a common cause of trouble and electronic, electromechanical and television circuitry. Capacitors become open, partially open, shorted, partially shorted, leaky, or develop internal leakage. Leakage resistance as high as 50 megohms can cause trouble in some circuits, whereas leakages as low as 1000 ohms have no effect in other circuits. This tester detects leakage resistance as high as 25 megohms.

In television circuitry intermittent or leaky capacitors often result in hard-to-find circuit trouble. Faulty capacitors in the agc, sync or video strip often result in a "tough dog" trouble. In using this handy tester, you will find it to be a valuable time-saving tool for locating defective capacitors in such circuits.

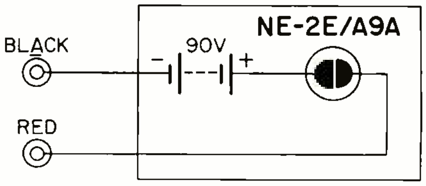
Construction

The tester is built into a 3¼" x 2⅛" x 1⅝" aluminum utility box (Bud CU2101-A) as shown in the photos. An inside view, with the batteries removed, shows how friction tape holds the neon lamp in place. Friction tape should also be used to insulate the case to prevent the leads from the neon lamp from shorting to the case. The three batteries should be taped together, and the terminals insulated as shown.

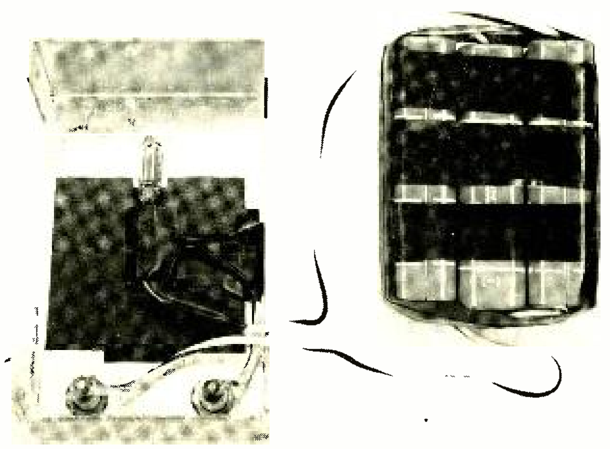
When constructing the tester, use the same combination of neon lamp (NE2-E/A9A) and batteries (Eveready photoflash No. 413) shown, since tests have shown that this combination gives the best results. Other combinations of lamps and voltages may not give the results specified in this article. Also, it is not necessary to add a series limiting resistor in series with the neon lamp, and doing so will impair the sensitivity. Under normal use (approximately 150 tests each day) the batteries should last for one year.

Testing procedures

When you have completed con-



CAPACITOR CHECKER SCHEMATIC. A neon lamp, three batteries and two binding posts. What could be simpler to build?



INSIDE VIEW SHOWS PARTS ARRANGEMENT in the simplest of capacitor testers.

structing your capacitor tester, short the two test leads that are connected to the pin jacks momentarily together; the neon lamp should light (do not keep it in this condition for long periods of time).

Now start to familiarize yourself with the indications of the neon lamp in testing capacitors. Take a 0.1- or 0.5-μF capacitor or any other that you have in the junk box. Momentarily short the leads or pigtails together to make sure that the capacitor is discharged. Clip one lead from the tester to one side of the capacitor (observe polarity if the capacitor is of the electrolytic type). Now while watching the indicator lamp, touch the remaining lead of the tester to the other lead of the capacitor and hold it there for at least 5 seconds. You will notice that the lamp flashed *only once* when the tester lead was first touched to the capacitor lead. This indicates that the capacitor has accepted a charge, is holding that charge, and that the capacitor is *good.* If the lamp did not flash, the capacitor is *open.*

When a capacitor has developed resistance or is leaky, the neon lamp will flash *intermittently (on-off);* the flash rate will depend upon the time constant of the circuit (t = R × C). For a given value of capacitance the lower the internal resistance, the faster the flash rate.

If the neon lamp glows continually the capacitor has developed very low resistance and should be considered *shorted.* NOTE: When testing small values of capacitors such as .001, .002 μF, etc., the indications on the neon lamp may be difficult to see because of the interference of the surrounding light. In any such case, cup your hand around the lamp to exclude any extraneous light.

Capacitors over 100 μF

Use the following procedure when testing electrolytic capacitors or any other capacitor that exceeds 100 μF: When you first touch the test leads to the capacitor, you will notice that the lamp stays lit and does not extinguish after a few seconds as before. Do not throw the capacitor away because it may still be good.

Hold the test leads on the capacitor for a minimum of 10 seconds (be sure to observe correct polarity). Momentarily remove one test lead from the capacitor then reconnect to the same place and hold it there for 10 seconds or more. The neon lamp *should not* glow or flash intermittently. If it does, the capacitor should be considered defective.

In-circuit tests

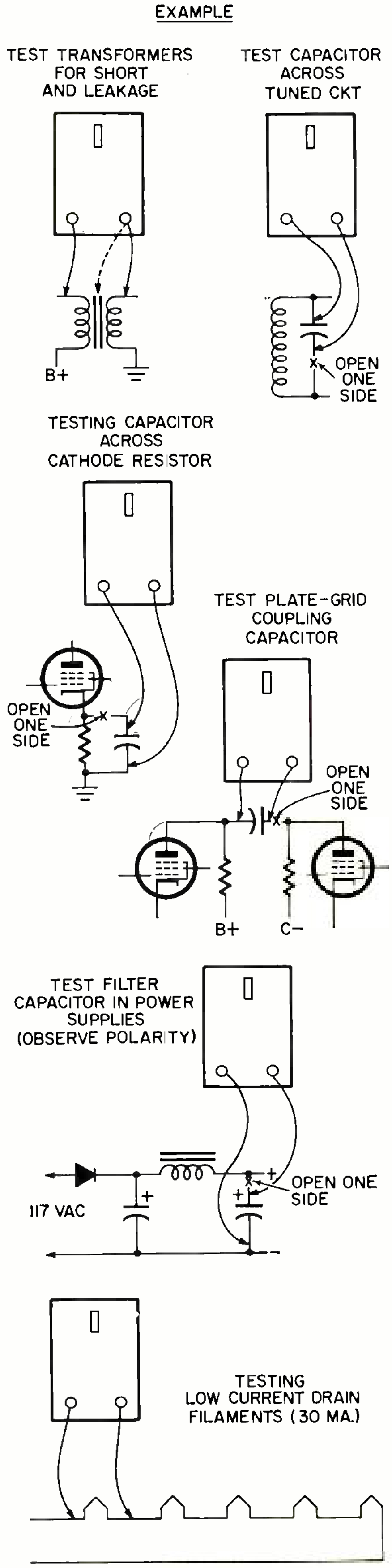
Capacitors in a circuit are generally associated with resistors and other components that often provide sneak paths which return to the capacitor. Because of the high sensitivity of the tester we recommend that one side of the capacitor be disconnected from the circuit, unless the resistance across the capacitor is over 25 megohms.

At times, it is often difficult and time-consuming to locate a defective capacitor or to decide whether a capacitor in a circuit is good or bad. Such capacitors may be in the agc, sync or video circuits. I have found it to be good practice to unsolder one side of each capacitor in the circuit where the trouble is suspected, and test each one.

A common defect in capacitors are loose or intermittent leads. This generally occurs where the lead is embedded in the seal. With both test leads connected to the capacitor, bend, rock and pull the capacitor leads carefully in all directions while watching the lamp for indications of shorts, leakage or intermittents. In some cases heat from surrounding components causes capacitors to become defective. A capacitor suspected of being heat-sensitive may be tested by applying heat from a soldering iron or heat lamp while observing the neon lamp for indications of leakage or shorts.

Capacitors ranging from .001 to above 100 microfarads may be tested providing their voltage rating is *50 volts or higher.* Leakage resistance in capacitors as high as 25 megohms could easily be detected. Before installing new capacitors into a circuit it is a good idea to test them. This takes only a few seconds and may save you a lot of time and headache later.

Besides testing capacitors, the instrument can be used as an excellent general-purpose low-current (approximately 30 mA) continuity tester. It may be used for checking the filaments of low-current battery tubes, lamps, etc. It is also excellent for checking leakage paths between the windings on i.f., af and flyback transformers, etc.



A FEW OF THE UNIT'S APPLICATIONS and details on how it's used. When testing in-circuit best results are obtained when one capacitor lead is opened as shown. You can also use the checker to test circuit continuity.

Summary

Indications on neon lamp when testing capacitors:

Good capacitor —Lamp flashes once

Leaky capacitor —Lamp flashes intermittently

Shorted capacitor —Lamp stays lit

Open capacitor —No initial flash

Voltage rating of capacitors— 50 volts and above

Range of capacitor values— .001 to 100 microfarads

One side of the capacitor should be unsoldered from the circuit, unless the resistance across the capacitor is above 25 megohms.

Excellent for locating shorts or leakage in transformers.

Excellent continuity tester for low-drain battery tubes. **R-E**

R-E's Service Clinic

getting to know varactor diodes

Varactors, VVC's or capacitance diodes—the latest thing in TV/FM tuning

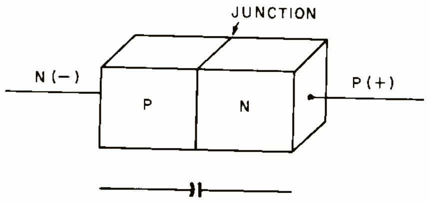
JACK DARR
SERVICE EDITOR

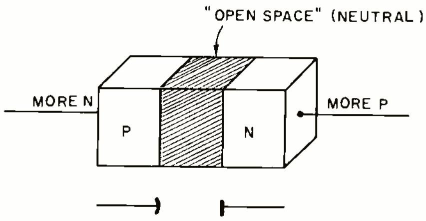
My crystal-controlled mind tells me that the next big thing they're going to throw at us will be varactor diode TV tuners.

They are coming—in fact, they're already here! RCA used all-varactor tuning in their model 2000 and Zenith used all-varactor tuning in some of the sets in their 1971 line. These have been used in several European FM and TV sets for some time, and now we're finding them in ours.

So let's see what a "varactor" is and how it works. As simply as I can put it, it's a plain diode. This, like all diodes, has a certain capacitance between cathode and anode. When we change the reverse bias on it, the capacitance changes. That's all there is to it. The drawing shows a diagram of the thing; a little crude, but this is how it works.

We have a block of semiconductor material. Each half is doped with impurities, one P and the other N. The interface between the two is the junction. Now if we reverse-bias the thing, it stops being a "diode" (something that conducts current one way but not the other) and becomes a completely open circuit for dc. (Capacitor is an open circuit; remember?) It will have a capacitance between the two elements. The value of this capacitor depends on the size of the block. (Incidentally, these are just like Zener diodes in one way; they are always operated with reverse bias. However, they do not conduct dc in normal operation, as a Zener does. If they do, they're shot.)





OK, now we have capacitance. We can connect it across a coil, and it will tune it—make it resonant at a given frequency. We need to be able to vary the capacitance so that we can tune the circuit where we want it. In a TV tuner, it doesn't take much, even at vhf; uhf even less.

Now how can we tune it? By applying more or less reverse bias to it. This will cause the "charge-layers" in the diode to repel each other, and move farther apart or get closer. Nothing actually moves, of course, since this is a solid-state device. However, the charge layers do actually move farther apart, or nearer. This is exactly the same as moving the plates of a variable capacitor closer or farther apart. The capacitance changes.

Now we've got something very useful! We can hook this gizmo across the coil of a TV tuner and vary its resonant frequency without all of those frightfully complicated multi-contact switches we are all so familiar with! All we need is a source of variable dc voltage; battery and variable resistor, in effect.

The guy in the back row with the red necktie, as usual, brings up a point; "How about the presence of dc in an ac (tuned) circuit?" Makes absolutely no difference! Proof? Look at the two-winding i.f. transformer of any tube radio; +200 volts dc in one winding, -3 to -4 volts in the grid winding, and it works. By properly *isolating* (bypassing) the dc, it will have no effect on the tuning action of the varactor.

So we can make a very simple TV tuner. The channel selector consists of a set of precision resistors, mounted on something like the familiar "turret" selector switch, so that only one is in-circuit at any time. Only two contacts instead of 8 or 10! In the actual tuner we'll get into next month, these variable resistors are of a special construction. They have an adjustment with about 10 turns, so that they can be set to a gnat's whisker. These are fed by a regulated dc power supply, and that's all there is to it!

To get a 4-circuit TV tuner, (Antenna, rf, mixer and oscillator) we sim-

> 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.

ply connect four varactors, one across each of the tuning coils, and feed them all from a common dc supply. For example (and this is close to the actual voltages used in the uhf section of the tuner mentioned before), if we switched a +22 volts onto the varactors, the tuner would "stop" on Ch. 65, or thereabouts. (Here's a point to remember in all varactors: the *greater* the reverse-bias voltage, the lower the capacitance; the smaller the reverse bias, the greater the capacitance—the closer the charge layers. Example: 0.5 volt, maximum capacitance; +28 volts, minimum capacitance).

For those who are wondering; yes, there are *trimmer* adjustments on the coils of all of these tuners, so we can still "tune" them up, for the proper bandpass, tracking, etc. In fact, in all of the varactor tuners I've seen so far, the varactor is in parallel with a small capacitor; sometimes fixed, sometimes an adjustable (trimmer) type.

So basically, these things are just like the tuning devices we've been used to. The big thing is that they're going to be a lot simpler, and a lot easier to work on and with. In fact, I wish that all present tuners could be magically converted to varactors! (Especially that intermittent dog in my own set!) Before we leave that point, "No, Irving, you can not (practically!) *convert* an existing tuner to varactor operation! Not without a complete redesign of the tuner.

Next month, we'll get into the actual "mechanics" and circuitry of a practical varactor tuner. Also, another unusual thing to most of us; "switching diodes," for changing from low-band vhf to high-band, and to uhf, all without any moving parts in the tuner itself! Just a few variable resistors! **RE**

Reader Questions

Hot power transformer

One of my customers replaced the EZ81 rectifier tube in his Eico HF-12 amplifier with a 6BQ5. He said it played well for about an hour, then the power transformer burned out! I replaced the power transformer with an exact duplicate, but it runs hot!

I have checked the current drain, and it runs only about 60 mA instead of the 90 mA specified. Dc voltage is +360 V, as shown, but the transformer still runs very hot. What do you think?—B.A., Houston, Tex.

Power transformers are heated by *power.* Power is "EI" which is voltage multiplied by current. So if your transformer has normal voltage and slightly less than normal current, your *load circuits* are not taking too much! If the transformer overheats, it may be the wrong transformer for this amplifier or it may even have a shorted turn in one of the windings. Check the transformer by pulling the rectifier tube, and disconnecting the hot wire to the filaments. In other words, take off *all* loads.

Now plug it into a wattmeter. Normal reading should be almost zero. All you should see is the iron-loss which will be below 5 watts. If the transformer *has* an internal short, you will read 25-35 watts or more. If it shows no internal short, but still gets too hot, it may be that it doesn't have the right current-rating.

No wattmeter? Hook a 1-ohm wirewound resistor in the primary; read ac voltage across it. 1.0 volt equals 1.0 ac ampere.

A transformer is "too hot" when it melts the wax, smells, etc. It may run too hot to hold your hand on, but if it doesn't stink, or smoke—it may be OK!

"Flat picture" problems

On several occasions, I've changed a picture tube and come out with a dull, flat picture instead of the bright clear one I should have. Can you tell me where I have gone wrong?—L.J., Marysville, Utah.

You didn't "go wrong," you just didn't go *far enough!* "Dull pictures" or washed-out, pale pictures can be caused by several things. Consider this; if the TV set is old enough to have worn out a picture tube, the chances are that it has several other weak tubes too!

This problem is simply a loss of video *amplitude*. You don't have enough video signal to drive the picture tube to full brightness and sharp cutoff. So, something in there is weak. Start at the video detector, with a scope and low-capacitance probe. This signal should be from 1.5 to 3.0 volts p-p video, and you should have at least a 50 to 75-volt (100 volts in color TV) video signal at the picture tube cathodes)

Slow heating color, Zenith

The color comes in very late, on this Zenith 24NC31 chassis. How can I tell what is causing this?—S.P., Chicago, Ill.

Feed a color-bar signal to the antenna. Now, scope the CRT grids. Look for the comb pattern. If there is no signal at all on the grids, the color is being stopped in the demodulators or color-amplifier stages. Using a crystal-detector probe, signal-trace back through these stages.

If you get a good comb pattern on the CRT grid (no color), but it is *flat-topped*, this points to trouble in the 3.58-MHz oscillator stage. The color signals themselves are getting through, but they are not being demodulated. If they were, they'd show the characteristic "Lazy-S" or rocker shapes on the grids.

Tuner won't stop

The channel selector won't stop running, when going from high channels to low in this Zenith A6208. I found that this was caused by a shorted "Tune Lower" transistor, 121-490, in the control unit of the S-77536 remote control. It had a collector-to-emitter short.

"Woooops! sorry about that!

You printed my question about bowed lines and convergence in the June issue of Radio-Electronics. I tried everything you told me to do, but nothing worked! I was just about to give up. Then, I happened to check the pulse waveform on the convergence board, and by golly it was UPSIDE DOWN! Someone had put in a new flyback, and managed to hook up this winding backward! One end is grounded! Thought you'd like to know.—G.S., Peoria, Ill.

Hooray! Glad you found the trouble in spite of all the "help" I gave you! Just goes to show the value of the old saw about "Don't give up the ship!" If it'll make you feel any better, I had a very similar case. Checked the waveform three times, and said "Yup! That's a good one!" and went on. Some time later, it dawned on me that the blasted thing was upside down! Same cause. Pulse winding reversed.

Slow heating brightener

I wrote you about a low-brightness problem in an Admiral. You recommended checking the cathode-currents of each gun in the pix tube. You were right—they were so low that I almost had to crawl under the meter to get a reading!

You said "Put a brightener on it"; so, I did. Turned it on; nothing happened. Having something else to do, I walked away from it for about 10 minutes. When I came back, there was the prettiest picture you ever saw! Currents almost up to normal, everything! First time I ever saw a slow-heating brightener. What happened?—L.N., Westfield, N.J.

Yep; this does happen. Rare but possible. I would say that the pix tube cathodes were so far gone that the higher heat from the brightener simply could not "boil up" enough fresh emitting material for a little while! I have heard this problem called "cathode interface," meaning that the cathode develops a layer of non-emitting material; possibly a sort of crust. With enough heat, this boils away.

RCA CTC-16 green screen

An RCA CTC-16 came in with a completely green screen, both color and B/W. This turned out to be caused by a loss or drop in plate voltage on the red and blue color-difference amplifier tubes. Green was normal.

The cause was a badly corroded wire jumper on the PC board. This connects the B+ side of the plate dropping resistor to the red and blue plate-load resistors. B+ goes directly to the green plate-load resistor, so it was still normal.

I've also run into two other sets, Philcos, with the same trouble. This wire is always corroded at the same end, where it connects to the R and B plate load resistors.

Thanks to Tom Noyes, Sigma TV, of Redondo Beach, Calif. for this one. Incidentally, we have heard of other troubles, due to corrosion of wire jumpers on PC boards. They all seem to be in seacoast towns. Could be due to salt air and excessive humidity? So, if you live near the ocean, watch out for this kind of problem.

RED FLASH

I'm getting intermittent "red flash" in a Sears color TV, Ch. 562.10422. It shows up on both color and B/W programs. I've chased it around until I'm dizzy, with no results—J.T., New York

Check out all resistors, peaking coils, capacitors, and the solder joints in the red amplifier tube circuits. This is quite common. It can happen with any of the three colors, of course. We have also found the grid and cathode resistors (1.0 megohm and 270 ohms, respectively) to show signs of being "thermal"; changing in value with heat.

Try spraying coolant on each of these resistors in turn, watching the screen. Since each tube in this color-difference amplifier circuit has its own cathode resistor (though they're all connected together) you can have "single-color" problems due to a bad cathode resistor in one stage.

SLOW WEAVE

In a Philco-Ford Model 5607WA color set the picture has a slow weave back and forth. All tubes that could affect this replaced. Sent it to another shop; no help. This is the second set I've seen with this symptom.

I suspect the filter capacitors. Am I right? B.T., British Columbia.

Yes.

ZERO CATHODE VOLTAGE

I'm just getting started in TV, and boy, am I stuck on this one! I had no hv on this color set. I replaced the horizontal output tube and got absolutely nothing! I can read the full B+ supply voltage on the damper plate, but the damper cathode reads zero.—Anonymous, N.Y.

Check that damper tube! I think you'll find that the filament is good, but the cathode is completely open! Look at the base with a magnifying glass; you'll see the tiny metal "ribbon" between the base-pin and the cathode sleeve broken. By the way, if you see "blobs" of metal on the ends of this, look out! This means that the cathode ribbon has been burned out by some kind of dead short in the damper cathode circuit. **R-E**

Circle 15 on reader service card

Circle 16 on reader service card

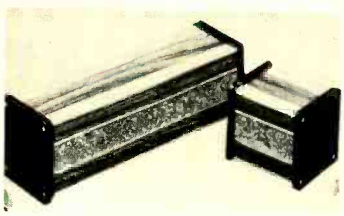
Advertisement

R-E's CHRISTMAS

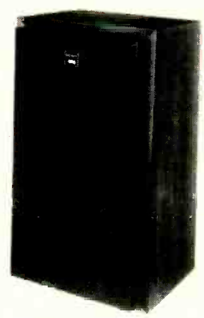
LENCO L75 TURNTABLE. Infinitely variable speed from 30-86 rpm, plus 16⅔. Precision arm with knife-edge bearings, anti-skating, damped cueing. In shock-isolating base with dustcover. Only $99.50. Benjmin Electronic Sound Corporation, Farmingdale, N.Y. 11735/div. of Instrument Systems Corp.

NOW, A DEVICE TO INSERT or extract DIP modules in the field or in the shop. The 4916A is a multi-purpose tool which will greatly benefit the user by saving components and time. Supplied by itself or in a complete DIP service kit the 4916A is available at $12.95 ea. or $39.95 in kit form, (which includes iron, desolder tips, aperture cleaner and heat sink). Techni-Tool, Inc. 1216 Arch St., Philadelphia, Pa. 19107 (215) LO 8-4457

SONY STR-6036 RECEIVER. Moderate power, moderate price—but nothing else in moderation. FET front end, ceramic IF's, fantastic FM Stereo/FM-AM performance. Power, 44W IHF @ 8 ohms (50W @ 4 ohms) at low distortion. Many features. Sony Corporation of America, 47-47 Van Dam St., Long Island City, N.Y. 11101



DELTALERT ULTRASONIC Burglar Alarm & Detection System, utilizing the sonar principle, monitors and blankets up to 300 sq. ft. of space. When activated by the slightest motion, alarm and lights automatically go on. The high-intensity horn and light combination drives away any intruder. Maintenance free. Anyone can install. Be secure with DeltAlert protection. DeltAlert: $69.95 ppd, DeltaHorn: $24.95 ppd. Delta Products, Inc.,—P.O. Box 1147RE, Grand Junction, Colo. 81501

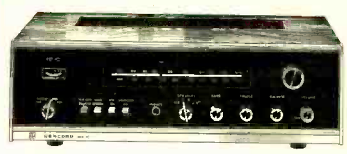


SONY SS-4200, acoustic suspension, 3-way speaker system employs an 8" high flux density woofer, 8" mid-range driver and two specially designed 3" dome cone tweeters. Provides unusually smooth and uniform response over the entire audible spectrum. Excellent value. Sony Corp. of America, 47-47 Van Dam St., L.I.C., N.Y.

ENJOY COMPATIBLE 4-CHANNEL records & FM using your present stereo system. Enhance regular stereo FM, records & tapes with new EVX-4 STEREO-4 decoder, only $59.95 plus second stereo amp and rear speakers. Or choose Electro-Voice E-V 1244X combined decoder and stereo amplifier. $149.95. Electro-Voice, Inc., 600 Cecil St., Buchanan, Mich. 49107.

K-50 TOOL KIT—contains 20 tools required for electrical/electronic appliance and equipment servicing. An excellent kit for beginners. Priced at $31.50 the kit comes in a lockable metal box. Techni-Tool, Inc. 1216 Arch St., Philadelphia, Pa. 19107 (215) LO 8-4457

OLSON FEATURE PACKED 175-Watt Stereo FM-AM receiver model RA-290 will deliver the ultimate in stereo listening pleasure from any speaker system. Feature for feature, dollar for dollar this is truly your best buy in stereo equipment. It's value priced at only $300. Order now or write for complete details to: Olson Electronics Dept. LX, 260 S. Forge St., Akron, Ohio 44308



CONCORD MARK 10 RECEIVER. Lots of watts for only $199.95; 80W (IHF @ 4 ohms), only 0.5% THD. FET/IC tuner section for top FM Stereo, FM/am reception. Tape Monitor. Walnut cabinet. Concord Div. Benjamin Electronic Sound Corporation, Farmingdale, N.Y. 11735/div. of Instrument Systems Corp.

SHOPPERS GUIDE

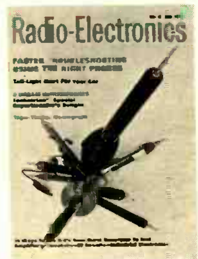
THE PHASE AUDIO SWEEP Generator is ideal for high fidelity audio systems maintenance and check out. The all solid state circuitry provides an electronic continuous sweep throughout the entire audio range, and generates several functions: Sine, Square, Triangle, Positive Sawtooth (with variable positive slope). Model ASG-200 Kit: $84.85; Factory Assembled: $108.09 postpaid. Order direct from The Phase Corporation, Dept. 80C, 315A Boston Avenue, Medford, Mass. 02155

SONY PS-5520 PLAYBACK System. A professional, single-play turntable with automatic convenience. Hysteresis motor, 12" balanced arm ensure flawless performance in manual or automatic operation. With base, cover. Sony Corporation of America, 47-47 Van Dam St., Long Island City, N.Y. 11101

"OPEN-AIRE" HEADPHONES have all the makings of a perfect gift: professional quality and reasonable price. New design principle combines unusually light (5 oz.) weight, wide (20-20 KHz) response . . . all the realism of stereo without cumbersome size and uncomfortable ear seals. Give a gift of privacy and perfect sound. Only $33.95 from Sennheiser Electronic, 500 Fifth Ave., N.Y.C. 10036

PERMABOND—A FAST SETTING contact cement joins practically all combinations of materials tensile strength of up to 5,000 psi. Sets with finger pressure—One drop covers 2 sq. in.—Impervious to most chemicals—Colorless transparent. Price $1.89/2 gm tube, $8.75 trial kit of 3 types (5 2-gm tubes). Techni-Tool Inc. 1216 Arch St., Philadelphia, Pa. 19107 (215) LO 8-4457

ELAC/Miracord 650 Automatic Turntable. Light-touch pushbutton operation—for manual, just lift the arm. Dynamically balanced arm has anti-skating, cueing damped in both directions. $99.95. ELAC Div. Benjamin Electronic Sound Corporation, Farmingdale, N.Y. 11735/div. of Instrument Systems Corp.



IDEAL XMAS GIFT for: your boss—co-workers and friends tuned into electronics! Give a RADIO-ELECTRONICS special *ONE YEAR* gift subscription and spread your cheer all year. One gift sub.—$7.00/ two—$6.00 ea./ Three—$5.00 ea./ four—$4.00 ea. We'll send gift cards. Simply send orders to R-E Gifts, Suite 1101, 200 Park Ave. S., N.Y., N.Y.

ELECTRONIC IGNITION SYSTEM—Don't settle for a hit and miss ignition system install a Judson Electronic Magneto. It offers the combined advantages of both the standard transistorized and capacitive discharge systems in one simplified circuit. It provides better performance, a smoother running engine and keeps your car in tune. Installed in twenty minutes. Sold at better electronics and automotive stores everywhere.—Judson Research & Mfg. Co., 541 E. Hector St., Conshohocken, Pa. 19428

New 1971 Solid State & Hobby Circuits Manual

$1.95 postpaid to your door. The new manual, HM 91 offers over 400 pages of circuits for the hobbyist, engineer, experimenter and do-it-yourself kit builder. HURRY—Supply limited. Free Catalog. Frazer & Associates 3809 Surfwood Rd., Malibu, Cal. 90265

OPTIMAN SPACE CONTROL Center—clean and compact the #609D provides a safe working surface and parts holder for all your repair components. Handy for holding parts of assemblies while servicing #609D also has convenient storage areas for tools. Complete 609D at $49.95. Other models available from $9.95. Techni-Tool, Inc. 1216 Arch St., Philadelphia, Pa. 19107 (215) LO 8-4457

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 89 and circle the numbers of the new products on which you would like further information. Detach and mail the postage-paid card.

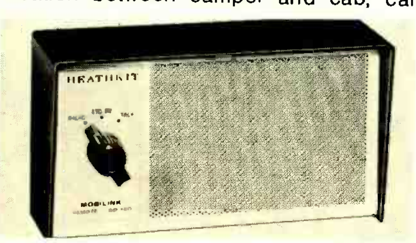
CCTV SYSTEM, *MW-501,* for security applications—area surveillance, gate control, small-business protection, hazardous-area control. Features 550 center line resolution, 4000 to 1 automatic light control.

The 10 in. long camera, equipped with a C-mount 25mm, f 1.9 lens, has output power to drive the 9 in. monitor over cable lengths of over 200 feet. For larger or specialized applications an infrared vidicon, multiple-camera switching multiple-moni-

tor consoles, other C-mount lenses and video amplifiers are available as options. Basic camera-monitor combination is $499.00. Detailed brochure available—**Mountain West Alarm Supply Company,** 4215 N. 16th St., Phoenix, Ariz. 85016.

Circle 31 on reader service card

INTERCOM SYSTEM, *model GD-160, Mobilink.* Provides instant 2-way communication between camper and cab, car



and trailer, or any other mobile application where a 12 volt 250 milliamp dc power source is available. A 3-position switch on the master unit selects monitor, standby, and talk modes. Mounting brackets for horizontal or vertical installation are included. $25.95.—**Heath Company,** Benton Harbor, Mich. 49022.

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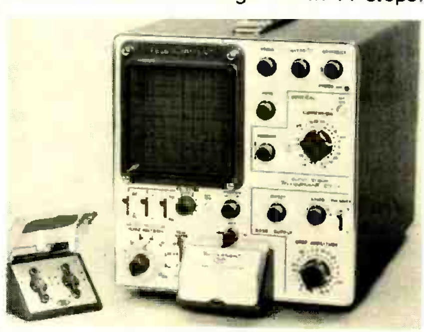
CURVE TRACER, *model CT71,* designed for displaying the characteristic curves of a wide range of transistor, FET and diode semiconductor devices on its 10 x 10 cm (5½") crt. Collector supply voltage is 0 to 1 kV, with positive and negative polarity; twice line frequency or dc. Peak current 2 amps (max 15 watts). Series resistances zero Ω ohms to 1.7 megohms in 11 steps.



Base step generator current is 0.2 μA to 20 mA in 16 steps . Features plug-in test fixtures with safety interlock. Power requirements: 100V to 125V in 5-volt steps: 200V to 250V in 10-volt steps; 48 Hz to 63 Hz line frequency, 37 VA. $795.00.—**Tektronix, Inc.,** Mr. M. E. Pryor, P.O. Box 500, Beaverton, Ore. 97005.

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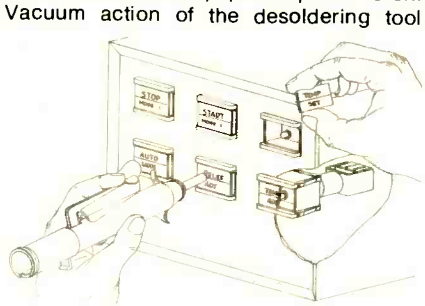
LAMP EXTRACTOR TIP for desoldering tool provides swift and simple lamp removal even while equipment power is on. Vacuum action of the desoldering tool



holds the bulb during removal; during reinstallation, the inside shaft ejects the bulb into lamp housings 2C and 2F and midget flanged lamp style T-1 ¾. $1.95 plus tax and shipping. (Include your desoldering tool part number when ordering.)—**Edsyn, Inc.,** 15954 Arminta St., Van Nuys, Calif. 91406.

Circle 34 on reader service card

STEREO PLAYBACK DECK, *Cortina 2 model TD-8.* Solid-state 8-track stereo cartridge playback deck connects to stereo amplifier or receiver tape input. Spillproof capstan bearing assembly; four individual track lights; selector push-button to permit track switching. Power out-

put 1 volt. Better than 38 dB signal-to-noise ratio. For 117 Vac, 60 Hz. Walnut grain finished metal case with brushed aluminum front panel. $49.95.—**EICO Electronic Instrument Co., Inc.,** 283 Malta St., Brooklyn, N.Y. 11207.

Circle 35 on reader service card

AMPLIFIER, *All American Sports.* This top-of-TV-set mounting device filters out all but one television channel, and amplifies that single channel by 22 to 25 dB gain. Initial marketing is aimed at fans who want to receive pro football games blacked out locally but available on 75 mile or more distant transmitters. The

"amplified bandpass filter" uses a new technique that combines etched inductors with ultra low noise figure amplification (typical low-band noise figure 3.0 dB, typical high-band noise figure 5.0 dB). $97.50.—**Cadco Systems,** 4444 Classen Blvd., Oklahoma City, Okla. 73118.

Circle 36 on reader service card

SERVICE KITS, containing convenient assortments of widely used electronic component parts, for service dealers, technicians, designers, experimenters, hams and hobbyists. *Kit-10F* holds Fastatch II controls; *Kit-20W* miniature wirewound controls; *Kit-30F,* miniature trimmer controls; *Kit-50A,* axial-lead electrolytics; *Kit-55P,* PC-lead electrolytics; *Kit-60D,* general-purpose capacitors; *Kit-70H,* high-voltage capacitors and *Kit-100P*, packaged electronic circuits. Each kit housed in steel frame, portable and stackable cab-

inets with 15 plastic drawers. Cabinets can be wall mounted. Replacement control guide literature included in *10F8, 20W*, and *30T*.—**Distributor Products, Centralab,** 5757 N. Green Bay Ave., Milwaukee, Wisc.

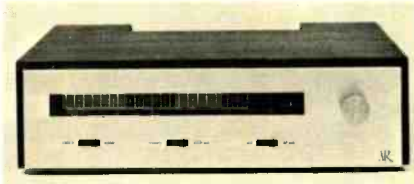
Circle 37 on reader service card

DIODES. Light-emitting diodes, gallium arsenide semiconductors, infra-red light sources, indicator lamps, alphanumeric

readouts, photo-sensors and opto-isolators available as replacements for devices installed in equipment. Some types can also replace conventional miniature lamps. Applicable to intruder alarms, counters, clocks, optical tachometers, computer readouts.—**Sprague Products Co.,** 81 Marshall St., N. Adams, Mass.

Circle 38 on reader service card

FM TUNER, *AR-FM* all-silicon solid-state stereo multiplex tuner. Sensitivity 2.0 μV or better; signal to noise ratio 65 dB, ASA "C" (flat) weighting; distortion less than



0.5% IM or THD, mono or stereo. Frequency response 20 Hz to 15 kHz, ±1 dB, 110-120 volts ac, 60 Hz, 12 W. Separation 35 dB min at 50 Hz; 40 dB min at 400 Hz; 30 dB min at 10 kHz. Optional oiled walnut cover available, $15.00; tuner $210.00.—**Acoustic Research, Inc.,** 24 Thorndike St., Cambridge, Mass. 02141.

Circle 39 on reader service card

DECODER, *model Quadio QC-1*. The 4-channel decoder accepts stereo program material from FM radio, phonographs, tape, cassette or 8-track cartridge player decks. Intended for use with *Qaudio* 4-channel/2-channel cartridge player models, or with any other player or set of components that produce four independent channels of sound. The "effect selector" control offers four types of effects: ordinary stereo; simulating small recital hall for listening to soloists or small groups; simulating large concert hall with full re-

verberation; surrounded by music. $49.95.—**Toyo Radio Company of America, Inc.**, 1842B West 169th St., Gardena, Calif. 90247.

Circle 40 on reader service card

STEREO AMPLIFIER, *model LA-2525, No. 99-02628W.* 4-channel solid-state stereo amplifier rated 40-watts ±1dB at 0.8% THD. This amplifier incorporates circuitry for deriving 4-channel stereo sound from conventional 2-channel sources such as stereo records, tapes, and FM broadcasts. Separate volume controls for front left and

right, rear left and right channels. Headphone jack for private listening from front amplifiers (channels). Total harmonic distortion, 1 kHz, 8 ohms, 1 watt = 0.125%.

Circle 64 on reader service card

Circle 65 on reader service card

Input sensitivity, Aux = 275 mV, tuner = 500 mV, phono mag = 3.5 mV. Comes with simulated walnut grained metal enclosure. $119.95.—**Lafayette Radio Electronics Corp.,** 111 Jericho Turnpike, Syosset, L.I., N.Y. 11791.

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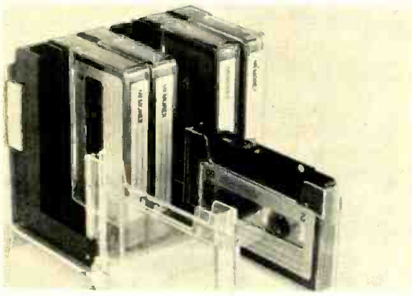
CASSETTE STORAGE. Aluminum cassette storage library exclusively for Memorex cassettes. Holds six albums neatly and compactly with easy accessibility. Equipped with interlock for adding on units. Identification labels clearly visible



on stored cassettes. For limited time only, offered free to customers purchasing three Memorex *60* or Memorex *90* cassettes at regular price.—**Memorex Corp.,** San Tomas at Central Expressway, Santa Clara, Calif. 95052.

Circle 42 on reader service card

IMPEDANCE-CONVERTING AMPLIFIERS, *Impedaverter models IMP-1 and IMP-2.* Solid-state high input and low output impedance converting amplifiers for use with medium- and high-impedance microphones and instrument pickups. Cables up to 500 feet may be used at the output without alteration of audio response or excessive pickup of hum and noise. Allows bridging lines without loading; output can be split to feed two amplifiers. Gain and phase switching provided. Input impedance greater than 4 megohms 30 Hz to

1 kHz, 3 megohms at 5 kHz, 1.5 megohms at 10 kHz, 1 megohm at 15 kHz. Output impedance 70 ohms at 60 Hz, less than 15 ohms 400 Hz—20 kHz. Specs for *IMP-1* and *IMP-2* identical except that *IMP-2* has no gain and phase switching and one 9-volt battery used. *IMP-1,* $34.95; *IMP-2,* $25.95.—**Russound/FMP,** P.O. Box 204, Stratham, N.H. 03885.

Circle 43 on reader service card

TUNER CARE KIT, a tuner degreaser, *Royal Clean,* and a heavy-duty lubricant and tuner cleaner, *Royal Lube,* for TV tuner contacts. The fast-drying, non-flammable degreaser does not affect plastics, and it dissolves dirt, grease and oil, evaporating completely after application, with no

residue. The foam spray lubricant maintains constant contact protection, cleaning and lubricating as the TV viewer changes channels. $4.98.—**Injectorall Electronics Corp.,** 4 North Road, Great Neck, N.Y. 11024.

Circle 44 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 89 and circle the numbers of the items you want. Then mail the postage-paid card.

HEAT-BLO GUN CATALOG, full color description and specifications on models of electric, portable *Heat-Blo* guns with heat ranges up to 1000° F. They all produce flameless, concentrated heat for use in heating or drying. Also gives details on new chrome contamination-free heat gun designed especially for use in labs, around computer equipment, in electronic plants. Features the 3 models of *Torrid Air Blowers* capable of use constantly, even day and night.—**Milwaukee Lock & Mfg. Co.,** 5028 North 37th St., Milwaukee, Wisc. 53209.

Circle 45 on reader service card

USES FOR AEROSOL COOLANT BOOKLET, entitled *The Cool Way to Find Thermal Intermittents*, describes typical thermal intermittents and how *Super Frost Aid* aerosol coolant will locate them. A step-by-step service procedure is outlined. Booklet also describes the other service aid applications of the coolant, including cooling delicate heat sensitive components prior to soldering; preventing cold solder joints and transformer burnout; and locating hairline cracks in PC board circuitry.—**Chemtronics, Inc.,** 1260 Ralph Ave., Brooklyn, N.Y. 11236.

Circle 46 on reader service card

STEREO & TAPE BROCHURE, fully illustrated with specifications. Complete line of headphones, cassette and cartridge carrying cases and portable storage units, and cassette albums are shown.—**RMS Electronics, Inc.,** 50 Antin Place, Bronx, N.Y. 10462.

Circle 47 on reader service card

FOIL CAPACITORS *Dual Temp Tantalum*, an 11-page technical data bulletin. Describes the tantalum foil capacitor type *TAND*.—**Cornell-Dubilier Electronics,** 150 Avenue "L", Newark, N.J. 07101.

Circle 48 on reader service card

AUDIO ACCESSORY LINE, *#FR-71-A*, 52-page catalog including items for use in all phases of home electronics, from hi-fi listening to stereo accessories for the car. The illustrated booklet shows TV antenna installation hardware, cable-connector-adaptors for stereo equipment applications, acoustic-suspension loudspeaker systems, speaker switching devices, stereo headphones, microphones and accessories, intercoms and telephone accessories.—**GC Electronics,** 400 South Wyman St., Rockford, Ill. 61101.

Circle 49 on reader service card

SOLDERING IRON TIPS CATALOG, *#0471*. This 28-page soldering iron tip and aids catalog features plug, sleeve and threaded shank soldering iron tips to fit all leading brands and models of soldering irons, desoldering tips, tip wipers, iron holders and desoldering wick. Diamond, cone, chisel, screwdriver, bevel, turned down and tapered tips from ⅛" to 1⅛" in diameter are illustrated with dimensioned drawings to help users to specify diameter, length, point shape, shank style and point tinning requirements.—**Plato Products, Inc.,** P.O. Box 1019, El Monte, Calif. 91734.

Circle 50 on reader service card

TV TIME & FREQUENCY BOOKLET. The experimental television-time-code system recently developed at NBS can provide inexpensive coarse- and fine-time signals and precise-frequency signals to a great number of users. The system is described in a 12-page booklet complete with diagrams.—**Program Information Office,** National Bureau of Standards, Boulder, Colo. 80302.

Circle 51 on reader service card

PORTABLE VOM BROCHURE. Four portable battery-operated FET vom's and accessories shown in this illustrated brochure. Specifications plus chart to help you select the vom that best fits your needs.—**Triplett Corp.,** Marketing Dept., Bluffton, Ohio 45817. **R-E**

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coming next

JANUARY 1972

- **9th Annual Color TV Issue**
  Start off the new year with this special issue packed full of the latest color TV information. You won't want to miss a single word.

- **Modular TV Is Breaking Out All Over**
  Picture report on the latest happenings in modules. Close ups of what they look like and how they improve color receivers.

- **Trinitron vs Shadow Mask**
  A comparison of how these very different color picture tubes operate and pointers on their respective advantages.

- **Automatic Color Control Circuits**
  The latest circuits do a lot to make the color on your TV screen look better. Here's how they work.

- **Build Instant Color**
  Add a group of preset controls and a front-panel pushbutton that restores perfect color no matter how the kids twiddle the front-panel controls.

PLUS:
Stereo Amplifier Design
Color Crosshatch Generator
Kwik-Fix Troubleshooting Charts
Jack Darr's Service Clinic

new books

ASTRONOMY, by Donald H. Menzel. Random House, New York, N. Y. 320 pages. 8½ x 11 3/16 in. Hardcover, $17.50.

While the book has been titled "Astronomy", we have a strong feeling it should have been called "Radio Astronomy". In the very early chapters of the book Dr. Menzel lays a groundwork for understanding our universe with a discussion of atoms, atomic energy, and radiation. In this very up-to-date text all of the instruments and techniques that have revolutionized astronomy in recent years are covered. The powerful radio transmitters and ultra-sensitive receivers, electronic amplification of light with image tubes, orbiting telescopes, rocket-borne cameras that translate photographs into electronic impulses, atomic clocks that measure in nanoseconds, laser beams that measure the distance to the moon within a foot, and computers that instantly calculate every detail of space flights, are all described in great detail.

Supplementing the text are 319 illustrations, including 210 photographs from the world's observatories and NASA space flights. Equally important are 85 diagrams and 24 sky maps. A book for anyone who wants to learn what science now knows about our universe.—*LS*

BASIC FOR BEGINNERS, by Wilson Y. Gateley and Gary G. Bitter. McGraw-Hill Book Co., 330 W. 42nd St., New York, N.Y. 10036. 5 5/16 x 8 in., 152 pp. Softcover, $3.95.

Provides a simple, easily understood introduction to the BASIC language of computers so that a student can use a terminal facility as a tool. Covers the language itself, control statements, loops and arrays, library functions and the DEF statement, input, printing, and string data. Meant to be used as a self-instruction manual with minimal outside help—*MCL* **R-E**

SCANNING MONITOR RADIOS
(continued from page 59)

by the application of base drive current from IC1.

Transistor Q10 is a Colpitts-type crystal oscillator with four third-overtone crystals connected between base and collector through switching diodes. These diodes are back-biased so they appear as open switches in series with the crystals. Note that the collectors of lamp-drivers Q1-Q4 are connected through 2700-ohm resistors to the junction of a crystal and a switching diode. Whenever a lamp-driver is turned on, its lamp lights and the collector voltage drops to a low value. This removes the blocking bias from the associated switching diode and lets it conduct. The conducting diode then appears as a closed switch connecting its crystal to the oscillator.

ELECTRA'S BEARCAT III features interchangeable plug-in rf modules for any two of the three bands. Crystal i.f. filters and LED indicator lamps are standard equipment.

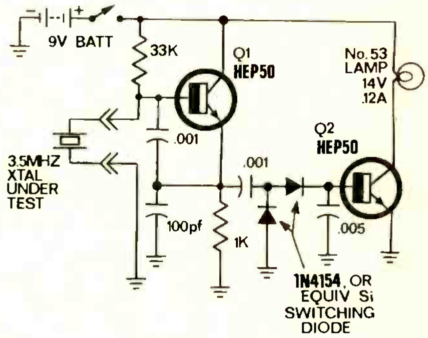
If a signal is present on that channel, the squelch opens and develops a control voltage that turns off the multivibrator; stopping the scanner on that channel. If there is no signal, the scanner continues to operate until a station starts transmitting on one of the scanned channels.

When the SCAN-MANUAL switch is placed in the MANUAL position, the multivibrator is disconnected from control transistor Q7. Pressing the CHANNEL SELECTOR button applies a positive pulse to the base of Q8 through C1. This causes the multivibrator to complete *one* cycle and then return to its steady state until the CHANNEL SELECTOR is released and then pressed again.

The 8-channel Monitoradios are similar with an additional J-K flip-flop operating at one-eighth the multivibrator frequency. One of the transistors driven by IC1 is in series with the lampdrivers for the even-numbered channels and the other is in series with the odd-numbered lamp drivers. The bases of the lamp-drivers are driven in sequence from the outputs of the IC's operating at one-quarter and one-eighth the multivibrator speed. **R-E**

COLOR-CRYSTAL CHECKER

Here is the circuit of little instrument I've found very handy for giv-



ing color crystals a go/no-go test. Just connect a crystal to the test leads. If the crystal is ok, Q1 oscillates, biasing Q2 on and turning on the lamp.—*Tom Noves*

ADJUSTABLE DIODE

It is hard to find a diode with just the right drop to bias a Class B transistor amplifier as in Fig. 1 or in other configurations, and then if you change transistors, the bias may not be right any more. Yet the low dynamic resistance is desirable, so try the simple regulator of Fig. 2. Connected between A and B in Fig. 1 in place of the diode, it constitutes an "adjustable diode" whose drop can be set as needed but must be enough—usually above 0.5 volt—to keep

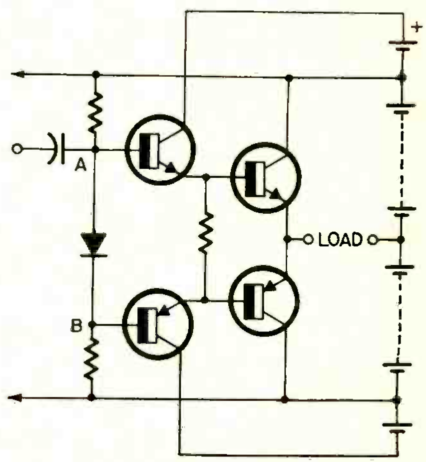


FIG. 1

the particular transistor used for Q1 beyond the knee of its common-emitter characteristic and its gain high.

With the components shown in Fig. 2, the "adjustable diode" has 10 ohms dynamic resistance and at midsetting 0.85 volts drop at 5 mA, dropping to 0.81 at 1 mA as current decreases from rectified signal opposing it when the amplifier of Fig. 1 is driven. This is correct bias for a two-stage complementary amplifier using germanium transistors of the 2N1320-21 etc. series (now obsolete). Taking hold of Q1 with the fingers in 15°C ambient drops the voltage from 0.85 to 0.82 at 1 mA, with less change at 5 mA. This tends to compensate for power transistor heating if Q1 is attached to one of the power transistors.

The "adjustable diode" can of course be used with other amplifier configurations if arranged for the right bias voltage, which for centertapped push-pull is half that for the complementary circuit and with germanium transistors may be too low for common-emitter operation of Q1 so a different type of regulator is necessary.—*A. H. Taylor* **R-E**

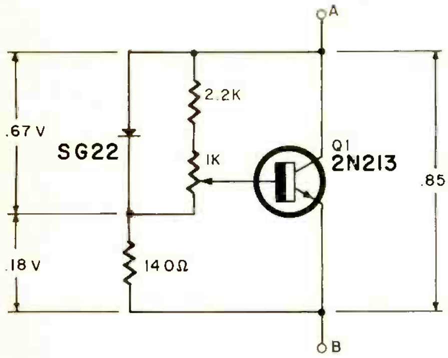


Fig. 2

TIC-TAC-TRONIX
(continued from page 35)

move counter then remains in this last state regardless of any additional plays until it is reset.

Although the move-3 logic output is positive during the reset time, no move-3 lamps will light prematurely as this occurs *before* a strategy is selected.

The strategy selector is shown in Fig. 6. Its purpose is to pick and hold one of five possible program branches or strategies in response to a test made during move one and is aimed at finding the initial player response. On the player's first move, one and only one red player lamp will be lit, and one of diodes D18-25 will be grounded at the lamp end and allowed to conduct. These diodes are OR'ed together to form five strategy lines, with the computer playing the same game with a B or an H initial response; for a D or a G; or for an F or an I.

At the end of move-1, a move-1 output pulse is generated by the move counter. This causes the strategy latch to catch and hold whichever input was grounded, thus remembering where the player went on his first move.

A quad latch is used for IC3, forming four of the strategy latches, while a quad two-input gate IC4 is connected as a fifth latch. On all five latches, the complimentary output connection is used. Thus, *before* a strategy is selected, all outputs are *grounded*. *After* a strategy is selected and for the remainder of the game, one selected output is *positive*, while the remaining four stay grounded. Depressing reset button S11 returns the latches to an all-outputs-grounded state.

Looking back over Figs. 4 through 6, we see that there are seven *logic lines* provided by these circuits. One of five strategy lines goes positive after the first move. A *move-two* line goes positive after the second move and stays there, and finally a *move-three* line goes positive after the third move.

The logic states on these seven lines are converted into moves by the play computer shown in Fig. 7. This diode-transistor logic array is the brain center of Tic-Tac-Tronix. Move-1 responses are associated with R52 through R56, while move-2 responses are handled by R57 through R61, and move-3 responses are handled by R62 through R66.

A move is made by allowing current from the +5V supply to reach the desired bases of the machine lamp drivers. The +5 volts arrives via resistors R47 through R51. These are all clamped to ground by the strategy selector before move-one, and after move-one, a single resistor is allowed to go positive. During move-one, the move-two and move-three logic lines keep their resistors clamped to ground. On move-two, the move-two line goes positive allowing completion of the second move, and finally on move-three, the move-three line goes positive, allowing completion of the game.

The play computer's outputs are used in conjunction with diodes D1 through D7, which provide the required testing for the second and third moves. Goof switch S11 operates by tampering with the second computer response of strategy III. In the SMART position, things are normal, while in the DUMB position, the wrong square is played, allowing the player to win.

The power supply is shown in Fig. 8. It provides 6.3 volts of moderately filtered dc for the lamps and a regulated 5 volts for the logic and the rest of the circuit.

How to build it

A printed circuit board is essential for this project. The foil pattern of the board is in Fig. 9.

Fig. 10 is a drilling guide that also shows how the 18 jumpers of No. 24 solid wire are positioned on the component side. PC terminals may also be optionally set on the com-

(turn page)

Circle 82 on reader service card

Circle 84 on reader service card

TIC-TAC-TRONIX

(continued from page 79)

ponent side; 23 are needed.

Components are located as shown in Fig. 11. The IC's are identified by a notch and dot between pins one and fourteen. They are shown top view everywhere in this article. Use a small iron and fine solder when installing. Be very careful in observing the polarity of all the diodes. To save some board space, two groups of resistors mount upright. R1 through R7 mount vertically in individual holes, while R23 through R30 mount vertically and a common bus is run along their top ends and terminated to +5 volts as shown.

Case and display

Everything mounts in a sloping vinyl-clad wooden case with the circuit board, goof switch, and power transformer near the bottom and the display on top. Fig. 12 shows how the display assembly goes together. A subchassis is used that holds the lamps and their color filters. The lamps press into grommets as shown in Fig. 13. Six dividers go above the lamps, eggcrate style, forming nine individual cubicles for each of the squares. The insides of each divider should be very shiny.

The playing screen

A frosted Mylar mask is made of drafting Mylar. Translucent X's and O's are added using the translucent red and blue printed-circuit tape sometimes used in two-sided PC board layout work. A front plate secures the entire assembly as well as holding switches S1 through S10. These switches are operated by the player to conduct his game.

Wiring is shown in Fig. 14. Sixteen-conductor flat cable is broken up into two 8-conductor sections, a 5-conductor section, and a 7-conductor section; and used as a wiring harness. Note that lamp A is lit all the time, and that S1 is not connected and used simply as a mechanical dummy. **R-E**

APPLIANCE CLINIC
(continued from page 16)

plug the thing in, and take an ac voltage reading between the case and a known ground. Should show absolutely zero voltage, of course. If you do get even a very small voltage, find out why. This can come from odd things. An accumulation of lint and dust making a conductive bridge from a hot terminal to the case, especially in damp environments, and so on. Of course there is always a chance of a careless repair job in the past leaving things such as strands of wire touching the case.

So the "Third Wire" is the best safety feature of all. By making the exposed metal case of the unit ground at all times, any electrical leakage will have a path to ground. If the leakage is high enough, it will trip the circuit breaker or blow the fuse. That's what it's supposed to do! If it is correctly hooked up, the appliance will never become a "Third Rail."

Just to make sure, it's not a bad idea to check this, in houses where the outlets are all of the 3-wire type. Use a standard electrician's test-lamp; a socket, a lamp and flexible test leads which can be plugged into the receptacle. The incandescent test-lamp should light to full brilliance between the hot terminal of the receptacle and the round hole or ground. If it does not; if it lights only dimly, this means that the protective grounding is bad! It is not correctly grounded! If you find this, let your customer know about it and tell him he must have it checked by an electrician at once.

As one of my old bosses used to say "My Gawsh, don't take chances with our customers! We haven't got enough of 'em as it is!" Remember that.

JACK DARR
SERVICE EDITOR

try this one

WRINKLE PAINT CLEANER-UP

One of the easiest and best ways to clean wrinkle and crackle finishes is to use one of the many hand cleaners with a sugar-beet base. This basic product is sold under such trade names as Goop, Go-Jo, and SBS. The usual soap and water treatment, even using a stiff bristled brush, is hard pressed to remove the dust and dirt which always collects in such finishes. Some liquid cleaners are inclined to leave a residue which renders the supposed cleaning job a complete disaster.

To do a really good job, remove all knobs and easily removable trim. Apply a tablespoonful of handcleaner and work it into the finish with your finger tips. The cleaner starts to liquefy almost immediately, it is this action which lifts the dirt out of the pores and cracks in the paint. Continue the application, doing a small area at a time. When you have finished wipe the cleaner off with a clean rag, reapply a small amount and give it a once over lightly to remove any stubborn spots. Again wipe with a clean rag, reinstall items previously removed and the job is complete.—*William P. Turner, WA0ABI*

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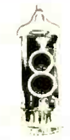

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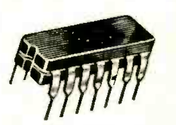

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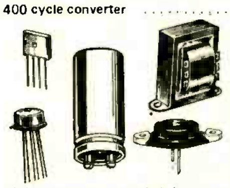

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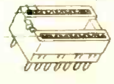

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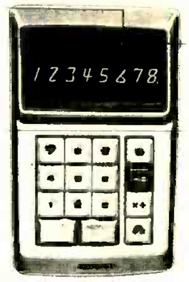

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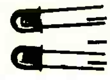

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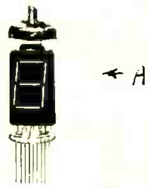

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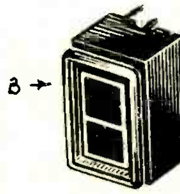

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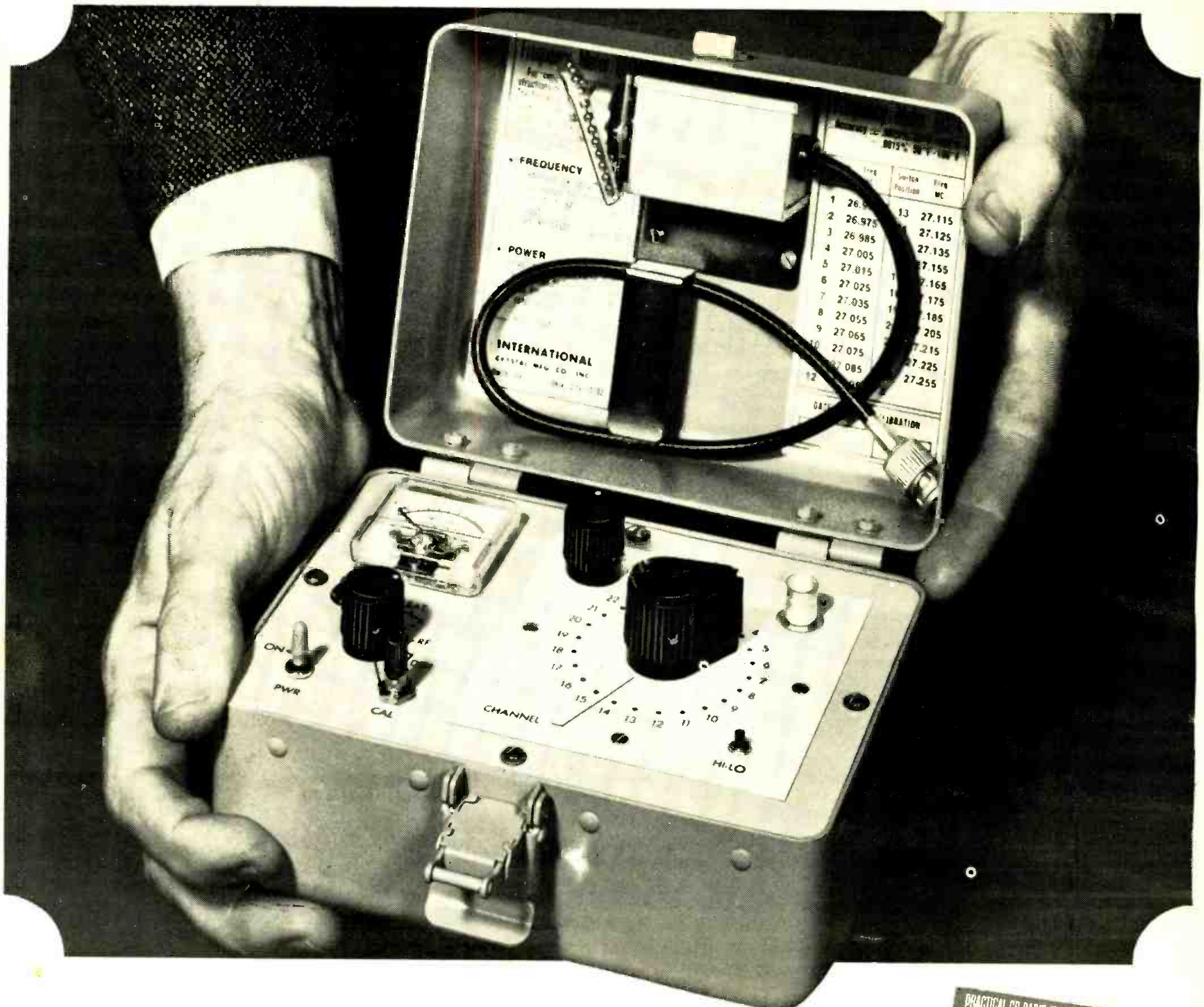
Poor edge convergence

We've got a problem with partial misconvergence on a late-model color TV. I've checked the convergence board and all waveforms, but no help. Any ideas?—R. G., Regina, Sask.

Several! Try this: put a cross-hatch pattern on the screen. Now, loosen the yoke clamp and *very carefully* juggle it just a wee bit, watching the pattern. You may find that the yoke is turned slightly off center or up and down. In a good many cases, this will affect edge convergence. Don't move it far enough to upset purity, of course.

Second: Try moving the convergence yoke just a tiny bit back and forth along the tube neck. If this is off by about half an inch, it can cause edge misconvergence too. Be sure that the blue vertical magnet is exactly straight up and down above the blue-gun polepiece.

Also, on this and any other set using the large, dual-magnet assembly on the blue lateral magnet, check its action. These use two magnets which are moved nearer and farther from the tube neck by a *track* arrangement inside the plastic housing. If one of the actuating dogs jumps the tracks, one magnet will move and the other one won't. This changes the action of the magnet. **R-E**



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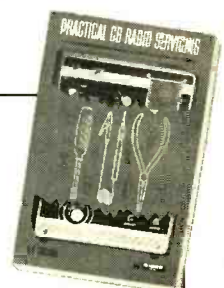

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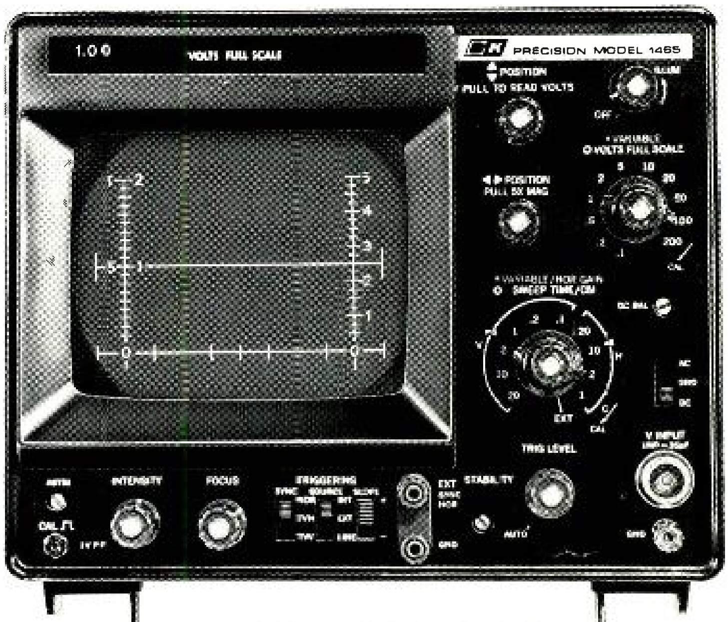
Circle 90 on reader service card

Where's the voltmeter?



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Servicing time goes down – picture quality goes up – when you use this scope. Now, in one instrument, you get triggered sweep to eliminate those waveforms that won't lock in, a vectorscope for color TV servicing, 10 MHz response for high resolution analysis. A unique sync separator generates special sweep synchronizing pulses to let you analyze any portion of the TV waveform. For economical performance, use the B & K Precision 1465.

About the Cali-Brain® System

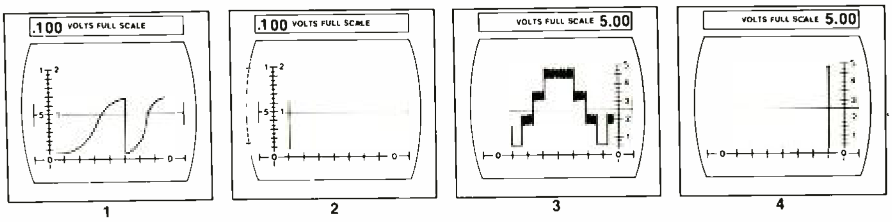
The CALI-BRAIN system increases your efficiency because it lets you measure its peak-to-peak voltage without changing your test set-up. Now you can confirm the manufacturer's service data exactly – checking out typical waveforms and peak-to-peak voltage readings at various test points.

Cali-Brain® in Action

Use CALI-BRAIN when you want to measure peak-to-peak voltage of the waveform displayed on the scope screen. Here's what happens when the CALI-BRAIN switch is activated:

A. The horizontal sweep collapses and the waveform under examination appears as a straight vertical line.
B. A numerical indicator in the CRT bezel lights up to show the full scale voltage (including decimal point) corresponding to the Vertical Attenuator setting.
C. A graduated scale on the graticule overlay is illuminated on either side of the scope screen. The scale corresponds to the full scale voltage indicator in the bezel
D. The vertical waveform line on the CRT moves to either side of the screen, to align itself with the illuminated scale.

The entire CALI-BRAIN action is automatic – and takes less than a second. After you have read waveform voltage on the scale, you deactivate CALI-BRAIN system with a single switch, and the waveform is again displayed as before. One probe and one test instrument – lets you concentrate on trouble shooting, not the test equipment!



1 2 3 4

To read peak-to-peak voltages utilizing Cali-Brain, note the full scale voltage reading in the bezel above the screen (fig. 1–.100 volts full scale) (fig. 3–5.00 volts full scale). Pull out the Cali-Brain knob and you will notice that the 1st waveform in fig. 2. reads .067 volts P-P and the second waveform in fig. 4. reads 4.95 volts P-P.

See your local distributor or write us for more information

B&K

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Circle 91 on reader service card