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USING OP-AMPS
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How they work

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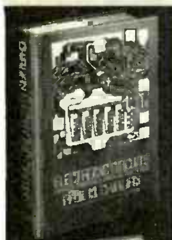

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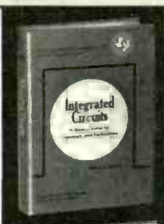

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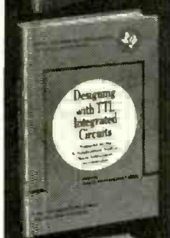

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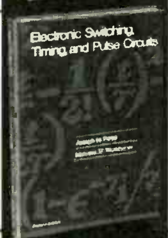

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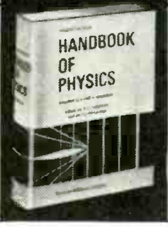

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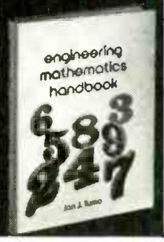

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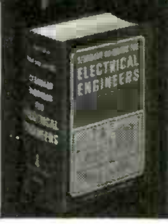

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New SONY ST-5130 FM Stereo/FM-AM Tuner

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Radio-Electronics

FOR MEN WITH IDEAS IN ELECTRONICS

June 1972

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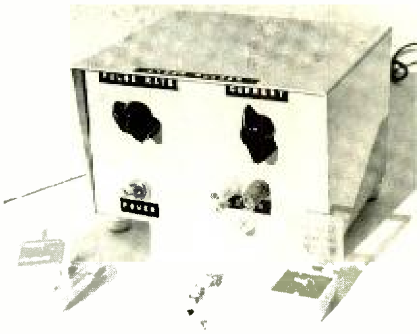
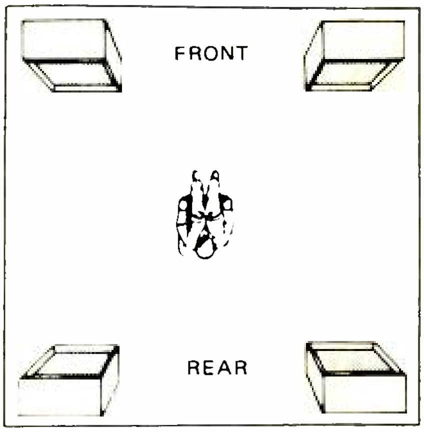


BUILD A $32 LASER? It can be done. You'll find complete construction details in this issue. . . .see page 44



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Cover photograph by Walter Herstatt
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looking ahead

4-channel broadcasting

The quadraphonic standards battle has prompted the Electronic Industries Association to start a study of the various proposals for four-channel FM broadcasting standards, with a view to making recommendations to the FCC. Several systems have already been proposed for transmitting discrete four-channel material. Many FM stations, however, are already transmitting four-channel matrix discs over the air. This requires no change in broadcast standards, and no special FCC permission. To receive a matrix broadcast in four channels, the listener merely uses the same decoder required for four-channel matrix discs. CBS says more than 100 FM stations have already requested SQ discs for broadcasting, and a large number of stations are also broadcasting the stereo-4 (Electro-Voice) system. Broadcasting discrete four-channel information, such as quadraphonic tapes or RCA records, would require special FCC rules. The EIA study is designed to determine whether such rules are needed and, if so, what is the best four-channel broadcast system.

Digit gadget

Unless you've lived in outer space for the last year or so, you've probably noticed that the biggest current radio craze is the digital clock radio. It's estimated that about 45% of the clock radios sold in the United States last year had digital readouts, rather than standard two-hand clock faces. This year, the majority of clock radios sold undoubtedly will be digital. And they generally cost more than their moon-faced counterparts. Long before they were called by their new name, "direct-reading" clocks were manufactured in the United States—since the early 1930's, using a simple, continuous-moving drum-type mechanism similar to that in an automobile odometer. The digital clock-radio, however, came into its own with the development of the so-called "flip-card," "leaf" or "page" mechanism made in Japan by a company called Copal.

Copal's grip on the digital-clock market was loosened last year by General Time Corporation, who offered radio manufacturers a new type of digital movement. This uses a backlighted Mylar tape, permitting bright lighting and easy visibility at night. Additional advantages claimed are numerals flush with the face of the radio, and absence of the "click" which some light sleepers find objectionable in flip-card clocks. But even the tape digital isn't the last word, apparently. Telechron is now offering radio manufacturers an "electronic"-appearing digital readout. It uses the principle of many electronic readouts—that is, each number element is composed of seven bars. But it works mechanically, rather than electronically. A series of cams and levers causes the unneeded bars to be blocked off and a light projects the rest onto a one-inch-high screen on the panel of the radio. You'll begin to see this new type of clock radio late this summer or early in fall.

What's next? Why the true electronic clock radio, of course. Some models are already on the market, but at very high prices because of the cost of the indicator devices. Radio manufacturers are carefully following the progress of liquid-crystal technology as the most promising source for a reasonably priced electronic clock readout. When liquid-crystal readout life expectancy is satisfactory, we'll likely see the debut of a clock radio with a completely electronic clock, using integrated circuitry for the clock movement. That is, unless somebody decides to introduce a marvelous new item called the "analog clock." This is a round disc with 12 numbers, a small hand to point to the hour and a larger hand for minutes. It permits you to tell the time without actually "reading" it, once you've got the knack of it. It could prove quite a novelty for some future generation.

4-channel discrete disc

RCA's first discrete quadraphonic LP album is scheduled for release at about the time you read this, and it will signal the start of an all-out four-channel record war with CBS, which is issuing records using its own four-channel SQ matrix system. RCA announced that it had perfected the CD-4 recording system developed by Victor Corporation of Japan (R-E, March 1972), which uses a 30-KHz carrier to convey the rear-channel signals. Like CBS's SQ system, the RCA method is compatible with regular stereo and monophonic record-playing equipment. But the RCA four-channel disc can't be played in four channels over SQ decoding systems, and SQ likewise can't play back four channels on RCA equipment.

RCA says it has overcome the drawbacks of the CD-4 system. A new record material containing a lubricator is claimed to double the life of the disc, RCA said tests showed that the new disc could be played 100 times with a low-priced stereo cartridge, showing no signs of wear to the high-frequency rear-channel carrier. Record masters will be cut at one-third normal speed to provide better definition for the high-frequency carrier. An improved demodulator, developed in Japan by Matsushita Electric (Panasonic), is claimed to eliminate the need for a special pickup cartridge, although such special cartridges will be recommended for use with top-quality audiophile equipment. The demodulator initially will cost about $80, roughly equivalent to top-quality SQ logic-type decoders. RCA's four-channel discs will sell at the same price as conventional two-channel stereo LPs, and the company says it hopes eventually to eliminate two-channel records entirely, since the four-channel disc is completely compatible. CBS's SQ records currently sell at a one-dollar premium. Playback equipment for the new disc will be made by RCA, JVC and Panasonic.

The videocard

A four-by-five card that can be inserted in a special videoplayer to give you 30 minutes of recorded color TV programming—that's the prospect posed by a new development of Digital Communications Corp., Encino, Cal., and Battelle Development Corp., Columbus, Ohio. The two companies are developing a prototype of the new video system that provides digitally encoded signals on photographic film.

A more conventional type of home video recorder-player has gone into production, meanwhile. Cartridge Television, Inc., is now delivering color video tape decks to Admiral, Teledyne Packard Bell and Warwick Electronics, that will be built into 25-inch color sets and marketed this fall under the brand names of Admiral, Packard Bell, Sears Roebuck, Emerson and DuMont. RCA has its own version of a home color video tape recorder, that probably will reach the market in 1973. **R-E**

by **DAVID LACHENBRUCH**
CONTRIBUTING EDITOR

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If you're the kind of guy who likes to devise his own equipment or the kind who appreciates clever mechanical design, then Mallory do-your-thing products are for you.

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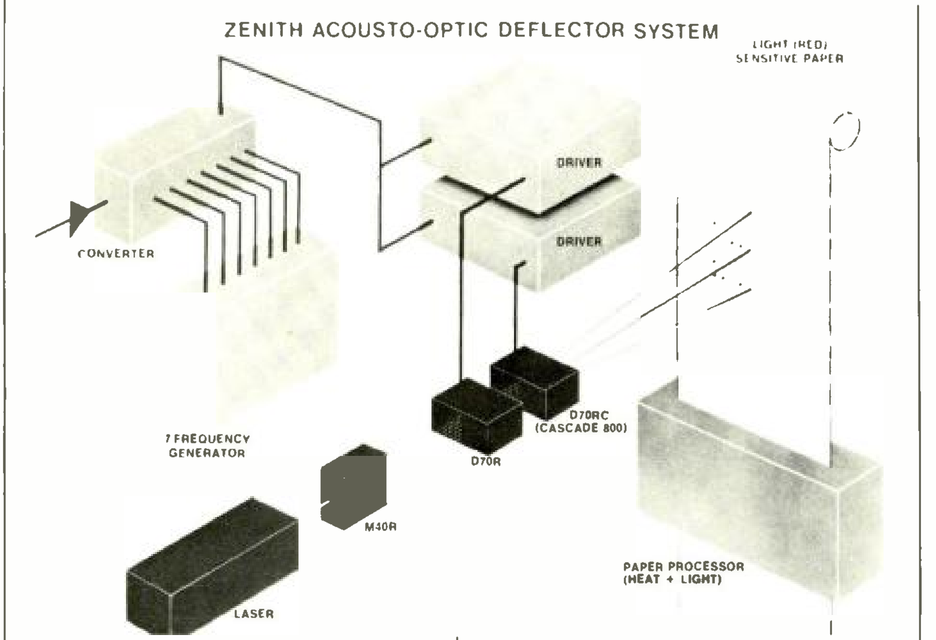
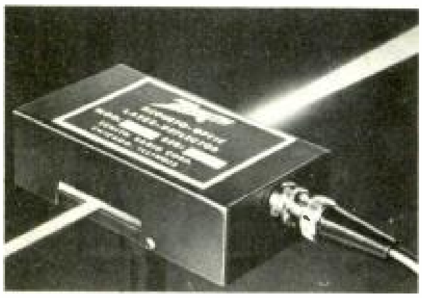


Laser deflector system

At the Electro-Optical Systems Designs Conference, Zenith Radio Research Corporation displayed a developmental news printer which is one version of an acousto-optic character generating system.

In this demonstration system, input signals from UPI (United Press International) newswire are converted into a code that is processed through a seven-frequency generator and fed into the Ze-



ZENITH'S *D-70R* ACOUSTO-OPTIC laser deflector shown with a simulated laser light beam.

nith *M-40R* modulator. This splits the laser beam into seven laser beams which are turned on and off as determined by the incoming newswire signal. In the *D-70R* laser deflector, the laser beams are made to scan, and in the *Cascade 800*, the resolution of the *D-70R* is doubled. The seven-beam fan is then scanned across a continuously moving roll of red-sensitive photographic paper, which feeds out of the news printer in just a few seconds, ready to read.

When discussing possible applications of the character generator, Dr. Robert Adler, Zenith vice president and director of research said, "This character generator could have important uses in any system of high-speed storage and retrieval of information." Additional uses of the system, which is capable of printout exceeding 100,000 characters per second, include direct printing of output of a computer on microfilm, laser beam communications, electronic typesetting, optical ranging, signal processing, and vibration analysis.

Microvolt electric signals from fishes

Dr. Eric G. Barham, marine biologist and oceanographer in the Marine Environment Division of the Naval Undersea Research and Development Center in San Diego, set out to conduct experiments duplicating the discovery of "novel" energy forms said to be produced by non-electric fishes. He used solid-state electronic components to sense signals generated by the small animals submerged in water.

"We have found many non-electric fishes generate extremely weak electric signals, of the order of one-tenth of a microvolt, that can be received remotely with electrode antennas and solid-state amplifiers," said Dr. Barham. His work indicates that the signals are not a novel energy form, but are extremely weak electrical impulses probably generated by the fishes' muscular contractions. The majority of similar signals picked up in large bodies of water are electrically-coupled components of ground currents and atmospheric noise originating from physical causes and are not generated by fishes.

Hugo Gernsback scholarship winner

Jerry E. Chamberlain, who is currently working as Federal Electric Corporation supervisor of communications sites in Thailand, has been selected by the Grantham School of Engineering to receive its Second Annual Hugo Gernsback Scholar-

ship Award. This $125.00 scholarship from **Radio-Electronics** is given each year to outstanding students at eight home-study schools of electronics.

Jerry joined the Navy in 1958, receiving training as an Aviation Electronics Technician and completing assignments in the United States and Spain. He was later employed by Philco Corporation as a bilingual technical representative instructing Spanish Air Force personnel on aircraft control. He went to Thailand with Philco in 1965 and subsequently began working for the Federal Electric Corp.

NEED A PICKPROOF LOCK

Try the electronic lock and key described on page 41 of this issue. The key is an IC mounted on a printed-circuit board; and the lock is just about tamperproof.

CATV venture

The Chromalloy American Corporation and the Laser Link Corporation have announced participation in a venture into the field of entertainment for CATV in

(continued on page 12)

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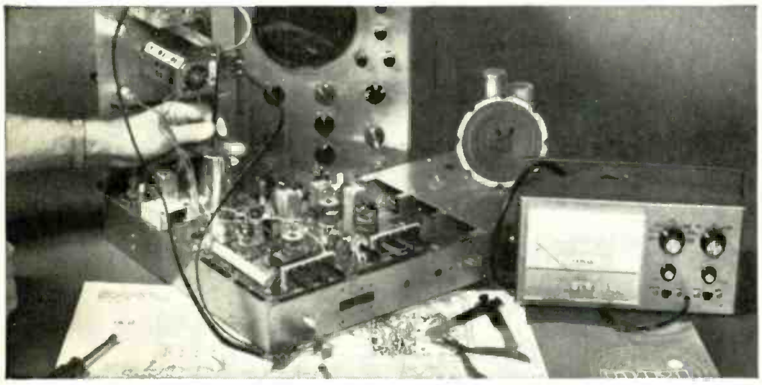

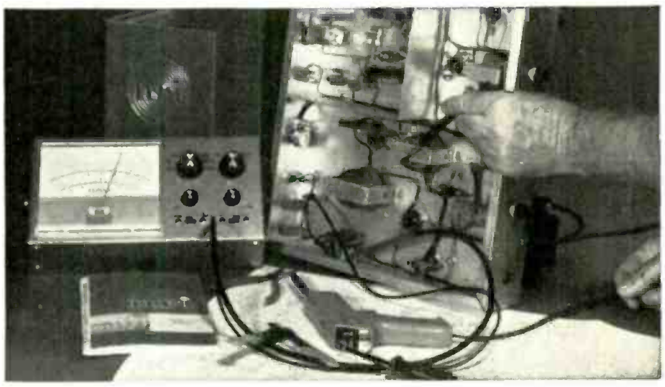

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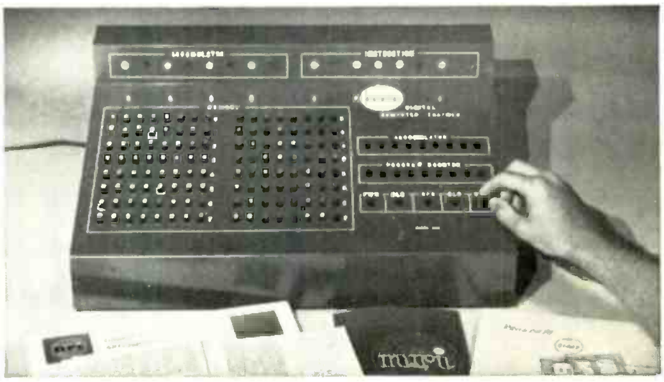

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new & timely

(continued from page 6)

homes, hotels, motels and hospitals, as well as for commercial VHF and UHF television stations. Their new company is TelePremiere International, and they call the proprietary system of TV exhibition TheatreVisioN Systems. Dore Schary, former vice president of MGM and RKO Pictures, is the president of TelePremiere International.

The telecast TheatreVisioN system will be submitted to the FCC to validate that it performs in accordance with FCC specifications for this type of service. "Negotiations are in progress with major cable systems operators, hotel chains and operators of hospital TV systems for the rights to TheatreVisioN Systems in the US and Canada," Mr. Schary disclosed.

Hologram-based security system

RCA Corporation has installed a lock-and-key system based on a laser-made hologram at its Zurich laboratory. The patented invention, called Hololock or Holocard, is designed to be used for admittance to restricted areas, as well as for credit card and other identification applications.

The hologram card contains a coded number and other information about the employee carrying it. When inserted into a slot in a special box at the laboratory's main entrance, the card's number is read

out by illumination with a standard light bulb. The number is then compared with a number punched into an associated keyboard by the employee. If the two match, the door unlocks for 90 seconds. The system also keeps track of the times each card is used.

(continued on page 14)

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new & timely *(continued from page 12)*

The hologram lock-and-key system offers a high degree of security because it cannot be altered, and highly specialized equipment is needed to produce the hologram.

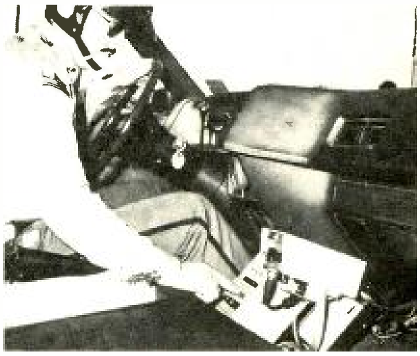
Competitive picture tubes

New color tube types, both large and small, are in the works from United States and Japanese manufacturers, to compete directly with Zenith's *Chromacolor* and Sony's *Trinitron*.

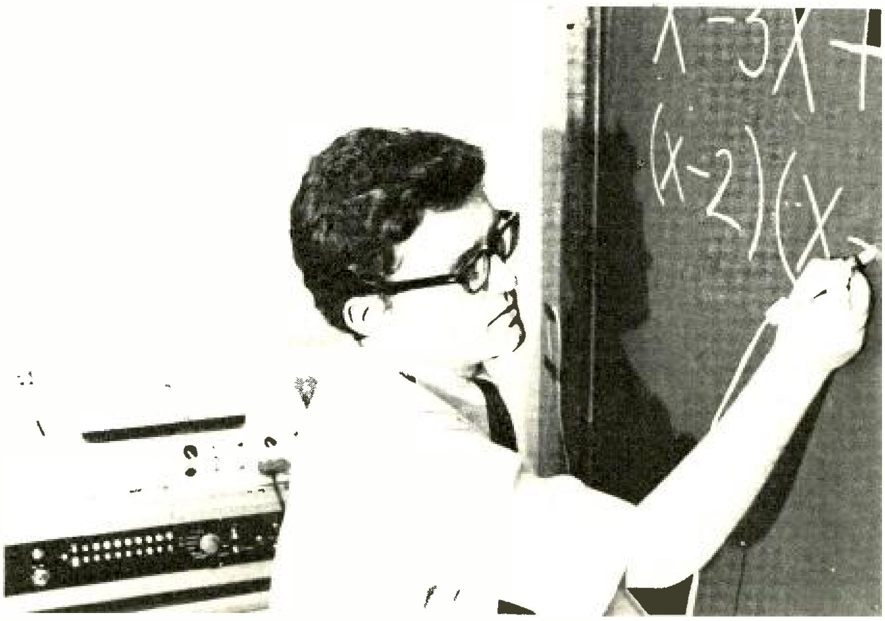
Both RCA and Sylvania are close to the sampling stage with "negative guard-band" tubes designed to deliver results similar to those of *Chromacolor*—higher brightness and better contrast. Westinghouse has also announced its *Lustrocolor Mark III* tube, another *Chromacolor* competitor.

RCA is also believed to be working on a "mini" series, probably in the new 15V" and 17V" sizes, that has some of the characteristics of Sony's *Trinitron*. The tube is said to use in-line electron guns (as opposed to triangular configuration) and a shadow-mask with elliptical, rather than round, holes. The end result is said to be greater brightness, sharper picture, and simpler chassis electronics.

Another competitor to *Trinitron* is Toshiba's *Linytron* tube, co-developed with Sharp and already featured in a Sharp television set. It has in-line guns, slit-type shadow-mask, and Toshiba announced the start of production on a 13V" version. Toshiba has also developed the *Briteron RIS* (for rectangular cone in-line gun/shadow mask). The new tube has an extremely rectangular funnel, and requires only a single horizontal output transistor.



New two-way radio digital-code system from RCA relays radio messages from a police patrol car to headquarters. The code units, integrated with the mobile radio system, can transmit up to 99 different number codes which substitute for routine voice messages. When the message is received the radio dispatcher pushes a button that automatically lights an "acknowledge" lamp in the vehicle.



AN EXPERIMENTAL SYSTEM ENCODES HANDWRITING motions on a writing surface into "bits" of information which are translated into ultrasonic pulses and then transmitted over ordinary telephone lines via the "remote blackboard" system. The handwriting appears at a distant location nearly as fast as it is written on the blackboard. Bell Laboratory engineers devised the system which can store recorded film for future viewing.

R-E

letters

PETER SCHEIBER COMMENTS ON QUADRAPHONICS

Dear Editor:

I read with great interest your excellent March, 1972 quadraphonic issue.

I'd like to point out one small thing in the table of matrix and discrete advantages and disadvantages: It was shown as an advantage of the discrete systems that their frequency range covered 30 to 20,000 Hz. In fact, it is the matrix, and not the discrete system that reproduces the full 20 to 20,000 Hz range. JVC-RCA Panasonic claim response up to 15,000 Hz. Response of the discrete disc must be cut off sharply above this point to avoid exceeding the bandwidth available in the multiplex process. Matrixing, however, imposes no bandwidth restriction on any of the four channels, and the matrix 4-channel disc does make it all the way out to 20,000 Hz. A fine point for purists, perhaps, but it is the matrixed, rather than the discrete disc which has the full 30 to 20,000 Hz response.

In an article about the CBS-Sony system, **Radio-Electronics** compared the results of this system with the discrete four channels, which you called, "the ultimate." Why is it that the discrete, rather than the matrix system is called, "the ultimate?" You'll answer, because the discrete system has full channel separation." So, if electrical separation figure is the sole criterion of four-channel performance, then you're right—discrete is the ultimate. But, what about the quadraphonic spatial effect—the capability of reproducing the acoustical space, or auditory environment of the original live performance?

I'll come back to that in a minute—Now let me ask this: What about the basic signal quality that we have come to expect from a modern stereo recording? What if we said, for instance, that signal-to-noise figure and inherent distortion were the basic criteria for judging a recording process—What system would come out "the ultimate?"

Japan Victor claims for its CD-4 disc a signal-to-noise ratio of "better than 50 dB." This is interesting, because that is not a very good s/n figure by modern recording standards. The reason is, in part, that modulation level on the multiplex discrete disc must be reduced below that of a normal stereo disc in order to make it possible to get the high-frequency sub-

(continued on page 22)

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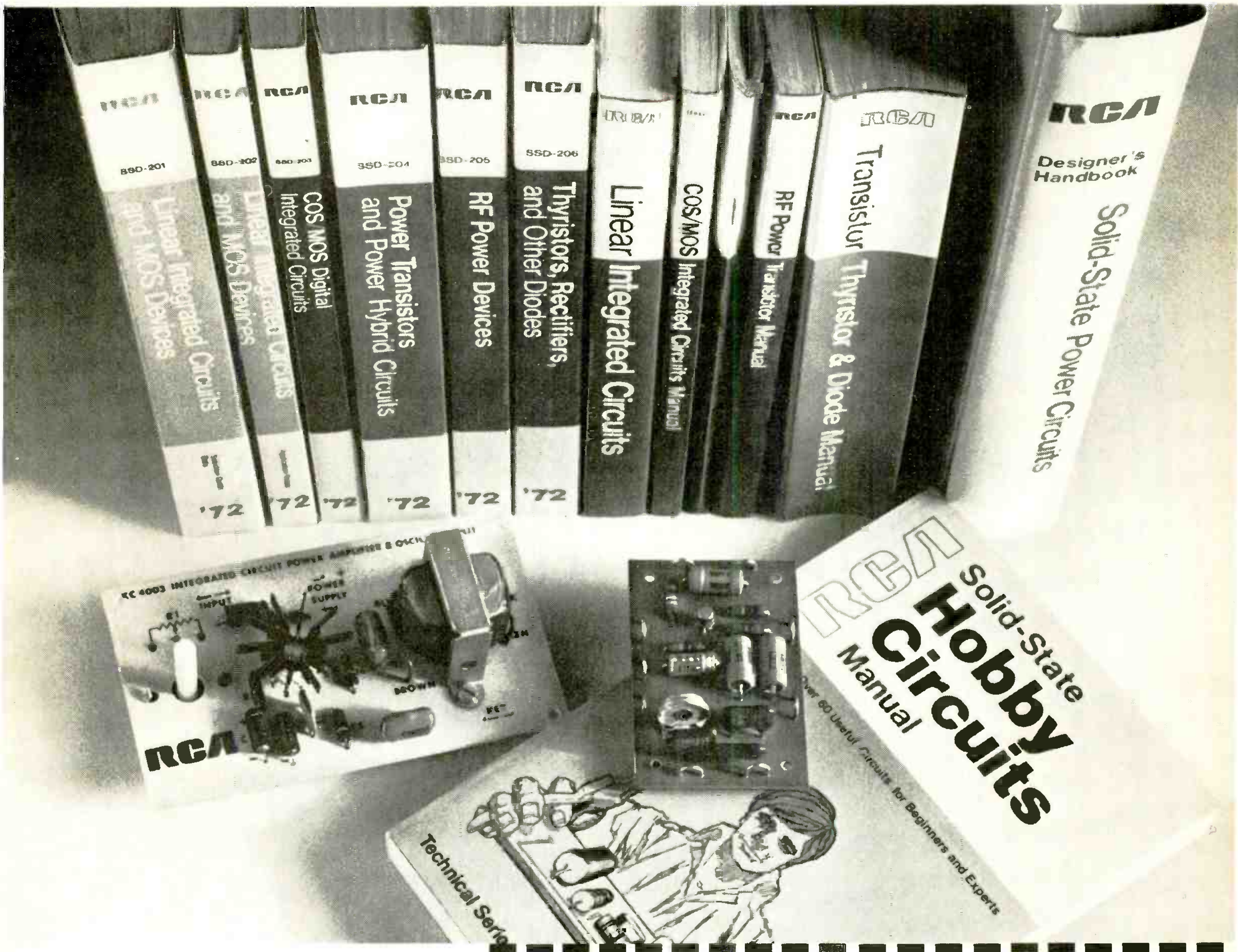

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LETTERS
(continued from page 16)

carrier together with the normal audio on the disc. This means that the discrete disc has its signal-to-noise ratio drastically reduced in comparison with the normal stereophonic, or the matrixed quadraphonic disc. How much is "drastically?"

In a paper given by John Eargle, then of RCA Records, at the 36th convention of the Audio-Engineering Society, it was shown that the stero disc is capable of better than 70 dB signal-to-noise ratio. The Electro-Voice, CBS, Sansui and other matrixed records contain no subcarriers, and are identical to normal stereo records in s/n—they are capable of better than 70 dB, rather than the 50 of the discrete record.

How important is this? If "sound reproduction" means, in fact, reproducing as nearly as possible the live event, what kind of dynamic range do we really need to do this effectively? Well, today's professional tape recorder, used in mastering all recordings on the market starts out with a signal-to-noise ratio of about 60 to 65 dB.

For recordings where quality is really important, the Dolby or other noise reduction system is used to effectively extend this by another 10 dB, resulting in a dramatic audible improvement. In other words, for *top quality* recordings, 60 dB or so is not considered quite good enough. Interestingly, then, given a good pressing, it is not the disc, but the *master tape recorder* which limits the recording's ultimate dynamic range.

A quality disc, then, stereo or matrix 4-channel, has at least 70 dB signal-to-noise. The discrete disc limits it to 50 dB. I think we should use great caution in describing as "the ultimate" a system which gives 20 dB less dynamic range than other systems. The astute reader will think of "Dolbyizing" the discrete disc; however, this applies just as well to the matrixed disc, which has a head start of 20 dB of dynamic range.

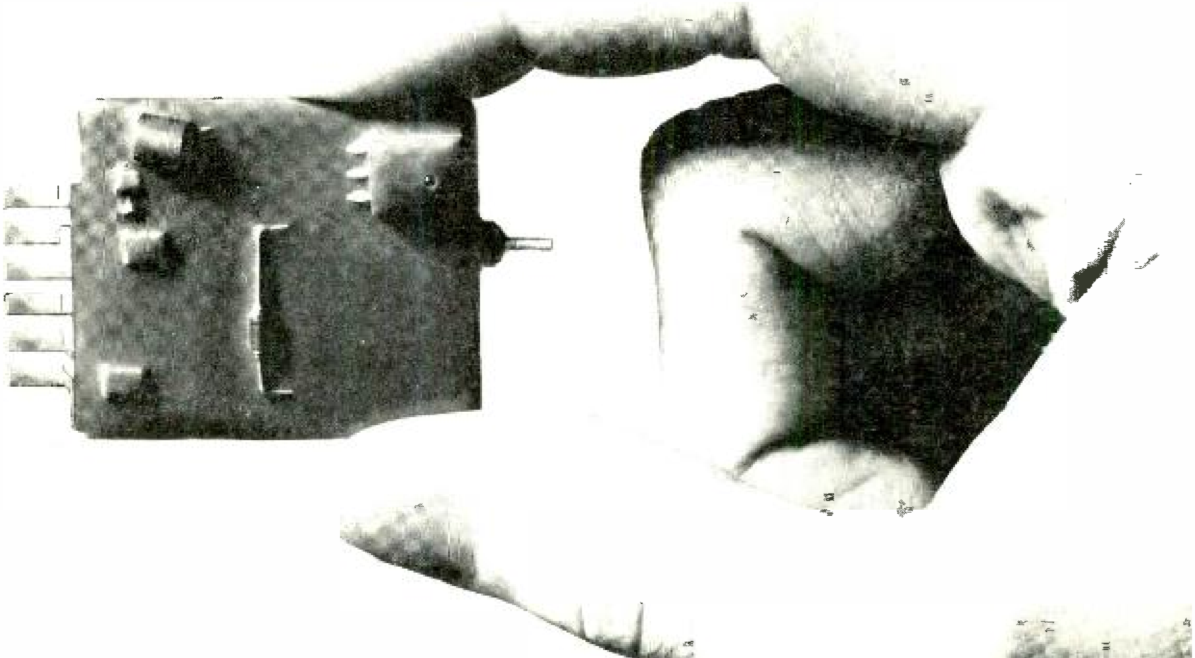
But, to return to the question of reproducing the acoustical space, or auditory environment of the original performance, consider this: The aim of "high fidelity" sound reproduction in its original sense is fidelity to *reality;* that is, to the *original sound* before it passed through the electronic gadgetry involved in its recording and reproduction. The ideal is that the equipment itself become less and less audible, or, we might say, more and more *transparent* so that, ideally, it is the original sound, rather than the equipment that we hear. That means that the loudspeakers themselves appear to vanish, and in the ultimate realism possible through quadraphonics, all sounds appear to come from their *original positions* around us, whether at the location of a loudspeaker, or *anywhere in between.* The claimed advantage of discrete systems is total separation between speakers. This means, if we break an orchestra into four discrete groups—four piles of musicians, one in each corner of the room, there will be absolutely no blending between the four isolated groups of instruments. This corresponds to nothing in real life—our awareness is of the four speakers, the equipment. Thus, the electronic gadgetry involved in sound reproduction is not, in this case, transparent, but rather the speakers themselves become the sound sources.

To get this effect, which is purely an electronic one, not strictly speaking a function of sound *reproduction* as we've defined it with the aim of making the gadgetry vanish—to achieve this, is it worth sacrificing the best state-of-the-art standards of signal quality, including dynamic range, frequency response, low distortion and peak level capability? All these signal quality considerations are handled with as good a quality as the best stereo recordings only in the *matrixed* disc.

Is it worth sacrificing the ability for practical quadraphonic broadcast, and playback on the vast majority of existing stereo equipment? These are possible only with the matrix recording.

Peter Scheiber
Advantage Sound Studios
New York, N. Y.

Why RCA XL-100's can be a quick fix:



RCA XL-100's are 100% solid state, with 12 plug-in, solid state AccuCircuit modules—like the ceramic kine drive amplifier you see above.

Since each of the 12 modules performs specific functions, diagnosis of the trouble is usually quick and easy. Most malfunctions can be fixed right in the home. That's bound to please your customer.

So when it comes to servicing RCA solid state color, XL-100's let you make more house calls—in a lot less time!

And you won't waste so much time hauling sets back and forth to the shop.

Something else: Whether you're servicing an XL-100 console, table model or portable, most modules are interchangeable, function for function. That will make your life easier, and you won't have to worry about stocking a large parts inventory.

RCA XL-100. It's already got a great reputation.
It could even add to yours.

RCA **XL-100**
100% Solid State AccuColor

Circle 11 on reader service card

appliance clinic

TVI FROM HOME APPLIANCES

by JACK DARR
SERVICE EDITOR

FORMULA FOR A DOMESTIC CATASTROPHE: Pop in living-room watching the evening news. Mom in kitchen decides to make up a batch of slaw in the blender. Or daughter decides to dry her hair with her new drier. Or son decides to finish *his* hair-do. Result: machinery starts, and there is a loud roar from the alleged head of the family: "Turn that thing off! it's tearin' up my TV!"

In other words, one of these useful household gadgets has decided to become a miniature broadcasting station, radiating assorted rf interference like mad. (TVI, for short.) Let's see what to do about it, to restore peace to the home.

Practically all appliances that cause TVI use small, high-torque "brush-type" motors. A few use "buzzer-type" contacts. Either of these cause tiny arcs, and the resulting hash contains noise components in every common frequency-band—AM, FM, TV, you name it.

There are two ways of reducing or eliminating this noise. The first is to reduce the amplitude of the arcing at brushes or contacts. Clean up the commutator, if it is dark and pitted. Check the brushes for length: if they're worn so that the springs do not have enough tension to hold them tightly against the commutator, the arcing is much worse. The end of a good brush is smooth and shiny.

A commutator can be cleaned, if you can get at it, by cutting a thin strip of fine sandpaper, wrapping it over the end of a small stick, and holding it against the commutator while it's running. **DON'T use emery-cloth.** The abrasive material is conductive, and will get into the motor. For most small motors, the standard "nail-boards" (sandpaper coating on stiff cardboard, available in the manicure section of drugstores) are very handy. They can be cut into thin strips, small enough to get into even very small commutators. Check to see that the brushes are not sticking in their holders and be sure that the springs have enough tension. If brushes bounce, this makes the arcing worse. If you can't reduce the arcing, and you see the "ring of fire" all the way around the commutator as it runs, the armature is apt to be defective. The only cure is to replace the motor.

The second method is filtering. This means providing an easy path for the noise to get to ground, or keep it inside the case of the unit. Fig. 1 shows

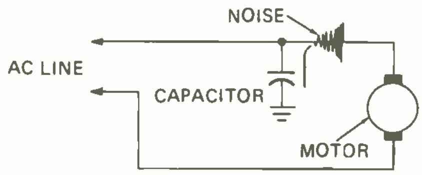


Fig. 1

the general idea. This noise is mostly very high frequency hash. We make use of the basic property of a capacitor—it will pass ac but block dc, and low frequencies. So we connect a bypass capacitor from the noise-source to a ground. This provides a very low-impedance path for the *noise*, but has no perceptible effect on the 60-Hz ac line voltage.

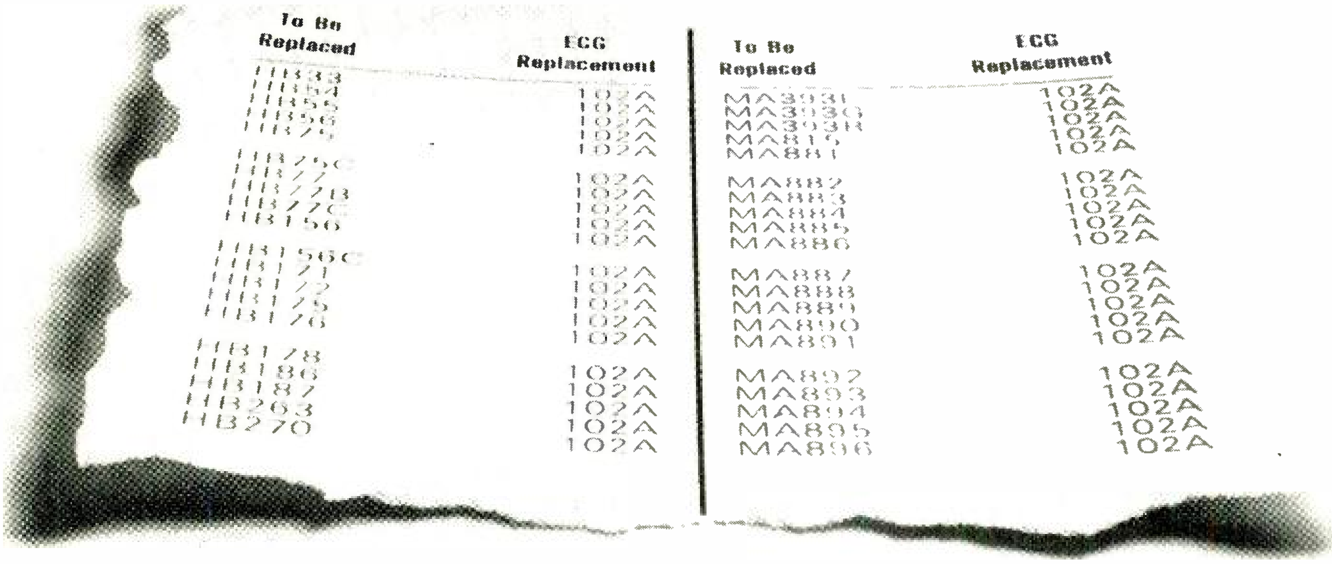
In older appliances, with metal cases, the filter capacitor can be connected from the brush to the frame of the motor. One capacitor should be connected from each brush to the frame. If the unit has one of the 3-wire line cords, with the separate external ground lead (the green one), filters could be connected from the brush to this wire, which is an external ground.

In the bigger units, space won't be too much of a problem. You'll be able to put the filter capacitors on the end of the motor, and tuck them away tightly. In some of the more compact types, with plastic cases, you won't have too much room. However, you can get disc capacitors now up to 0.05-μF, that are small enough to tuck away inside of the smaller ones. Be sure to insulate the leads well. Use a good grade of braid or glass fiber spaghetti (**NOT a thermoplastic tubing**, that will melt if the case gets too hot!)

For 117-volt circuits, use capacitors with a minimum voltage rating of 200 volts. 600-volt types are better if you can get them in. For subminiature types, using dc motors and low voltages,

(continued on page 94)

Our ECG 102A transistor replaces...



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HB55	102A	MA393R	102A
HB56	102A	MA815	102A
HB75	102A	MA881	102A
HB75C	102A	MA882	102A
HB77	102A	MA883	102A
HB77B	102A	MA884	102A
HB77C	102A	MA885	102A
HB156	102A	MA886	102A
HB156C	102A	MA887	102A
HB171	102A	MA888	102A
HB172	102A	MA889	102A
HB175	102A	MA890	102A
HB176	102A	MA891	102A
HB178	102A	MA892	102A
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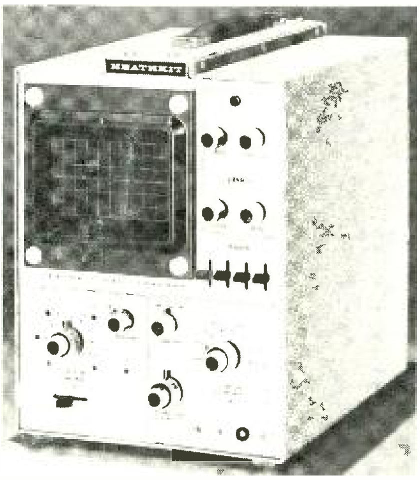
equipment report

Heathkit IO-103 Triggered-sweep scope



Circle 100 on reader service card

THE HEATH COMPANY HAS INTRODUCED a variety of new oscilloscopes in the last year. The IO-103 Triggered Sweep Scope is the latest addition. Priced with the service scopes, its impressive specifications make it equally useful for lab work.

The vertical amplifier has a response from dc to 10 MHz, with a rise time of less than 50 ns, and a calibrated, compensated vertical attenuator, so you can read the important peak-to-peak voltage of any waveform at a glance. A continuously variable vertical gain control lets you adjust the waveform height if needed. To return to the CAL(ibrated) setting, just turn this fully clockwise.

Horizontal sweep has a sensitivity of 0.25 V/cm, and a step switch for selecting any sweep-speed from 100 ms/cm to 100 ns/cm. The HORIZONTAL control also has a variable section, for adjusting the display so that you can see as many cycles as you want.

Most useful of all, the IO-103 has a full triggered sweep. For those who have never used one, it enables instant locking of any pattern you want to see. This can speed up servicing considerably. For example, setting the horizontal sweep to the 10-μs/cm position, you'll see 1.5 lines of horizontal sweep from the TV set, locked firmly in place. The only requirement is that you have a signal on the vertical input that will give you a minimum of 1.0 cm height on the screen.

This has two positions, AUTO and NORM(al). The sweep is triggered in both positions. Setting to AUTO locks the pattern automatically. In NORM, you can adjust both trigger level and stability of the pattern. Switches allow selecting either + or – going parts of the waveform, ac or dc triggering, as well as INTERNAL or EXTERNAL triggering. (Incidentally, I treated myself to an exhibition of this feature, while checking out the IO-103 on a small stereo amplifier, with a test tape. The tape had an audio sweep signal, continuously varying from 8500 to 40 Hz. I was watching the output for distortion, and all of a sudden it dawned on me that this scope was staying *locked* to this constantly-varying signal! Fascinated, I ran it again; it did.)

Input empedance of the vertical amplifier is 1 megohm shunted by 30 pF, very close to a standard. A 10:1 low-capacitance probe is available, with a trimmer to compensate for cable capacity, etc. The input can be either ac or dc, selected by a switch.

Set alongside my old 5-inchers, the IO-103 looks small! It doesn't take up nearly as much room on the bench, although it has much more than twice the number of stages and functions. I tried to count the number of transistors in it, and gave up! FET's are used in the vertical input, for high impedance, and in the horizontal sync. An IC works in the trigger stages.

The IO-103 can be used with sweep generators, for alignment work. Just turn the TIME/CM switch to EXT IN. The variable horizontal sweep control then becomes a plain horizontal gain control.

For viewing different parts of a waveform, there is a 2X MULTIPLIER control, on the horizontal position control. Just pull out on the knob, and the waveform doubles in horizontal size, while remaining firmly locked.

This is a superior service instrument. The tremendous bandwidth of the vertical amplifiers will show you details of waveforms that simply aren't visible on many older scopes, and the triggered sweep will pin 'em down while you look! **R-E**

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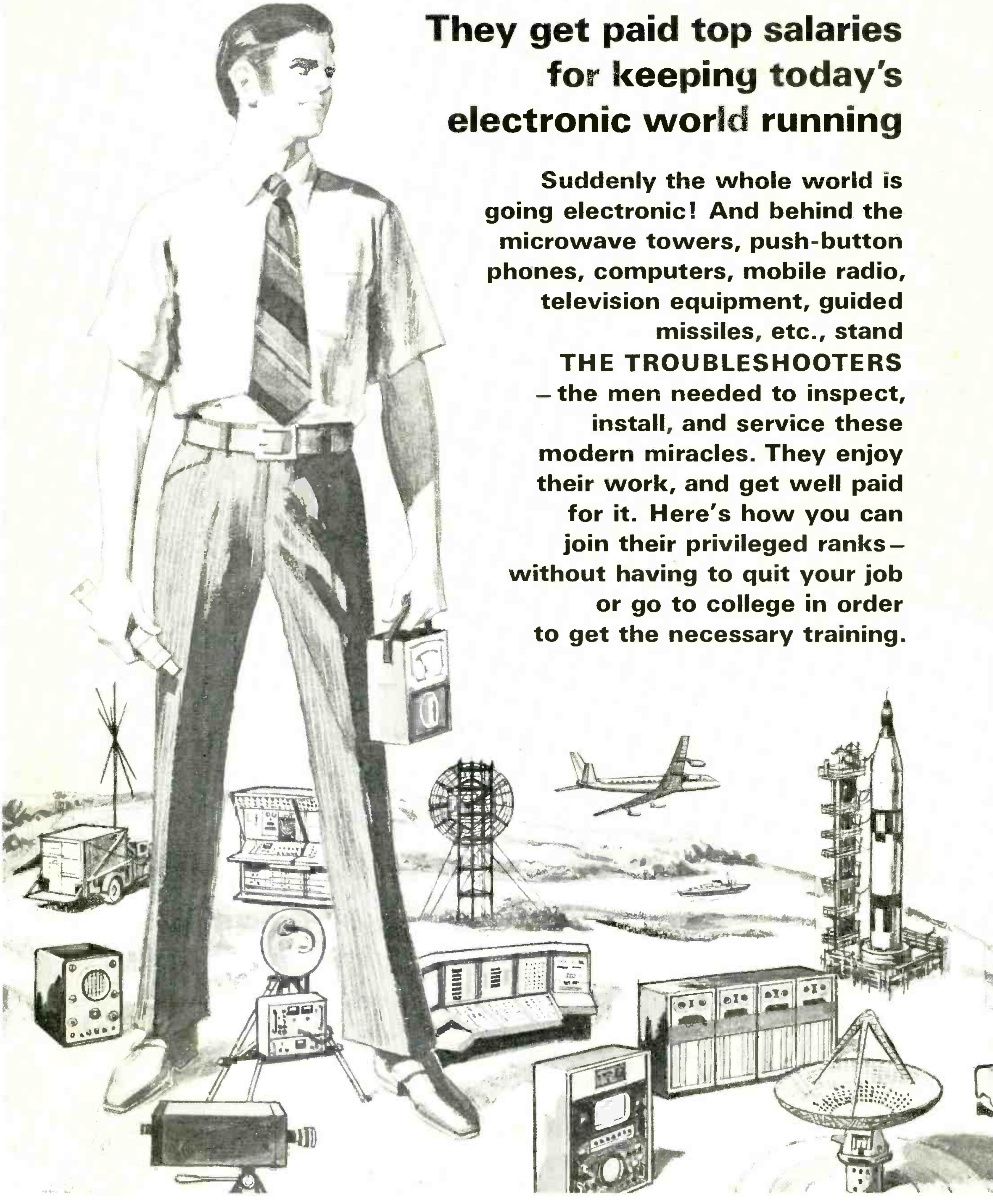

Just think how much in demand you would be if you could prevent a TV station from going off the air by repairing a transmitter . . . keep a whole assembly line moving by fixing automated production controls . . . prevent a bank, an airline, or your government from making serious mistakes by servicing 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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What do you need to break into the ranks of The Troubleshooters? You might think you need a college degree, but you don't. What you need is know-how—the kind a good TV service technician has—only lots more.

Learn at Home . . . In Your Spare Time

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

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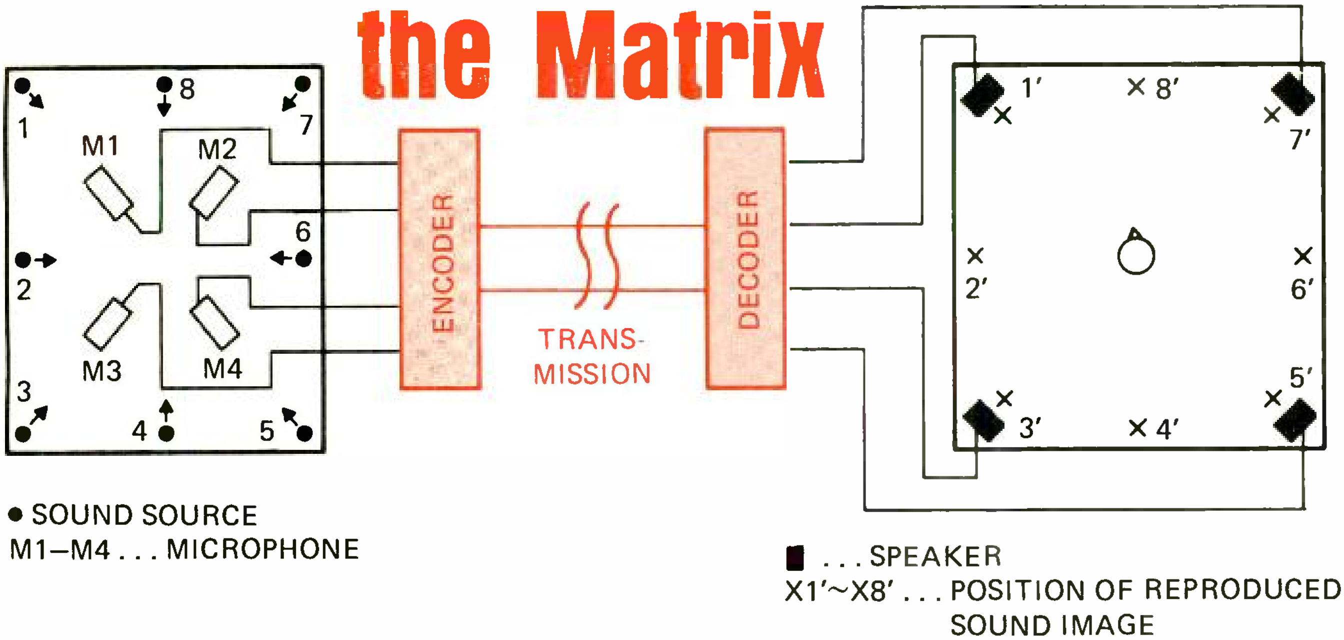
Circle 15 on reader service card

the Matrix



and 4-Channel stereo

by JOE SHANE

The Sansui matrix makes it possible to put four-channels of information on any two-channel medium. Here's the story that tells how this and other matrix systems work

SEVERAL DIFFERENT MATRIX SYSTEMS are in use today to make it possible to take four-channel sound, combine it onto a two-channel medium—records or FM stereo—and play it back as four channels. This is called 4-2-4 coding. Such systems have been announced by several manufacturers. These include the CBS SQ, Electro-Voice, Pioneer and Sansui QS. This article will show in detail how the Sansui matrix operates. At the same time it outlines the basic principles of all matrix systems used for four-channel reproduction.

Suppose that there are eight sound sources in a live sound field. Then suppose four microphones are picking up the direct and indirect sounds. Such a coding system, then, involves encoding the four channels of signal picked up into two channels through a matrix encoder, transmitting them to the desired place, processing them through a matrix decoder for conversion back to four channels and finally projecting the resulting sound waves from four speaker systems into a common space to realize a sound-field effect (see Fig. 1 above).

To put this simply, it is a technique to encode sound images and the concurrent effect of indirect sounds in the live sound field into two channels on the recording end, and then converting these two channels back to four channels on the receiving end to recreate the original sound images and accompanying acoustic effect.

The conventional two-channel stereo system only provides a mixture of the sense of sound movements along the line connecting the two speaker systems. In contrast, a coding system allows two channels of signals to provide an approximate sense of sound movements in full 360-degree circle. In a live sound field, however, sound information arrives from a three-dimensional space, and we would need a system of three-dimensional coding to recreate such a sound field in its truly original state. Unfortunately, present technology only provides for two-dimensional coding through the use of two channels.

Encoding and decoding

By encoding, we mean lending certain phase differences to among four or more channels of information and then reducing them to two channels that can be reconverted to the original number of channels. By decoding, we mean restoring the encoded signals to the original number of channels.

The two processes can be explained with simple mathematical equations. If we call the left-front channel LF, the right-front channel RF, the left-rear channel LR, and the right-rear channel RR; these four channels of signal can be encoded into two channels—one left and one right by the circuit shown in Fig. 2 through these equations:
A sample of encoding equations (encoder outputs):

$$\left.\begin{aligned} L &= LF + \Delta RF + LR - \Delta RR \\ R &= RF + \Delta LF + RR - \Delta LR \end{aligned}\right\} \quad \text{......(1)}$$

When fed to a decoding matrix, these two-channels of signal are converted to four signals to produce sound images as shown in the diagram of Fig. 3.

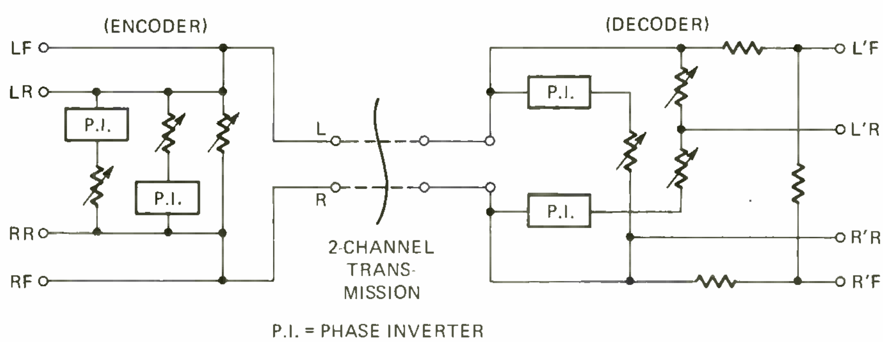


FIG. 2—BLOCK DIAGRAM of a typical coding matrix circuit.

$$
\left.\begin{aligned}
L'F &= L + \Delta R = LF(1+\Delta^2) + RF(2\Delta) + LR(1-\Delta^2)\\
R'F &= R + \Delta L = RF(1+\Delta^2) + LF(2\Delta) + RR(1-\Delta^2)\\
L'R &= L - \Delta R = LR(1+\Delta^2) - RR(2\Delta) + LF(1-\Delta^2)\\
R'R &= R - \Delta L = RR(1+\Delta^2) - LR(2\Delta) + RF(1-\Delta^2)
\end{aligned}\right\} \quad (2)
$$

There is one serious pitfall to watch out for here. In equations (1), (three other types of equations are possible to achieve encoding, but they are all basically identical), if LR = RR = 1.

$$
\left.\begin{aligned}
L &= LF + \Delta RF + LR - \Delta RR = LF + \Delta RF + (1-\Delta)\\
R &= RF + \Delta LF + RR - \Delta LR = RF + \Delta LF + (1-\Delta)
\end{aligned}\right\} \quad (1')
$$

As the reverse-phase components are cancelled inside the encoder, the resulting left and right-channel signals only contain four-channel signals that are in phase. This means that the rear-channel sound components would shift toward LF and RF in the decoder outputs. This is an undesirable deviation resulting from the encoding. It should also be clear from the same equations that the same undesirable phenomenon occurs if signals of identical strength and phase are fed to LF, RF, LR, and RR simultaneously. It seems that many four-channel encoders cannot avoid this serious defect.

Furthermore, equations (2) demonstrate that LR′ and RR′ are in completely reverse phase with each other. This means that any musical instruments located in the rear in a four-channel program source would sound unnatural and unclear as would any reverse-phase signals. A new technique is needed to overcome these defects.

QS coding system

The QS coding system is a four-channel coding system developed by Sansui. A block diagram of this system is shown in Fig. 4.

On the encoder side, note that the 180-degree phase-inverting circuit usually used to produce reverse-phase components is no longer employed. Instead channels LR and RR are phase shifted by +90 degrees and -90 degrees respectively, to get a 180-degree reverse-phase relationship between them.

This puts the four encoded channels in an ideal phase relationship as shown in Fig. 5-a. Signals are no longer cancelled inside the encoder, and any information from anywhere in the original sound field can be faithfully encoded.

On the decoder side, channels LR and RR are phase-shifted in a manner contrary to the encoder; namely, channel LR by -90 degrees and channel RR by plus 90 degrees to place the matrixed reversed-phase signals in the two rear channels in-phase with each other as in Fig. 5-b.

Thus, the Sansui coding process is expressed by these equations.
Encoder outputs are:

$$
\left.\begin{aligned}
L &= LF + \Delta RF + LR(\angle +90^\circ) + \Delta RR(\angle +90^\circ)\\
R &+ RF + \Delta LF - RR(\angle -90^\circ) - \Delta LR(\angle -90^\circ)
\end{aligned}\right\} \quad \ldots\ldots(3)
$$

Decoder outputs are:

$$
\left.\begin{aligned}
L'F &= L + \Delta R\\
&= LF(1+\Delta^2) + RF(2\Delta) + LR(1-\Delta^2)(\angle +90)\\
R'F &= R + \Delta L\\
&= RF(1+\Delta^2) + LF(2\Delta) + RR(1 = \Delta^2)(\angle -90^\circ)\\
L'R &= (L - \Delta R)(\angle -90^\circ)\\
&= LR(1+\Delta^2) + RR(2\Delta) + FL(1-\Delta^2)(\angle -90)\\
R'R &= (R - \Delta L)(\angle +90^\circ)\\
&= RR(1+\Delta^2) + LR(2\Delta) + FR(1-\Delta^2)(\angle +90)
\end{aligned}\right\} \quad (4)
$$

Advantages of QS coding

The advantages of the QS coding system based on the Sansui 90-degree phase shifting are:

1. It permits all present two-channel recording and reproducing media to continue to be used.

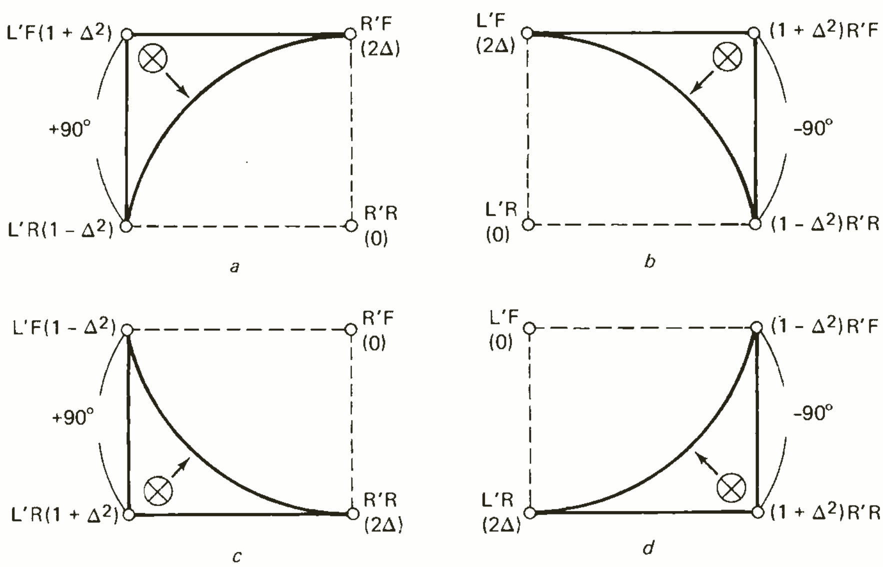


FIG. 3—SOUND-IMAGE POSITIONS in the four channels when a matrix is used.

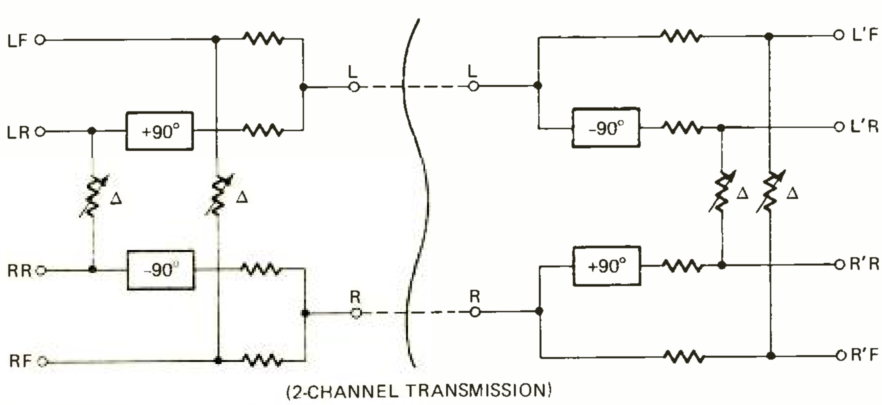


FIG. 4—BLOCK DIAGRAM showing Sansui QS-coding matrix system.

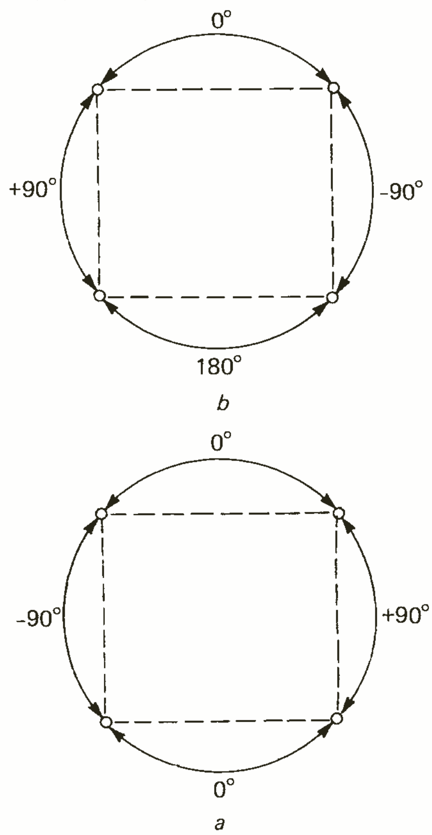


FIG. 5—PHASE RELATIONSHIPS among the four channels when the matrix is used. a—Encoder output. b—Decoder output.

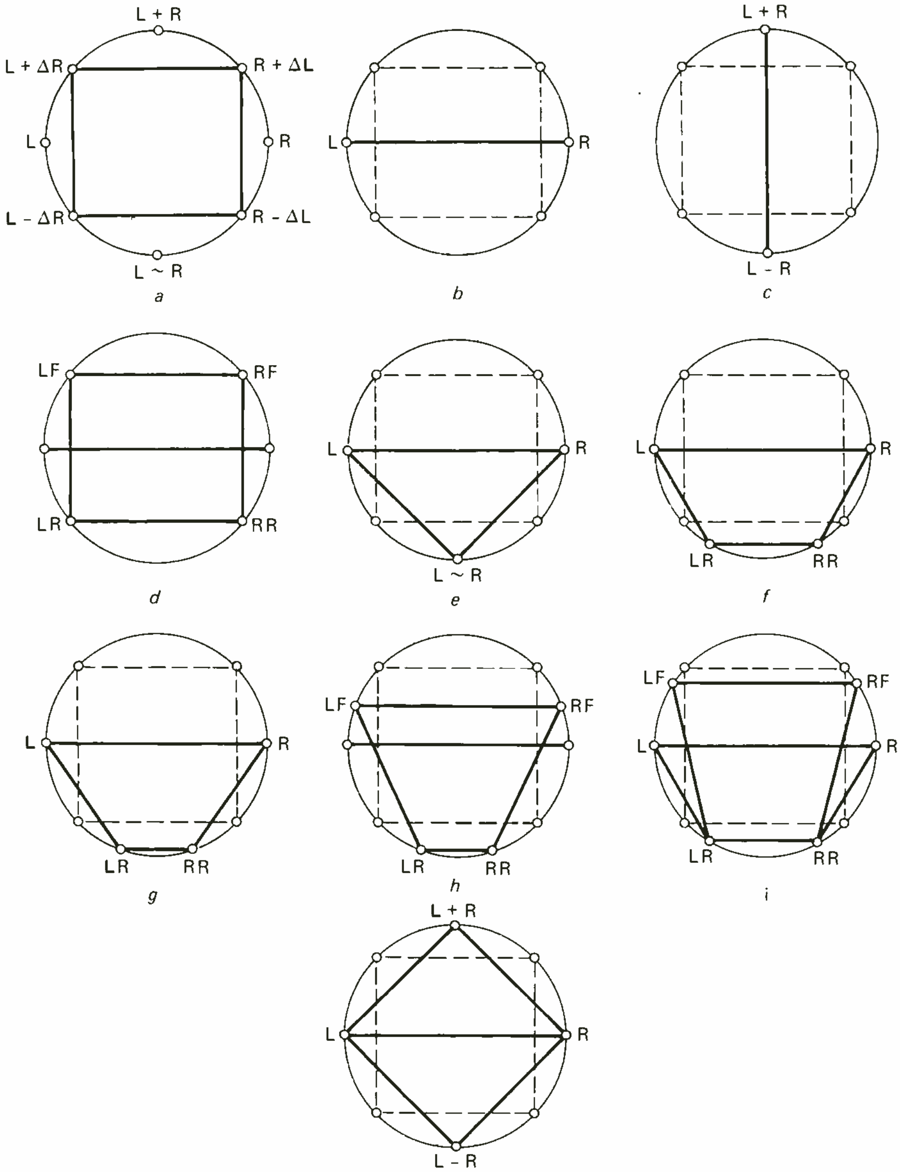


FIG. 6—VALUES APPLIED TO DECODERS of various manufacturers. a—Basic pattern ($0 \leq \Delta \leq 1$). b—When $\Delta = 0$: conventional two-channel stereo. c—When $\Delta = 1$: mono image of direct sound at front center and mono indirect sounds at rear center. d—$\Delta = 0.414$ as used in Sansui, and Scheiber systems. e—front $\Delta = 0$, rear $\Delta = 1$. f—front $\Delta = 0$, rear $\Delta = 0.5$; Dynaco II system, g—front $\Delta = 0$, rear $\Delta = 0.717$. h—front $\Delta = 0.18$, rear $\Delta = 0.7$; Electro-Voice system. i—front $\Delta = 0$ or 0.4 (selectable), rear $\Delta = 0.5$. j—front $\Delta = 1$, rear $\Delta = 0$; Dynaco system or speaker matrix.

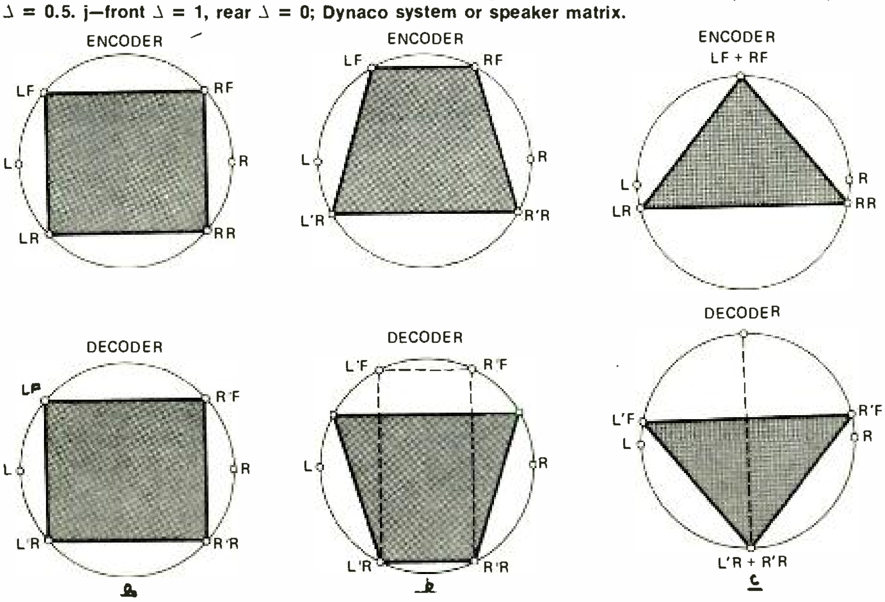


FIG. 8—SIGNIFICANCE OF VALUE. a—$\Delta = 0.414$. b—front $0<\Delta<0.414$, rear $1>\Delta>0.414$. c—front $0<\Delta<0.414$, rear $\Delta = 1$.

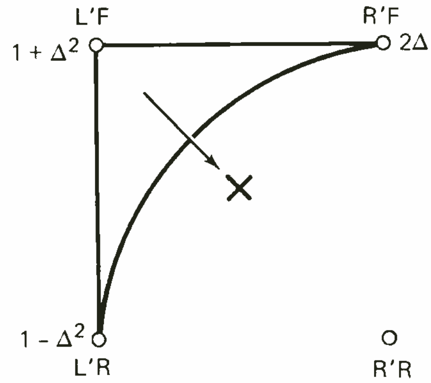


FIG. 7—QUANTITY OF LEFT-FRONT (LF) signal blended in three channels.

2. It overcomes what was previously considered an essential weakness of all matrix systems—the deviation and loss of sound images in their coding process.

3. It does not impair the original sound volume or tonal quality and is completely compatible with two-channel stereo and mono.

How to select the value of Δ

The value of Δ now varies from one manufacturer to another and represents the major difference between coding systems. Sansui's analysis of them is shown in Fig. 6. As shown it is set at 0.414 in the Sansui system. This delivers several important results.

If a 1-volt signal is fed to LF, the final decoder outputs in the four channels are:

$$L'F = (1 + \Delta^2) \times 1V = 1.1713V$$

$$R'F = 2\Delta \times 1V = 0.828V$$

$$L'R = (1 - \Delta^2) \times 1V = 0.828V$$

$$R'R = 0V$$

The signal fed to LF is thus accurately positioned in the direction of LF' (see Fig. 7), clearly demonstrating that 0.414 is a value that enables the decoder to reproduce a precisely square sound field with idential separation between adjacent channels.

If the value of Δ is greater than 0.414, the signal ordinarily produced in channel LF would be heard to the right of its original position; and if smaller, to the left of its original position.

When determining the value of Δ, it is imperative that is it kept identical in both the encoder and decoder to lend correct directions of sounds. Figure 8 illustrates how Δ values of the encoder and decoder have to be set. However, Fig. 8 is the only way to get uniform separation between the front and rear, left and right channels. **R-E**

speaker setups for 4-channel stereo listening

ONE OF THE FIRST QUESTIONS ASKED by the proud owner of a new 4-channel stereo system is, "Where should I put the speakers?"

There is no easy answer to this basic query. The problem is that there are several different speaker setups that can be used. Some, it is true, are tied to a specific 4-channel system, but many of them can be used with almost any system with equal success.

The only way to determine the arrangement that is best for you is to try them all, and then use the one that provides the results you find most listenable in your home.

Eight different speaker setups are illustrated on this page. Let's examine them one at a time.

(a) This is perhaps the most conventional 4-channel speaker setup and it is used by many manufacturers.

(b) Here is a variation of the setup shown in **(a)**. It has the advantage of reducing the apparent level of the rear speakers. However, it does have a drawback. If the signals coming from the rear speakers are 180° out-of-phase they will cancel, and therefore can cause problems with some matrix systems.

(c) Here's a good compromise between the setups of **(a)** and **(b)**. It has the advantages of both arrangements yet reduces the signal cancellation.

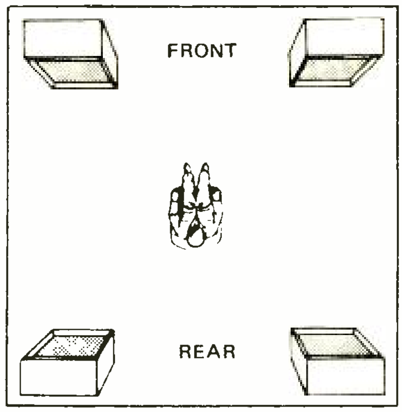
(d) Another variant that works well. The main problem here is that the listening area is restricted to a small section in the middle of the room.

(e) In an ambience-retrieval system, (speaker matrix a-la-Dynaco) this is an excellent speaker arrangement. It places the listener out in the audience with the performers in front of him.

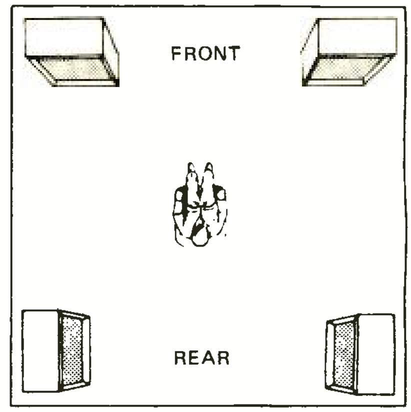
(f) and **(g)** Are two approaches that seem to work best when listening to concerts. Both arrangements tend to give the orchestra depth, yet they permit the listener to sit in the audience rather than in the middle of the orchestra.

(h) This is the speaker system setup that was recommended for use by Dynaco with their first ambience-retrieval system. It is not practical to use with any matrix system because with this system there is no right-front or right-rear or left-front or left-rear.

When using 4-channel increased spacing between the speakers seems to enhance the performance of the system. Don't be distressed if you've got a large room, want to put the speakers in the corners, but feel that they are too far apart. Instead, try it out. The results might be surprising. **R-E**



a



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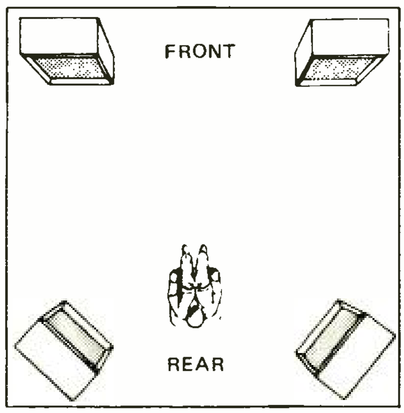

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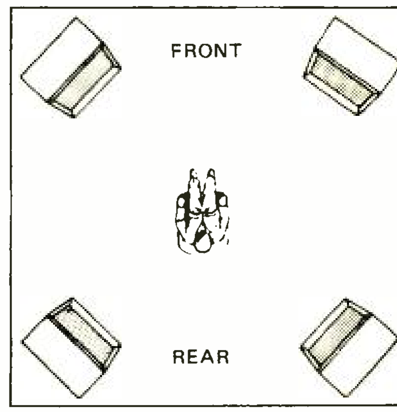

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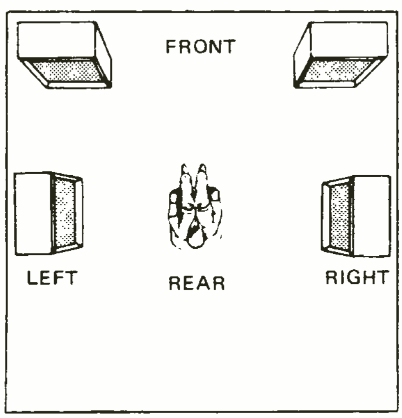

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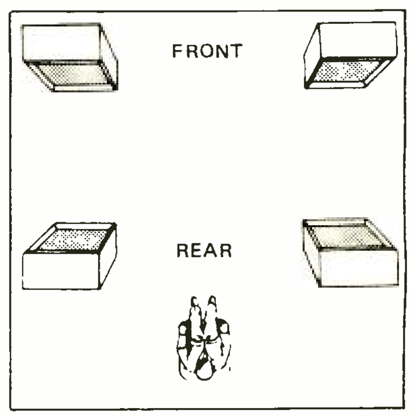

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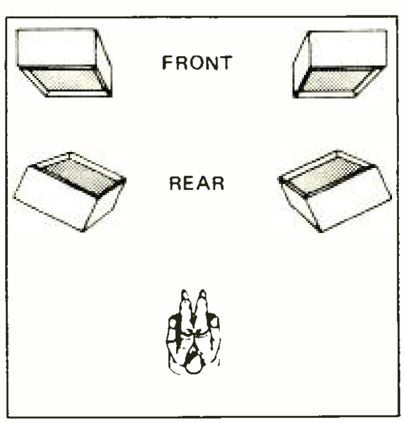

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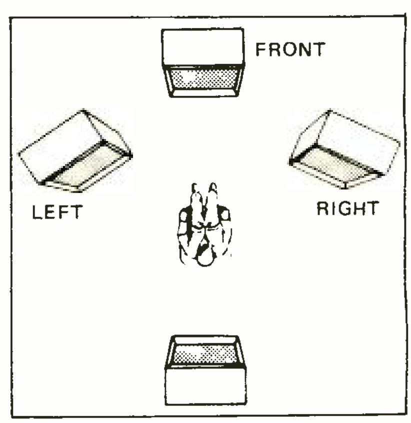


h

ELECTRONICS OUTDOORS
CB-Marine-Stereo

As Americans move outdoors a lot of electronic equipment goes outdoors with them. They use CB radios, play stereo tape decks, put radar in their boats, burglar alarms in their cars. Where people go, electronics goes too

by LEO G. SANDS

MORE THAN EVER BEFORE, ELECTRONICS plays a big role outdoors for communications, security and entertainment. Thousands of motorists use CB radio daily to get route information, make hotel, motel and trailer parking space reservations, and to call for assistance. They play stereo tape cartridges or cassettes while driving. And, when they leave their cars, many take their portable television sets, radios and tape players with them.

Boat owners use CB or vhf/FM marine radios for safety communications, and electronic depth sounders as a navigational aid and to find fish, as well as radio direction finders. Owners of larger boats also use radar and/or loran for piloting. And, while their occupants are enjoying the outdoors, homes are protected by electronic security systems.

This ever-widening use of electronics outdoors means more business for those who sell, install and service these electronic devices. It also means that electronics technicians must learn about these devices and, in many cases, need new test equipment to service them properly. In addition to servicing portable and mobile electronic equipment, there is a growing need for technicians to service equipment at fixed locations, such as roadside call boxes, intrusion alarms and CCTV systems including those using cameras that operate at extremely low light levels.

One out of every 55 cars is already equipped with a CB transceiver, according to a General Motors Research Labs engineer, and it is anticipated that many more will be equipped this summer. A CB transceiver in a car can be used to communicate with other cars (mobile units) and CB base stations at police barracks, gas stations, garages, homes and other fixed locations.

Nearly all mobile CB transceivers are fully solid-state and operate only from a 12-volt vehicular electrical system. Owners of cars with 6-volt electrical systems can now get a solid-state voltage converter that makes it possible to use a 12-volt mobile unit. Most CB units are factory-equipped with crystals for 23-channel operation. While the majority of CB transceivers are AM-only types, several SSB units are now on the market. They can be operated in either the AM or SSB mode.

To extend communicating range, countless CBers (Citizens band operators) buy more efficient antennas. They also buy ignition noise suppression kits to reduce noise to a tolerable level.

Since only very few CBers are legally-qualified to service their own equipment, they must look to a pro to match their transceivers to the antenna system and to keep them operating.

Those motorists who need a telephone while on the road have installed or plan to install a "mobile telephone" so they can have MTS, IMTS or RCC service. An MTS (mobile telephone service) or IMTS (improved mobile telephone service) unit is used to obtain telephone service through the base station of an independent common carrier (not a telephone company). Both types can be used in populated areas anywhere in the country. Both consist of an FM transmitter-receiver, a control head and an antenna system, and are available for the 150-174 MHz or 450-470 MHz band. The equipment can be owned or leased by the user.

SERVICE-STATION ATTENDANT uses a CB radio to communicate with stranded motorists.

In addition, many motorists are installing scanner-type FM communications monitor receivers to tune in radio transmissions of police and fire departments as well as to National Weather Service broadcasts on 162.40 or 162.55 MHz. Such receivers are available in single-band 30-50 MHz, 150-174 MHz or 450-470 MHz) or dual-band types. These receivers automatically scan several channels and lock in on an active channel.

In some parts of the U.S. and Europe, emergency call boxes are located at frequent intervals alongside principal highways. Some are connected to a road service center through wire lines, but most contain a radio transmitter-receiver. The call boxes being installed in West Germany by Standard Electric Lorenz (ITT) have an automatic lockout circuit that prevents a call box from transmitting when the radio channel is in use.

Communications on the water

Until CB transceivers became available, boats operated on inland waters, Great Lakes and major rivers, could not use two-way radio for safety and navigations communications because there was no one to talk to. Now, according to an FCC official, some 300,000 boats carry CB transceivers. A CB radio on board won't provide direct contact with the Coast Guard, but the user can summon aid through another CB station and can also communicate directly with other boats and, if the distance is not too great, with home.

Installing a CB set on a boat is different from installing one in a car. Obviously, a 12-volt dc power source is required, and so is an antenna system. But, an automotive type CB antenna can't be used unless it is mounted on a metal deck or a metal screen or plate attached to a wood or fiber glass deck. A special marine-type CB antenna, that does not require a ground plane, is normally used.

Radio transmission range over water is considerably greater than over land in either the Citizens (27-MHz) band or the vhf marine (156-162 MHz) band. The more affluent boat owner will install a vhf marine radio in addition to, or in lieu of a CB transceiver. It makes it possible for the boat owner to communicate directly with the Coast Guard (when within range), other boats and with Limited Coast Stations at locks, dams, waterway control points, yacht clubs and marinas. It can also be used for telephone service through Public Coast Stations.

Since the FCC has banned the installation of new AM marine radios that operate in the 2-3 MHz band, there are many new FM marine radios for the vhf marine band available. These radiotelephones are designed to operate on six or more channels and most can also receive one of the National Weather Service channels.

Communicating range is limited mainly by the height of the antenna above the water. The antenna may be a ground-plane type with a radiator and ground radials about 18 inches long. A coaxial antenna or ⅝-wave antenna, that has no horizontal elements, is generally preferred and is usually mounted on the mast as high above the water as practical to deliver maximum range.

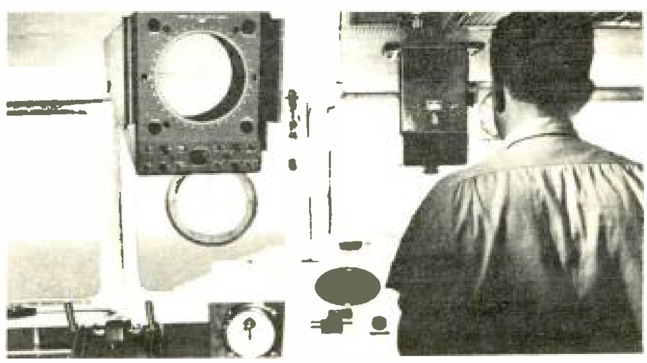
Navigating and piloting

Even the smallest boats can be equipped with an electronic depth sounder that indicates the depth of the water. The more sensitive types also indicate the presence of fish and their distance below the hull. A depth sounder can

DIGITAL DEPTH SOUNDER is a handy accessory for anyone's boat. Unit shown is Heathkit model MI-101.

be used for navigating when water depth charts are available.

Although once considered a luxury, marine radar has become an essential piloting tool on boats that must operate when visibility is poor. Many can be powered by a 12-volt



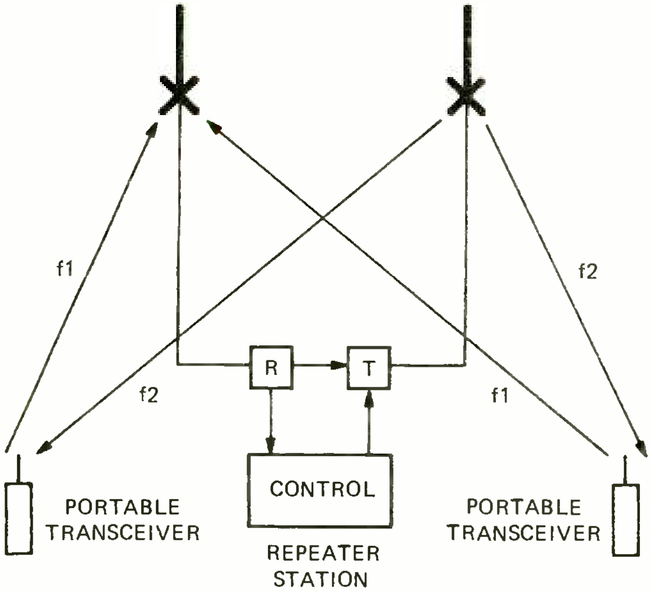
A MARINE RADAR ON BOARD enables the skipper to pilot his vessel safely even when visibility is zero.

electrical system. In addition to electric power, a basic requirement is space for the rotating radar antenna.

Communications on foot

Millions of AM walkie-talkies are sold each year. Most of them are of the Part 15 type, and may be operated without an FCC license on any frequency within the 27-MHz Citizens band, and whose transmitter power input is less than 100 milliwatts. Range is usually less than a mile. When not licensed, they *may not* be used legally to communicate with *licensed* stations. Greater range can be obtained with an AM CB walkie-talkie, that must be licensed, whose transmitter power input can be as high as 5 watts.

More expensive are the Class A (450-470 MHz) CB walkie-talkies that employ FM. They work well inside of buildings and are free from skip interference from distant stations. They are used to communicate with similar portable



MOBILE RELAY SYSTEM RANGE IS INCREASED BECAUSE OF THE HIGH EFFECTIVE ELEVATION OF THE REPEATER STATION ANTENNA.

MOBILE RADIO SYSTEM RANGE can be easily increased if a repeater station can be located to extend reception area. Effectively, point-to-point range is doubled.

units as well as Class A mobile units and base stations. When used in a *mobile relay system,* the range can be many miles.

People who need to be contacted when on foot can subscribe to a radio paging service. The subscriber buys or rents a pocket-size radio paging receiver. Ordinarily, it is left turned

BOY SCOUTS OFTEN CONDUCT training sessions in the use of CB radio transceivers.

on, but is silent until it intercepts an appropriately coded radio signal. Then it issues a beep sound that alerts the wearer to call a pre-arranged office by telephone or to take some specific action. Some paging receivers also receive a spoken message after being alerted by a coded radio signal.

Entertainment

The 8-track cartridge-type auto stereo system is getting heavy competition from auto stereo systems that play tape cassettes. The type selected usually depends on whether cartridges or cassettes are used at home so the same tapes can be played at home or in the car. Most auto stereo systems currently operate as two-channel stereo gear, but some four-

CASSETTE CAR TAPE PLAYER is combined with FM radio in this Bell & Howell add on. Car tape players are very popular now.

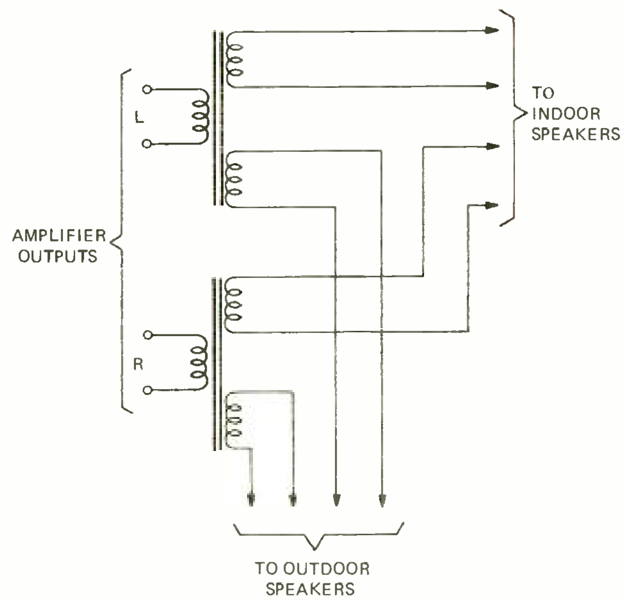
channel equipment is available and more is on the way. Auto stereo systems are used on boats too. However, the tape player must be installed where it won't get wet.

Boat owners are also installing battery-operated television receivers on their boats. The antenna is the main problem unless reception with a built-in monopole or pair of rabbit ears is adequate. Special marine-type television antennas are available; they resemble the limousine TV antennas that look like antlers.

And, of course, there are numerous hand-carried portable radio receivers and tape players that can be used on boats and almost anywhere.

Outdoor stereo

The home stereo system can be wired to extension speakers that are set up outdoors to provide music on the patio or in the yard. The extension speakers should be built for out-



CONNECTIONS FOR INDOOR AND OUTDOOR SPEAKERS THROUGH MIX-N-MATCH TRANSFORMERS

WHEN STEREO SYSTEMS MOVE OUTDOORS some new wiring becomes a must. Here's one method commonly used.

door use if they are installed where they can get wet. There are alternative ways of hooking them up. They can be connected through a multi-pole switch that transfers the outputs from the indoor speakers to the outdoor speakers. Or, they can be connected through a pair of Mix-n-Match transformers (Alco Products) so both sets of speakers operate simultaneously. This type of transformer matches an 8-ohm amplifier to two 8-ohm speakers. The insertion loss is somewhat greater than 3 dB since amplifier power is equally distributed to the two speakers.

Electronic security systems

There are two security problem areas—the vacant home when the occupants are away, and the car, mobile home, or vacation cottage.

Many homes are protected by a central station alarm service company that receives a signal when an unauthorized intrusion or fire takes place. A sensor is tripped, or a metallic loop circuit is opened, shorted or grounded: causing a signal to be transmitted to the central station. Other home protection systems energize a local alarm which, hopefully, someone will notice and call the police.

Cars are often protected by a security system that sounds the horn when a door is opened. The driver closes a fender-

CAR BURGLAR ALARMS are being installed in ever-increasing numbers. This Horn-type system is made by Universal Security.

mounted lock switch when leaving the car. When returning to the car, the driver uses a key to disable the alarm so the car can be entered without actuating the horn. The same kind of system can be used to protect an unoccupied motor home, camper or cottage.

More sophisticated security systems for use when a cottage or home is occupied uses one or more low-light CCTV cameras that can produce a useful image even when existing light is provided by the moon or stars.

A vehicle moving into a driveway or near the home—or away from the home—can be sensed by an overhead radar vehicle detector or a buried magnetic loop detector. Movements of persons within a protected area can be sensed by a radar, ultrasonic or infrared detectors.

While it might seem expensive to install such security equipment, it is often cheaper than paying burglary insurance premiums. In some areas, such as New York City, burglary insurance is extremely expensive, and is not available at all in some neighborhoods.

A burgeoning market

The development of the transistor and the subsequent development of equipment that could be operated for long intervals from self-contained batteries and vehicular electrical systems has led to growing use of electronic equipment outdoors without relying on electric power lines. And it's only

POCKET-SIZE radio-paging receiver is activated by a coded radio signal, and then reproduces a voice message.

the beginning. More and more electronic equipment is being developed for use outdoors to meet the demands of the public on the move.

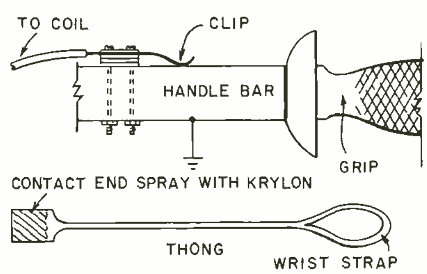
Clark Quinn of General Motors Research Labs, in a report to the Highway Research Board, said that motorists now make 4,000,000 emergency calls annually with CB radios, and that new CB transceivers are being installed at the rate of 40,000 per month. Sales of portable and mobile tape players are soaring and the electronic security system business is just off the take-off platform. **R-E**

safety switch for bikes

A safety switch for mini-bikes was described in "Noteworthy Circuits" in the October 1970 issue. A much simpler switch can be constructed using a technique used by motorcycle hill climbers.

On the right handlebar near the throttle grip, mount an insulated spring clip which becomes the hot side of a normally closed switch. This is connected to the ignition coil by a length of test lead. The spring clip contacts the handlebar, thus shorting out the coil.

To operate the bike, a dielectric must be inserted between the clip and the handlebar. This insulator consists of a leather thong with one end stiffened by spraying with Krylon and the other formed into a loop to fit around the rider's wrist. If the rider is thrown from the bike, the engine is instantly killed when the thong is pulled from between

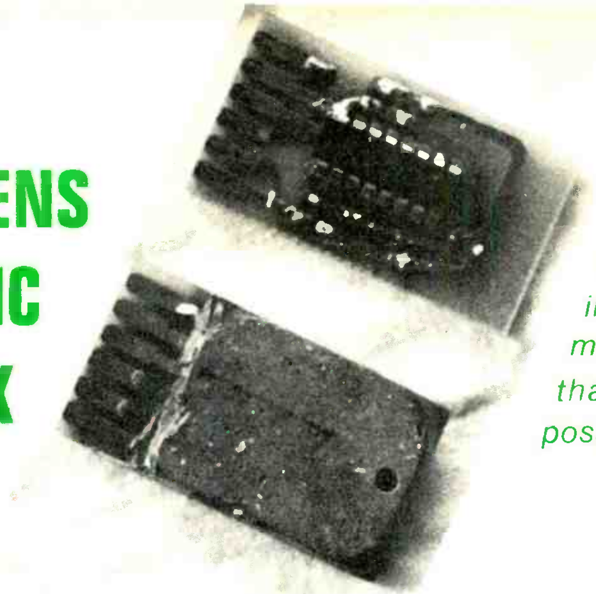


the switch contacts.

In practice, I have used contacts from a heavy-duty relay for the switch contact. The thong should be made just heavy enough to operate without breaking.—*John Garboury*

"Herbert! Can't you forget for just two weeks that you're a TV repairman?"

IC KEY OPENS ELECTRONIC DOOR LOCK



Pickproof lock can only be opened by an integrated circuit that makes an active key that is just about impossible to duplicate.

by J.B. WICKLUND

THE RAPID INCREASE IN CASES OF theft and burglary in this country indicates the need for a lock that cannot be "picked." Modern electronics can provide such a lock. One form of electronic lock would use a "key" capable of storing a binary code, and a lock that could be programmed to read and recognize the correct code.

A binary code is nothing more than a series of 1's and 0's called bits. If two bits are used, there are four possible codes (00, 01, 10 and 11). With sixteen bits, there are 65,536 possible combinations. Availability of low-cost digital computer type IC's makes a digital lock practical.

The feasibility of such a lock can be demonstrated by the construction of an eight-bit lock and key set. The lock is built with inexpensive TTL logic modules and is battery powered.

Principles of operation

The key is very simple and consists of a small eight-bit code stored in its memory. When inserted into the lock, its code is read and the lock responds with a positive output signal when the key has the correct code. *The eight-bit code is chosen at the time of construction and wired into the lock and key.*

The key is constructed with an eight-bit data selector that has eight inputs and one output, with three control lines to control its operation. The data selector acts like an eight-position switch, with the output connected to one of the inputs, where the three control lines electronically operate the switch. The eight-bit code can be stored by wiring the eight inputs to ground or +5 volts for zero and one respectively.

A schematic diagram of the lock and key is shown in Figs. 3 and 4, respectively, on the next page.

A square-wave oscillator is built with IC9 and drives IC8 which is a decade counter. The decade counter counts these pulses from zero through nine and then starts over. The counter output is connected to the three control lines of the key, and as the counter goes from zero through seven, the eight bits of data stored in the *key* are read by the *lock*. The eight bits are stored in a shift-register memory made up of IC2, IC3, IC4 and IC5. After the eighth bit is read and stored, the eight-bit code is decoded by IC1 and if the correct code is present, the output flip-flop (IC6) will be set. When the key is removed or an incorrect code is read, the flip-flop is reset again.

The output flip-flop drives Q2 and Q3 which can be used to drive a relay or solenoid or door opener. The TTL in-

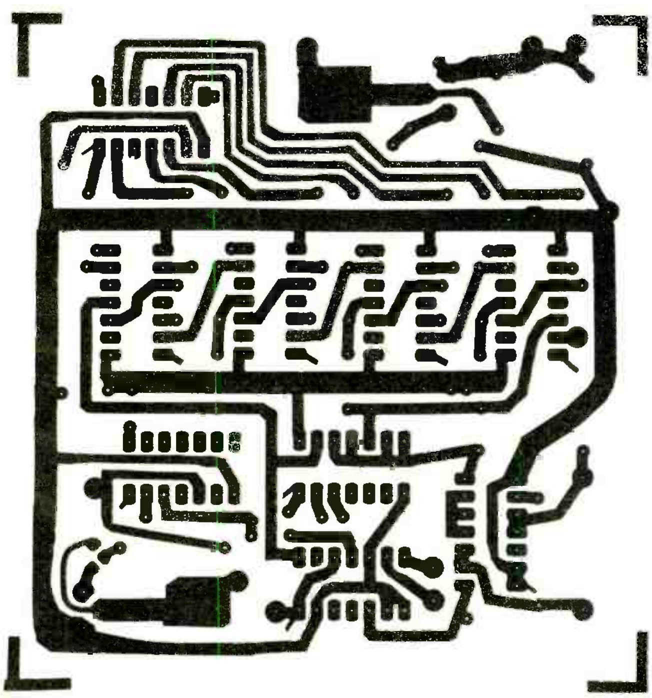


FIG. 1—FOIL PATTERN for the electronic lock. The board measures 3½ x 3¾ inches. Parts are positioned and mounted as in Fig. 2

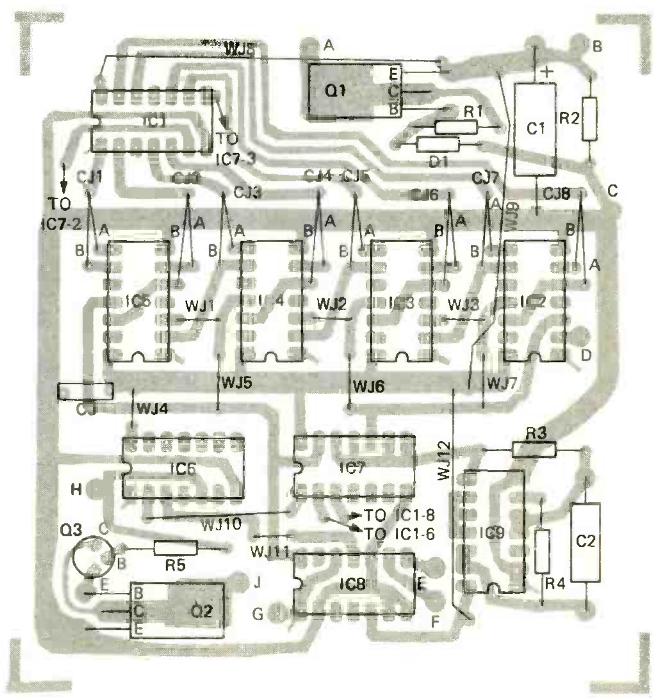
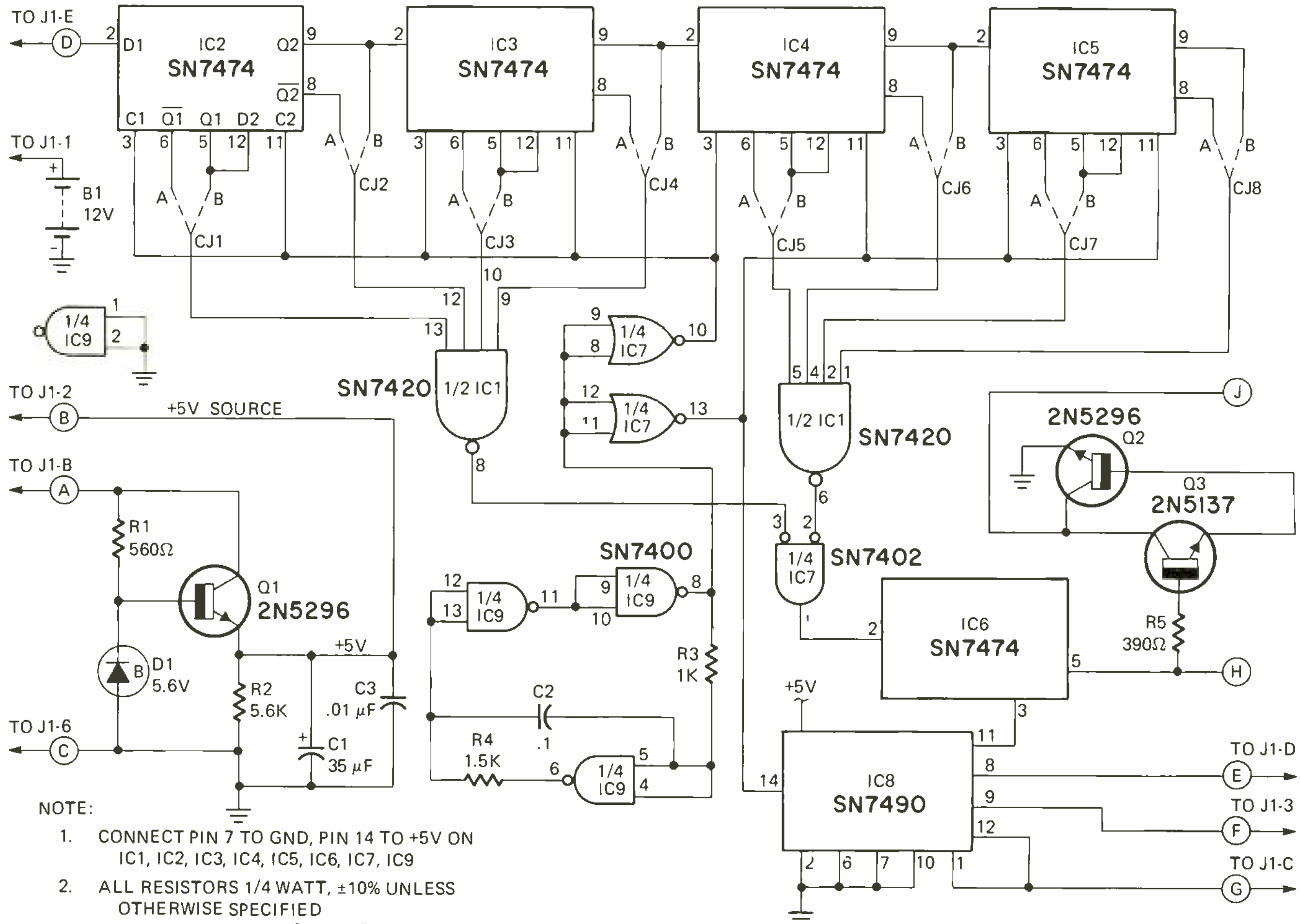


FIG. 2—WHERE LOCK PARTS ARE LOCATED. Jumpers CJ2-A, CJ2-B, etc) set digital code used to insure secrecy and fool-proof operation.



NOTE:

1. CONNECT PIN 7 TO GND, PIN 14 TO +5V ON IC1, IC2, IC3, IC4, IC5, IC6, IC7, IC9
2. ALL RESISTORS 1/4 WATT, ±10% UNLESS OTHERWISE SPECIFIED
3. CIRCLED LETTERS (Ⓐ, Ⓑ etc.) CORRESPOND TO POINTS ON P-C BOARD.

FIG. 3—THE ELECTRONIC LOCK uses digital logic circuitry and digital IC's for its foolproof operation. Digital code wired into key is read by the lock and must be correct before the circuit will operate and release the mechanism.

PARTS LIST

R1—560 ohms, ¼ watt
R2—5,600 ohms, ¼ watt
R3—1000 ohms ¼ watt
R4—1500 ohms ¼ watt
R5—390 ohms ¼ watt
IC1—SN7420N
IC2, IC3, IC4, IC5, IC6—SN7474N
IC7—SN7402N
IC8—SN7490N
IC9—SN7400N
D1—5.6V ± 5% Zener diode 1N752A
D2—1A, 1N4003 (see Fig. 7)
Q1, Q2—2N5296
Q3—2N5137
C1—35μF/6 Vdc (Sprague TE-1093 or equal)
C2—.1μF Mylar (Sprague 225P10491 or equal)
C3—.01μF disc ceramic
J1—Connector (Elco 00-6007-012-980-00 or equal)
B1—12V (2 Eveready 510S or equal)
FOR KEY:
IC1—SN74151N

The following parts are available from Northwest Engineering; PO Box 5426; Seattle, Wash. 98107

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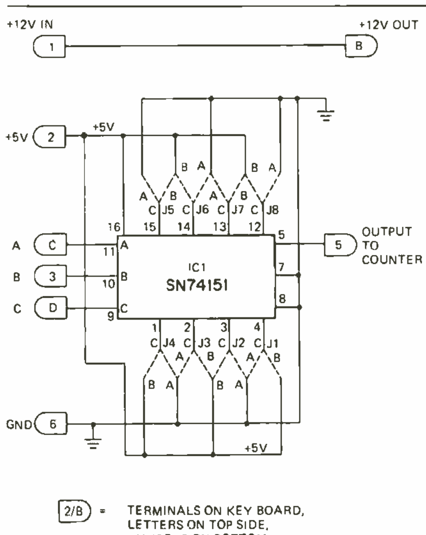


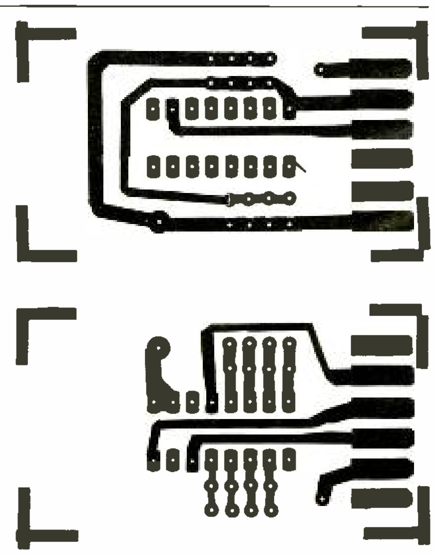
tegrated circuits used in this lock are designed to operate from 5.0 volts and should never have more than 5.5 volts applied to any terminal. The circuit (Fig. 3) provides a 5.0 V voltage regulator (Q1, D1) which allows for any input voltage between 8 and 14 volts to operate the lock.

Construction

Printed-circuit construction is used to insure accuracy and a compact installation. The pattern for the lock is in Fig.

FIG. 4—DIAGRAM OF THE KEY. The IC is mounted on a small 2-sided PC board with contacts to match a PC card-edge connector.

FIG. 5—TWO-SIDED BOARD USED FOR KEY requires careful alignment of both foil patterns so all drilled holes coincide. Patterns full size.



1 and the pattern for the double-sided key board is shown in Fig. 5.

To prevent a possible wiring error in the voltage regulator from damaging the integrated circuits, the regulator (Q1, R1, R2, C1 and D1 in Fig. 3) should be built and checked out prior to wiring the rest of the circuit. With 12 volts applied to the input of the regulator, the output voltage should be between 4.5 and 5.5 volts.

The remainder of the circuit board can now be assembled, with the exception of the code jumpers (CJ1–CJ8) which are used to select the desired binary code. The location of all wire jumpers are shown in Fig. 6. The next step is to wire the board to the connector (J1), which is used as the "key slot." The connector can be located several feet from the lock circuit if desired.

After selecting an eight-bit code, refer to Table 1 for a listing of which of

TABLE I

CODE JUMPERS TO IMPLEMENT EIGHT BIT CODE ABCDEFGH

	A	B	C	D
0	CJ1A	CJ2A	CJ3A	CJ4A
1	CJ1B	CJ2B	CJ3B	CJ4B

	E	F	G	H
0	CJ5A	CJ6A	CJ7A	CJ8A
1	CJ5B	CJ6B	CJ7B	CJ8B

the 16 jumpers should be installed to implement that code. Eight of the jumpers will be used, the other eight being left open. For example, if the code 10101010 is selected, jumpers CJ1B, CJ2A, CJ3B, CJ4A, CJ5B, CJ6A, CJ7B and CJ8A will be used. The table also lists the jumpers necessary to implement the same code on the key.

The key can now be assembled as shown in Fig. 6. The jumper wires as listed in Table 1 should be installed. On the key, the jumper wires only connect the top foil to the bottom foil on the PC board and should only be long enough to go through one hole and be soldered

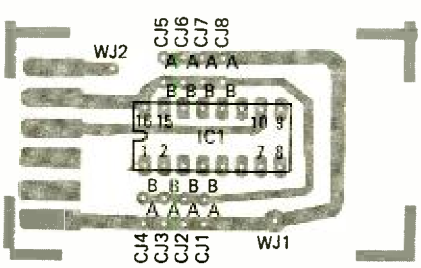


FIG. 6—LAYOUT FOR THE KEY. Key coding is provided by eight jumpers—each with two possible connections—to ground or to =5 volts. Jumpers extend through board from foil to foil.

on top and bottom. The key should not be potted until everything is completely tested and is working correctly.

Connect a 12-volt battery to the power terminals and a dc voltmeter to pin H of the PC card. The voltmeter should read 0 volts. Now plug the key into the socket: the voltmeter should change to 5 volts. If the voltmeter does not change, check to be sure the key is not upside-down in the socket.

If the key/lock does not operate correctly, disconnect the power and check the wiring and assembly of the PC cards and the connector socket. Check that all the necessary jumpers are in place on both cards and that the same code is wired onto both the key and the lock. The oscillator can be checked with an oscilloscope at pins 10 and 13 of IC-2 when power is applied and the key is inserted in the lock.

After the key has been checked out, it can be potted to protect the circuitry and to hide the code jumpers. Epoxy cement or Silicone Rubber can be used if a regular potting compound is not available. The epoxy cement provides a good hard compound that can be filed to shape.

Application

When used as a door lock, the output transistor, Q2, is used to drive a door opener to activate the latch. The door opener can be operated from the same battery that operates the lock or from a separate source as shown in Fig. 7. The diode D2 protects Q2 from re-

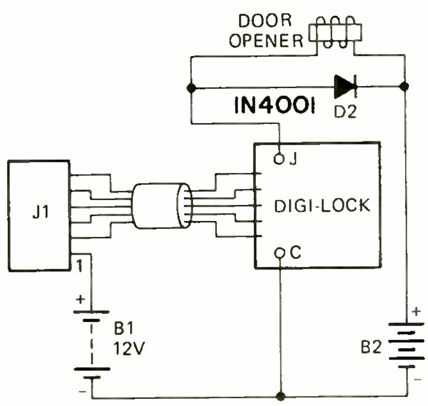


FIG. 7—THE DIGI-LOCK drives door opener. A 1N4003 diode is preferred for D2.

verse voltage breakdown due to counter emf when the solenoid or door opener is released.

The lock can also be used to prevent unauthorized people (or children) from operating power tools or other pieces of electrical equipment. For this application, the lock is used to drive a relay as shown in Fig. 8. If the lock is to be used for long periods of time (turned on with the key inserted) in this application, the power supply shown in Fig. 9 can be built to power the lock.

Under normal operation, the lock

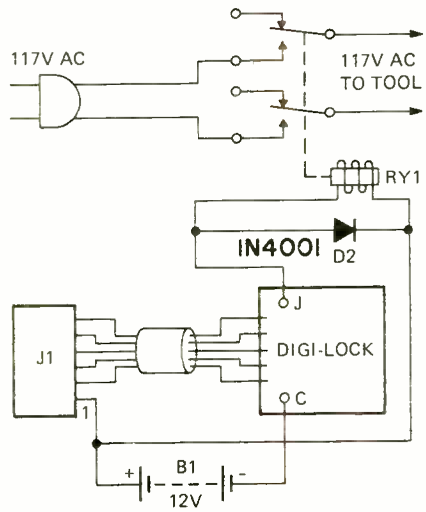


FIG. 8—TO LOCK TOOLS, use Digi-Lock to operate relay with contacts between line and load.

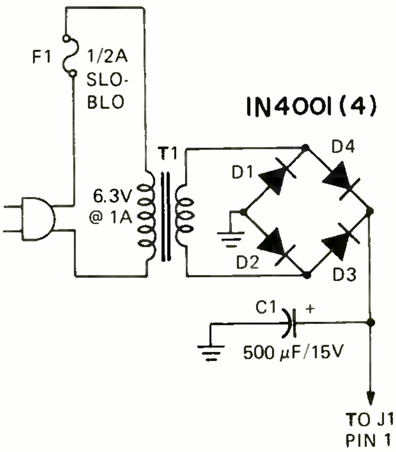


FIG. 9—SIMPLE POWER SUPPLY replaces batteries when Digi-Lock is used on power tools.

only draws power from the battery when the key is inserted in the lock. Therefore, when used for short periods of time, as in the case of a door lock, the battery life will be nearly equal to the shelf life of the battery. **R-E**

For a small extra fee I can manage to keep it until after baseball season is over.

EXPERIMENT WITH A

For quite a few years laser technology has been cost and complexity of equipment. A new

PROBABLY THE MOST INTRIGUING electro-optical device around is the laser. And while many experimenters, engineers, and hobbyists would like to have one for their own use, costs thus far have been prohibitively high for most.

You need worry no more, since for a cash outlay of less than $20 any electronics experimenter can assemble his own full function laser pulse generator. Semiconductor diode laser prices (in addition to the price of the pulser) begin at less than $12 in single quantities, making this laser project one of the least expensive yet published.

How it works

For room-temperature operation, commercial semiconductor laser diodes require a very brief high-current pulse for proper operation. The current must be high to stimulate the atomic processes of laser action and the pulse must be brief to keep the tiny semiconductor chip that makes up the laser from burning up.

This pulser uses a common technique of generating a fast, high-current pulse—discharging a capacitor through an SCR. In the circuit diagram in Fig. 1, note that a unijunction oscillator supplies trigger pulses to the gate of a high-voltage SCR. The frequency of the pulses is adjusted with R2.

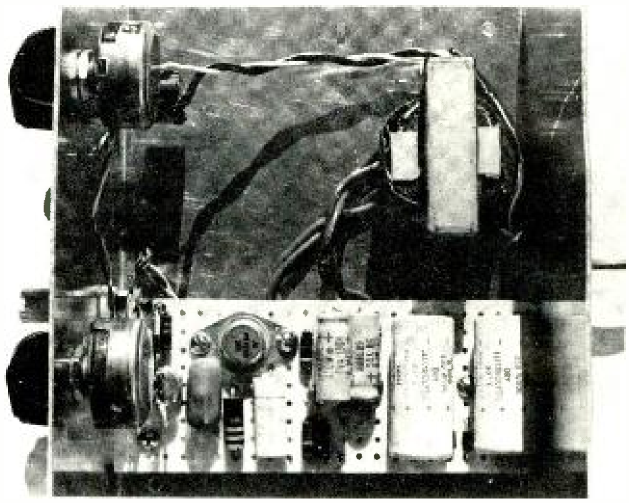
Between pulses of the unijunction circuit, capacitor C7 charges through R5 and R6. When the SCR gate is triggered ON, C7 discharges through the SCR, R7, and the laser diode. R7 is a one-ohm resistor that permits the peak current through the laser during a discharge pulse to be monitored accurately. Potentiometer R5 is used to adjust this current so the laser's peak current rating is not exceeded.

Summing up operation of the unit, the repetition rate can be increased to more than 500 Hz before peak current begins to fall (due to the charging time of C7) and peak current can be adjusted from zero to more than 40 amps. Pulse width is only 200 nanoseconds.

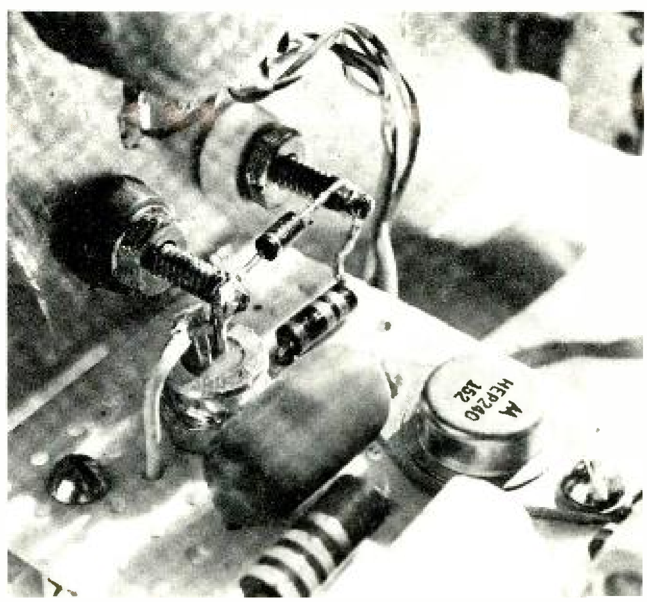
Put a laser together

Construction of the laser pulser is relatively straightforward, but several precautions must be followed for good results. We'll get to those later. First collect the necessary components and install them on a 2" x 4¾" perforated board as shown in the photo of the internal layout of the unit. Most of the parts values are not critical and substitutions, particularly in the power supply, are permissible so long as proper voltages are supplied to the circuitry. The high-voltage supply should deliver at least 300 volts dc and low-voltage supply 15 volts dc. With the parts values shown in the circuit diagram, the high and low-voltage supplies deliver 380 and 19 volts respectively.

Four components are critical and their values should not be changed. They are the SCR (Q3), C7, R7, and D5. The SCR has been specially selected and only higher voltage types in the same series may be substituted. C7 is designed to permit maximum pulse width permissible without damaging the laser. **Do not increase its value.** R7 is only one ohm, but **it must be included** in the circuit to calibrate the laser pulser. Removing R7 may cause the laser to receive far more current than it is rated for. And D5 is designed to reduce possible current undershoot.



INTERNAL VIEW OF THE LASER PULSER shows component layout. Power supply parts are on the right. Pulser parts are close together at left.



CLOSEUP OF PARTS in the laser discharge circuit. The SCR is soldered directly to one binding post to reduce lead length. C7 is the capacitor between the SCR and the HEP240 replacing the 2N3439 in this particular model.

$32 SOLID-STATE LASER

denied many experimenters because of the high low-cost laser opens experiments to all.

by FORREST MIMS

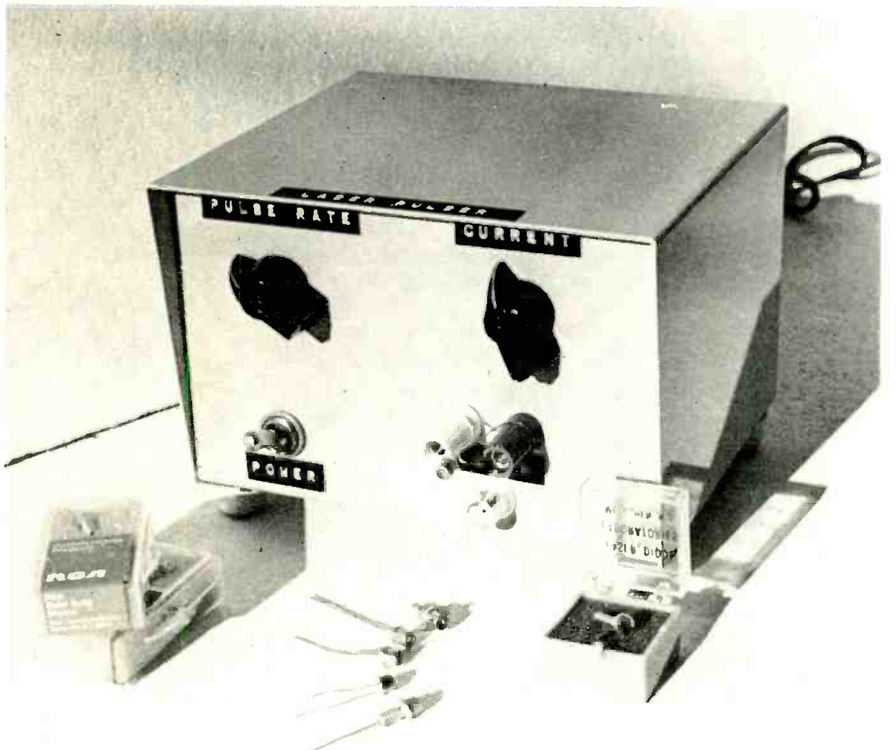
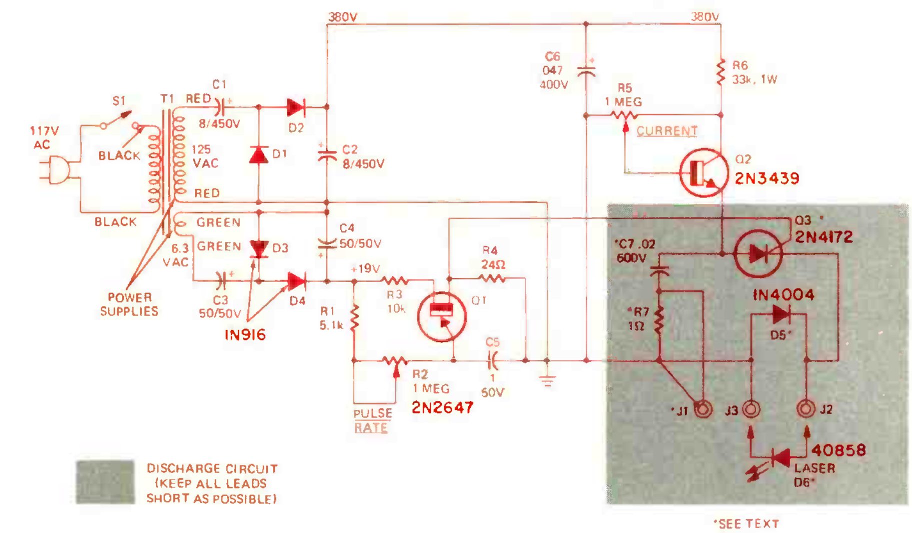


FIG. 1—SCHEMATIC DIAGRAM OF THE LASER PULSE GENERATOR. The discharge circuit is in the shaded area. Keep all leads as short as possible here to insure proper operation.



Diodes other than the one specified may not perform this function properly and cause the laser to receive possibly damaging reverse current. Since semiconductor lasers don't like excess current, pulses wider than a few hundred nanoseconds, and reverse current, stick with the values specified for these four components for best results.

Install the components on the board, using a layout identical or similar to the one shown in the photo. Use point-to-point wiring and spaghetti insulation where there is any chance of a short. Insulation is particularly important in the power supply circuitry.

When complete, trim all leads *except* those of R7. R7's leads are connected to a current monitoring terminal later. Also, note that D5 is not installed on the circuit board itself. D5's installation is described later.

The most important part of the circuit layout involves the four components described earlier. Since they form the pulse discharge circuit, the SCR, C7, R7, and D5, must be mounted as close as possible to one another. Excess lead lengths means increased inductance and the currents and pulse widths used here will result in ringing and undershoot with inductances measured in nanohenries. As mentioned earlier, this can be harmful to the laser diode.

PARTS LIST

R1—5100 ohms, ½ W
R2, R5—1 megohm pot
R3—10,000 ohms, ½ W
R4—24 ohms, ½ W
R6—33,000 ohms, 1 W
*R7—1 ohm, ½ W
C1, C2—8 μF, 450 V
C3, C4—50 μF, 50 V
C5—0.1 μF, 50 V
C6—0.047 μF, 400 V
*C7—0.02 μF, 600 V
D1, D2—HEP 58 or equal
D3, D4—1N916 or equal
*D5—1N4004 or 1N4007
D6—Laser diode (see text)
J1—BNC panel connector or equal
J2—Red insulated binding post (Cambion 3285-1-03 or equal)
J3—Black insulated binding post (Cambion 3285-1-03 or equal)
Q1—2N2647 unijunction
Q2—2N3439 (RCA) or HEP 240 (Motorola) 300-400 volt
*Q3—2N4172 SCR (Motorola)
S1—spdt toggle
T1—Power transformer: primary 117 Vac; secondary 125 V and 6.3 V (Calectro D1-760 or equivalent).
Misc.—Line cord, cabinet, hardware, stand-offs, perforated board, knobs (2), labels, marking pen, solder, hook-up wire, etc.

***Do not substitute (see text)**

When the circuit board is complete, compare it with the circuit diagram and photos to make sure there are no errors or shorts. Be sure that all diodes and capacitors are installed with proper polarity alignment. Then set the board aside

(continued on page 50)

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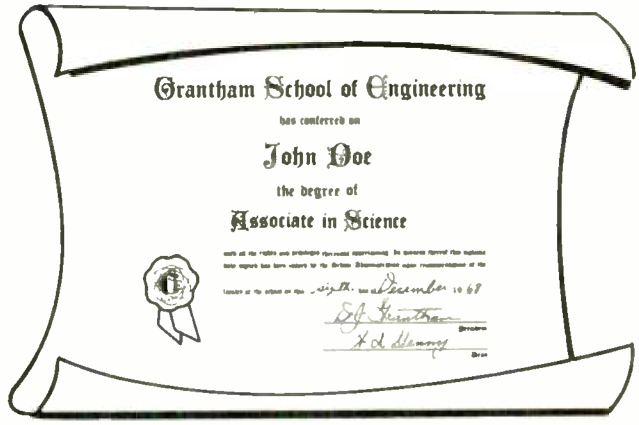

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City ________ State ________ Zip ________ and prepare the enclosure.

The prototype pulser shown in the photos is housed in an LMB No. 564 Glamor Cabinet (5" x 6" x 3"). The cabinet is ideal for the pulser since it's prepainted and supplied with rubber feet.

Actually, any enclosure can be used as long as it's functional. Prepare the housing by drilling appropriate holes for the transformer, controls, output terminals, and stand-offs. Drill a hole in the back of the cabinet for the line cord. Force a rubber grommet into the hole to prevent fraying and insert the exposed end of the cord. Tie a knot a few inches from the exposed end and solder one end of the cord to one of the black transformer leads. Carefully tape the connection with black electrical tape to prevent possible shorts and shock hazards. The remaining end of the cord is soldered to the power switch. Use an extension wire if necessary and be sure to tape the connection.

Next, mount the transformer with 4-40 hardware and install the controls and output terminals. The remaining wiring is straightforward. Connect the transformer leads to the circuit board, paying attention to the color code (high-voltage secondary is red and low-voltage secondary is green). Don't mix them up like I did the first time or you'll burn out some diodes!

It's a good idea to trim the leads to convenient lengths, but don't cut them too short. Next, wire the remaining switch terminal to the black transformer lead and hook up the two potentiometers.

If the laser terminal holes were drilled following the layout in Fig. 2, the cathode terminal of the SCR should be adjacent or very close to the solder

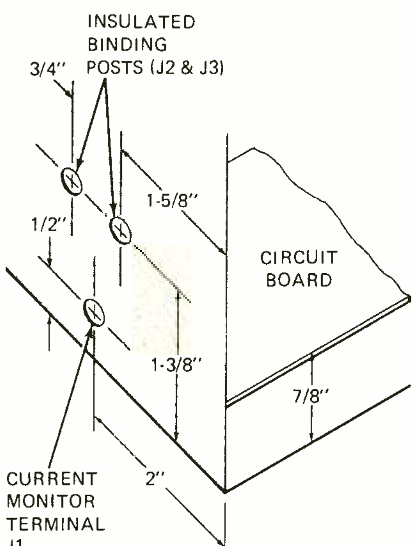


FIG. 2—LOCATION OF TERMINALS ON PANEL insures short leads to discharge-circuit parts.

portion of the right terminal when the circuit board is installed. If so, it may be possible to solder the cathode directly to the terminal. This is preferred since it results in the shortest lead length. The remaining terminal is connected to ground by a one-inch length of wire.

When the laser output terminals are connected, trim and bend the leads of D5, a 1N4004 diode, so that they fit between the two terminals. Solder the diode leads to each of the terminals so the diode's anode is connected to the ground terminal. The white band on one end of the diode will then be nearest the SCR terminal.

The only remaining wiring is hooking up the current monitoring terminal. If you have access to a fast (15 MHz) oscilloscope, go ahead and wire the terminal by connecting the grounded lead of R7 to the terminal ground and the remaining lead of R7 to the other terminal connection. For convenience, the prototype pulser used a BNC connector which can be easily connected to a scope via a short cable. Use care when soldering the leads of R7 to the terminal since they are under the already installed circuit board.

If you do not have access to a 15 MHz (or better) scope, read the calibration instructions before hooking up the monitor terminal. You may prefer to try one of the monitoring techniques which can be used with a slow scope or even a voltmeter.

Operating test

Before calibrating your laser pulser, test it to see if it's operating properly. Simply connect a length of hook-up wire between the laser output terminals (don't use a laser yet) and place a radio near the unit. When the power switch is turned on, you should hear a buzzing sound from the radio. If the sound is not present, try rotating the control pots until it is. The sound comes from the electromagnetic field radiated during the high-current discharge.

Another simple test is to carefully listen to the pulser itself. When operating, the discharge capacitor will emit a definite humming, with frequency dependent on repetition rate of the unit and amplitude dependent on the current setting. You may have to remove the top of the cabinet to hear the capacitor, but don't place your ear too close to the circuit board or you may receive a shock.

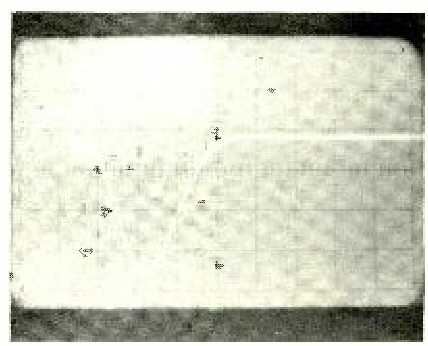
If these simple tests show that the pulser is not operating, recheck all wiring and components. Pay particular attention to the power supply circuits and look for possible shorts. Use a voltmeter to check the output of the power supply circuits. A scope can be used to check the unijunction pulser by looking across the gate of the SCR and ground (spikes) and the discharge capacitor C7 (high-voltage sawtooth waveform).

Calibration techniques

When the laser pulser is operating, it must be calibrated to prevent accidental application of excess current to a laser under test. First, make sure the current and repetition rate pots are connected properly so that rotation to the extreme left gives the least current and rep rate. It's easy to perform this procedure with the radio test. Repetition rate is easily heard as a buzz or tone and the higher the current the louder the tone. If necessary, reverse the outside (stator) contacts of either pot if it is connected backwards.

Three techniques can be used to calibrate the pulser and they are described in decreasing order of reliability. First and best is to use a 15 MHz or faster oscilloscope with triggered sweep (nearly all scopes rated at this frequency are triggered). The pulser can be quickly and accurately calibrated by making use of the one-ohm current monitoring resistor. Simply connect the scope to the monitor terminal (J1), insert a laser into the output terminals (using care to observe polarity; the SCR cathode terminal goes to the laser anode), and with both control pots turned to the far left activate the power switch.

Advance the REPETITION RATE control to a pulse rate of a few hundred Hertz (use the radio technique and estimate or connect the scope to the SCR gate to set the rep rate) and very slowly begin advancing the current control. With the scope set to a sweep speed of about 100 nanoseconds (0.1 microsecond) per division and a vertical amplitude of about 2 volts per division (compensate accordingly for a 10X probe if one is used), begin watching for



LASER OUTPUT PULSE looks like this on a fast scope. Sweep speed is 100 ns per division and amplitude is 5 volts or amps/div.

the current pulse. It may take a few minutes to find the pulse, but adjustments of the triggering (be sure it's set to negative) will soon show a very clean 200 nanosecond pulse.

CAUTION: Since an actual laser is being operated during calibration, be sure to avoid applying too much current. The inexpensive laser described in the Parts List, an RCA type 40858, can be operated at up to 25 amps but some lasers must be operated at much lower levels.

Do not advance the CURRENT control more than one third revolution when attempting to see the laser pulse for the first time with the 40858. If the pulse is not visible, the scope is not being operated correctly.

When the pulse is properly displayed on the scope, calibrate the current control by making a small mark at one-amp intervals. According to Ohm's Law, current is the quotient of voltage divided by resistance. Since resistance in this case is one ohm, the amplitude of the pulse displayed on the scope in volts equals the current amplitude. Knowing this, you can easily letter in current values every five amps.

If you don't have a fast oscilloscope, you can calibrate the pulser with practically any scope having a calibrated voltage setting for the vertical trace. Almost all but the most inexpensive scopes have a calibrated voltage setting. To perform the calibration, simply connect the scope across the positive side of C7 and ground and observe the capacitor's charging curve. It's amplitude will range up to 300 volts and more, depending on the current control setting (remember the cautionary information about the laser and start the calibration at zero current and *stop* at the laser's maximum rating).

Next, using the calibration graph shown in Fig. 3, mark the current output at one-amp intervals. It's important to note that this calibration graph applies only when the pulser is operated with a laser in the circuit (not a wire) and was made with the prototype pulser which used the discharge parts values specified

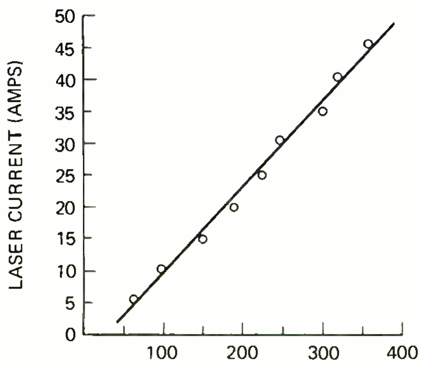


FIG. 3—CALIBRATION GRAPH for use with an ordinary "slow" scope to determine the panel markings for the current control potentiometer.

in the Parts List. While it is not as accurate as direct calibration with a fast scope, it is adequate for nearly all applications. In fact, if a fast scope will probably not ever be available, it's a good idea to hook up the monitor terminal to the capacitor and ground instead of the one-ohm resistor (be sure *not* to remove the resistor though). Also, the graph will always be handy if it is cut out and glued to the back of the case.

A third method of calibration can be used by the experimenter who doesn't have access to any kind of scope (though if at all possible a scope should be borrowed since calibration takes only a few minutes). This procedure requires a voltmeter and the calibration graph shown in Fig. 4. Simply connect the meter across the rotor of the CURRENT control pot and ground while monitoring the voltage as the control is slowly rotated. Use the graph to mark the current in amps. This method of calibration is not as accurate as either of the other two, but it will serve until a better method can be used.

Choosing a laser

A very economical laser which is ideal for this laser pulser is RCA's 40858. This laser emits a peak optical power of at least 3 watts at its maximum rated current of 25 amps. For more money, higher power lasers can be obtained. For example, the $23.20 40862 will emit at least 10 watts at 40 amps. For more information write the three main manufacturers of commercial semiconductor lasers:

Laser Diode Laboratories
205 Forrest Street
Metuchen, NJ 08841

RCA Semiconductor Lasers
New Holland Pike
Lancaster, Pa. 17604

Texas Instruments, Inc.
P.O. Box 5012
Dallas, Texas 75222

When writing, request data sheets and prices. Some lasers can be easily ordered through local electronics dealers (particularly RCA and TI types).

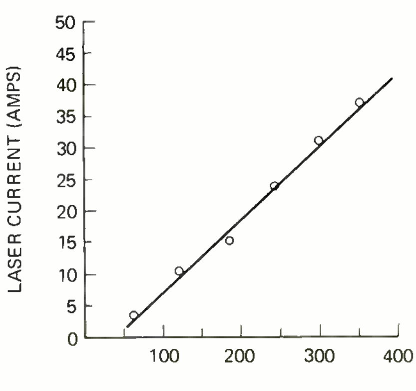


FIG. 4—IF YOU DON'T HAVE A SCOPE, use this graph and a vtvm for current calibration.

Applications

Since the beam emitted from nearly all commercial semiconductor lasers is invisible to the human eye, applications might seem tough. Not so. These little lasers are invaluable in detection-proof intrusion alarms, long range optical communications, short range IR (*I*nfra-*R*ed) photography, IR illumination, interferometry, and general experimentation. Optical radar is even a major application.

If there is enough reader interest, some of these applications can be described in detail in future articles. Meanwhile, the first general experimentation and fact book on semiconductor lasers has just been published by Howard W. Sams. Titled "Semiconductor Diode Lasers," the 192 page book is crammed with theory, applications, and dozens of circuits (all tested) for pulsers, receivers, and IR image converters. This book should keep anyone interested in semiconductor lasers busy for quite some time.

Laser safety

A final word about laser safety is in order. Though the semiconductor lasers used here are rated at average power outputs well below a desk lamp, the *peak* power output may be measured in watts. There are no known cases of eye injury resultant from observing a diode laser at close range, but play it safe and follow these simple precautions:

1. Do not look directly into the laser at close ranges. Since the beam spread is about 20°, increasing the distance from the laser greatly reduces the amount of light which can enter the eye.

2. If a lens is used to collimate the laser beam, avoid looking into the lens itself. A simple lens can easily be used to produce a 0.1° beam with the diode laser.

3. Avoid aiming the laser at shiny surfaces.

4. Inform others in the area when the laser is being used so that they will also follow the safety procedures. **R-E**

"It's only a bad tube, but by the time you get here we'll probably have to talk trade-in."

Experiments With OP-AMPS

One of the more basic linear IC's, the op amp has a myriad of applications and is a handy device to have around.

by B. R. ROGEN

The modern operational amplifier (usually shortened to just plain "op amp") comes the closest to the engineer's dream of the perfect amplifier. What are the qualifications for this nebulous amplifier? Well to start, it should have an infinite input impedance so it does not present a load to the circuit it follows. It should have infinite open-loop gain. It should have zero response time to an input signal—meaning that it should have infinite bandwidth. It should have zero offset—that is, with no voltage at the inputs, it should have zero output. And this perfect amplifier should be inexpensive.

Although this goal has not yet been reached, the modern op amp does have input impedances approaching many megohms; gains run from 20,000 to 1,000,000; response time is measured in nanoseconds, and offset can be reduced to zero. The price for this package-of-gain runs from under a dollar to several dollars depending on what special characteristics you may need for your application.

What's inside

Essentially, an op amp uses a high-input-impedance differential amplifier driving a voltage-gain stage, followed by a low-output-impedance power-output stage. The theory of operation is somewhat complex, but all the experimenter has to know is that the symbol for an op amp is shown in Fig. 1. Note that there are two input terminals, one marked with a plus and one marked with a minus sign, and a dual power supply having a common ground is required.

Since the op amp is "bipolar", its output can swing either positive or negative with respect to ground.

The input feeding the "minus sign" is called the *inverting input*. If a signal is applied to this lead while the other input is grounded, the polarity of the output signal will be *opposite* to the polarity of the input signal. The input feeding the "plus sign" input is called the *non-inverting input* and if a signal is applied to this lead while the other input is grounded, the polarity of the output signal will be the *same* as the input signal.

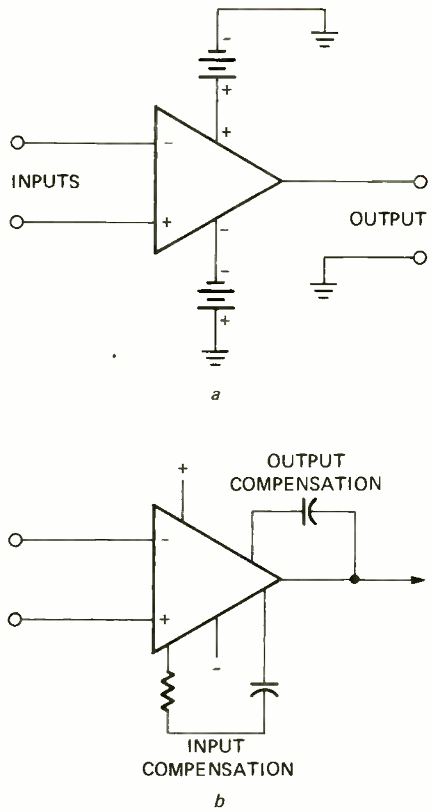


FIG. 1—OP-AMP OR DIFF-AMP (a) is characterized by dual inputs and often requires compensation networks (b) for input and output.

This essentially, is the "meat" of the op amp. A little thought will show that for an ac input, the output of the op amp will be 180° out-of-phase with a signal applied to the (–) input, but in-phase with the signal at the (+) input. Also consider that if a signal is applied to both inputs simultaneously, they will cancel each other and the output will be zero. This is because the op amp responds to a *differential input* only and is sometimes called a "differential amplifier".

As an interesting aside, consider a signal "drowning" in a 60-Hz hum, applied to the two inputs. Instead of a poor output signal, the 60-Hz hum common to both inputs will be cancelled while the signal difference between the two inputs will be amplified. This is called *common-mode rejection*.

There is one other thing that you will see in many op-amp circuits. It takes the form of a resistor-capacitor, or a capacitor connected between some pins. These are called "frequency-compensation" components, and unless the op amp is specifically identified as internally compensated, *these outboard devices must be used.* The reason is simple. No matter how careful the design of the IC is, the very nature of construction requires that some (albeit tiny) capacitance exists between stages. The reactance of these tiny "capacitors" is very small at the lower frequencies, but begins to play an important role as the frequency goes up. What can happen then, is that at certain higher frequencies, the op amp can have positive feedback (oscillation) that could make quite a difference to circuit operation. The frequency-compensating components are inserted between various stages in the op amp to prevent this unwanted tendency to oscillate, which is a natural when you remember the very high gains that exist in these IC's. Some IC's, the 741 have compensation built into them.

At some later date, a complete circuit design procedure for op amps will be described. But first to give the reader a chance to "play" with these amazing devices, and see what can be done at low cost, we will present a small sampling of circuits that use these "near perfect" packages of gain. We will start with some simple low-cost pieces of test gear.

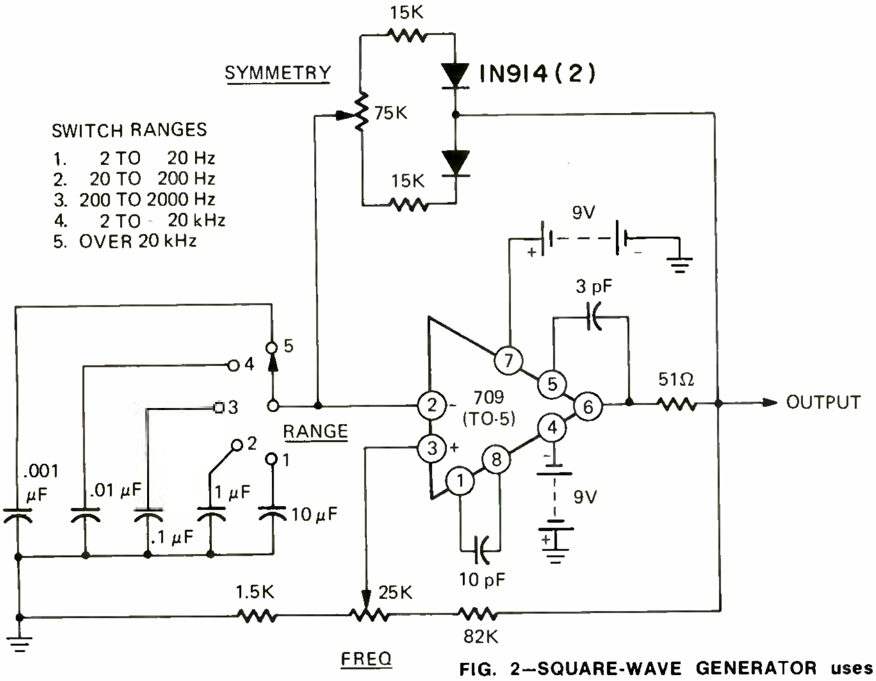
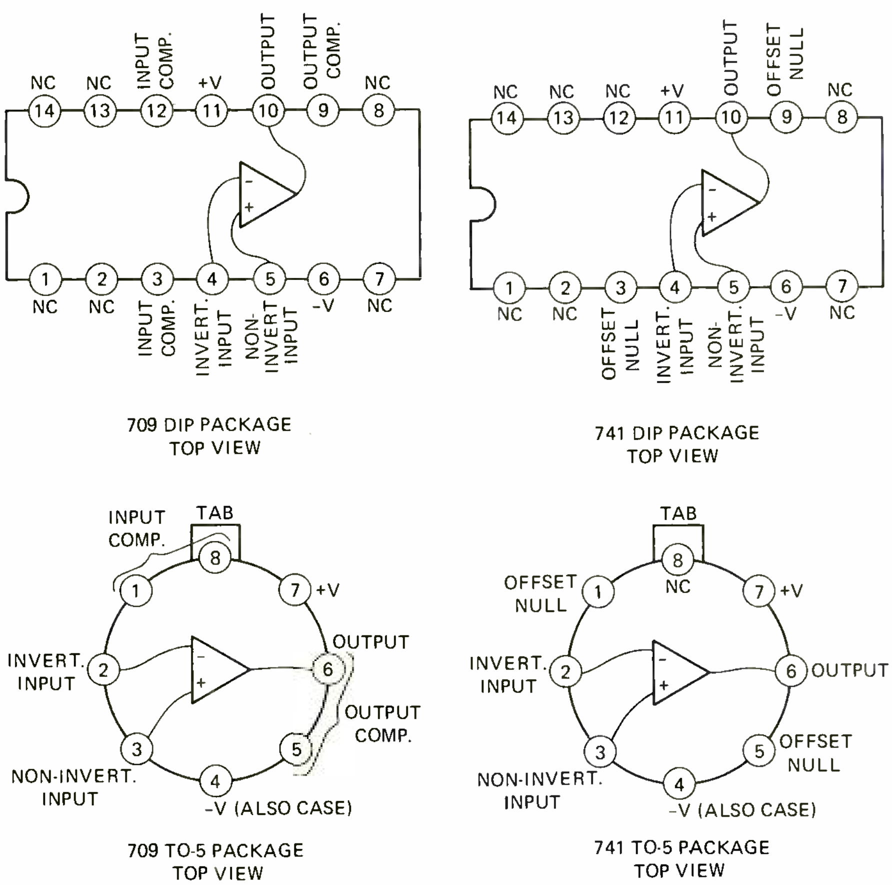


FIG. 2—SQUARE-WAVE GENERATOR uses positive feedback to sustain oscillations.



BASE DIAGRAMS OF TWO POPULAR IC's IN TO-5 AND DUAL-INLINE PACKAGES. The type 709 requires input and output compensation to neutralize internal capacitances.

Square-wave generator

The circuit shown in Fig. 2 uses the well-known 709 op amp as a square-wave generator. It can be built on a small piece of perf board, or even a small PC board. This particular version uses the TO-5 style case for the op amp. If you use a Dual-Inline-Plastic (DIP) device, change the leads accordingly. The circuit can generate clean square waves between 2 Hz and over 20 kHz with the various bands switch-selected, and intermediate values and wave shapes set by the FINE frequency and symmetry potentiometers. The circuit is essentially a regenerative comparator using positive feedback to sustain oscillation. The charging time of the switch-selected capacitors, in conjunction with the preset voltages at the inverting and non-inverting inputs, determines the exact frequency.

Triangle-wave generator

One of the least used test instruments is the triangle generator. If you stop and consider it, not many people can recognize a clean sine wave when they see it. Actually, it takes quite a bit of distortion before you actually see a change in the waveform. If you use a square wave to test an amplifier, you must be careful that what you are seeing is actually a square wave, and not clipping. However, with a triangle wave, the sides must be as straight as a ruler and the peaks sharp. Any distortion in the amplifier under test will make great changes in the output triangle, and clipping or crossover distortion is very easy to see. In clipping, the sharp tips of the waveform are the first to go, and amplifier distortion changes the straight sides of the triangle to make this distortion very apparent.

If you already have a square-wave generator, the circuit in Fig. 3 will suffice. Known as an "integrator", this circuit converts a square-wave input to a

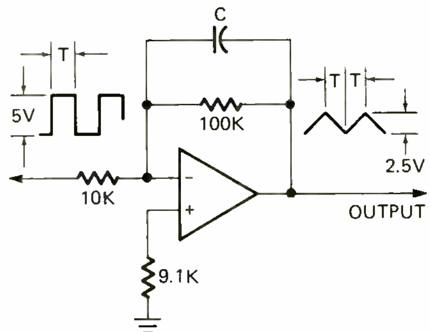
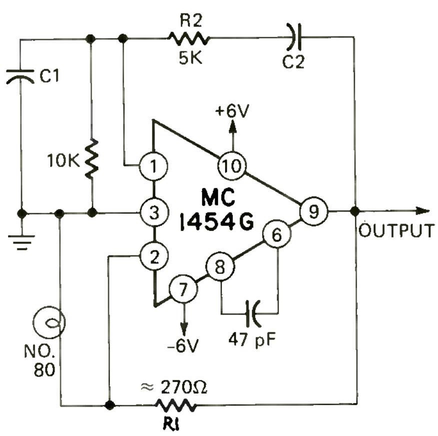


FIG. 3—INTEGRATOR CIRCUIT converts square wave input to a clean triangular wave.



FREQ.	C1, C2
1 Hz	33 µF
100 Hz	.33 µF
500 Hz	.065 µF
1 kHz	.033 µF
10 kHz	.0033 µF
50 kHz	650 pF
100 kHz	330 pF

FIG. 4—SINE-WAVE GENERATOR drives voice coils at power levels up to 8 watts.

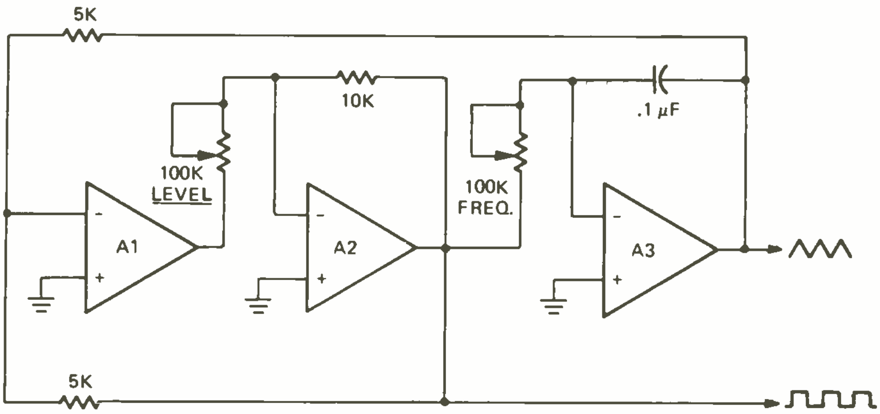
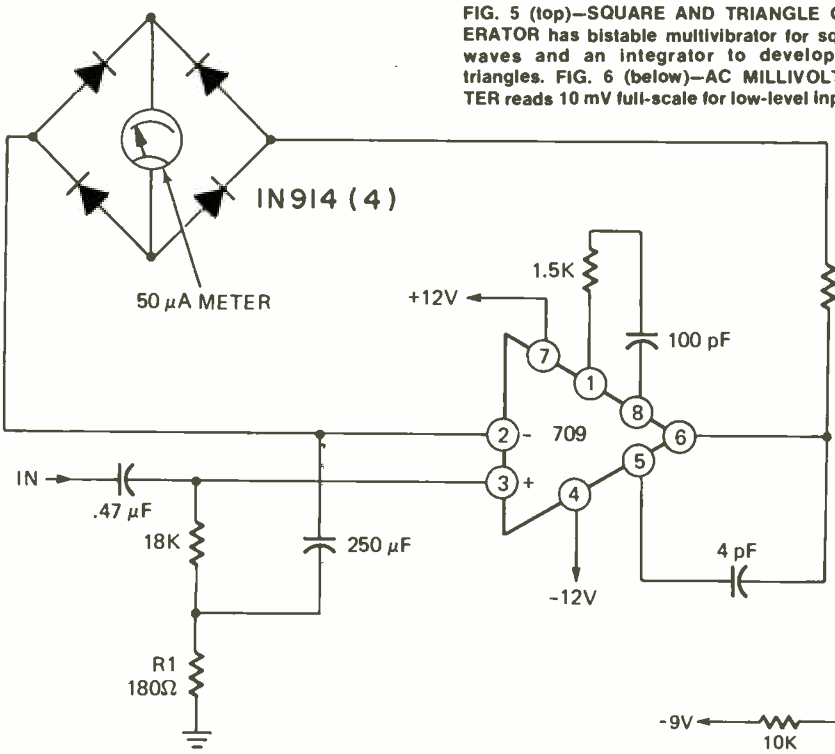


FIG. 5 (top)—SQUARE AND TRIANGLE GENERATOR has bistable multivibrator for square waves and an integrator to develop the triangles. FIG. 6 (below)—AC MILLIVOLTMETER reads 10 mV full-scale for low-level inputs.



clean triangle waveform. Any op amp will do, and if a 709 is used, don't forget the compensation (see other schematics for typical values). No value is given for C1 so use a switched set of values that will produce a clean triangle wave output with the selected square-wave inputs.

Combined generator

If you want to build a combination square and triangle waveform generator, then use the circuit of Fig. 5. A1 and A2 form a bistable circuit generating square waves. A3 is an integrator that forms the triangle waves. Both the frequency and level of the signals can be controlled by the potentiometers.

Sine-wave generator

The op-amp sine-wave generator shown in Fig. 4 can drive 8- to 10-ohm loads and can provide up to 8 volts output. Harmonic distortion is typically less than 0.5% over the frequency range. The lamp provides automatic gain control, while R1 provides the necessary feedback, and to a limited degree, determines the output amplitude. The frequency is equal to ½πR2C1. The 47-pF capacitor between pins 8 and 6 provides the high-frequency compensation.

Working with solid-state circuits often calls for measuring very small signal levels. The circuit of Fig. 6 shows a 10-mV (.01-volt) full-scale ac millivoltmeter. Suitable attenuators can be used to change the measurement range. The use of input bootstrapping raises the input impedance to over one megohm. Resistor R1 has to be trimmed for full-scale deflection with 10-mV input. Accuracy is 2% and frequency range is within 3 dB to 150 kHz.

As another example of op-amp use in measuring circuits, that shown in Fig. 7 is a low-voltage-drop microammeter that will operate between 10-µA and 100 mA with an accuracy of 1% if a decent meter and accurate resistor values are used. Variation of accuracy with temperature is approximately .2% /°C.

The circuits shown are only a very small sampling of some of the unique uses of the op amp in test equipment. In future issues we will show you how to make a two op-amp circuit that forms a multimeter with twelve voltage ranges from 0.001 volt full scale to 300 volts full scale, twelve current ranges from 1 µA full scale to 300 mA full scale. Battery powered (two conventional 9-volt transistor radio batteries), this multimeter will be the equal of one selling at many times its construction cost. **R-E**

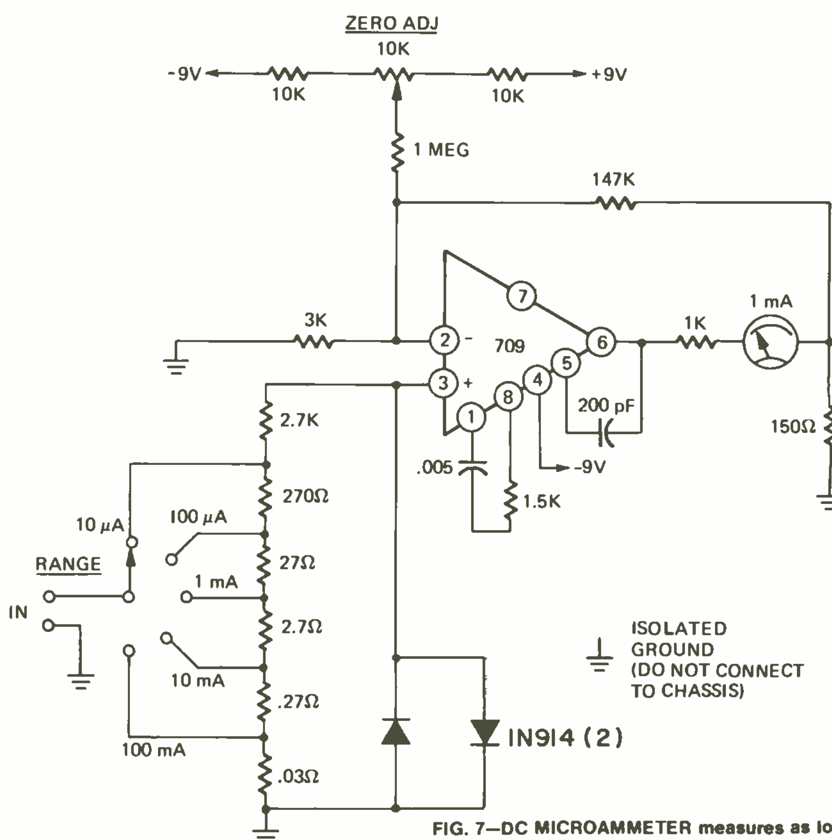


FIG. 7—DC MICROAMMETER measures as low as 10 µA full scale with very low voltage drop.

If you built R-E's digital IC tester last month you must be ready to put it to work. Here's a detailed manual of operation

how to use R-E's IC Tester

by JACK CAZES

NOW THAT YOU'VE COMPLETED THE construction of your DIGI-DYNA-CHECK (**Radio-Electronics,** May 1972), let's see how it can be used for both in- and out-of-circuit testing of a wide variety of digital integrated circuits. By simulating actual operating conditions for the unit under test; the DIGI-DYNA-CHECK performs a functional check of an ic under truly dynamic conditions. Operating power is supplied (+5 volts at 1 amp, regulated), where necessary and logic levels are readily applied to the inputs of the IC under test. All input and output logic levels are monitored, *simultaneously*, with a bank of sixteen indicator lamps, a lighted lamp representing a **1** logic state. A lamp that is off is indicative of either a **0** logic state or an indeterminate condition that is possible when there is no connection at that test terminal.

Gates of all types can be put through their paces by checking the output levels that result from various combinations of input levels. Flip-flops, counters, and shift-registers are advanced through their various states either stepwise (manually), or continuously (automatically) at a frequency of approximately 50 kHz, a rate that can be easily observed with most commonly used oscilloscopes.

Before we get into the actual examples of test procedures that can be used with different types of digital IC's, let's take a closer look at the matrix switch to learn the how and why of its operation. Since it's the heart of the DIGI-DYNA-CHECK, a thorough understanding of its operation is necessary.

The matrix switch consists of twenty 10-position slide switches, each having, in addition to ten *common* positions, a neutral or "no connection" position. The first sixteen sliders are wired to correspondingly numbered pins of the DIP (Dual-Inline Plastic) test socket and to the inputs of sixteen lamp indicators. The remaining four sliders are brought out to four binding posts marked **W, X, Y,** and **Z.**

Each of the ten switch positions is wired, internally, in common, for all 20 switches, to the following functions. See Table I on next page.

Looking at Table I, we see that any number of the sixteen IC contacts as well as binding posts **W, X, Y,** and **Z** can be connected to any of the six internally available functions by merely moving their corresponding matrix sliders to the positions representing the desired functions. Since all switches have their identically numbered positions wired in-common (bussed together), two or more sliders resting on the same numbered positions will result in their IC terminals and/or binding posts being connected together. Sliders **W** through **Z** and positions **A** through **D** form a 4 × 4 matrix with their eight binding posts which, as we shall soon see, can be useful in connecting the test IC to the outside world—to a scope, external power supplies, resistors, capacitors, test leads, etc. When any or all of the sliders **W** through **Z** are in positions **1** through **6,** the corresponding internal functions are available for external use. This can come in handy when checking external circuitry. Note that when sliders **1** through **16** are in positions **A** through **D,** the corresponding monitor lamp inputs are automatically connected to the external binding posts.

Thus, for example, with slider **1** in position **A,** and test leads plugged into binding post **A** and ground, lamp **1** can be used as a logic level test probe for checking relative logic levels on PC boards at locations other than at IC terminals.

The numbering system for DIP integrated circuits is illustrated below. Very often, there is some sort of mark, such as a dot or a number 1 at pin 1. However, even in cases where there is none, pin 1 will always be at the notched end of the IC package as shown in Fig. 1. The remaining pins are numbered counting counterclockwise.

POSITION	TABLE I WIRED TO
0	No connection (Neutral)
1	Ground (to provide circuit common and logical **0**)
2	+ 5V, regulated (to provide circuit power and logical **1**)
3	STEP (via manual stepping button)
4	$\overline{\text{STEP}}$ (complement of position 3)
5	INT CLOCK (internally available 50 kHz square-wave generator)
6	$\overline{\text{INT CLOCK}}$ (complement of position 5)
7	Binding post **A**
8	Binding post **B**
9	Binding post **C**
10	Binding post **D**

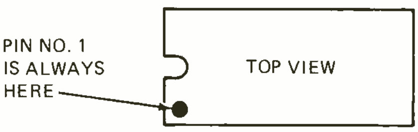


FIG. 1—FINDING PIN 1 of a dual-inline-package (DIP) IC is easy. Just look for the notch in one end as shown here.

In-circuit testing

To test IC's in-circuit plug the in-circuit adapter cable into the test socket of the DIGI-DYNA-CHECK and connect the test clip at the other end of the cable to the IC to be checked. Be sure that the clip is properly oriented, i.e., with IC pin 1 connected to the 1 position of the clip. *A ground connection must* be made between the circuit being tested and the checker to provide a common reference point for the lamp monitors. This can be done either by moving the matrix slider corresponding to the ground lead of the IC under test (if this is known) to GND (position 1), or by connecting a clip lead between one of the ground posts in the checker and a ground or common point on the board containing the IC being tested.

If the IC being checked is operating under its own power supply, the logic levels existing at all of its terminals will be displayed by the indicators directly. If the circuit is not self-powered, power can be supplied from the DIGI-DYNA-CHECK to the V_{cc} terminal of the IC via the matrix switch. Since up to 1 amp is available, the checker's power supply can "fire-up" a board containing many IC's; most digital IC's draw only a few milliamps each. However, current drain for most integrated circuits is dependent upon the output states and how often these states are changing—frequency. This happens because many gates draw extra current while changing state. Most manufacturers specify a maximum current consumption, and their literature should be consulted when in doubt.

One more word of CAUTION about using the internal +5 V supply for powering integrated circuits. The internal supply can only be used with IC's that are designed to operate at +5 volts. RTL (Resistor-Transistor Logic) circuits, for instance, require 3.6 volts and can be damaged if connected to 5 volts. RTL units operating from their own power supply or from an external power source of the proper voltage *can*, nevertheless, be checked with the DIGI-DYNA-CHECK via the lamp monitors because their logic threshold region is within the threshold region of the lamp-driver circuits. A knowledge of what the logic states at the IC's terminals should be for a given circuit may be obtained from the spec sheets for the units under test.

It is possible, during in-circuit testing, to connect any of the internally available functions to the circuit under test. Thus, you can connect the STEP or CLOCK function to the input of a shift register, or a counter, or a flip-flop, and carry it through its paces under control of the DIGI-DYNA-CHECK. You can connect up to four IC terminals simultaneously (via positions **A** through **D**), to external components, or to a scope for monitoring input and output relationships.

Out-of-circuit testing

Out-of-circuit IC testing is performed much the same way as is done with a tube tester. The unit to be tested is plugged directly into the test socket, suitable input parameters are set (in the present case, via the matrix switch), and the result is read out on the front panel. In our case, we do not merely get a GOOD-?-BAD reading as with a tube tester, but rather, we obtain a lot more information about the IC under test. We are able to monitor all input and output logic levels *simultaneously*, and to compare them with each other and with expected levels based upon either a prior knowledge of the normal mode of operation of the logic type involved, (gate, counter, flip-flop, shift register, etc.) or from literature describing the specific unit being tested in which the normal input/output relationships are given. This latter type of data is generally contained in a TRUTH TABLE. This table indicates what the outputs should look like when certain combinations of input levels are present as well as what changes should occur when changes are made in the input levels.

Gates are the most basic logic systems. They can have, generally, either of two output states: a *high* or **1** level and a *low* or **0** level. The level or state that is present at the output of a particular gate depends upon the condition of the input(s) to the gate. The simplest gate, the INVERTER, or NOT gate always has an output state that is the opposite of its input (it has only one output and one input); a **1** at its input results in a **0** at its output, and vice versa.

Let's briefly look at truth tables for some of the more common types of logic building blocks (basic logic circuit types). The following table is a combined truth table for two-input NAND, AND, NOR, OR, and EXCLUSIVE-OR gates:

INPUTS		OUTPUTS				
A	B	NAND	AND	OR	NOR	EXCL-OR
0	0	1	0	0	1	0
0	1	1	0	1	0	1
1	0	1	0	1	0	1
1	1	0	1	1	0	0

Some generalizations may be made:

- For the first four types of gates, the output is at one condition for all input combinations *except one.*
- The NAND outputs are the opposite or inverse of the AND outputs for a given set of input conditions.
- The NOR outputs are the opposite or inverse of the OR outputs for a given set of input conditions.
- The EXCLUSIVE-OR gate is at one state if both inputs are identical and in the opposite state if the inputs are different. This property of the EXCLUSIVE-OR gate makes it useful as a digital comparator—for comparing two digital quantities or two digital states with each other.

Similar truth tables and general observations can be made for gates containing more than two inputs; the number of input combinations, of course, increases with the number of inputs involved.

Flip-flops represent the next most complex systems in digital circuitry. One widely used type is known as the J-K flip-flop. Unlike simple gates discussed above which have no memory, *flip-flops remain in a given state even after the input conditions that put it into that state have been removed.* Flip-flops often have two complementary outputs known as **Q** and **not-Q** (written $\overline{Q}$). A J-K flip-flop has a "clock" input that serves as the trigger for the device. Output states are made to change by applying a pulse at the clock terminal. The states assumed by the **Q** and $\overline{Q}$ outputs depend upon the levels present at the **J** and **K** inputs immediately preceeding the clock pulse as well as the states of the **Q** and $\overline{Q}$ outputs at that time. The normal transitions are summarized in the next table.

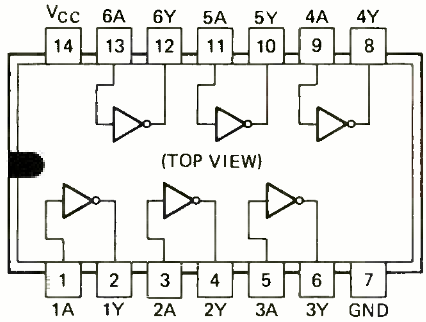
At time, t		At time, $t + 1$
J	K	Q
0	0	No change in state (maintains whatever state was present at time, t)
1	0	1 0
0	1	0 1
1	1	Assumes the inverse of the output states that were present at time, t

NOTE: t is the time just before the "clock" pulse.
$t + 1$ is the time just following the "clock" pulse.

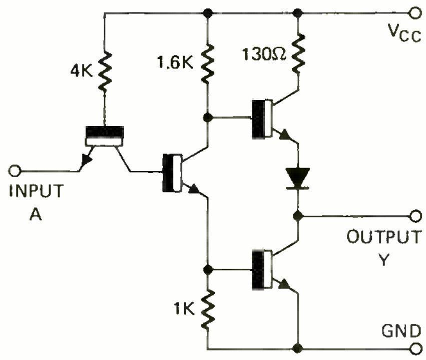
Now we're ready to apply what we've learned about the basic digital logic building blocks to checking digital IC's with the DIGI-DYNA-CHECK. We will select several IC's and carry them through their tests. The following table lists some of the more commonly used TTL (Transistor-Transistor Logic) integrated circuits with their internal terminal connections. We will look at several units listed in the table in order of increasing complexity, including an INVERTER, NAND, NAND with open-collector outputs, J-K flip-flop, and, finally, a **decade counter.**

TABLE II

Pin No.	Set to	Remarks
7	GND	Power supply to the IC
14	+5 V	
1, 2	+5 V	Inputs to gate 1 at logical "1"
4, 5	+5 V	Inputs to gate 2 at logical "1"
9, 10	+5 V	Inputs to gate 3 at logical "1"
12, 13	+5 V	Inputs to gate 4 at logical "1"



SN7404



SCHEMATIC (EACH INVERTER)

FIG. 2—THE SN7404. Basing diagram is at the top. Schematic of each inverter is also shown. There are six in this IC.

SN7404: Hex inverter

This 14-pin IC contains six separate inverters with their inputs and outputs wired as shown in the table below and in Fig. 2. Plug it into the test socket making certain that it is properly oriented, with its pin **1** in hole **1** of the socket. Connect pin **7** to GND and pin **14** to +5 V by moving matrix sliders corresponding to these pins to the positions indicated. This will provide operating power to the IC. Now set the sliders for terminals **1, 3, 5, 9, 11,** and **13** (the six inputs) to +5 V (logical **1**) and note the conditions of the lamps. All lamps corresponding to terminals that are connected to +5 V should be on (**1**) whereas all lamps corresponding to output terminals (**2, 4, 6, 8, 10,** and **12**) should be off (**0**); we have already seen, in our discussion of gates, that INVERTER outputs should maintain states that are the inverse of their inputs. Try other combinations of input states and note that, if the IC is operating properly, all outputs will be the inverse of their respective inputs.

Thus, we can check the entire integrated circuit at the same time . . . all six inverters, simultaneously.

SN7400: Quad two-input nand gates

This IC contains four two-input NAND gates on a single chip. Here again, we will perform tests on all parts of the unit simultaneously. Plug the circuit into the test socket, properly oriented. The truth table for each of the four NAND gates is as was given earlier. Make the initial settings as per Table II at the left.

All input lamps should be at logical **1** (on) and all outputs should be at logical **0** (see truth table for a NAND gate).

Now change the settings for the in-

NUMBER/TYPE	PIN NUMBERS 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
SN7400-QUAD 2-IN NAND GATE	IN 1A	IN 1B	OUT 1	IN 2A	IN 2B	OUT 2	GND	OUT 3	IN 3A	IN 3B	OUT 4	IN 4A	IN 4B	VCC	—	—	SN7400
SN7401-QUAD 2-IN NAND-O/C GATE	OUT 1	IN 1A	IN 1B	OUT 2	IN 2A	IN 2B	GND	IN 3A	IN 3B	OUT 3	IN 4A	IN 4B	OUT 4	VCC	—	—	SN7401
SN7404-HEX INVERT GATES	IN 1	OUT 1	IN 2	OUT 2	IN 3	OUT 3	GND	OUT 4	IN 4	OUT 5	IN 5	OUT 6	IN 6	VCC	—	—	SN7404
SN7430-8-IN NAND GATE	IN A	IN B	IN C	IN D	IN E	IN F	GND	OUT	N/C	N/C	IN G	IN H	N/C	VCC	—	—	SN7430
SN7442-4 TO 10 BCD DECODER	OUT 0	OUT 1	OUT 2	OUT 3	OUT 4	OUT 5	OUT 6	GND	OUT 7	OUT 8	OUT 9	IN D	IN C	IN B	IN A	VCC	SN7442
SN7473 DUAL J-K M-S FLIP-FLOPS	CLK 1	CLR 1	K 1	VCC	CLK 2	CLR 2	J 2	NQ 2	Q 2	K 2	GND	Q 1	NQ 1	J 1	—	—	SN7473
SN7474-DUAL D-EDG TRIG FLIP-FLOPS	CLR 1	D 1	CLK 1	PRE 1	Q 1	NQ 1	GND	NQ 2	Q 2	PRE 2	CLK 2	D 2	CLR 2	VCC	—	—	SN7474
SN7480-GATED FULL ADDER	B*	B c	C n	NC n+1	SUM	NSUM	GND	A 1	A 2	A*	A C	B 1	B 2	VCC	—	—	SN7480
SN7486-QUAD 2-IN EXCL-OR GATES	IN 1A	IN 1B	OUT 1	IN 2A	IN 2B	OUT 2	GND	OUT 3	IN 3A	IN 3B	OUT 4	IN 4A	IN 4B	VCC	—	—	SN7486
SN7490-DEC CNTR-DIV BY 2+5	IN B-D	RST 0-1	RST 0-2	N/C	VCC	RST 9-1	RST 9-2	OUT C	OUT B	GND	OUT D	OUT A	N/C	IN A	—	—	SN7490
SN7491-8 BIT SHIFT REGISTER	N/C	N/C	N/C	N/C	VCC	N/C	N/C	N/C	N CP	GND	IN B	IN A	Q	NQ	—	—	SN7491
SN7492-DIV 12-CNTR DIV BY 2+6	IN B-C	N/C	N/C	N/C	VCC	RST 0-1	RST 0-2	OUT D	OUT C	GND	OUT B	OUT A	N/C	IN A	—	—	SN7492

ABBREVIATIONS:
IN—INPUT
OUT—OUTPUT
GND—GROUND
VCC—SUPPLY VOLTAGE
CLK—CLOCK
CLR—CLEAR
Q—FLIP FLOP OUTPUT
NQ—INVERSE Q ("NOT" Q)
PRE—PRESET INPUT
N/C—NO CONNECTION
RST—RESET

puts to correspond to the other input combinations shown in the truth table for a NAND gate to see if the outputs conform to those given.

SN7401: Quad two-input nand gates with open collectors

Testing of these NAND gates is similar to that procedure already discussed above for the SN7400, except that these gates have open-collector outputs and require the addition of "pull-up" resistors to drive the indicator lamps. Pull-up resistors are normally connected between the outputs and +5 V. This is done in the DIGI-DYNA-CHECK as follows:

Move slider **W** to +5 V to bring +5 volts out to binding post **W.** Now, connect pins **1, 4, 10,** and **13** (the NAND gate outputs) to binding posts **A** through **D,** respectively, via their matrix sliders. You can now connect the required resistors (approx. 1000 to 4000 ohms).

Connect V_{cc} and ground and set the inputs as before (for the SN7400) observing the proper terminal connections for the SN7401, and carry the gates through their various input combinations as before.

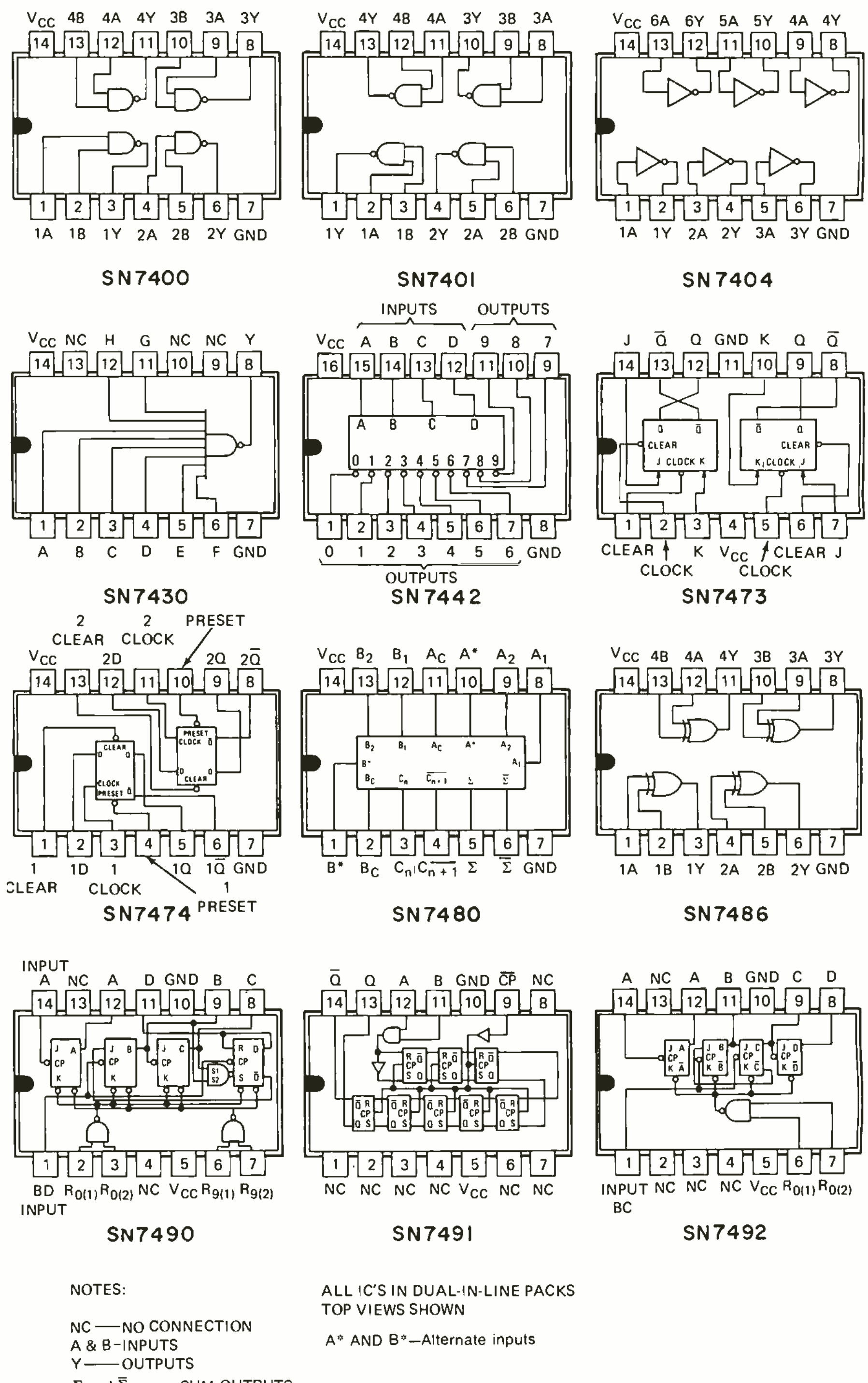
SN7473: Dual J-K flip-flops

This integrated circuit contains two complete J-K flip-flops in a single package. For the sake of simplicity, and since both flip-flops operate identically, we will only go through the tests for one of them. After the IC has been properly inserted into the test socket, connect pin 4 to +5 V and pin 11 to GND to supply operating power to the circuit. Let's go through a manual test, first. Set pin 1 (CLOCK input) to the STEP position and pins 14 (**J**-input) and 3 (**K**-input) to one of the combinations shown in the truth table for a J-K flip-flop. Momentarily connect pin 2 (CLEAR) to GND and then to +5 V and leave it there. This is done to clear it, i.e., bring it to an initial state. Enter a "clock" pulse, manually, by depressing the STEP button one time only and releasing it. The outputs, **Q** and $\overline{\textbf{Q}}$, should react according to that which is given in the truth table for the particular combination of **J** and **K** inputs that you have entered. Clear the flip-flop again by momentarily grounding the CLEAR input (pin **2**) and returning it to +5 V. Set the **J** and **K** inputs (pins **14** and **3,** respectively) to a different combination of logic states and then enter a clock pulse. Check the result once again and compare it with the truth table. Try the other two J-K combinations, referring, again, to the table. You can also try entering several clock pulses for the **1, 1** combination of J-K inputs. The outputs should oscillate back and forth between two states. The second flip-flop in this IC can be checked out in a similar manner, either separately, or simultaneously with the first one, as above.

To operate the flip-flops automatically, at a rate of 50 kHz. for monitoring input/output relationships with a scope, use the INT CLOCK setting instead of the STEP setting for the clock input. Set the matrix sliders corresponding to the output terminals of interest to positions **A** through **D** and move the sliders **W** through **Z** to the same positions as the input terminals of interest and connect the scope to the binding posts. For every two clock pulses, you should see one square-wave pulse at either of the two outputs. The two outputs (**Q** and $\overline{\textbf{Q}}$) should be 180° out of phase. A flip-flop is, thus a divide-by-two device.

The SN7490 contains four flip-flops that are internally wired to form separate divide-by-two and divide-by-five counters. These can be operated either separately with their own individual inputs and outputs, or they can be wired, externally, together as a single divide-by-ten (decade) counter by connecting the output terminal of the divide-by-two section to the input terminal of the divide-by-five section and using input A (to the first flip-flop) as the decade input. When it is operated in this mode, the outputs are in BCD code; the four outputs have the values:

Output:	A	B	C	D
Value:	2^0 (1)	2^1 (2)	2^2 (4)	2^3 (8)



BASING OF ALL IC's listed in the table on the preceding page. You'll want these diagrams handy when you set up your IC tester to check out any of these units.

Thus the BCD-coded output of the decade counter is represented by the following conditions of the four flip-flop outputs:

Number	A	B	C	D
0	0	0	0	0
1	1	0	0	0
2	0	1	0	0
3	1	1	0	0
4	0	0	1	0
5	1	0	1	0
6	0	1	1	0
7	1	1	1	0
8	0	0	0	1
9	1	0	0	1

When the unit has counted ten input pulses, it automatically resets itself to zero and starts again. Let's now see how this IC is tested with DIGI-DYNA-CHECK.

1. As separate ÷2 and ÷5 counters—

Make the following initial settings:

Pin No	Set to	Remarks
10	GND	To supply power to the IC
5	+5 V	
2	GND	This deactivates the reset inputs to permit the flip-flops to function
3	GND	
6	GND	
7	GND	
14	STEP	Input to the ÷2 counter
1	STEP	Input to the ÷5 counter

Momentarily move the sliders corresponding to pins 2, 3, 6, and 7 to +5 V, simultaneously, and then back to GND. This resets both counters to zero and allows input pulses to be counted. All output lamps should now be off (logical**0**). Depress the STEP button and release it to enter a single count pulse to both sections. Repeat this four more times, comparing the output logic states with those shown in the table above:

Lamp No	Input Pulses 1st	2nd	3rd	4th	5th	Remarks
12 (Output A)	1	0	1	0	1	÷2 counter
9 (Output B)	1	0	1	0	0	÷5 counter
8 (Output C)	0	1	1	0	0	
11 (Output D)	0	0	0	1	0	

2. As a single ÷10 (decade) counter—

Make the following changes in the matrix switch settings:

Move Pin No	to Position
1	A
12	A

Remarks
This disconnects input of the ÷5 unit from STEP and connects a jumper (bus A) between the ÷2 output and ÷5 input.

Reset all counters as described above and then enter ten pulses, noting whether the outputs correspond to the 0 thru 9 BCD code given earlier. Here again, as in our earlier discussion involving the flip-flop tests, the use of the automatic INTERNAL CLOCK function instead of the manual STEP function permits you to use a scope to monitor input/output logic states and waveforms.

Checking current drain IC

It's a simple matter, with the DIGI-DYNA-CHECK, to route +5 volts to the V_{cc} terminal of an IC, indirectly, via a pair of binding posts. An ammeter connected to the posts will then be in series with the power supply to the circuit and will indicate current drain. This is accomplished by moving one of the sliders **W** through **Z** to +5 V, thus bringing +5 volts out to a binding post. Moving the slider corresponding to the IC's V_{cc} terminal to one of the positions **A** through **D** will bring it out to a binding post. Current drain can be monitored continuously while performing other tests on the IC.

We have seen that there are many ways in which the DIGI-DYNA-CHECK can be used to test digital ICs. A complete description of all of its uses is beyond the scope of this article. The use of a matrix switch together with the input/output binding posts makes the checker *almost* universal. Any IC terminal can be connected to any function, either internally or externally. Where needed, special adapters can be made to accommodate package types other than 14- and 16-pin DIPs. Thus, you might say that the DIGI-DYNA-CHECK is as close to *obsolete-proof* as you can get!

The multitude of ways in which this tester can be applied to digital IC testing is limited only by your imagination! **R-E**

Many readers have already asked "Where do I buy parts to build my own Digital IC Tester, as described in the May 1972 issue?" The answer to that query was supposed to have appeared at the end of the parts list last month. As you must know by now, it did not. Therefore, we are presenting here, the listing that was omitted last issue:

The following kits of parts are available from The Electronetics Co. Inc., P.O. Box 278, Cranbury, N.J. 08512.

DDC-1 consisting of Q1 thru Q36; D1 thru D5; bridge rectifier; IC1; matrix switch and DIP test clip: $54.50, including postage and insurance.

DDC-2 consisting of a manual listing pin connections for many popular integrated circuits, useful for programming the DIGI-DYNA-CHECK: $2.00 including postage.

cb radio call light

CB transceivers are often installed on motorcycles, sports cars, snowmobiles and in countless other noisy locations. The high noise level may cause an operator to miss an incoming call. An article in *Electron* magazine (Toronto, Ont.) shows how a call light can be added to indicate that a signal is being received.

The circuit in Fig. 1 can be added to receivers that produce a negative-going voltage at the squelch output when a signal comes on the air. The lamp turn-on voltage depends on the setting of the squelch control. The indicator circuit can also be driven by the emitter voltage of an rf transistor if this voltage swings negative on an incoming signal. With this arrangement, the lamp comes on with a S4-S6 signal. The circuit in Fig. 2 can be used in sets where an incoming signal develops a positive-going voltage.

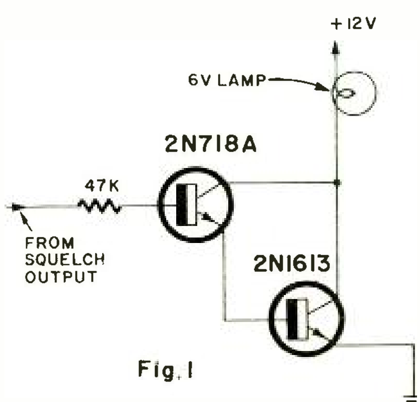


Fig. 1

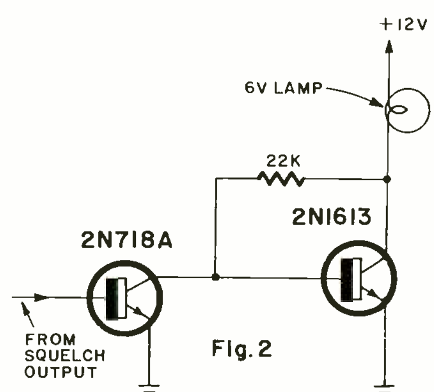
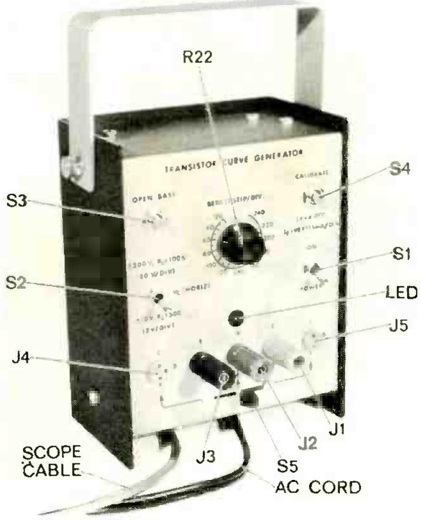


Fig. 2



FRONT VIEW of the completed transistor curve generator. This compact instrument measures only 6" high x 4½" wide x 2½" deep.

Build This Transistor Curve Tracer

Used with your scope, the transistor curve tracer lets you check transistors and other solid-state devices in-circuit as well as out-of-circuit

by CHARLES E. MULLETT, P.E. & CHARLES CARINGELLA, W6NJV

TRANSISTORS AND OTHER SOLID-STATE devices are now found in all types of equipment. If you are involved in designing or servicing such equipment, the transistor curve generator described here will be a valuable addition to your test equipment. If you already own an oscilloscope, you will want to build this sophisticated, yet easy-to-use test instrument. For the circuit designer, and even the experimenter, the combination of scope and transistor curve generator form a versatile tool for evaluating transistor and other solid-state device parameters. Service technicians will find the curve generator indispensable and a real time saver when troubleshooting and servicing all types of equipment, since the unit checks transistors and other solid-state devices *in-circuit*, as well as out of circuit.

Using high-gain silicon Darlington-amplifier transistors, silicon programmable unijunction transistors, silicon pnp transistors, and a ±15-volt integrated circuit (IC) regulator in the transistor curve generator circuit, simplifies what would normally be a rather complex design. The clean straightforward design results in an instrument that is easy to build, and even easier to use. Even the panel indicator light is solid-state! An LED (Light-Emitting Diode) is used to indicate when the power is on.

When used with an oscilloscope, the transistor curve generator displays the dynamic characteristics of both npn and pnp transistors, field-effect transistors, diodes, Zener diodes, tunnel diodes, and other devices. It can be used with almost any scope that has a vertical sensitivity of 0.1 V/cm, a horizontal sensitivity of 2 V/cm, and a minimum bandwidth of 100 kHz.

The instrument includes all the circuits needed to generate the base steps and collector sweeps, and the internal regulated power supply operates from the 117-volt ac line.

The number of front panel controls have been kept to a minimum, making the unit almost as easy to operate as a vom! Several unique features are built into the transistor curve generator:

1. Simultaneous calibration of the vertical and horizontal channels in the scope is done by simply pressing the CALIBRATE button on the front panel. This eliminates any guesswork in analyzing the scope traces.

2. Direct readout of transistor beta is available on the front-panel dial of the BASE DRIVE control.

3. Both npn and pnp transistors can be tested consecutively without changing any controls or switches.

There are two transistor test sockets and a set of three binding posts on the front panel for testing various semicon-

PARTS LIST

All resistors are ½-watt carbon. Tolerances are 10% except as noted.
R1—330 ohms
R2—150 ohms
R3, R10—4,700 ohms
R4—1,800 ohms
R5—68,000 ohms
R6, R19—47 ohms
R7—33,000 ohms
R8—1,000 ohms
R9—15,000 ohms
R11, R14, R18, R20, R21—10,000 ohms
R12—47,000 ohms
R13—390 ohms
R15—82 ohms
R16—100 ohms, miniature circuit board trimmer (Mallory MTC12L1 or equal)
R17—820 ohms
R22—100,000-ohm potentiometer, see text (Allen-Bradley type "J")
R23—1,500 ohms
R24—100,000 ohms, 5%
R25, R26—12 ohms, 5%
R27—910,000 ohms, 5%
R28—110,000 ohms, 5%
R29—20 ohms, 5%
R30—390 ohms, 5%
R31—620 ohms, 5%
C1—0.1µF, miniature disc
C2—.01 µF, mylar
C3—.002 µF, mylar
C4, C7, C8—.05 µF, mylar
C5, C6—100 µF 35-volt, printed circuit type electrolytic
C9, C10—10 µF, 25-volt, printed circuit type electrolytic
C11, C12—270 pF, ceramic capacitor
D1, D2, D3, D4, D5, D6—1N914 silicon diode
IC1—Dual-polarity tracking regulator (Silicon General SG3501T)
J1—Red binding post
J2—Blue binding post
J3—Black binding post
J4, J5—Transistor socket (TO-5 type)
LED—Light-emitting diode, with mounting clip (Monsanto MV5020 series, red solid-state lamp)
P1—Ac power plug
Q1, Q9—Motorola MPS-A14, npn silicon Darlington amplifier
Q2, Q10—Motorola MPS-A65, pnp silicon Darlington amplifier
Q3, Q5, Q6, Q7—Motorola 2N3905 pnp silicon
Q4, Q8—Motorola MPU-131, silicon programmable unijunction
S1—dpdt miniature toggle (JBT type JMT-223 or equal)
S2—3-pole double throw minature toggle (JBT type JMT-323 or equal)
S3, S4—spdt pushbutton (Switchcraft 953 or equal)
S5—3-position miniature lever (Oak 3991-63-184)
T1—power transformer: primary 117 volts; secondary windings: 33 volts ct rms @ 20 mA; and 170 volts rms @ 2 mA.
Printed circuit board
Cabinet with handle
AC power cord
Strain relief for ac power cord
Thumb screws, 6-32 x ¼" (2)
Knob
Small tapped angle brackets (tapped for 6-32 screws) (8)
MISC—Shielded cable, screws, hex nuts, lockwashers, flat washers, hook-up wire, solder

The following are available from Caringella Electronics, Inc., P.O. Box 327, Upland, Ca. 91786. California residents must add 5% sales tax.
Printed circuit board—No. TCG-1, drilled and printed with part numbers, $14.95 postpaid
Power Transformer—No. PT-1431, $9.95 postpaid
Set of semiconductors— $17.00
Complete kit—No. TCG-1K, includes cabinet with printed panel, all parts and hardware, wire, and solder. Complete step-by-step instructions, $79.95 +$1.50 for handling and shipping.

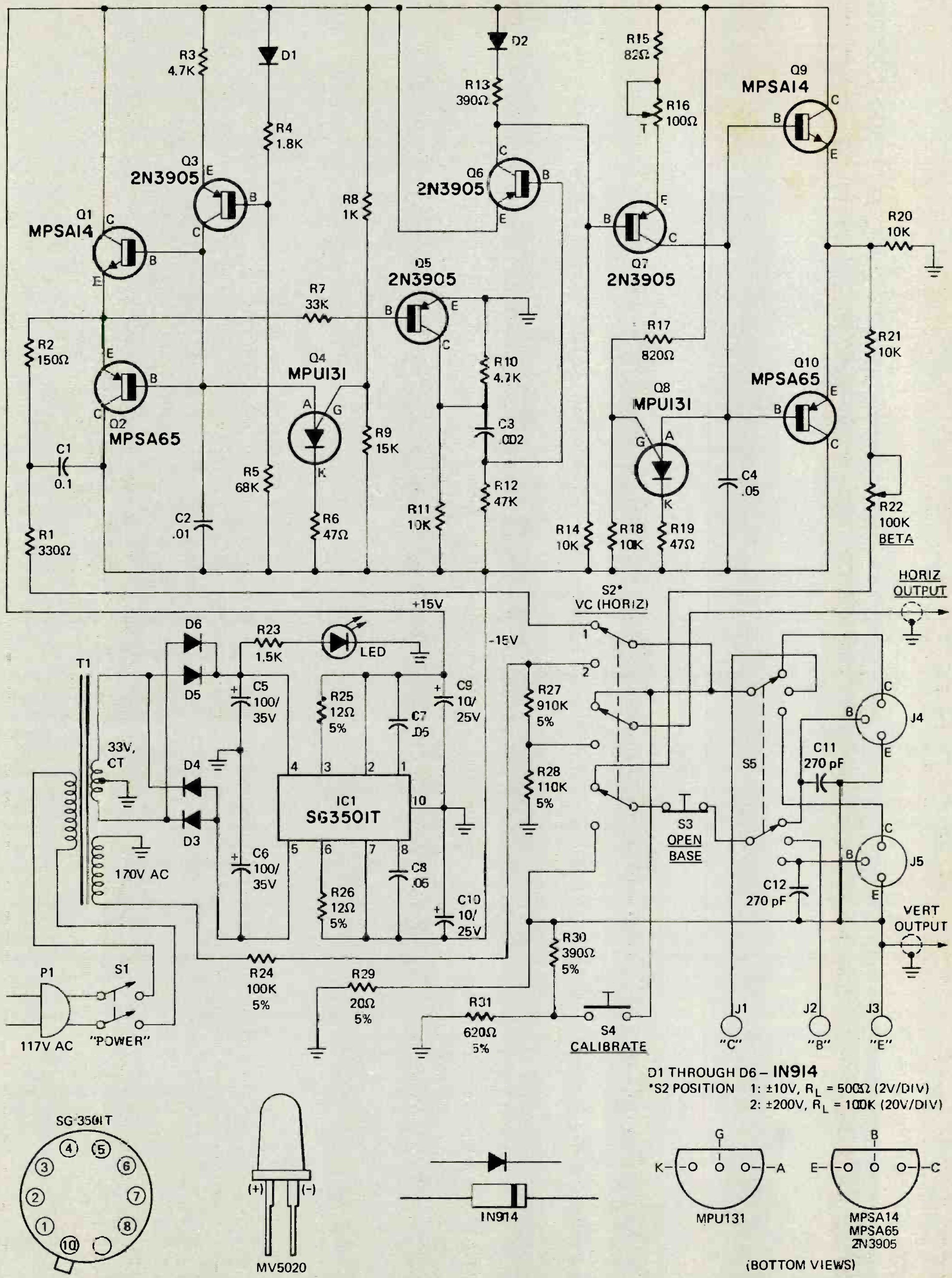


FIG. 1—COMPLETE SCHEMATIC DIAGRAM. "V_C" switch, S2, is shown in the normal mode, which is the ±10-volt, R_L = 500-ohm position. Switch S5 is the three-position lever switch. The LED is powered from the +15-volt unregulated side of the power supply.

ductor devices. A three-position lever switch is located directly below the binding posts. It switches either socket, or the three binding posts into the circuit. Standard ¾-inch spacing is provided between each binding post. The binding posts will accommodate a variety of test leads, each terminated with clamp-on type clips, for in-circuit testing. Comparing or matching the parameters of two transistors can be done quickly by simply using the two sockets on the front panel, and flipping the lever switch back and forth.

The block diagram of the instrument is in Fig. 2, and illustrates the five basic sections of the circuit. The power supply delivers +15 volts and −15 volts to the signal generating circuits, as well as a ±200-volt sinewave for the breakdown test. A ±12-volt sawtooth waveform from the collector sawtooth generator also triggers the pulser circuit. The pulser circuit produces a short (17 μ sec) current pulse for each cycle of the sawtooth. This pulse advances the base staircase generator one step for each cycle of the sawtooth. The base staircase generator then produces 12 steps, from −12 volts to +12 volts. The test switches deliver the proper signals to the device under test.

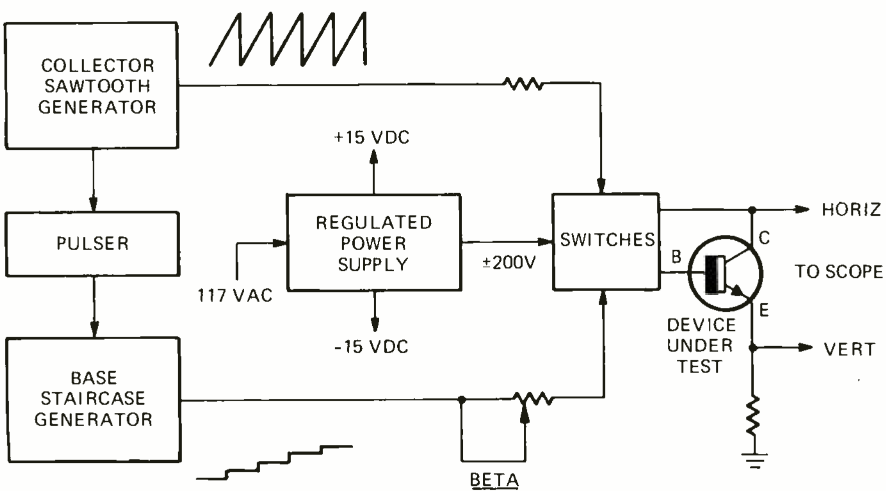


FIG. 2—BLOCK DIAGRAM of the curve generator illustrates the five basic sections of the circuit.

The complete schematic diagram is in Fig. 1, as are the base connections for the various transistors, diodes, and the light-emitting diode. Operation of the instrument consists of three modes: **1.** Normal mode **2.** Breakdown mode **3.** Calibrate

Normal Mode (V_C switch, S2, in the ±10-volt, R_L = 500-ohm, position)

Base current is delivered from a staircase of 2-volt steps from −12 volts to +12 volts through the BETA potentiometer, R22, which determines the base current per step.

Collector voltage is supplied from the sawtooth generator through a 500-ohm fixed load impedance. Collector voltage is delivered to the scope's horizontal amplifier and is displayed as the horizontal axis of the characteristic curves.

Emitter current through the transistor under test is displayed on the scope's vertical axis by sampling the current through resistor network R29, R30, and R31, and feeding the resulting voltage waveform to the oscilloscope's vertical amplifier. Since emitter current is equal to the sum of base current and collector current, and since base current is small compared to collector current (by a factor of the current gain, or "beta") the display is a good approximation of the usual collector characteristics of a transistor, namely, collector current versus collector voltage.

Collector voltage is swept from −12 volts to +12 volts during each step of the base current staircase.

Breakdown Mode (Vc switch, S2, in the ±200-volt, R_L = 100K, position)

In this mode, a ±200-volt sine wave is applied to the collector of the test transistor through R24, a 100,000-ohm source resistor. This high source resistance limits test current to a maximum of 2 mA to prevent damage to the device under test. Since the sole purpose of this test is to determine the collector breakdown voltage, the base drive is disconnected. To display both open-base breakdown (BV_{CEO}) and the shorted-base breakdown (BV_{CES}), a pushbutton switch is provided to open the base or short it to the emitter, as desired. Resistors R27 and R28 sample the applied collector voltage and reduce it by a factor of 10 for compatibility with the sensitivity of the horizontal amplifier of the oscilloscope. A horizontal sensitivity of 2 volts/division will then display 20 volts/division from the device under test. Vertical deflection in the display is again derived from the emitter current resistor network, R29, R30, and R31.

Note that in BASE SHORTED (pushbutton not depressed) one polarity of the sine wave displays BV_{CES}, while the other half-cycle produces forward bias on the collector-base junction. In BASE OPEN (pushbutton depressed) one polarity of the sine wave produces BV_{CEO}, while the other half-cycle forward biases the collector-base junction and displays this diode drop in series with BV_{EBO}, the breakdown voltage of the emitter-base junction, another parameter of interest.

Calibrate Mode (V_C switch, S2, in the ±10-volt, R_L = 500-ohm, position)

The system is calibrated by depressing CALIBRATE switch S4. For proper calibration, all test transistors must be removed from the test sockets and binding post connections. In the calibrate mode, the sawtooth waveform is applied simultaneously to the oscilloscope's vertical and horizontal amplifiers, producing a diagonal line display. The sawtooth applied to the vertical channel swings from −0.2 volts to +0.2 volts, while the sawtooth applied to the horizontal channel swings from −4 volts to +4 volts. By adjusting the oscilloscope's sensitivity controls so that the diagonal line is displayed across a 4 x 4 division grid, the oscilloscope will read 2 volts/division horizontally and 0.1 volt/division (corresponding to 5 milliamperes/division) vertically.

Let's look at the circuit

A rather complex dual-output regulated power supply has been greatly simplified by using a unique integrated circuit regulator. The integrated circuit, IC1, is a new Silicon General type SG3501T. It is actually a dual-polarity tracking regulator designed to provide balanced positive and negative output voltages. A total of 24 active elements (transistors and a temperature-compensated Zener diode) are included in this unique IC. The regulator output provides +15 volts and −15 volts for the curve generator circuitry.

The collector sawtooth generator is a simple unijunction sawtooth oscillator. It uses a programmable unijunction transistor, Q4, fed from a constant-current source, Q3. The sawtooth is delivered to the output via a complementary emitter follower composed of Q1 and Q2. These are Darlington-amplifier type transistors and provide high current gain to avoid loading timing capacitor C2. The sawtooth oscillator frequency is approximately 550 Hz, and results in a flicker-free display on the oscilloscope.

The sawtooth is fed to Q5's base to make it saturate when the sawtooth is negative, and to be non-conducting when the sawtooth is positive. As a result, a square wave is produced at Q5's collector, with its positive-going edge coincident with the negative-going transition of the sawtooth. The positive transition of the square wave is coupled to Q6's base via capacitor C3. This cuts off Q6 until capacitor C3 charges through R12 to return Q6 to its normal saturated state. While Q6 is saturated, Q7 cannot conduct, so no current appears at its collector. During the brief "off" period of Q6, however, Q7's base voltage falls, causing it to conduct, with its collector current determined by potentiometer R16, which calibrates the base steps. This current is delivered to the base staircase generator, and its magnitude determines the amplitude of each step in the staircase.

The base staircase generator is another unijunction circuit similar to the collector sawtooth generator. Because capacitor C4 is fed from short pulses of current from transistor Q7, rather than from a constant-current source, its output is a staircase waveform with each "step" held at a fixed voltage by capacitor C4 between current pulses. Each current pulse raises the output voltage one step, until programmable unijunction transistor Q8 fires and the staircase begins again. Q9 and Q10 form another complementary emitter follower. R22 is the front-panel BETA control.

S5 is a two-pole three-position lever switch. It simply switches the base and collector signals to either test socket or the binding posts, which all are located on the front panel. S2, the V_C switch, is a three-pole double-throw toggle switch, and is used to select the NORMAL or BREAKDOWN test mode.

S3 is a normally closed pushbutton switch and is used for OPEN BASE operation. This opens the circuit to the base of the device under test.

CALIBRATE switch S4 is a normally open pushbutton switch. It connects the output of the collector sweep generator to the emitter circuit of the device under test and also loads this output. The result is a ±4-volt sawtooth at the horizontal output and a ±0.2-volt sawtooth at the vertical output.

Construction tips

The entire transistor curve generator circuit, with the exception of the various switches and controls, is assembled on a printed circuit board measuring only 3½" x 5". An actual-size drawing of the circuit board pattern, as viewed from the copper-foil side, is in Fig. 3. An X-ray view of the circuit board is in Fig. 4. This view clearly shows the location of all components mounted on the top side of the circuit board.

The following sequence should be followed in building up the circuit board assembly. First install the jumper wire on the board. Solder in the six diodes next. They should rest flat against the circuit board. The integrated circuit goes in next. Space the IC about ¼" above the circuit board. Make sure it is oriented properly on the board before soldering. Once it has been soldered in place, it is extremely difficult to remove. In this circuit, the IC runs slightly warm, but a heat sink is not necessary for safe operation. All of the transistors should be installed next. Space them about ¼" above the circuit board.

The resistors can all go on the board next. Mount them vertically, with one end of each resistor resting against the board. Next mount all of the capacitors. Be sure to observe the polarity of the electrolytics. R16, a printed-circuit type potentiometer, is installed next.

Power transformer T1 is installed last. The leads from the secondary windings are connected directly to the circuit board, while the 117-volt primary leads are run directly to switch S1. The high-voltage leads (blue leads) connect to holes **H** and **G** on the circuit board. Connect the low-voltage leads

(continued on page 68)

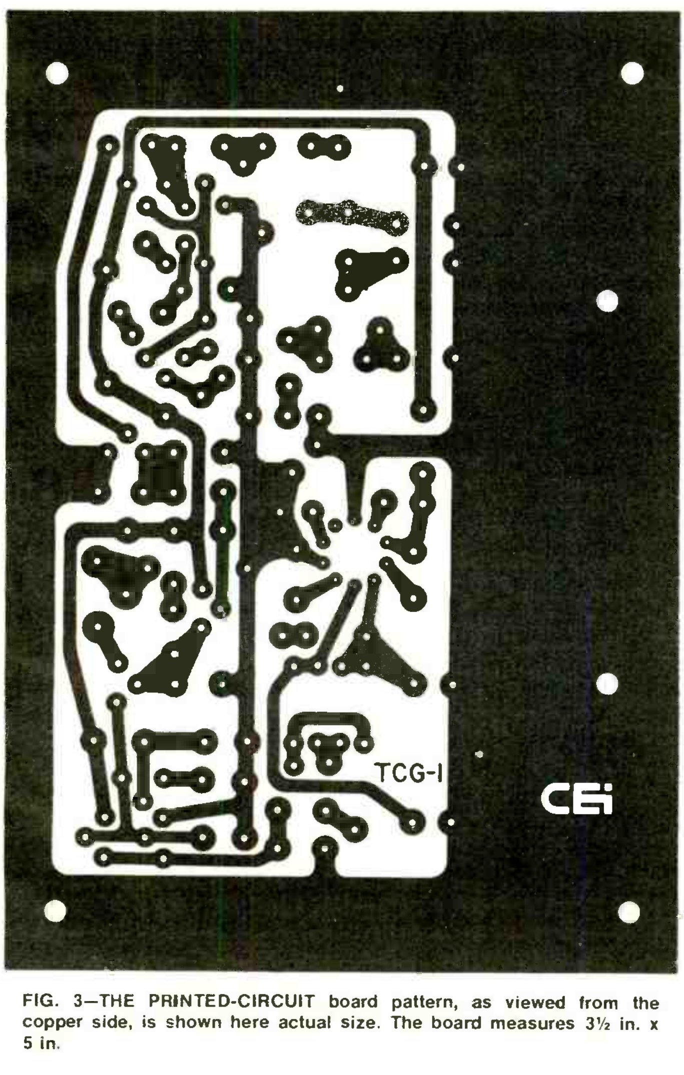


FIG. 3—THE PRINTED-CIRCUIT board pattern, as viewed from the copper side, is shown here actual size. The board measures 3½ in. x 5 in.

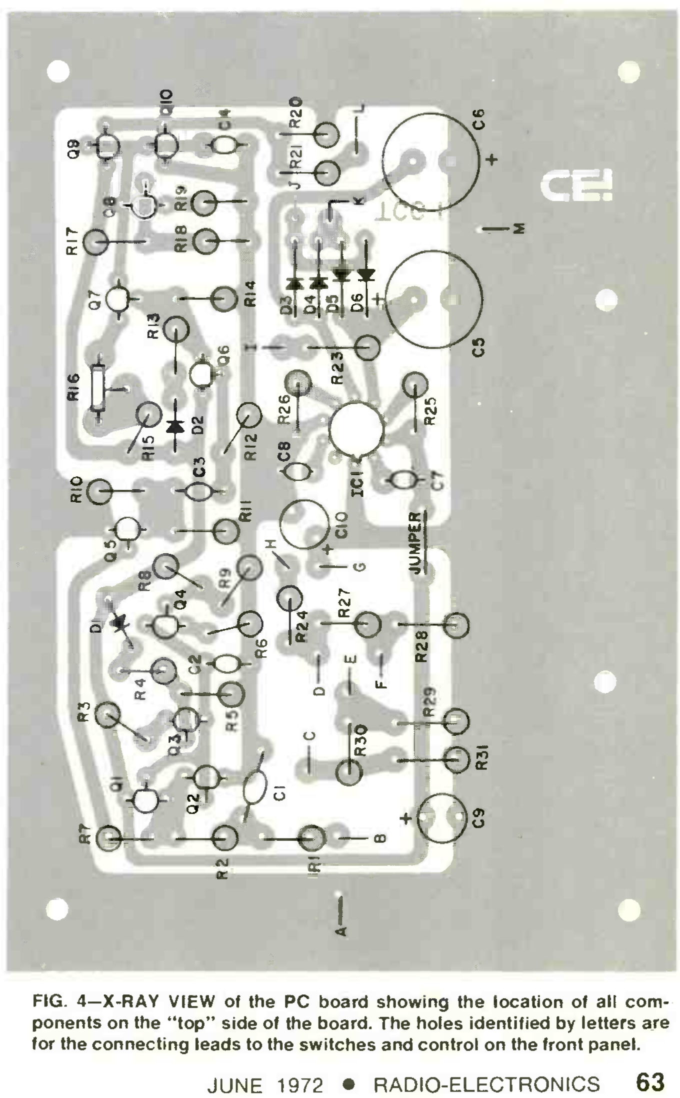


FIG. 4—X-RAY VIEW of the PC board showing the location of all components on the "top" side of the board. The holes identified by letters are for the connecting leads to the switches and control on the front panel.

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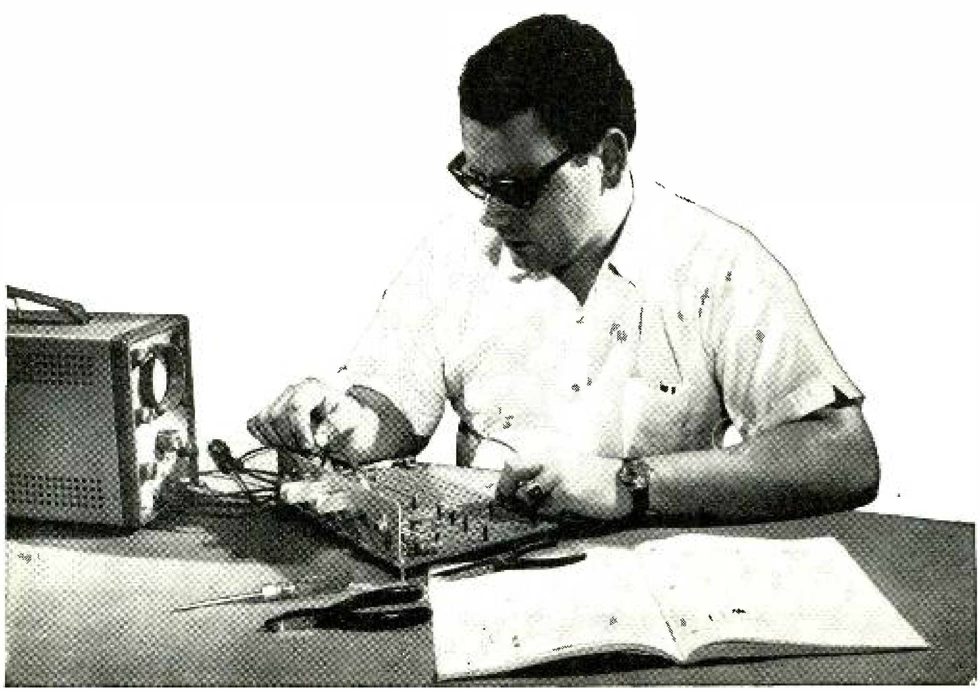

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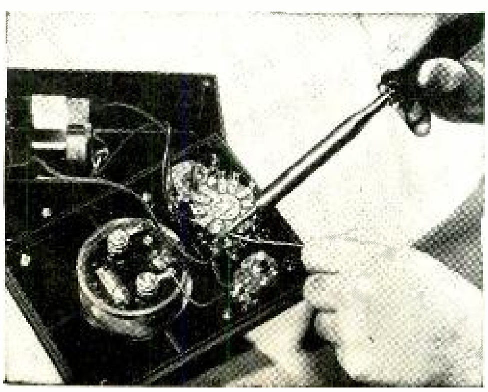
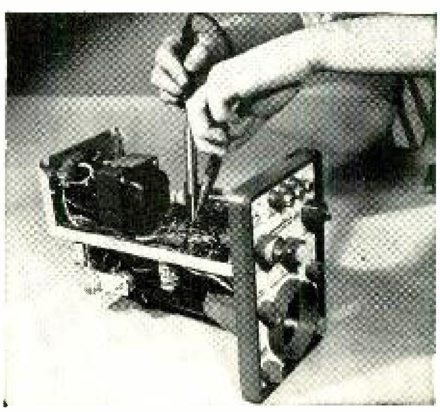
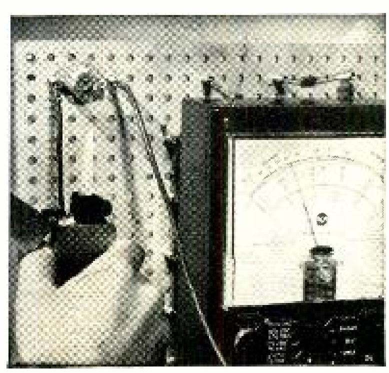
Construction of Multimeter.





Construction of Oscilloscope.

Temperature experiment with transistors.



(red leads) to holes **J** and **K.** The center tap lead (red-yellow lead) is connected to hole **M;** ground.

The remaining holes on the circuit board are used for the connecting leads to the switches and control on the front panel. The leads from the circuit board assembly to the front panel can be formed into one 8-conductor cable. (Fig. 5)

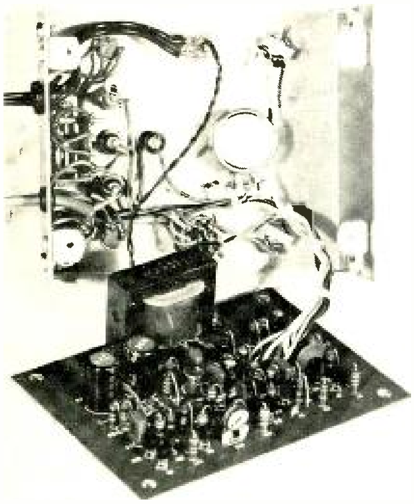


FIG. 5—INSIDE VIEW of the completed Transistor Curve Generator. An 8-conductor cable is used between the circuit board assembly and the front panel.

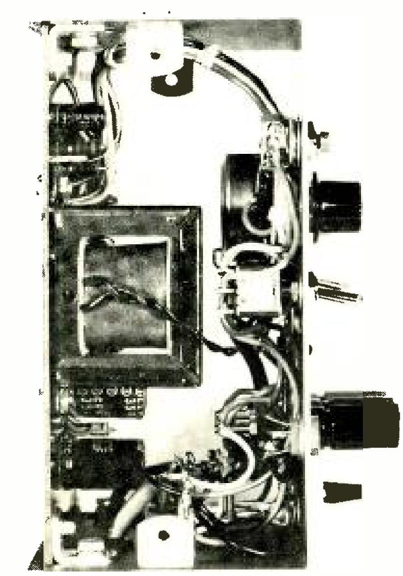


FIG. 6—SIDE VIEW of the completed instrument.

The cabinet can be made from .050" sheet aluminum formed into two "U" shaped pieces. One piece is used for the front panel, and the other piece for the cover. The handle should be fabricated from slightly heavier gauge sheet aluminum. Tapped angle brackets hold the cover to the front panel. A total of eight angle brackets is required. Four are used for the cover. The other four hold the circuit board assembly in place. (see Fig. 6) Using the screw which holds one of the angle brackets in place, install a solder lug for the chassis ground connection. This "ground" solder lug should be installed at the location nearest the point-of-entry of the shielded output cable.

Install two standard TO-5 transistor sockets on the front panel. Lever switch S5 is installed directly below the binding posts. Three colors are used for the binding posts—black for emitter connection J3; blue for base connection J2; and red for collector connection J1. The LED (*L*ight *E*mitting *D*iode) panel indicator light is located directly above the binding post. The type specified in the parts list comes with a plastic mounting clip. The two miniature toggle switches, S1 and S2, can be installed next.

BETA potentiometer R22 is installed last. This control must be a high-quality molded composition potentiometer, with a ±10% tolerance, such as the Allen-Bradley type "J". An actual-size drawing of the beta dial is shown in Fig. 7.

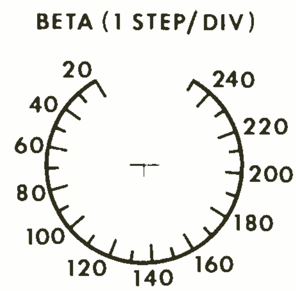


FIG. 7—ACTUAL SIZE DRAWING of the dial for the "BETA" control.

Once all of the parts have been installed on the front panel, the unit is ready for final wiring. These connections are made between the circuit board assembly and the front cover:

Hole A to chassis ground lug
B to S2
C to S4
D to S2
E to S2
F to S2
I to LED (positive or "plus" lead)
L to R22

The ac power cable is brought into the cabinet through the bottom of the front panel and connects to power switch S1. Use strain relief on the panel for the power cord. The oscilloscope connecting cable is not critical, and may be an ordinary 2-conductor shielded cable, or even two single-conductor shielded cables. One is used for the vertical output and the other for the horizontal output.

Using the generator

The LED panel indicator light should glow when the unit is turned on. This indicates that the unregulated +15-volt side of the power supply is working. Next, the +15-volt and −15-volt dc outputs from the power supply regulator should be checked. Using a vom, read these voltages at C9 and C10, with respect to ground, as shown in the schematic. If the voltages check out properly, proceed with the final adjustments.

Connect the transistor curve generator to your oscilloscope's vertical and horizontal inputs. Press the CALIBRATE button and a diagonal line trace should appear on the scope. The calibrating voltages are accurate to ±10%. Adjust the scope's vertical and horizontal sensitivity controls so the diagonal line is displayed across a 4 x 4 division grid. The oscilloscope is now calibrated and will read 0.1 volts/division vertically, which corresponds to 5 mA/division. The vertical axis displays the collector current of the test transistor. In the normal operating mode, the scope will read 2 volts/division horizontally, and in the breakdown mode, the scope will read 20 volts/division horizontally. The horizontal axis displays the collector voltage of the test transistor.

If you use an oscilloscope with triggered sweep, then its sweep generator should be turned off to eliminate the possibility of Z-axis modulation of the display.

The only internal adjustment required is to set trimmer resistor R16. This adjustment calibrates the base steps. First, plug a pnp transistor into one of the test sockets on the front panel, and an npn transistor into the other socket. Now, turn the BETA control fully counterclockwise (pointing to "240" on the dial). Flip lever switch S5 back and forth, so the pnp and npn transistor curves are alternately displayed on the scope. Adjust the trimmer resistor so only five curves appear for the pnp display, and likewise, five curves appear for the npn display. Switch back and forth between the two transistors until this has been done. The end result should look like the family of curves shown in Fig. 8. Fig. 8-a is the typical display for a pnp transistor. Fig. 8-b is the typical display for an npn transistor.

The base steps are now calibrated. Beta for the transistor under test can be read directly from the dial by simply turning the BETA control for a spacing of one division between curves in the display. The spacing between curves increases as the BETA control is turned clockwise.

Fig. 8-c shows the breakdown for a 2N2369 npn transistor. This is actually a double exposure. Reading left to right, the first and third lines on the trace are produced when the OPEN BASE pushbutton is depressed. When it is not depressed, the second and fourth lines ap-

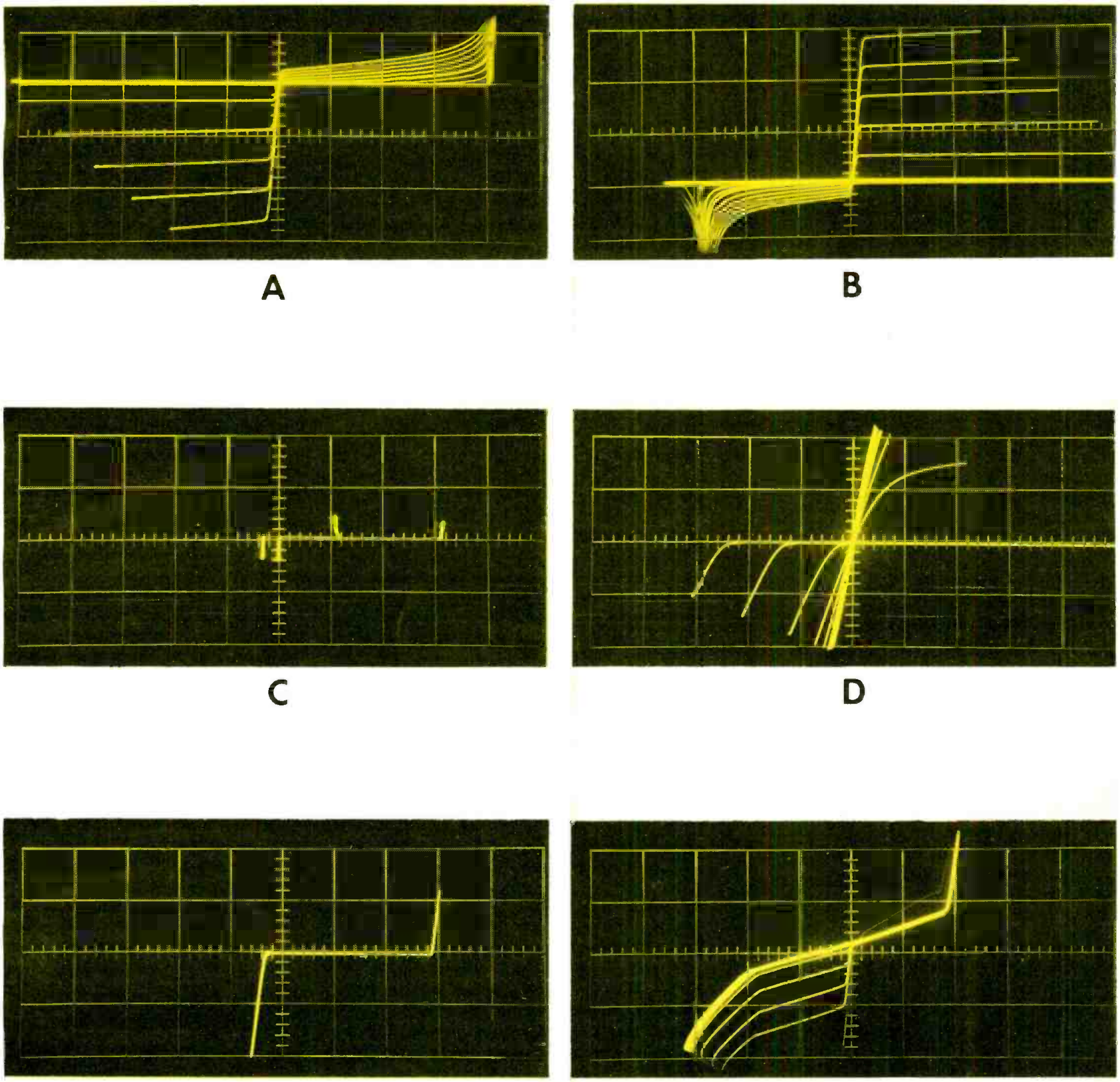


FIG. 8—TYPICAL OSCILLOSCOPE DISPLAYS shown here are as follows: a—pnp transistor, b—npn transistor, c—2N2369 breakdown test, with traces reading left to right, BV_{EBO} + C-B diode, C-B diode, BV_{CEO}, and BV_{CES} (Note that this photo is actually a double exposure), d—n-channel junction field-effect transistor, e—6-volt Zener diode, and f—pnp transistor "in circuit".

pear on the trace. Be careful when checking metal-can transistors in the breakdown mode. There is high voltage between the transistor case and ground since the collector is tied to the case in most types. The current is limited to only 2 mA, so it is not dangerous.

A typical n-channel junction FET is shown in the display in Fig. 8-d. When checking FET's, the drain is connected to the collector test point, the gate is connected to the base test point, and the source is connected to the emitter test point.

Diodes are connected between the emitter and collector test points, and may be oriented either way. A typical 6-volt Zener diode is shown in Fig. 8-e.

A typical pnp transistor, measured in circuit, is shown in Fig. 8-f. When making in-circuit checks, the power to the equipment under test should be turned off! In-circuit testing of transistors is strictly a "go/no-go" type of test, since the family of curves will vary drastically from those produced out-of-circuit. The transistor curve generator will spot defective transistors quickly and efficiently, and should make a worthwhile addition to any service facility. **R-E**

R-E's Service Clinic

time savers—why you should

Time is money—new tools and techniques help you save both

by JACK DARR
SERVICE EDITOR

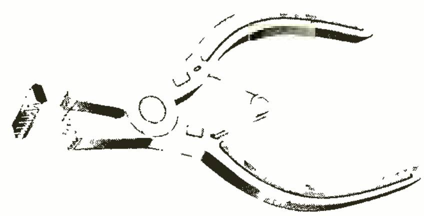
A LONG TIME AGO, I HEARD A VERY wise man make a speech at a convention. He made a point that has stuck with me ever since. To him, there are two types of electronics technicians; the professionals, and the "hobbyists." Both are in this bewildering business of ours because they *like it.* However, the pro does it to make money! The hobbyist actually does it for fun. He won't use the right business methods, and he won't use special tools, test equipment, etc. to save time. The pro, on the other hand, is always on the lookout for things like this—he knows that they'll save him time, which in this business means money.

There are a lot of these, lately. Let's look at a few of them. This'll be a kind of mixed bag, for we won't have time to go into all of 'em. Keep your eyes open each time you visit your friendly radio-TV parts supply house. They often have these things on display. (Also, keep an eye on the small ads in the back pages of **Radio-Electronics!** You'll find a lot of 'em there (Adv't!).) Look for small tools and things that can help you get through some of the hard jobs in less time.

For one example; Xcelite makes a special nutdriver, with a shank 2 feet long or more. This will get the tuner out of a lot of Zenith, etc. models in about ⅓ the time you used to need. They also make very short ones, for the opposite cases; tight places where you can't get the standard 6-7-inch nutdrivers into.

If you work on sets with integrated circuits in 'em (and we're going to, more and more, it looks like), Techni-Tool, Inc., 1262 Arch St., Phila., Pa. 19107, has a kit of things which will help. This includes a small soldering iron, with a set of special tips. One of these is designed for heating and loosening all of the pins of a 10, 12, 14 pin DIP (Dual-In-line Package) IC at once. The IC can then be lifted out easily without damage. Another tip has 14 small pins in the same shape. This is for opening up all of the tiny holes in the PC board after an IC has been taken out. A third tip looks something like a miniature snow-shovel! It is used for soldering all of the pins of an IC at once, on one side; or, for any job calling for heating of a good-sized area at the same time, for multiple-lead components.

To work with these, a special "IC Extractor" tool has been designed. Looks like a pair of plastic pliers with



metal jaws like a clam-shell digger bucket! These jaws are made of aluminum; solder won't stick to them. They're spaced so they'll go between the pins of any standard DIP IC package, from 10 up to 32 pins. Spring-loading holds the IC firmly. You can get a handle on the things, by holding either of the extractor handles. This will speed up the most infuriating part of IC work; getting the things in and out of PC boards, or even IC sockets. If necessary, the same tool can also be used for removing or installing IC sockets, too.

One of the handles of this tool is intentionally made so that it is the same width as the stock DIP IC package. If you get any of these delicate pins bent, just slip the IC over this handle, and you can straighten the pins with ease.

The "A" version of this tool has a flat-ended, spring-loaded plunger between the jaws. This is used for inserting IC's into sockets or PC boards. After getting it in position, press down on the top end of the plunger, and the IC will be forced "home" without danger of bending the pins. (I had occasion to bless this tool during the construction of a piece of kit test equipment, which used many many IC's. Very handy, especially if you have occasion to be just a little bit shaky, or suffer from the "Technician's Trembles".)

The same tool can also be used for pulling transistors in T0-5 cases, getting resistors or capacitors out of tightly-packed PC boards, and similar jobs. You'll find a lot of uses for it as you go along.

As the old vaudeville song used to go "Many other items I could mention",

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.

but I'm running out of room. Just time for a few quickies:

1. **Extension harnesses,** for picture-tube, deflection and convergence yokes and high voltage. With these, you can work on the chassis of a TV on the bench, using its own picture tube and yokes. **(Eby, Telematic)**

2. **"Above-the-board" test socket** adapters. Plugged into tube sockets, they lift the tube up, and provide test points for each element. No pulling of chassis to get at the underside. Can be bought for every tube-base in use today. **(Pomona)**

3. **Screw-holding screwdrivers. (Hunter)**

4. **Special pliers,** for doing odd-shaped jobs. Example; bent-nose longnose pliers, with about ½ inch of the tips bent at right angles. There are places where only this type of plier will hold the part and let you get at it with a soldering-iron. **(Klein, Utica)**

5. **"End-cutters".** These look like longnoses, but have cutting blades right at the tip. Ideal for getting into crowded PC boards and clipping off leads, cutting out defective parts, and so on. **(Klein)**

6. **Locking-pliers** or "seizers". Like a surgeon's hemostat. Very long and thin, with notched locks in the handles. Useful for holding small parts for insertion or removal. **(Xcelite)**

7. **Simplest of all;** a few pieces of plastic tubing or spaghetti. Get one piece which is just big enough to slip the case of a T0-5 transistor inside the end. Cut it about 6 inches long, and this is a "handy handle" for installing transistors in tight places. You can find tubing which will fit any of the other stock transistor cases, from the tiny epoxy types on up. A simple trick, but a real time-saver.

As you go along, keep an eye out for these little jobs that give you a hard time. Then, stop for a minute and see if you can't figure out some kind of sneaky little gadget that will help out. You'll be surprised at the amount of valuable time you can save, with only a little ingenuity. Here's another example, sent in by a Canadian reader: To insert screws in tight places, just put a tiny dab of the gummy substance called "dum-dum" by auto-body repair men, on the end of your screwdriver blade. Stick the screw onto this, and it'll stay there until you can get the screw started. **R-E**

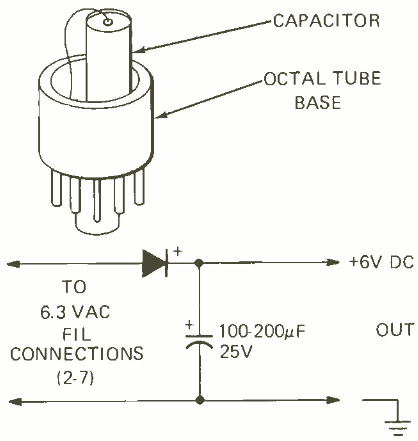
Reader Questions

SUBSTITUTE ULTRASONIC OSCILLATOR

I've got this old NATCO sound projector. It works fine, but someone has torn

up the ultrasonic oscillator circuit for the exciter lamp filament, beyond recognition. Do you know where I can get a circuit on this, or a transformer for it?—N.S., Waterbury, Conn.

Sorry. No data on replacement oscillator transformers for this one. However, how about using dc? The purpose of the ultrasonic filament supply is to

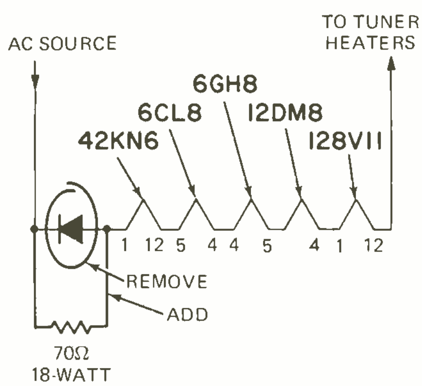


get away from 60-Hz hum.

Mount a 1.5-amp silicon diode and a low-voltage electrolytic filter capacitor in an old tube base, and plug it into the original 6V6 oscillator tube socket. Connect the diode to the original filament. Use about a 100 to 200-μF, 25-volt capacitor, and you should get enough filtering to take out any ripple.

SLOW RISE CATHODE CURRENT

In a Sylvania DO-5 color TV the horizontal output tube cathode current starts out within limits, and slowly rises over a long period of time. It will get up to 300 to 400 mA. Picture, width, contrast, brightness, etc. all stay within limits until the current gets way up there. Grid drive, regulator, boost, etc have been checked. Bias has been clamped on 42KN6 with no



help. All dc supply voltages within limits. Help!—C.B., Greensboro, N.C.

You've already checked all of the regular things. So look for something unusual. There are two odd-ball possibilities. One is a heater-cathode short in the next tube in the heater string. It would cause the heater *voltage* on the 42KN6 to rise, and could cause the excess current.

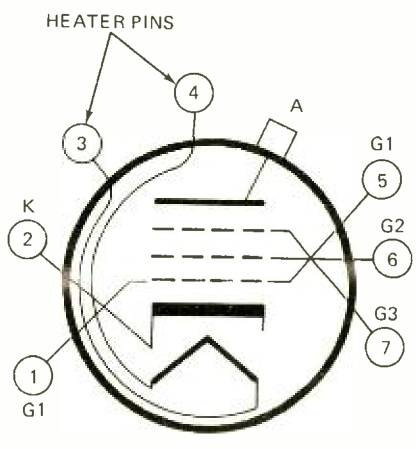
The second, from a Sylvania Service Note, is the possible failure of the silicon rectifier used in series with the heater string. It was used in early production runs of the DO-5 chassis. They recommend replacing it with a 70-ohm 18-watt resistor.

REPLACEMENT PIX TUBE

This Olympic 3P48 imported TV seems to have a bad pix-tube heater. It goes on and off at odd intervals. Voltage supply OK, socket OK, and so on. I can't find a replacement listed anywhere for it, and the company doesn't answer my letters.

This is a "310GB4" tube. Do you know of a substitute?—C.C., Cornwall, Ontario.

After much searching of characteristics lists, tube manuals, and so on, I may have come up with one. The characteristics of the original are: 12-inch rectangular, 110° deflection angle, 12-volt heater at 75 mA. The heater in this little set is fed directly from the +12



7GR BASE

volt supply for the transistors.

Wonder of wonders, I located a tube in the Sylvania Technical Manual, 13th Edition. It is a 12BVP4, and all of the characteristics match, even to the 12-volt 75-mA heater. Also, and even more unusual, the base seems to be the same. It is a "7GR" base, 7 pins. So with crossed fingers, I'd say that it ought to work.

US vs U.K. TV STANDARDS

I'm being transferred to England. Can I use my American TV there? I understand their line voltage is 220 volts at 50 Hz. Wouldn't a step-down transformer take care of that?—E.B., Dover, Del.

The line voltage would be the least of your troubles. (Learn to say "mains": that's English for line voltage.) The standard NTSC US TV set wouldn't work very well on either of the British TV systems.

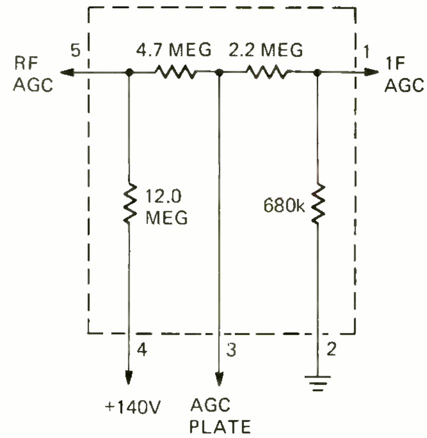
BBC-1 uses a 405 line system, 50-Hz vertical, positive-going video modulation (opposite to ours), sound on AM instead of FM. BBC-2, and ITA use a uhf system, and most of it will be on the 625-line CCIR system, as I get it. This is closer, but still no cigars. Color is even worse. They use the PAL system, which is incompatible with NTSC.

Incidentally, you'll find a flourishing TV *rental* system in the British Isles. My English friends tell me that they rent more sets then they sell. Your best bet would probably be to rent one for the duration of your stay. Many English housing developments have the "telly" wired-in, with special receivers. This service goes with the apartment, so it might help, too.

RF AGC TROUBLE

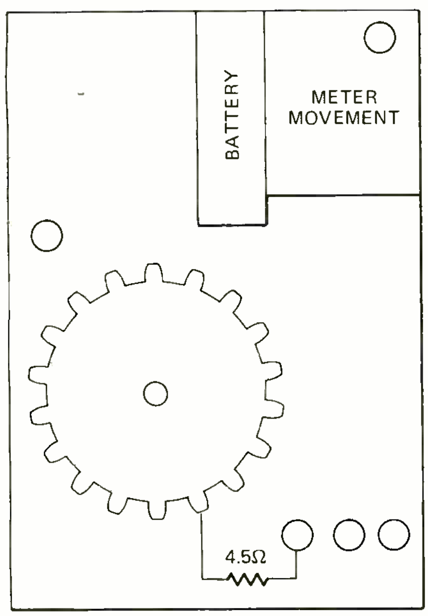
This Motorola TS-454YC portable has developed a peculiar condition. Acts very much like agc trouble, but there is no agc adjustment on this chassis. All voltages, etc seem to be OK and tube replacement didn't help.—D.L. Wash. D.C.

Yep. This could be a thermal trouble in a printed-circuit unit in the agc circuit. The 12.0-megohm resistor could be drifting from heat, and upsetting the rf agc bias. It can be replaced with a duplicate, or with separate series resistors if you can't locate the right value. Thermal drift in any of these resistors would upset agc. **R-E**



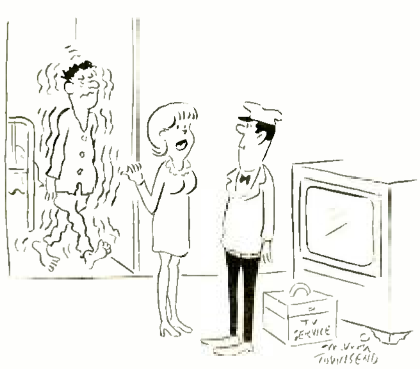
BURNT RESISTOR, IMPORT VOM

I have a Midland vom, model 23-101. This is an import. There's a resistor burned up; goes from the "–" terminal to the switch. Can't read the value. Can you help?—H.E., Ottawa, Ont.



BACK VIEW, COVER OFF

Yep. It is a 4.5-ohm wirewound. You can probably get a 1% resistor in that value, or make one, by winding fine resistance wire on a 2.2-megohm resistor, etc. Use silk-covered wire.

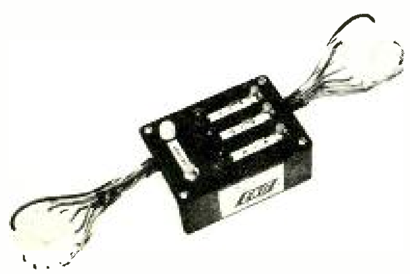


"I woke up Fred so you could see how the set looked before we lost the picture."

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

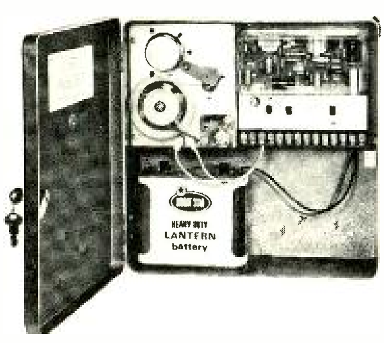
COLOR TUBE TESTER, *EKG,* test instrument to predict accurately if rejuvenated color tube will last for at least six months. Field-tested for over four years on thousands of color duds, the *EKG* has a proven accuracy exceeding 98%. Simply connect the unit between the color tube



and any standard CRT tester–rejuvenator. No dials to turn, no switches to throw or meters to read. The tester automatically checks all three cathodes simultaneously and gives results in just 60 seconds. $49.95.—**EKU, Inc.,** 12401 Mt. Pleasant Drive, Laurel, Md. 20810.

Circle 31 on reader service card

AUTOMATIC TELEPHONE DIALER, dual channel, with line seizure, time delay, anti-jam signal, abort, automatic reset, built-in tester, and rechargeable power supply. The dialer has precise, automatically governed motor which will maintain constant



speed even under different voltage conditions. Speed variations which can lead to garbled messages are prevented. Unit has precision molded part to guide the tape and serve as mounting for the magnetic "reading" head. Perfect alignment between the head and the tape, necessary for reliable message transmission, is assured. Other features include patented shut-off circuit requiring only one stop post and a "non-stick" pressure roller made of a material which won't flatten, even if the unit is not triggered for several months.—**Alarm Device Mfg. Co., Div. Pittway Corp.,** 165 Eileen Way, Syosset, N.Y. 11791.

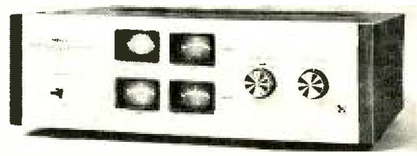
Circle 32 on reader service card

SPEAKER SYSTEM, *Poly-Sonic model E-41,* is an outdoor and indoor bi-directional hi-fi paging system of all-weather design. The high-temperature high-impact styrene enclosure comes in colors with complementary trim and all necessary hardware to allow you to stand, hang or mount the unit anywhere. The model *E-41*

has 40 watts peak, frequency range of 50 Hz to 20 kHz, input impedance 8 ohms. The unit is two inches by 13¼ inches x 16¼ inches and weighs less than 4 lbs. It comes in ivory white or walnut brown color finish. $23.95.—**Magitran Co.,** 311 East Park St., Moonachie, N.J. 07074.

Circle 33 on reader service card

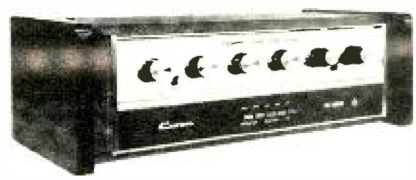
POWER AMPLIFIER, *model QM-800.* 4-channel quadrasonic power amplifier with four independent level meters directly correlated to corresponding front (left and right) speakers and rear (left and right) speakers. Meter sensitivity can be adjusted in three stages—0 dB, -10 dB, and -20 dB—permitting precise setting at all times. Input sensitivity/impedance is 0.5V/70 kilohms; 1V/110 kilohms and 2V/170 kilohms. Power bandwidth (IHF) is 5 Hz to 50,000 Hz, with two channels driven across 8 ohms, and 10 Hz to 50,000 Hz with 4 channels, 8 ohms. Harmonic dis-



tortion less than 0.5%. Response 5 Hz to 80,000 Hz, ±1 dB. $299.95.—**U.S. Pioneer Electronics Corp.,** 178 Commerce Road, Carlstadt, N.J. 07072.

Circle 34 on reader service card

STEREO PREAMPLIFIER, *model IC-150,* features 7-position input selector, tape monitor for two recorders, HF and LF filters, tone control cancel (for flat), and loudness-volume selector. Frequency response ±0.6 dB at 3 Hz to 100 kHz with hi-impedance load; power requirement



about 2 watts at 120 V or 240 V 50 to 400 Hz ac; volume control over 60 dB dynamic range with calibrated tracking. Comes with optional *5-D* walnut cabinet, $33.00. Without cabinet, $269.00.—**Crown International,** Box 1000, Elkhart, Indiana 46514.

Circle 35 on reader service card

TURNTABLE, *Realistic/Miracord 45.* Top-of-the-line automatic turntable comes complete with walnut wood base and factory-installed elliptical diamond-stylus

stereo cartridge. Features push-button operation, four-speed turntable, tracks as low as ¾ gram, to minimize wear. Has viscous-damped cuing, adjustable anti-skate control, die cast platter and precision threaded counterbalance. Wow and flutter under 0.1%. Rumble, 50 dB below average recording level. $149.95. Optional dust cover for $12.95; 45-rpm automatic spindle for $6.00.—**Allied Radio Shack,** 2617 W. 7th St., Fort Worth, Texas 76107.

Circle 36 on reader service card

STEREOPHONE SYSTEM, *model PEP-77C.* Offers virtually flat frequency response and negligible distortion over entire audio range. Provides dual polarization capability for self-energized and 117/Vac use. Features lightweight headphone with *Conform* ear cushions and ad-

justable headbands. Control console accommodates two sets of the headphones. Frequency response 10 Hz to 22,000 Hz; independent, separate grounds—1 per channel; 4 to 16 ohm impedance. $99.00—**Superex Electronics Corp.,** 151 Ludlow St., Yonkers, N.Y. 10705.

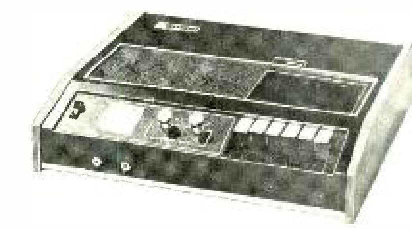
Circle 37 on reader service card

MICROPHONE, *Beyer model M67.* Dynamic unidirectional moving-coil studio microphone has a very tight cardiod pattern even at extremely low frequencies. A special cartridge suspension eliminates the very poor handling characteristics

generally associated with this type of polar pattern and keeps noises minimal. The microphone is water and humidity proof and works under all temperature extremes. It has built-in windgag capabilities, separate windshield, and built-in speech-off-music switch. $95.00.—**Revox Corp.,** 155 Michael Drive, Syosset, N.Y. 11791.

Circle 38 on reader service card

CASSETTE RECORDER KIT, *model AD-110.* Kit with reel-type performance specs has frequency response of ±3 dB from 30 Hz to 12 kHz; hum and noise −45 dB, and less than 0.25% wrms wow and flutter. Designed for full-fidelity recording and play-



back of stereo or mono cassettes through existing hi-fi systems. Adjustable bias permits use of chromium dioxide tapes. Six pushbuttons control record, rewind, play, fast forward, stop-eject, and pause. Separate level controls and meters allow taping any input from less than 100 mV to 10 volts. $119.95 for kit; optional microphone, $19.95.—**Heath Company,** Benton Harbor, Mich. 49022.

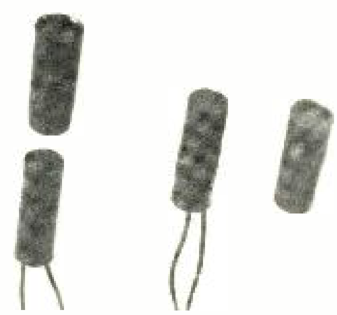
Circle 100 on reader service card

TAPE CONTROL SYSTEM, *Servo-Matic model 550.* Turns off all hi-fi components at the end of any tape. Miniature low-voltage switch installs inside any tape recorder to feed the motion sensing circuit

of the control. The compact unit operates completely independently of the cassette, cartridge or reel, so no alteration of existing tapes is required. Dual pilot lights blink alternately while unit monitors play, record, and rewind operations of tape recorder or deck. Turns itself completely off when tape stops. Kit is $22.50; Factory wired, $35.00.—**Cymax Audio Accessories,** 162 Buffalo St., Hamburg, N.Y. 14075.

Circle 39 on reader service card

MAGNETIC CONTACTS, *model S6*, of interest to alarm installers and industrial security users. This miniature, easily installed, concealed magnetic contact is designed to allow *all* wiring associated with an intruder alarm system to be "invisible", thus preventing shorting to disable



the contact. Both the magnet and switch element are only 7/16 in. in diameter, permitting installation with any hand electric drill. After drilling the contacts are readily cemented in place with epoxy or RPV.—**Mountain West Alarm Supply Co.,** 4215 North 16th St., Phoenix, Ariz. 85016.

Circle 40 on reader service card

New Literature is on page 84

Circle 64 on reader service card

new books

VINTAGE RADIO (Greenwood's Classical Pictorial Album Revised, Edited & Expanded) by Morgan E. McMahon. Vintage Radio, Box 2045, Palos Verdes Peninsula, Calif. 90274. 5¼ x 8 in., 240 pp. Softcover, $3.95 ($4.15 in California).

Though it claims modestly to be only a revision and expansion of Harold Greenwood's photographic museum of wireless equipment and radio appartus, the new material makes this a new and advanced work. Printed text—chapters that tell the history of radio and describe the equipment—are interspersed with the groups of photographs. They give the book continuity and help the younger reader (who wasn't around when the equipment was being used) to understand the photos.

The expanded format has made it possible to include a number of illustrations (some of them classics) from publications of the period. A much greater number of ads—some from companies unknown after the '20's—bring back memories of the sets that seemed ideal in those days, from the beautiful Atwater-Kent—long since gone—to the still-leading Zenith. Some pages of small-parts photos—interesting chiefly to people who were technicians at the time—have been omitted to include these.

It is regrettable that the proofreader knew no radio. Almost all the errors are misspellings that could have been detected easily by a person familiar with the subject of the text.—FS

HOME SECURITY MANUAL. Lew Williams & Associates, Box 19905, Dallas, Texas 75219. Distributed by Jones Home & Leisure Products, Box 57, Talmadge Road, Clayton, Ohio 45315. 5½ x 8 5/16 in., 40 pp. Softcover, $2.50.

Improved home and apartment security is the subject of this manual. All phases of lock security, methods of forced entry, and burglar alarm systems are thoroughly discussed. Emphasis is placed on what the average home owner can do himself at moderate cost to make his home more secure against casual intruders and determined professional burglars.

The author, a former Treasury Man and CIA agent, treats home security both from the point of view of the potential intruder and the seasoned security expert.

RADIO-ELECTRONICS HOBBY PROJECTS. Tab Books, Blue Ridge Summit, Pa. 17214. 5⅜ x 8½ in., 192 pp. Softcover, $3.95.

Five categories of projects are collected here: hi-fi stereo, music, automotive, home gadgetry, and test and measuring devices. They were each chosen to appeal to a wide range of interests and varying technical skills and construction dexterity—some simple enough to put together in an evening, others more complex and challenging. Each project has complete parts list, and applicable schematics, detailed drawings and construction procedures. Some sample projects are an FM stereo tuner, rhythm lights, road icing alarm, dancing Christmas lights, and a scope camera.

WORKING WITH SEMICONDUCTORS, by Albert C. W. Saunders. Tab Books, Blue Ridge Summit, Pa. 17214. 5 11/16 x 8 11/16 in., 224 pp. Hardcover, $7.95.

Beginning with just enough background data on semiconductor technology, this book tells about the various semiconductor devices in use today. Exposes the make-up of diodes, transistors, and then components combining the attributes and characteristics of both. Most of the book, however, deals with applications. Designed to serve as a study guide as well as an experiment-type project book, component values are included in most circuits. Fully diagrammed. **R-E**

SUPERCLOCK IS COMING

The end-all electronic digital clock story will appear in the next issue of **Radio-Electronics.** It uses LED readouts, has push-button switches for telling the time in other time zones, and provision for plug-ins that will keep the clock synced with WWV. Don Lancaster designed the clock and prepared the story.

"At ComSonics we encourage all our technicians and engineers to enroll with CREI. Know why?"

WARREN BRAUN, *President. ComSonics Inc., Virginia Engineer Of The Year, ASE International Award Winner,* **CREI Graduate**

Photographed at ComSonics, Inc., Harrisonburg, Va.

"As a CREI graduate myself, I know the advantages of their home-study programs. CREI education has proven an excellent tool of continuing education for our employees and for me. And I strongly believe in CREI's ability to teach a man to learn independently and to use reference materials on his own.

"As President of ComSonics, I see changes taking place in our Electronics business every day. We're in closed circuit TV and acoustical engineering...and pioneered in Cable TV. CREI gives my men the knowledge they need to work in new areas...CREI's new course in Cable TV is an example. The CATV industry is expected to grow 250% in the next three years. I know the opportunities in Cable TV. I designed one of the first CATV systems in 1950. But technical advances are constantly changing the field. And since CREI's experts know most of what's going on in all areas of Electronics, I know that CREI can give my men some of the important, specialized training they'll need to maintain our position in Cable TV and our reputation in Electronics.

"We've interviewed many technicians and engineers for jobs in the past year and had to reject them because their knowledge is archaic and out-of-date. A man is of no value to us if he doesn't keep up-to-date."

Some of the biggest names in electronics buy CREI courses for their own employees. CREI students and graduates prove themselves on the job. They move ahead of the pack by earning promotions and salary increases.

The Future Belongs To You

You've been in Electronics long enough to know that the field is changing more rapidly than ever. New industries, like Cable TV, are born almost overnight. But surveys show that three out of four men now working in Electronics aren't technically qualified to work in these new areas. Clearly, the future will belong to the man who gets the right education *now*.

Start Learning At Home

But what you learn depends on which school you choose. Here's why CREI is among the best.

With the CREI program you study at home. At your own pace. There are no classes to miss, no work to make up. Each lesson is explained in clear, easy-to-read language. That's why many men do far better in home study than they ever did in school...even if they've been out of school for years. And the study habits they learn from CREI are sustained through life.

As a CREI student, you'll be assigned to an experienced instructor who will grade your assignments and offer constructive comments and criticism. If there's a special problem, the instructor will work with you until you understand it fully. You'll receive personal attention from your instructor because he deals with each student individually—as a class of one.

What Will I Learn?

You'll be learning the latest in advanced technology, geared to specific industry programs. Both theory and practical material are presented to meet all phases of job-related training needs.

CREI courses are written for the man who knows basic Electronics, but whose advancement depends on keeping his technical know-how current. You choose what you want to learn. You study subjects which help you grow and advance in your present job and which relate to your career objectives. CREI offers you the opportunity to continue your education throughout your working life.

Constantly Up-Dated Courses

Because of rapid changes in Electronics, CREI courses are constantly being revised and up-dated by professionals who work in Electronics every day. New developments are included as quickly as they occur. Right now, CREI students are getting the latest up-to-the-minute information on such things as Cable TV, LSI chips, microminiaturization, lasers and masers, telemetry systems, servomechanisms, and data links. If it's new in electronics, CREI—and you—will know about it!

Developed By Top Scientists And Engineers

CREI maintains a full-time advisory faculty of some of the top names in Electronics. Each is a specialist in his own field, an expert who plans and develops CREI lesson material. After each expert submits his course plan, it is carefully reviewed and written by the CREI educational staff. Then each course is broken down into individual lessons. And they make certain each lesson is clear and self-explanatory. Just the right length for easy understanding and effective study.

How Can I Qualify?

If you've read this far, your interest in getting ahead in Electronics is evident. Send for our famous book on how to prepare for tomorrow's jobs in Electronics—the book that has helped thousands of men just like you get ahead. For your free copy, simply mail postpaid card today.

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try this one

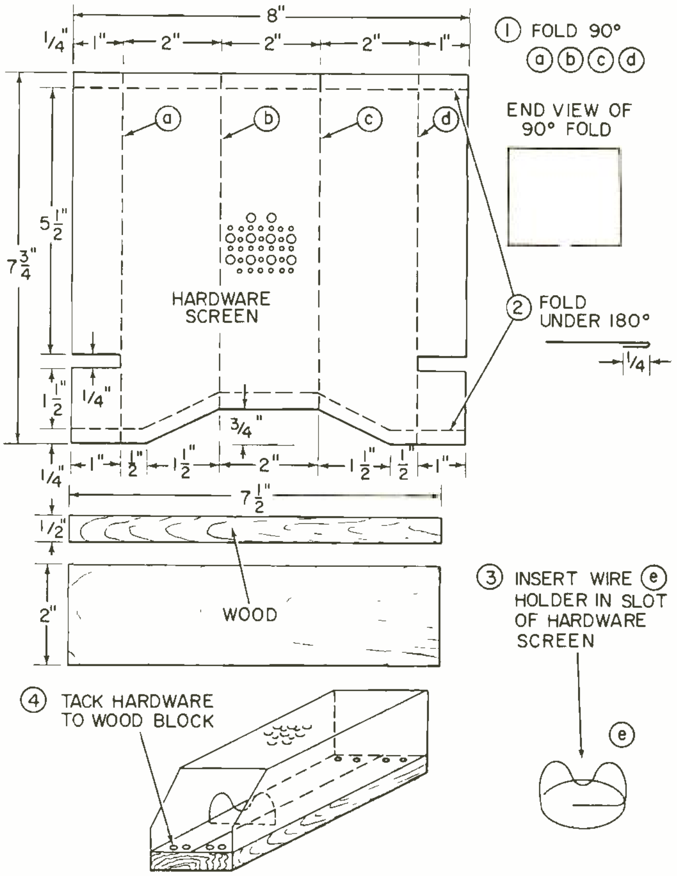
HANDY SCREWDRIVER

When working on electronics equipment it is often necessary to replace screws and small bolts into difficult places. Rubbing the tip of your screwdriver on the permanent magnet of a loudspeaker will magnetize the screwdriver enough to hold the screw on the blade while it is being guided into position.—*Julien J. Meyer*

BUILD A SOLDERING IRON GUARD

Aaach!! I exclaimed as my arm touched the bare soldering iron where it rested on the wire holder. I vowed that it would never happen again. After some thoughts and a few crumpled papers in the waste basket, I gathered my materials together: hardware screen; block of wood (7½x2x½ inches); tin snips; slip-joint pliers; etc.

I cut out the screen with the snips according to the pattern "A". Folded the screen into a rectangular box being careful of the just cut edges. Then, I took my slip-joint pliers and bent the edges (180°) about ¼" all over the outside. The double edges made it safer and stronger.



Placing the wire holder on the board exactly 1⅝" from the end so that the hardware screen would just fit over the wire holder. I tacked the screen down to the board and it was finished.

This is a one-night job and should take you less than an hour from start to completion. The materials and tools are easy to find and should be in any hobbyist's tool box. The soldering iron cover might save somebody from a nasty burn someday.—*Fred H. Horan*

OHMMETER TRANSISTOR TESTING

When checking out-of-circuit transistors with an ohmmeter, it is something of a nuisance to hold the transistor while using the prods.

A couple stiff rubber bands around some convenient part of the meter can be lifted to hold the transistor, freeing the hands for prod use.

A spring type clothespin inserted under the elastics also makes a convenient clamp.—*Arthur A. Aalto*

REED RELAY HOLDER

Sure—you can leave that reed relay dangling, supported by the wires it's controlling, but wouldn't it be better if it were mounted? If you have an extra fuse holder (or a couple of clips), just mount it then just slip the glass relay into it. In some cases you might have to tighten the tension on the clips of the holder.—*Robert Conover*

SOLDER SEMICONDUCTORS SAFELY

Don't worry about spoiling semiconductors, even germanium with short leads, if you solder them with Wood's metal (melting point 65.5 C), or some of the other low-melting alloys I have not tried. Cool down the soldering tool so it barely makes water sizzle, have the metals to be joined very clean, and for flux try rosin dissolved in alcohol. If that doesn't work, use Kester or Nokorrode paste or acidified zinc chloride solution and wash off with water and alcohol when done. Wood's metal has high resistivity, so keep its area large and the path through it short if the current is large. I have used it successfully with power SCR's.

Thanks for this one to the late Professor Karl S. Van Dyke, the crystal decrement authority. He used to hang a large 20-kHz quartz bar on a fine wire soldered with Wood's metal to the silver coating.—*Albert H. Taylor*

FORMING ELECTROLYTICS IN OLD EQUIPMENT

When a receiver or other piece of ac operated electronic equipment has been out of service for a long period of time the electrolytic capacitors tend to develop excessive leakage. Good capacitors will usually form rapidly when the equipment is first turned on, but it is safer to subject the capacitors to lower voltage during the forming process. Each capacitor could be disconnected from the circuit and a forming voltage applied, but a far simpler method is to apply test voltage from the leakage-test circuit of your capacitor checker. The only precaution to be observed is to be sure that there is no bleeder to ground in the high-voltage circuit. A simple ohmmeter test from B+ to ground will confirm this in addition to spotting any obviously shorted filter capacitor. A bleeder resistor or other dc path to ground would draw excessive current from the leakage tester and reduce the test voltage to a very low value. As the capacitors form up the leakage current will decrease to a minimum fixed value and the test voltage will rise to a maximum fixed value.—*F. J. Bauer* **R-E**

new lit

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 103 and circle the numbers of the items you want. Then mail the postage-paid card.

LUBRICANT CATALOG, *Dri-Slide.* Covers widely proven usage area where dust, abrasives, moisture and maintenance-oriented operations exist. Illustrated field case studies demonstrate multi-use factor for *Dri-Slide* lubricant involving critical applications with chain, valves, linkage, cables, controls, intricate devices and locking mechanisms.—**Dri-Slide, Inc.,** Industrial Park, Fremont, Mich. 49412.

Circle 41 on reader service card

INTRUDER/FIRE ALARM CATALOG, *No. A-107.* Describes eleven detector-transmitter and receiver-alarm devices that can be used in various combinations to indicate the presence of fire or burglars. The unusual line of devices uses existing house wiring to transmit a signal from the transmitters to receivers which may be located in adjacent apartments, offices or homes.

Transmitters plugged into 117-volt ac receptacles transmit coded pulses over the power lines when triggered "on" by fire, smoke or intrusion detectors. Receivers actuate buzzers, bells, lights or cameras. Accessories include indoor and outdoor horns, power-failure alarm and magnetic window and door switches.—**Functional Devices, Inc.,** P.O. Box 368, Russiaville, Ind. 46979.

Circle 42 on reader service card

HARD TO FIND TOOLS CATALOG, *1972,* 48 pages including 185 rarely stocked tools. Among the items included are wire strippers, tungsten carbide grit files, files and drills for plastics, side-action funnels, garnish awls, 8-way scrapers, handsaws, tenon saws, pruning saws, portable sand blast guns, range finders, fire detector alarms and nylon vise jaws. Complete with illustrations and descriptions of the items.—**Brookstone Co.,** Dept. C, 10 Brookstone Bldg., Peterborough, N.H. 03458.

Circle 43 on reader service card

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

TUNER REPLACEMENT GUIDE & PARTS CATALOG, *No. 2, June 1, 1971.* This 62-page catalog shows blow-up photos of all types of tuners, enabling reader to find the problem quickly, and locate the exact replacement part easily. A replacement guide for antenna coils and shafts also provided. Over 600 exact-replacement tuners are listed under their original manufacturers' number. **$1.00, redeemable on first parts order.—PTS Electronics, Inc.,** P.O. Box 272, Bloomington, Ind. 47401. **R-E**

next month

JULY 1972

- **The VTR's Are Coming**
  Up-to-the-minute details on the many different kinds of video tape recorder systems now available. A table showing the important characteristics of a variety of low-cost equipment makes comparison easy.

- **Build R-E's Superclock**
  Here's a digital clock that thinks for itself. It tells the local time down to the second, and at the push of a button the correct time in other parts of the world.

- **Single-Sideband Story**
  Single-sideband is a widely used system in all forms of modern communications. Here's an in-depth look at how single-sideband operates.

- **Using Test Tapes And Records**
  How to use test tapes and records to get the best possible performance from your stereo system.

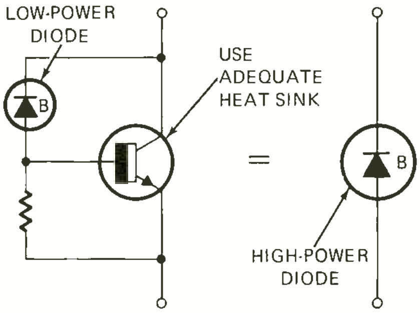
- **The Technician In Field Operations**
  Closeup portrait of the electronics technician on the job. Illustrates careers open to the qualified person.

PLUS:
Kwik-Fix Troubleshooting Charts
Appliance Clinic
Television Service Clinic

noteworthy ckts

SMALL ZENER + POWER TRANSISTOR = BIG ZENER

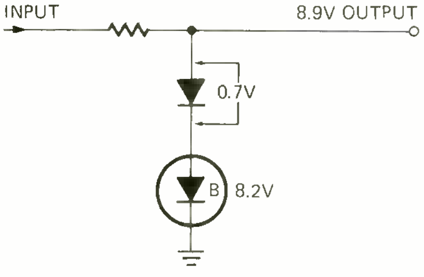
Small Zener diodes and power transistors are now cheap but big Zeners are still dear, especially for high voltages. A small Zener diode, a resistor and a well heat-sunk power transistor, arranged as shown, constitutes a two-terminal device equivalent to a Zener diode with the dissipation rating of the transistor. The resistor keeps down the leakage current when $V < V_z$ and is non-critical in value and not always necessary.



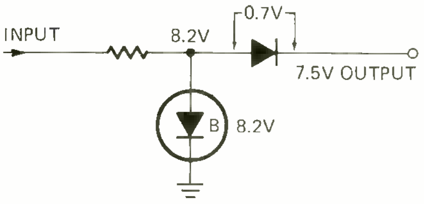
Example of use: Something was needed to clip at about 150 volts the commutation pulses getting through to the output of an SCR inverter. One-watt and some 10-watt Zener diodes failed even though *average* dissipation was low; but a type 40322 transistor (35 W, 300 V) with a 1-watt, 150 V Zener and a 1000-ohm resistor stood up OK.—*Albert H. Taylor*

USE RECTIFIERS TO ADJUST ZENER VOLTAGES

A conducting silicon rectifier has a characteristic and reasonably constant voltage drop of about 0.7 volts. A conducting germanium diode or rectifier has a characteristic and reasonably constant voltage drop of 0.2 volts. These volts drops can be used to either increase or decrease the regulated voltage of the Zener diode as shown at *a* and *b*



a



b

respectively. In the case of germanium diodes increase the current capacity by connecting two or more diodes in parallel. Polarity must be in the conducting region.—*Edward N. Emery* **R-E**

"This must be the place."

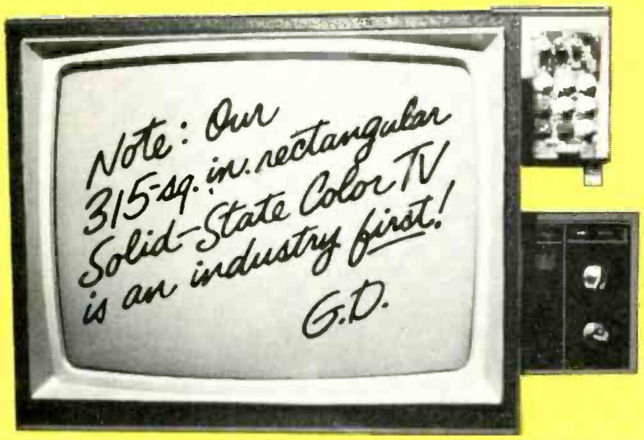
Bell & Howell Technical Report

Subject: New Home Entertainment Electronics Systems Program

Competitive Advantages:

- Features first Solid-State Color TV (315-square inch, rectangular screen) Kit for at-home training to build, keep.
- Helps prepare recipient for Color TV Service Business of his own. Covers solid-state circuitry in depth--also other Home Entertainment equipment. Fully updated.
- Provides three additional professional quality kits to assemble, keep, use.

COMPONENTS:



Specifications:

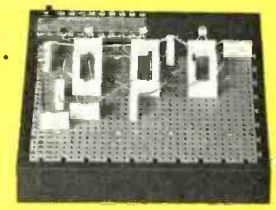
New 25" diagonal, ultra rectangular screen. 315-sq. inch viewing area. 25,000 volt, solid-state design, w/ 45 transistors, 55 diodes, 2 silicon rectifiers. 4 advanced IC's w/46 transistors, 21 diodes. 2 tubes: picture and high voltage rectifier. Solid-State VHF and UHF tuners. 3-stage solid-state IF. AFT standard. VHF power tuning. Also: "Instant On" circuit, automatic color control, noise limiter.

Descriptive analysis:

Modular plug-in circuit board design provides for more than 100 advanced solid-state devices. Insures premium color, sound control, exceptional reliability, easy access. Includes Hi-Fi amplifier for sound output, built-in dot generator, tilt-out convergence panel. Handy Volt-Ohm meter permits initial set-up and adjustment plus detailed trouble-shooting. 315-sq. inch picture tube face transmits entire image. Push button channel advance. AFT module brings in perfect picture, sound automatically. Easier to service than older, non solid-state sets. Quality components throughout.

Electro-Lab-at-Home: Components included:

The Electro-Lab® consists of three units, arriving in 16 shipments which recipient assembles, keeps. All components are professional quality. The circuit DESIGN CONSOLE contains built-in power supply, test light, speaker. Patented Modular Connectors permit plug-in to console to rapidly "bread-board" many different circuits. No soldering or messy un-soldering necessary.



The portable 5-inch, wide-band OSCILLOSCOPE is calibrated for peak-to-peak voltage and time measurements... offers 3-way jacks to handle test leads, wires, plugs. Images on screen are bright, sharp.

The lightweight TRANSISTORIZED METER combines most desired features of a vacuum-tube voltmeter and a high-quality multimeter. Features a highly sensitive, 4-inch, jewel-bearing d'Arsonval meter movement. Registers current, voltage and resistance on large, easily read dial

CONSENSUS: first class gear.

Program is designed to give:

- Understanding of electronic circuits in most home entertainment electronic systems
- Ability to analyze and trouble-shoot a wide variety of advanced solid-state and other TV circuits
- Capability to understand and use test equipment and procedures with special emphasis on TV testing
- Ability to assemble, test and adjust the solid-state TV kit included with the program

MAIL CARD TODAY FOR ALL THE FACTS
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Color TV is going Solid-State—here's how to help yourself get ready for it:

There's nothing else like this exciting new program that offers the *first* 315-sq. inch Solid-State Color TV available for at-home training.

As you follow the simple, step-by-step assembly and testing procedures, you will soon become thoroughly familiar with the most advanced solid-state TV circuitry. And you'll help prepare yourself for a profitable Color TV service business of your own—either full or part time.

Why Color TV pays better.

Today, Color TV is the big seller. And tomorrow, when it goes all solid-state, the man who has mastered this circuitry, will be in demand. This, of course, is where the money is going to be made.

But, this new Bell & Howell Schools program will also give you the in-depth knowledge of the basics as well as TV circuit analysis. You'll get the theory and practical experience you need to handle radios, Hi-Fi's, stereos, tape recorders, B & W television as well as most other home entertainment electronic devices.

Build, keep your own 25″ diagonal Solid-State Color TV Set

Whether you are a beginner, an experienced hobbyist, or a pro working in the field, you are going to be delighted with the performance you get from this new solid-state kit. So proud, you'll want to show it off to your relatives and friends.

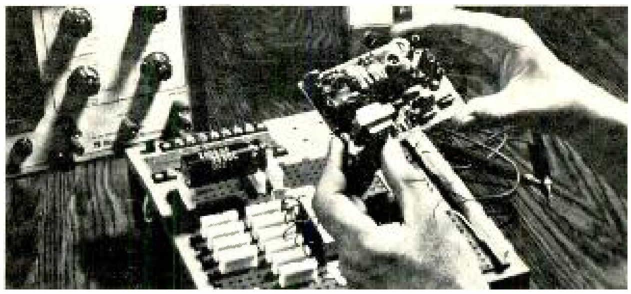
The "specs" at left give a few of the facts. But there are many, many features besides these which you will not find in any set on the market today. Send for all the facts and this is the one you'll want.

You're ready for many kinds of Home Entertainment Equipment

This is a thorough-going program, put together by professionals, with completely up-dated components and materials. When you have completed it, you'll have a new kind of confidence in your ability to tackle almost anything related to electronics in the home. And I can assure that these devices are definitely on the increase!

In addition, you'll have the kind of sound technical background you need for either a career as a technician in the Electronics industry or a business of your own—either full or part time.

Note: TV picture is simulated.



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Bell & Howell Schools Electro-Lab-at-Home Plan gives you thorough, career-oriented training in solid-state Color TV. Everything comes to you by mail. No traveling. You go at your own speed and never miss a paycheck!

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ONE OF THE
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(TV kit is not available in Canada)

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322

equipment report

Onkyo Model 20

Circle 87 on reader service card

SEALED IN A 1.3 CUBIC-FOOT ENCLOSURE: a 12-inch woofer, 2-inch mid-range dome radiator and a 1-inch high-frequency dome radiator join forces to produce some fine sound in the Onkyo model 20. Not specifically promoted as such, this speaker is an acoustic-suspension type as evidenced by its respectable bass response in a relatively small volume cabinet along with the manufacturer's minimum and nominal power specifications of 10 and 25 watts respectively. These air-suspended speakers operate on the analagous physical principle of a tuned circuit broad-banded by resistor loading. The heavy acoustic loading within the tightly sealed cabinet flattens a more resonant response into a wider, smoother frequency characteristic. Since the laws of nature once again remind us that we never get something for nothing, the gain-bandwidth product remains constant. We pay for the wider bandwidth by decreased acoustical energy output, thereby requiring the minimum power specification.

The appearance of the oiled walnut cabinet and its dimensions is an immediate reminder of the classic speaker of this ilk, the AR-2A. The Onkyo speaker is only 3/4" shorter and 1/8" deeper and identical in height (23 1/4" x 13 1/2" x 11 5/8").

Studying the manufacturers' response curves measured in the non-objective anechoic room shows the Onkyo to be 17 dB down at 30 Hz as compared to the 10 dB loss of the AR system, both relative to the loss at 1 KHz. Swept frequency response curves of speakers often hide holes in the speaker responses since the combined mechanical inertia of the chart recorder's pen and drive system may mask such anomalies, but the curves serve as a starting point for comparison. Onkyo's plot shows somewhat of a depression in the 100 to 500 Hz region, while a depression in the AR response appears between 500 and 2000 Hz. The high-frequency response for the AR speaker was not shown for this model, but the Onkyo speaker has about equal responses at 20 kHz and 1 kHz with a 10 dB relative loss 30 degrees off axis.

As you have correctly suspected the comparison was further extended by connecting a pair of both the Onkyo and the AR speakers to a proven amplifier, tuner, turntable combination with provision for rapidly switching between the two sets of speakers. This rapid switched comparison method was revealing as usual with some surprises.

While the expected differences were generally in the direction implied by the examination of the two response curves, the mid-range performance differences were more pronounced than predicted. The 12-inch long-coil Onkyo woofer suspended by specially treated neoprene performed exactly as expected with somewhat weaker bass than the AR's and otherwise identically clean response. On the other hand the mid-range and the transient response of the Onkyo was very clean (almost brilliant), making the AR's seem almost muffled in this side-by-side comparison.

The Onkyo 2-inch mid-range speakers use a super-hard duralumin hemispherical dome which seems to do the trick. According to Onkyo, the small diameter of its diaphragm results in dispersion which is much wider (no numbers given) than that of conventional mid-range speakers. The same type of

APPLIANCE CLINIC

(continued from page 24)

even the little transistor-type capacitors can be used. Average value of these capacitors will run around .05-μF, as I just said. However, they aren't too critical. Use whatever value cuts down the noise the most.

If the filter capacitors won't cut the interference to a suitable level, you may have to try small rf chokes in series with the motor leads. These can be hand-wound, air-core, out of solid wire. Cover them with tape and tuck them away in the case.

If there isn't room for anything like this, you may have to use an external filter. Fig. 2 shows a typical circuit for

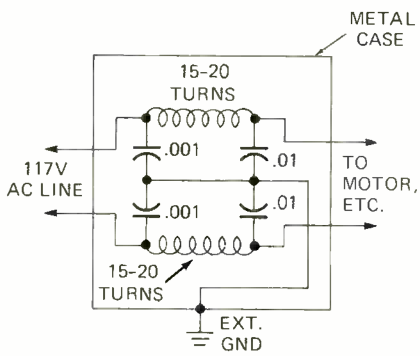

Fig. 2

one of these. If there is room inside the appliance case, this works better at that point. If not, you can build it, and connect it in series with the ac line. There are several different types and makes of these, made with a plug and socket, so that they can be plugged into the outlet, and the appliance line cord plugged into the filter. Some of these have an external ground terminal on the side of the case. In severe cases, this will often help a good deal. Run a short lead to a cold-water pipe, etc. While I don't know the model number right now, there is undoubtedly a filter built with one of the 3-wire plugs, that will do its own external grounding when plugged into a correctly-wired outlet.

If you want to make up one of these, put it in a small metal case, and make the case the external-ground terminal. Do not try to use the "line ground" or white wire. Keep both ac line conductors well insulated from the case of the filter. Use terminal strips, etc. to support the connections.

The basic principle of all noise-filtering, of course, is to keep the noise inside the apparatus generating it. Once it gets out onto the line-cord, you have it on a pretty darned efficient antenna for radiating it. If this isn't practical, then kill the noise as soon as possible: by a plug-in filter at the line-cord plug. **R-E** diaphragm is used in the 1-inch dome tweeter. The important crossover frequencies are at 700 and 7000 Hz.

Polarized terminals on the rear panel are hex shaped for easy nutdriver tightening. Also on the rear panel a pair of 5-position switches permit ± 4 dB level adjustments to the mid- and high-frequency ranges to be used for correction of room responses. A welcome addition to the packing is a generous supply of quality speaker wire with spade lugs on both ends.

An opaque grille cloth surrounded by an attractive beveled edge give the speakers a handsome appearance in their $199.95 40-pound packages. **R-E**

storing utility drill

The indispensable ¼-inch power drill can be stored conveniently when not used by providing it with an angle bracket so it can then be suspended from a pegboard hook. Small angle brackets with pre-drilled holes are obtainable at hardware or variety store and need no alteration. Fasten one end

of the bracket to the drill housing and use the hole in the other end for the pegboard hook. This hole should be considerably enlarged to facilitate easy removal and replacement of the tool. A handy place to keep the chuck key is in the jaws of a spring-type clothespin taped to the tool's power cord near the handle.—*Glen F. Stillwell* **R-E**

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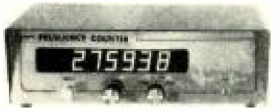
FEATURE ITEM

50 MEGAHERTZ LOW COST COUNTER



Here is a new item, featured because of numerous customer suggestions.
We have taken the basic power supply, chassis and cover from our clock kit, and by substituting a new front panel and printed circuit board, have made a lowest cost frequency counter. The unbelievable low cost is due to our use of our large stock of unused surplus nixies, the new 74196 50 MHz decade counter, and the commonality of parts with our other kits. Readout is to six decades, time base is 1 second, 0.1 seconds, or external. Design is modular, for ease of construction, compactness, and expandability.

☐ 50 MHz six digit counter, using line frequency as time base, complete except for cover $97.50
☐ Optional crystal controlled time base plug-in conversion $23.50
☐ Cover, blue or black anodized . . . . $ 4.50

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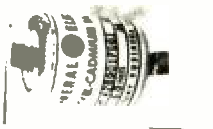

These batteries are the type used in electronic flash units, electric knives, toothbrushes, etc. They are rated at 6 volts, 0.080 ampere hours. They are of sealed construction, and may be operated in any position.

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So reliable and simple to build, we can make this guarantee: If for any reason you cannot succeed in getting your calculator to function properly after completing construction, for a flat handling fee of $10.00, B and F will repair and ship back your calculator anywhere in the USA. This applies regardless of the age of the assembler, barring gross negligence or the use of acid core solder in construction.

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This calculator with L.E.D. readout and rechargeable self contained nickel cadmium battery was advertised in our March ad at $215.00 (if you ordered it at the higher price we will refund you the difference in merchandise on request). Due to a special purchase, we can now offer this $299.00 list calculator at only $175.00, making it the outstanding calculator buy in the USA. Comes complete with charger/power supply and case. Has eight digit display, with 16 digit capacity. Unit is only 1½" thick, easily slips in pocket. You can charge it by phone to BankAmericard or Mastercharge.
☐ Sanyo Calculator . . . $175.00

☐ SHRINK TUBING SPECIAL. Assortment of 200 pieces of shrink tubing, diameters 1/8" to 1/2", length 1/2" to 2" $1.25
Price $1.25

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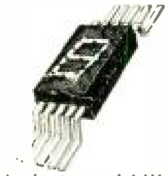
Three keyboards are available, as illustrated. 20 key calculator key board, 40 key alphanumeric, and 12 key touch tone. All have separate contacts brought out to edge connector.
☐ Touch Tone Keyboard . $ 9.50
☐ Calculator Keyboard . $14.50
☐ Alphanumeric Keyboard $29.00

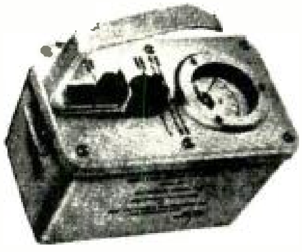
LIGHT EMITTING DIODE



This display is excellent for small portable electronics, such as DVM's, calculators, etc. Equivalent to Montsanto MAN 3A. Operates from 5 volts, 20 milliamperes, with 47 ohm dropping resistor.
3.25 each ~~$3.95 each~~
10 for 27.50 ~~10 for~~ $35.00
☐ Complete counter kit, 7490, 7475 latch 7447, printed circuit board, led readout . . . $9.50

Last minute special !!! Extra large size MAN-7 $4.50 each, 10 for $40.00

RADIATION METER ("Geiger Counter")



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You can buy a complete radiation meter, complete with original instruction books, at less than the price of the meter movement alone. Range is 0.02 to 50 Roentgens/hour. This is not sensitive enough for prospecting, but useful for other radiation measuring and monitoring purposes. If not used for its original function, then the case, meter and battery holder alone are worth our asking price as a basis for building a metal locator, etc. Uses standard D cell and 22.5 volt Battery.
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☐ Low current readout, in dual-in-line package. Plugs into 16 pin integrated circuit socket. Ideal for miniature battery powered instruments current is 8 milliamperes at 5 volts. Life is rated at 250,000 hours. Works fine from 7447 decoder Driver.
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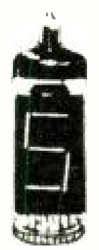
☐ Complete counter kit, above readout with 7490 decade counter, 7447 decoder driver and etched printed circuit board
$8.00 each



☐ Extra large size readout, in glass envelope package with wire leads, draws 20 milliamperes at 5 volts, works from 7447 driver, 100,000 hours rated life
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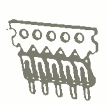
4 for $12.00

☐ Counter kit, 7490, 7447, P.C. board as above . . $8.50 each.

☐ On either of above kits, add $2.00 for 74192 Up/Down counter option, $1.50 for 7475 latch.

MOLEX SOLDERCON CONNECTIONS



Molex soldercon connections for I.C.'s. With these you can build low cost I.C. sockets by just cutting off the number of connections required, i.e., two strips of seven for 14 pin socket.
☐ 500 Molex soldercon . . . $ 4.75

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Circle 84 on reader service card

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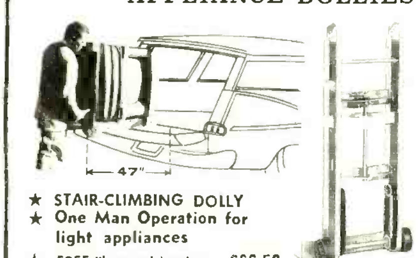

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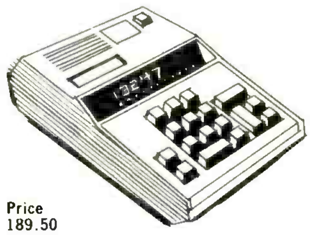

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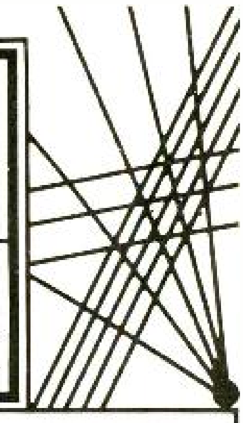

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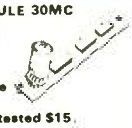

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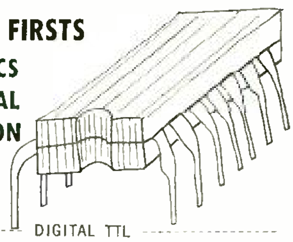

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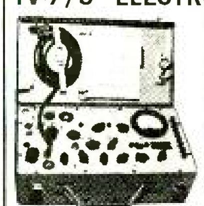

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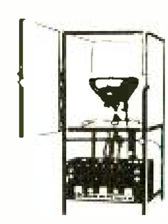

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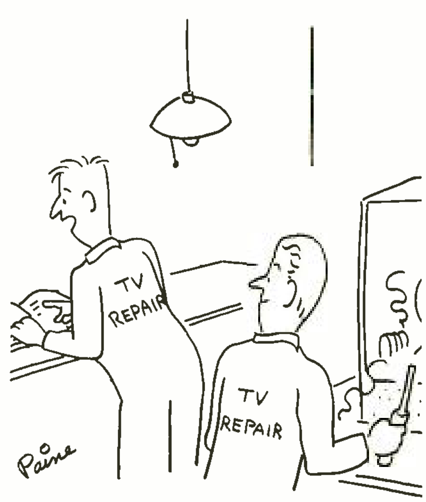

"By golly, you're right . . . in the parts catalog it is listed as thing-ah-ma-jig."

READER QUESTIONS

(continued from page 73)

SIGNAL-TRACING WITH VTVM ONLY?

Is there a way I can signal-trace a TV set, with only a vtvm?—J.C., Yonkers, N.Y.

There's a fairly good way. Check all of the voltages in the set which normally *change* with the presence of a signal. Agc, video detector output, sync, noise-amplifier, etc. Read the voltage, no-signal, then hook up the antenna. Look for the change in dc voltage.

If you see no change where there ought to be one, go back through the amplifier circuits and find out why. For example, your agc line should go negative on tube sets with the presence of a signal. If it doesn't, you've got either an agc problem or a signal problem in the tuner or i.f. Not as fast as standard signal-tracing, but useful.

ONLY BLUE AND GREEN?

I've got a Magnavox T920 color chassis. With my color-bar generator hooked to it, I can see green bars with a blue background. I've checked out the R-Y amplifier stage, but everything seems to be OK. Color program looks very weird.—E.K., Billings, Montana

Check your 3.59 MHz *oscillator.* In this, and several other color sets, you'll see this "blue-green" pattern if the color-oscillator is OUT. A good check is to look at the waveform on the pix-tube grids, with a color-bar pattern input. If this shows a flat-topped "comb" pattern, you have no demodulation. However, the fact that the signal *amplitude* is normal shows that the color-difference amplifiers are working, and that signal is getting through the demodulators. If the oscillator is working normally, you'll see the regular "rocker" patterns on the grids.

REPLACEMENT POWER TRANSFORMER

Where can I get a replacement power transformer for a Heathkit O-12 scope? Everything else checks, I have no high voltage, and the rectifier tube is OK.—A.D. Salada, Colo.

You're in luck. The Thordarson catalog lists a 24R78 power transformer as an "exact replacement" for Heathkit O-12 oscilloscope. Incidentally, their catalogue shows several other scope power transformers as well.

LEAKY VIDEO-COUPLING CAPACITOR

In a Hotpoint 17S301, the picture gets gradually darker; in about 30 minutes, it's almost out. Turn it off for 20 minutes, and it goes again, same cycle repeats. What's going on?—R.E., New York, N.Y.

One of two things. The 0.1-μF coupling capacitor between the video output tube plate and the pix-tube cathode is leaking, or you have some trouble in the *audio* amplifier stage. Either of these will make the pix-tube cathode voltage go more positive. Positive voltage on the pix-tube grid is the same as more negative voltage on the grid; cuts the tube off.

The brightness control in this set is fed from the +125-volt line, and this comes from the cathode of the audio output tube. If one of the grid resistors of the audio tube is changing in value, this can upset the bias, and make the +125-volt line go higher; same results. These grid resistors are connected as a voltage-divider across B+ to ground. They clamp the grid bias of the audio tube.

You can get an opposite symptom from this, of course. If the resistors change so that the audio tube is cut off, the +125 volt line will go down (less positive), the pix-tube cathode will go more negative, and the pix-tube will get very bright; brightness control won't cut it off. Old faithful "Stacked-B+."

MYSTERIOUS BREAKER-TRIP

Here's one for you. I've had four of them lately. In the RCA KCS-153 chassis, the circuit breaker tripped, shortly after turn-on. No apparent reason. After some work, I turned out the lights, and turned it on. The rectifier tube was glowing a beautiful bright blue. (Very, very gassy!)

Replacing this and the connecting lead to the tube fixed it. This is a 2BJ2 tube. Hope this will help others.—Wm.A. Heller, Huntingdon Valley, Pa.

It will Thanks.

BUZZ ON RECORD

Here's one for you. This M8400D GE tape recorder had a loud buzz on RECORD, and it was weak. Playback was OK on known-good tapes. The trouble turned out to be a poor ground on the microphone, due to a faulty crimp in the mike jack. If you run into this, check J3 for continuity to ground, and on to the first amplifier stage input. Best cure; replace the jack.

Thanks very much to Odis D. Crowell, GE Service Center in Dallas, Texas for this one. Here's a companion to it, from my bench. A "friend" brought in two new small Motorola tape-recorders. Same symptoms; good playback, weakness and loud buzz on RECORD. I fiddled with them without too much luck.

Finally discovered that "friend" had brought in a mike that he happened to have on his bench. It didn't match When I got the *original* mikes, both of them worked perfectly. Originals were low-Z, and test-mike high-Z; input oscillated.

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7406	.52	.50	.47	.44	.42	.39
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7416	.52	.50	.47	.44	.42	.39
7417	.52	.50	.47	.44	.42	.39
7420	.26	.25	.23	.22	.21	.20
7421	.26	.25	.23	.22	.21	.20
7426	.34	.32	.31	.29	.27	.26
7430	.26	.25	.23	.22	.21	.20
7437	.56	.53	.50	.48	.45	.42
7438	.56	.53	.50	.48	.45	.42
7440	.26	.25	.23	.22	.21	.20
7441	1.73	1.64	1.55	1.46	1.37	1.27
7442	1.27	1.21	1.14	1.07	1.01	.94
7443	1.27	1.21	1.14	1.07	1.01	.94
7444	1.27	1.21	1.14	1.07	1.01	.94
7445	1.71	1.62	1.53	1.44	1.35	1.26
7446	1.24	1.17	1.11	1.04	.98	.91
7447	1.16	1.10	1.04	.98	.92	.85
7448	1.44	1.37	1.29	1.22	1.14	1.05
7450	.26	.25	.23	.22	.21	.20
7451	.26	.25	.23	.22	.21	.20
7453	.26	.25	.23	.22	.21	.20
7454	.26	.25	.23	.22	.21	.20
7460	.26	.25	.23	.22	.21	.20
7470	.42	.40	.38	.36	.34	.32
7472	.38	.36	.34	.32	.30	.29
7473	.50	.48	.45	.43	.40	.38
7474	.50	.48	.45	.43	.40	.38
7475	.80	.76	.72	.68	.64	.60
7476	.56	.53	.50	.48	.45	.42
7480	.76	.72	.68	.65	.61	.57
7483	1.63	1.55	1.46	1.38	1.29	1.20
7486	.58	.55	.52	.49	.46	.44
7489	4.25	4.00	3.75	3.50	3.25	3.00
7490	.80	.76	.72	.68	.64	.60
7491	1.43	1.35	1.28	1.20	1.13	1.05
7492	.80	.76	.72	.68	.64	.60
7493	.80	.76	.72	.68	.64	.60
7494	1.18	1.12	1.05	.99	.93	.87
7495	1.18	1.12	1.05	.99	.93	.87
7496	1.18	1.12	1.05	.99	.93	.87
74100	1.52	1.44	1.36	1.28	1.20	1.12
74107	.52	.49	.47	.44	.42	.39
74121	.56	.53	.50	.48	.45	.42

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74123	1.21	1.06	1.00	.94	.89	.83
74141	1.63	1.55	1.46	1.38	1.29	1.20
74145	1.41	1.33	1.26	1.18	1.11	1.04
74150	1.63	1.55	1.46	1.38	1.29	1.20
74151	1.20	1.13	1.07	1.01	.95	.88
74153	1.63	1.55	1.46	1.38	1.29	1.20
74154	2.43	2.30	2.16	2.03	1.89	1.08
74155	1.46	1.39	1.31	1.23	1.16	1.08
74156	1.46	1.39	1.31	1.23	1.16	1.08
74157	1.56	1.48	1.39	1.31	1.23	1.15
74158	1.56	1.48	1.39	1.31	1.23	1.15
74160	1.89	1.79	1.68	1.58	1.47	1.37
74161	1.89	1.79	1.68	1.53	1.47	1.37
74162	1.89	1.79	1.68	1.58	1.47	1.37
74163	1.89	1.79	1.68	1.58	1.47	1.37
74180	1.20	1.13	1.07	1.01	.95	.88
74181	5.20	4.90	4.59	4.23	3.98	3.67
74182	1.20	1.13	1.07	1.01	.95	.88
74192	1.98	1.87	1.76	1.65	1.54	1.43
74193	1.98	1.87	1.76	1.65	1.54	1.43
74198	2.81	2.65	2.50	2.34	2.18	2.03
74199	2.81	2.65	2.50	2.34	2.18	2.03
NE501	2.99	2.82	2.66	2.49	2.32	2.16
NE531	3.81	3.58	3.36	3.14	2.91	2.69
NE533	3.81	3.58	3.36	3.14	2.91	2.69
NE536	7.31	6.88	6.45	6.02	5.59	5.16
NE540	2.16	2.04	1.92	1.80	1.68	1.56
NE550	1.24	1.17	1.11	1.04	.98	.91
NE560	3.57	3.36	3.15	2.94	2.73	2.52
NE561	3.57	3.36	3.15	2.94	2.73	2.52
NE562	3.57	3.33	3.15	2.94	2.73	2.52
NE565	3.57	3.36	3.15	2.94	2.73	2.52
NE566	3.57	3.35	3.15	2.94	2.73	2.52
NE567	3.57	3.36	3.15	2.94	2.73	2.52
N5111	.90	.86	.81	.77	.72	.68
N5556	1.87	1.77	1.66	1.56	1.46	1.35
N5558	.80	.76	.72	.68	.64	.60
N5595	3.40	3.20	3.00	2.80	2.60	2.40
N5596	1.87	1.77	1.66	1.56	1.46	1.35
709	.42	.40	.38	.36	.34	.32
710	.42	.40	.38	.35	.34	.32
711	.44	.42	.40	.37	.35	.33
723	1.00	.95	.90	.85	.80	.75
741	.44	.42	.40	.37	.35	.33
748	.48	.46	.43	.41	.38	.36
1N270	.15	.14	.13	.12	.11	.10
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1N4002	.15	.14	.13	.12	.11	.10
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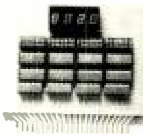

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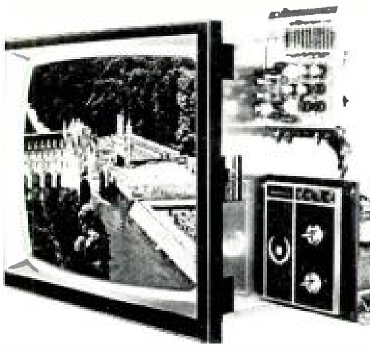

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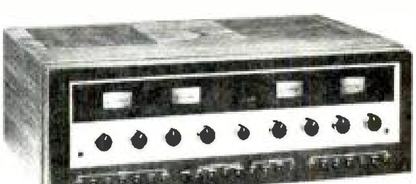

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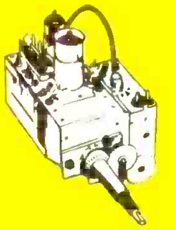
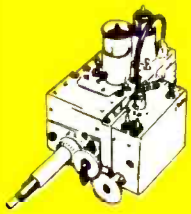
Originators of Complete TV Tuner Service

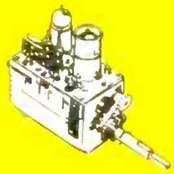
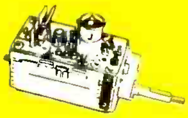
Castle offers the following services to solve ALL your television tuner problems.

Universal Replacements from $8.95

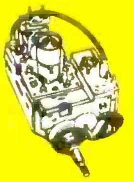
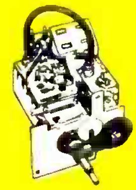
These universal replacement tuners are all equipped with memory fine tuning and uhf position with plug input for uhf tuner. They come complete with hardware and component kit to adapt for use in thousands of popular TV receivers.

STOCK No.	HEATERS	SHAFT Min.*	SHAFT Max.*	I.F. Snd.	PRICE
CR6P	Parallel 6.3v	1¾"	3"	41.25	8.95
CR7S	Series 600mA	1¾"	3"	41.25	9.50
CR9S	Series 450mA	1¾"	3"	41.25	9.50
CR6XL	Parallel 6.3v	2½"	12"	41.25	10.45
CR7XL	Series 600mA	2½"	12"	41.25	11.00
CR9XL	Series 450mA	2½"	12"	41.25	11.00

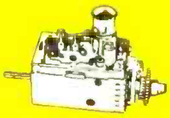
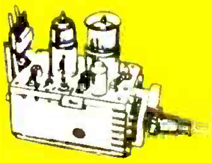
Castle Replacements $15.95

Castle custom replacements made to fit in place of original tuner. Purchase outright . . . no exchange needed. Write for current list of Castle replacements, or request the part number you require (use number on ORIGINAL TUNER ONLY; do not use service literature numbers). Available for many of the popular models of following manufacturers: Admiral, Curtis Mathes, Emerson, GE, Heathkit, Magnavox, Motorola, Muntz, Philco, RCA, Sears, Sylvania, Westinghouse, Zenith and many private labels.

Tandem uhf-vhf replacements NOW $21.95

Available in popular models of: Muntz, Olympic, Philco, Sears, Westinghouse and private labels.

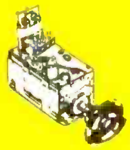
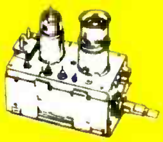
Overhaul Service $9.95

This is the service pioneered by Castle! We are now in our third decade of serving the TV Service Industry

Service on all makes and models, vhf or uhf, including transistor and color tuners . . . one price $9.95 (does not include tuners older than 10 years). Overhaul includes parts, except tubes and transistors.

Simply send us the defective tuner complete; include tubes, shield cover and any damaged parts with model number and complaint. Your tuner will be expertly overhauled and returned promptly, performance restored, aligned to original standards and warranted for 90 days.

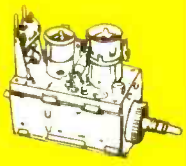
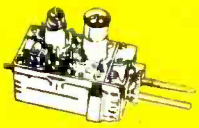
Dismantle tandem uhf and vhf tuners and send in defective unit only. Remove all accessories . . . or dismantling charge may apply.

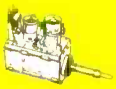
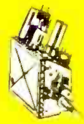
Custom Exchange Service $17.95

When our inspection reveals that original tuner is unfit for overhaul, and it is not available from our stock of outright replacements, we offer to make a custom replacement on exchange basis. Charge for this service is $15.95 for uhf tuner and $17.95 for vhf tuner.

If custom replacement cannot be made we will custom rebuild the original tuner at the exchange replacement price.

All replacements are new or rebuilt. All prices are f.o.b. our plant. Add shipping and handling of $1.25 on all prepaid orders. We will ship C.O.D.

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EAST: 130-01 89th Rd., Richmond Hill, N.Y. 11418 • Ph. 212—846-5300