

# Popular Electronics

INCLUDING

**Electronics World**

HOW TO MATRIX FOR

## QUADRA PHONIC SOUND

### **HOW TO BUILD:**

- Electronic Thermometer
- Two Simple  
Alarm Circuits

### **LIQUID CRYSTALS**

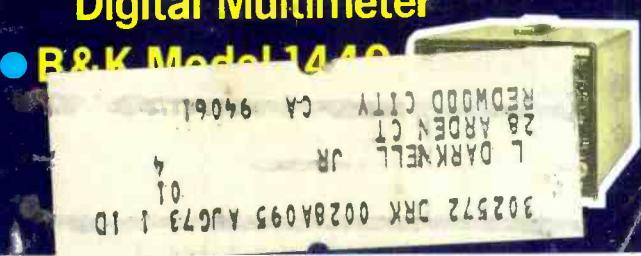
and how they work

An **ALPHA**  
**BRAIN-WAVE**  
**MONITOR** you  
can construct

How to Select  
a **CB**  
**ANTENNA**

### **TEST REPORTS:**

- Teac AS-100  
Integrated Amplifier
- Lafayette LA-524  
Decoder/Amplifier
- RCA WC-528  
Transistor Tester
- California Instruments 8310  
Digital Multimeter
- B&K Model 1440



# NOW you can train at home building a NEW 25" Solid State Color TV engineered by NRI for learning and trouble-shooting

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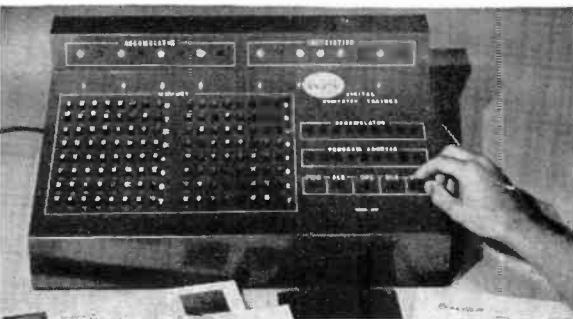
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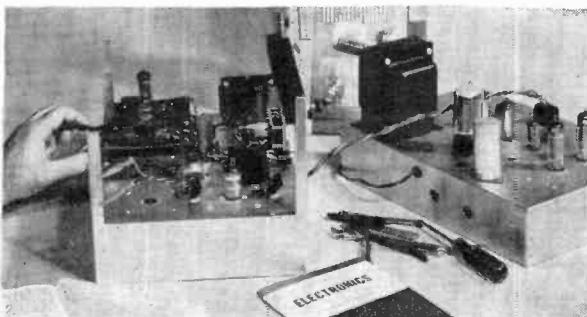
# NRI FIRSTS make learning Electronics fast and fascinating—to give you priceless confidence



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The NRI color TV and digital computer kits are the latest in a long line of "firsts" for NRI. For more than fifty years, NRI has been providing unique 3-dimensional home-study training that has helped hundreds of thousands of students reach their goals quickly and easily.

What NRI provides is a combination of kits and bite-size texts that give you hands-on experience while you are learning. The texts average only 40 pages each, and they are fully illustrated. You are taken step-by-step from the first stages into the more advanced theory and techniques...with an expert instructor ready at all times to provide valuable guidance and personal attention. (The level of personal attention provided is more than you would receive in many classrooms.) Once you've grasped the fundamentals, you move with confidence and enthusiasm into new discoveries in the fascinating world of electronics.

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# Editorial

By Milton S. Snitzer, Editor

## QUADRAPHONICS NOW OR LATER

We recently attended the New York High Fidelity Music Show (sponsored by the Institute of High Fidelity for the public and for dealers) and, a few weeks earlier, the Audio Engineering Society Convention (for professionals in the field). Evidence of the interest in hi-fi components was shown by the 25,554 attendees of the IHF show.

There was no question in anyone's mind that the most important subject at both shows was four-channel sound, or quadraphonics. At the IHF show there were daily seminars on four-channel sound as well as demonstrations and lots of four-channel equipment. At the AES show the lead-off technical session was on "Quadrasomics" and there were many other papers given on this topic throughout the technical sessions. At both shows there was much talk about the various methods of putting four channels on a phono disc, tape, or FM broadcast. We were offered discrete four-channel sound on discs (championed by RCA and JVC) or the matrix technique of combining four channels into two (being advanced by CBS, Electro-Voice and Sansui).

But the big question is, "Who's still waiting for whom?" Some marketing people are waiting for their engineers to develop the "best" four-channel system that will sell at a reasonable price. Some engineers, typically suspicious of something new, are holding back until there is more standardization so that they know which way to go. Many electronics experimenters and hobbyists are buying the new four-channel equipment. But others, if we read the signs right, are standing back and waiting for the dust to clear.

They're waiting for standardization on a single system so they won't be saddled with a limited library of discs and tapes. They're waiting for compatibility. They're also waiting to see and hear some more four-channel discs and tapes being played on four-channel equipment.

So what kind of advice can we give on whether to buy now or wait? First of all, there is plenty of four-channel equipment around for those who are experimenters and for those who must be "first on their block" with the newest equipment. Fortunately, only the least expensive item, such as a decoder that handles only one specific type of encoded material, may have to be put aside. "Universal" decoders, which offer a good compromise in handling all the various matrix systems, will continue to be useful. More expensive items, such as four-channel amplifiers, are coming to the market with two pairs of channels strapped together for use on two-channel material. By simply operating a switch that unstraps the amplifiers, you have a four-channel amplifier. Equipment such as this can be used for either two or four channels and will not become obsolete at all. (For details on four-channel equipment see "Tape Recorder Guide 1973" now on your newsstand.)

On the other hand, some may prefer to wait until there is a single standardized system before buying. They may have to wait a long time since there may never be complete standardization and agreement on a single four-channel system for disc, tape and broadcasting. To those we say, "Don't wait too long or you'll be missing out on a lot of four-channel sound right now."

Regardless of whether you buy now or later, we get the feeling that buy you will—but at the right time for you.

# Some of the reasons why other turntables don't perform quite like a Dual.

Because of the wide acceptance and acclaim Dual has earned over the years, especially among audio experts, many Dual features inevitably appear on competitive turntables.

To copy a Dual feature is one thing; to achieve Dual performance and reliability is quite another matter. The true measure of a turntable's quality is not its features alone, but how well the entire unit is designed and manufactured.

Following are just some of the ways in which Duals differ from other automatic turntables.

## Gyroscopic gimbal suspension.

The gyroscope is the best known scientific means for supporting a precision instrument that must remain perfectly balanced in all planes of motion. That is why the tonearms of the 1218 and 1229 are suspended in true, twin-ring gimbals.

Every Dual gimbal is hand-assembled and individually checked with gauges especially developed by Dual for this purpose. This assures that the horizontal bearing friction of the 1229 for example, will be no greater than 0.015 gram, and vertical friction no greater than 0.007.

## True single-play automatic tonearm.

A turntable of the 1229's caliber is used primarily in its single play mode, so the tonearm is designed to parallel a single record on the platter. For multiple-play, the entire tonearm base is moved up to parallel the tonearm to the center of the stack.

The 1218 tonearm provides the single-play adjustment within the cartridge housing, and the cartridge pivots around the stylus tip to maintain the correct overhang.

Dual 121SS. \$109.50



Dual 1218. \$155.00

Dual 1229. \$199.50



United Audio Products, Inc., 120 So. Columbus Ave., Mt. Vernon, N.Y. 10553  
Exclusive U.S. Distribution Agency for Dual.

Circle No. 37 on Reader Service Card

# Stanton quality is a very special quality... in headphones too.



Two things are constant in all Stanton headsets — their exciting "presence" and their equally exciting sense of styling.

At the top of the Stanton Dynaphase dynamic headset line, our brand new Dynaphase Seventy-Five (\$74.95) employs a true two-way system (separate woofer and tweeter) and an L-C crossover network in each earpiece, plus a remote control station for volume and tone adjustment, as well as stereo and mono mode selection.

This same exceptional system is offered in the Stanton Dynaphase Model Sixty (\$59.95) without remote control station.

Three other Dynaphase models feature a special high-performance Stanton wide-range single-speaker system at a popular price — Model Forty and Model Forty-600 ohm, and Model Fifty with balance level controls on each earpiece (\$49.95).

Write Stanton Magnetics, Inc., Terminal Drive, Plainview, L.I., N.Y. 11803.

All Stanton cartridges are designed for use with all 2 and 4 channel matrix derived compatible systems.



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## Letters

### THE LESLIE TRADEMARK

POPULAR ELECTRONICS Including ELECTRONICS WORLD proved itself not so popular with CBS Musical Instruments Division when it did it again! An article appeared in the March 1971 issue in which the registered CBS trademark LESLIE was corrupted by being used as part of the vernacular. You then promised not to do it again. But the *identical article* was just reprinted in your ELECTRONIC EXPERIMENTER'S HANDBOOK! Incredible!

DON SAUVY, Vice-President  
Electro Music Department  
CBS Musical Instruments Division  
Pasadena, Calif.

*Our previously red face is now scarlet. We apologize profusely and recognize the LESLIE is a brand of organ accessories; that only acoustic tremolo apparatus made by CBS carries the famous LESLIE brand.*

### HOME STUDY ADDRESS CORRECTION

In my article "A Guide To Home Study In Electronics" (Sept. 1972), the address given for the National University Extension Association was incorrect. The correct address is: NUEA, One DuPont Circle, N.W., Washington, DC 20036. Also, the price of their booklet is now 75¢.

LOUIS E. FRENZEL, JR.  
Silver Spring, Md.

### REHASHING THE POWER RATINGS HASSE

I agree with your October 1972 editorial titled "The Hi-Fi Power Rating Hassle." There certainly is confusion with regard to amplifier power ratings. Something should be done to standardize the situation. Meanwhile, what do we educators do? Before the hi-fi boom, we taught in terms of average or continuous (rms) power. Now, we avoid the topic completely. Obviously, we are not the only ones who avoid this topic. I don't know of any "standard" textbook that discusses power amplifier ratings and calculations.

To make matters worse, I have even forgotten what these other power ratings are or how they are obtained. Can you help me to get back on the track, rather than to avoid the problem?

Specifically, can you tell me briefly what the terms "instantaneous peak," "peak," "dynamic," "music," "IHF," and "EIA" powers are and how they are obtained.

J. J. DEFRENCE, PROF.  
Dept. of Electrical Technology  
New York City Community College

The "EIA" power is a short-term power rating obtained by using an external power supply with the amplifier. The output voltage of the power supply artificially maintains the peak output voltage (no load) of the equipment's own power supply. Further, EIA power is measured at 5 percent distortion. The "IHF" power is the same except that it is usually taken at a much lower distortion level, 1.0 percent or less. "Music" power is the same as IHF power. "Dynamic" power is the same except that an additional technique involving a step input and an oscilloscope may be used to obtain short-term power ratings. "Peak" or "instantaneous peak" are simply twice the power measurement obtained on either a steady-state or a short-term basis.

## ELECTRONICS TECHNICIANS' UNION

Are electronics technicians' salaries realistic? How could industry possibly ask for so much experience and knowledge and offer so little money in return? I am thinking about "The

Medical Electronics Technician" article in the October 1972 issue. For all that is required of him and the high degree of responsibility entrusted to him, he is earning only \$10,000-\$12,000 per year. Could you please tell me the reason behind the inequity? Should there be a national electronics technicians' union?

RAY KONCHULCHII  
New York, N.Y.

The inequities apply not only to ET's; electronics engineers are in just as bad shape as ET's—worse, if you compare EE and ET figures on unemployment. True, EE's can earn more money than can ET's in the long run, but both frequently start at roughly the same wage. So long as there are more than one applicant to fill each job, wages will be low.

## DESPERATELY NEEDS HELP

I recently acquired a rapid tube tester, Model 820, made by Superior Instruments Co. It came without a manual and schematic diagram. Can one of your readers help me locate the missing items? Any help would be much appreciated.

JOE FINE  
1807 Skipwith Rd.  
Richmond, VA 23229

If anyone can assist Joe in locating an operating manual and schematic for his tube tester, please write directly to him.

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# 10 exciting new Heathkit projects you can assemble yourself ...and save!

(There are 350 more in your  
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## NEW Heathkit 21V Color TV —

**Solid-State Plus Detent UHF Tuning ... 499.95\*** less cabinet

Power detent selection of all VHF and any 12 pre-selected UHF channels; exclusive angular tint control for consistently better flesh tones; voltage controlled varactor UHF tuner & MOSFET VHF tuner for unmatched sensitivity; black matrix tube, built-in dot generator, convergence panel and voltmeter — full remote control options, too. It's Heathkit TV at its finest in a space-saving size.

Kit GR-271, less cabinet, 121 lbs. .... 499.95\*

Assembled GRA-501-21, table model cabinet shown, tough walnut Marlite® finish, 33 lbs. .... 54.95\*

## NEW Heathkit 30 MHz Counter ... 169.95\*

Gives 1 Hz to over 30 MHz counting on a full 5-digit readout with 8-digit capability. The lighted overrange indicator makes misreading virtually impossible. Stable timebase circuitry assures accuracy better than  $\pm 3$  ppm from 22° to 37° C. Diode protected J-FET gives improved triggering over 100 mV to 150 V input range. Solid-state circuitry mounts on one large board.

Kit IB-1100, 6 lbs. .... 169.95\*

## NEW Heathkit 2½-Digit VOM ... 79.95\*

Four overlapping ranges to measure voltages from 10 mV to 1000 V on DC (either polarity), 10 mV to 700 V rms on AC, 10 uA to 2.5 A on AC or DC current. Five resistance ranges measure from 1 ohm to 2 megohms. Front panel polarity switch reverses inputs without changing leads.

Kit IM-1202, 6 lbs. .... 79.95\*

## NEW Heathkit/Thomas Spinet Organ with two 44-note keyboards ... 689.95\*

Full 44-note keyboards for Solo and Accompaniment, exclusive Color-Glo keys that light up to indicate notes and chords. There are six solo stops, five accompaniment stops, plus both regular and a new "light" vibrato effects. Other features include keyboard jacks for private earphone listening or use of a tape cassette deck. Cabinet is shipped fully assembled, includes bench.

Kit TO-1160, 211 lbs. .... 689.95\*



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in this NEW  
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CIRCLE NO. 15 ON READER SERVICE CARD

## NEW Heathkit Dual-Range

**Visual/Audible Fish Spotter ... 99.95\***

Super-bright flasher can be set to read from 0-60' and 0-240' for greater definition and accuracy. Audible alarm can be set to sound at any depth in between. Runs on lantern batteries (not supplied).

Kit MI-2901, 9 lbs. .... 99.95\*

## NEW Heathkit 8-Channel VHF Band-

**Scanning Monitor with digital readout ... 119.95\*** less crystals

Crystal-controlled monitor tunes any selected 9 MHz segment of the 146 through 174 MHz band — gives you police, fire, marine, ham 2-meter, etc. Features manual or automatic scanning with numerical readout; priority channel; built-in speaker and rear-panel jack for remote speaker; gimbal bracket for either base-station or mobile use. Operates on either 120/240 VAC or 12 VDC. Includes crystal OSC/Mixer signal source for easy alignment. Order up to eight Crystal Certificates with kit.

Kit GR-110, 9 lbs. .... 119.95\*  
GR-110-1, Crystal Certificate, postpaid ..... each 4.95\*

## NEW Heathkit Engine Analyzer ... 64.95\*

For 3, 4, 6 and 8-cylinder engines. Includes leads and accessories for testing conventional, transistor, and magneto ignition systems, regardless of voltage or grounding. Uses 3 "C" batteries (not included).

Kit CM-1050, 9 lbs. .... 64.95\*

## NEW Heathkit C-D Ignition System ... 39.95\*

Increases spark-plug and point life up to 50,000 miles on any car or truck using a 12-volt, negative ground system. Automatically varies spark duration. Screw-on terminals make installation easy; external pushbutton lets you override system without removing leads.

Kit CP-1060, 4 lbs. .... 39.95\*

## NEW Heathkit 6-Digit Electronic Alarm Clock ... 54.95\*

Displays hours, minutes and seconds on highly visible cold-cathode readout tubes. A gentle "beeper" alarm can be set for 24-hour cycle and features a snooze switch that gives you seven more minutes of sleep before the alarm sounds off again. Conventional 12-hour or 24-hour international time display.

Kit GC-1005, 4 lbs. .... 54.95\*

## NEW Heathkit Dolby® Cassette Deck ... 249.95\*

A kit-form cassette deck utilizing the famous Dolby® noise reduction system. Accommodates the greater fidelity and dynamic range of chromium dioxide cassettes. Independent switches provide Dolby on/off and regular or CrO<sub>2</sub> bias control. Domestic-make tape transport comes preassembled for easy kit building.

Kit AD-1530, 21 lbs. .... 249.95\*

HEATH COMPANY, Dept. 10-1  
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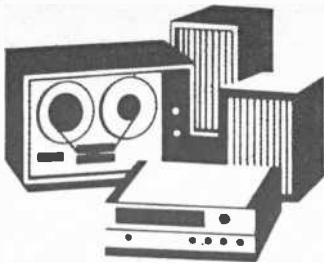
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# Stereo Scene

By J. Gordon Holt

LAST MONTH, we took a look at some various and sundry gadgets for tape recording and recordists. Now, let's see what's available for the discophile and his preferred medium.

## PHONO USE GADGETS

**Plastic sleeves.** Most discs are supplied with a paper sleeve inside the outer jacket, and while this helps prevent dust from getting into the jacket, it offers little protection from dust that adheres to the disc when it is put away. Plastic sleeves, usually sold in packs of twelve, replace the paper sleeves and provide a cushion to prevent dust particles from being embedded in the disc surface when the jacket is compressed between other discs on the shelf.

**Cueing controls.** For tone arms that aren't already equipped with a lowering lever, these add-ons can be an investment in reduced wear and tear on lead-in grooves and a lessening of accidental damage due to dropping the pickup or scraping it across the grooves. Not all of these are equally satisfactory. The best have a damped action that lowers the arm slowly regardless of how fast the lowering lever is moved. There is at least one motorized arm raising-and-lowering device, the Deccalift, that has provision for remote control from your favorite listening location.

**Cataloging kits.** If you own enough records to make cataloging them a worthwhile project, you can buy one of a var-

iety of "kits," including a listing book with alphabetized pages; or you can save money by devising your own catalog system and using adhesive labels on the disc cover spines with file cards in a box. My preference of all the ones I've seen is the Old Colony system, which comes as a kit including gummed labels, file-card dividers, and an adjustable rubber stamp that prints a five-digit letter-and-number code in a vertical row (for making record spines).

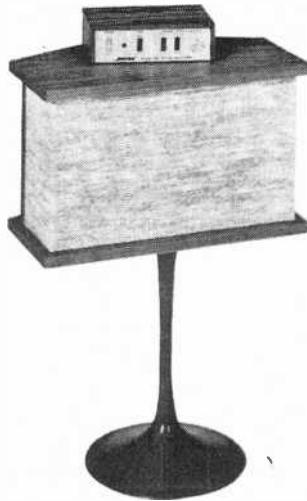
**Stylus timers.** These are little motor-driven devices that you connect to your turntable motor, to show total elapsed running time over periods of up to 400 or 1000 hours. They are based on two assumptions: one, that you don't leave your turntable running for long periods when no discs are playing, and two, that stylus life is purely a function of playing time. The first depends on your personal habits; the second is a dubious premise, for tracking force, stylus tip radius, and the cleanliness of your discs will also substantially affect stylus wear. Timers are useful though, as a reminder to have your stylus checked for wear periodically—like every 250 hours or so.

## PHONO MAINTENANCE GADGETS

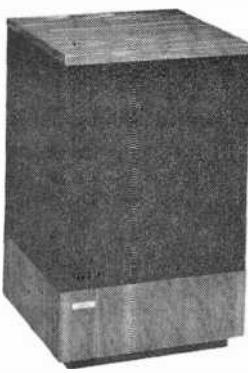
The best **stylus-force gauges** are those which measure tracking force with the stylus at exactly the same height above the motor board as it would be when playing a disc. Other requirements include adequate range (0 to 4 grams will cover all exigencies) and low friction, to ensure accurate readings at fractions of a gram. Accuracy of calibration is important, too, and this is easily checked. A 5-cent piece weighs exactly 5 grams. With a tone arm counterbalanced to zero and a nickel Scotch-tané above its stylus, this is easily checked. A dime weighs  $2\frac{1}{2}$  grams. With

# More Gadgetry

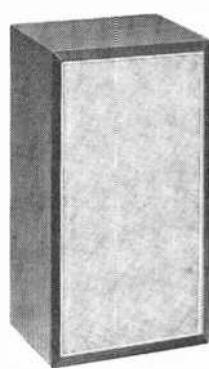
# Twelve years — Five major advances



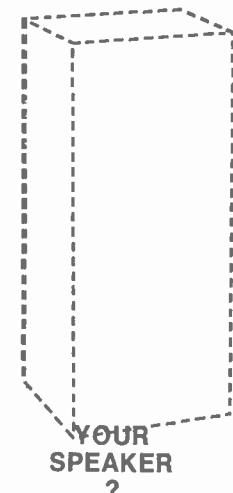
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a tone arm counterbalanced to zero grams and a dime Scotch-taped above its stylus, it should weigh out to  $2\frac{1}{2}$  grams on your force gauge. (A new penny weighs 3 grams.—Ed.)

Generally speaking, the category of **record cleaners** includes more unsatisfactory devices than any other gadget group. Sprays and cleaning pads or cloths contain silicone, which is supposed to lubricate the groove for easier passage of the stylus. Actually, the sticky silicone deposit left in the grooves does more harm than good. It holds tiny dust particles that could otherwise be easily wiped off with a suitable brush, and the combination of dust and "lubricant" eventually forms a highly abrasive goo that accelerates groove and stylus wear, as well as causing mistracking by piling up in a lump on the stylus tip.

Record-cleaning sponges will remove coarse dust particles, like lint and dog or cat hairs; but, because they wipe only the tops of the grooves, they tend to push finer dust particles, which are the major source of wear, down into the groove valleys where the stylus rides. And the use of detergents or water with sponge cleaners only serves to produce a more homogeneous accumulation of gunk in the record's groove valleys.

Most of the so-called perpetual record cleaners—the ones that sweep the grooves during the whole playing cycle—are of little value, too, for about all they do is push the dust around a bit and redeposit it on the disc, meanwhile building up a static charge which attracts even more airborne dust to the disc. Perpetual brushes are only really effective when (1) they provide some means for eliminating static buildup (such as a radioactive element or a suitable fluid treatment), and (2) when their bristles are directed *against* the direction of the groove's motion, so they can scoop up and hold the dust.

Anti-static or record-cleaning fluids that do *not* contain silicones are far better than ones that do, but it is important that they be self-dissolving so that each subsequent treatment removes the previous deposit instead of merely adding another layer to it. The Cecil Watts cleaning devices and an ingenious little gadget called the Discwasher (with "directional" fibres that literally scoop dust from the grooves) are the only disc-cleaning devices I've found (short of some very expensive ones that literally launder

the record grooves) that meet all of the requirements for ideal groove care.

**Stylus cleaners.** No matter how careful you are about keeping your grooves clean, your pickup stylus will accumulate a load of debris with repeated playings, and if not removed, it will interfere with tracking. Many brand-new discs, in fact, have a light coating of slightly gummy material (which is added to minimize adhesion of the vinyl to the record stampers) that can build up sufficiently in one play (or less) to impair tracking cleanliness. This is easily removed from the stylus shortly after it accumulates, but the longer it stays there, the harder it gets; until the only recourse is to clean it off with a solvent (like isopropyl alcohol) and a small watercolor paint brush. So, stylus cleaning, like disc cleaning, should become part of the discophile's playing routine.

For manual pickups that slide horizontally into their arm rest post (instead of sitting on top of it), the simplest and most effective stylus cleaner is one of those little brushes that you mount on the motor board where the stylus will brush over it each time the pickup returns to its at-rest position. It's important, though, that the brush be located where the stylus won't touch it when it is in its rest position, for this will put a permanent "set" in the bristles that reduces their cleaning efficacy. The brush should be just to the left of the stylus, so that the brush contacts the stylus only when it is moving toward or away from its rest position. And the height of the brush should be set so that only the tips of its bristles touch the passing stylus.

With other kinds of tone arms, a manual stylus cleaner must be used, and this can be either a small nylon-bristled brush (like a miniature tooth brush) of the type supplied with many pickups, or a small, specially contoured velvet-pile pad. Elpa sells the latter type for a pittance. Whichever is used, though, it should always be drawn across the stylus from the rear of the arm. Cleaning *against* the angle of the stylus (in a direction opposite to normal groove motion) will mangle the armature assembly.

**Stylus inspection microscopes** can be a menace, for in the magnifications provided, they cannot reveal wear flats on the tip until the wearing is enough to be doing serious damage to grooves. It takes at least 80X magnification and a very practiced

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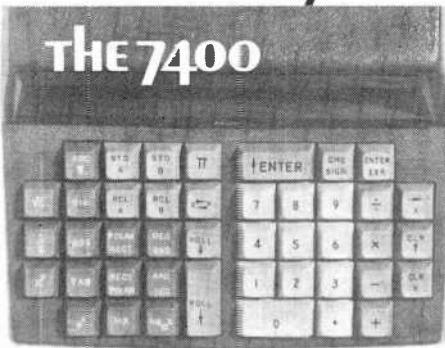
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eye (and hand) to detect flats early enough to preclude record damage. Those little pocket microscopes are fine for telling whether or not the stylus tip is still there or whether it has a large chip out of it, but critical evaluations of stylus wear are best done by the pickup manufacturer on a routine basis. A stylus timer is probably the best indicator of when a stylus should be checked, if you elect not to have it done according to the calendar.

**Spirit levels** are useful for checking the level of a record player if you move it around or change tone arms frequently, but many of them are not very accurate—particularly the cheaper round ones. You can, however, check accuracy with a low cocktail glass and a small mirror. Fill the glass to the brim and place it on the mirror, prop up the edges of the mirror until the surface of the water is parallel to its reflection, as viewed from all sides, then test the spirit level on the mirror. If the level isn't level, it's inaccurate.

As far as I've been able to determine, all of the **stroboscope discs** sold for checking turntable speed are equally satisfactory, as long as you remember *not* to try judging wow from them. Rhythmic back-and-forth wander of the pattern usually indicates only that the strobe pattern is printed slightly off-center. Some strobos are printed on both sides, one of which is often for viewing under 50-Hz ac illumination. If you don't live in Europe, make sure you use the 60-Hz side.

## MISCELLANEOUS GADGETS

**Quadraphonic decoders** vary from excellent to pretty poor. All of them do a satisfactory job of dematrixing four channels from two, but some have painfully high distortion, and some are merely badly designed. A matrix decoder should provide dematrixing for (at the least) Columbia SQ discs and Hafler-type ambience extraction from 2-channel recordings. If the decoder is really to do justice to SQ discs, it would also include logic enhancement circuitry for widening front-to-rear-channel separation.

Apart from excessive electrical distortion, the major shortcoming of most quadraphonic decoders is in their control facilities. Very few of them provide control of volume both in all four channels simultaneously and in rear channels alone, so you may have to choose carefully on the basis of how the unit will be connected into your system. If

you have a receiver with no facilities for connecting between the preamp and the power amplifier, the decoder itself should have a master volume control for all four channels, as well as for the rear channels. If the rear-channel control is absent, the power amplifier for the rear channels should have input-level controls. If you have to use different speakers for the rear channels, there should also be provision, on the decoder or via controls on the rear-speaker amplifier, to adjust rear-channel balance.

Incidentally, some phono pickup manufacturers are claiming that their products are "suitable for 4-channel sound," with the implication that their competitors' products are not. This is misleading; the whole purpose of matrixed quadraphonic recording is to allow the use of *any* pickup that is suitable for 2-channel playback. Matrixing imposes no requirements on a pickup that 2-channel stereo does not.

I haven't personally tested any of the adapters for the JVC/RCA discrete 4-channel disc system, but there has been so much skepticism about the practicality of that system on the part of the industry in general that it is probably safe to assume that the first decoders made available will do justice to it. It is very likely, though, that special pickups will be needed for JVC-encoded discs; few current models have adequate high-end response to pick up the ultrasonic groove modulations that provide the rear-channel information.

**Graphic Equalizers.** Basically, these are tone controls for people who want to do things to their frequency response that bass and treble controls can't do. For example, a bass control can boost lows or cut lows, but it can't cut mid-bass boom without also attenuating deep bass. A treble control can't reduce mid-treble shrillness without erasing the higher frequencies. And neither a bass control nor a treble control can put a hump or a dip in the middle-range response without affecting any other part of the audio range. Many graphic equalizers can do all of these things.

Instead of controlling all frequencies below a certain point (bass) or all above a certain point (treble), graphic equalizers divide the audio spectrum into a number of ranges or bands, and allow each band to be increased or decreased in level without affecting any other band. The "volume controls" for each band are usually vertical slider-type controls, and are arranged side

by side, so that the positions of the knobs at any time can be thought of as points along a frequency-response graph, showing graphically at a glance what the equalizer is doing to the response. Hence the name "graphic equalizer."

Graphic equalizers with four or five controlled bands are more flexible than conventional tone controls, but the more bands, the greater the flexibility. The most versatile units (like the Soundcraftsmen 20-12) have 10 octave-wide bands, and can be used for rudimentary equalization of loudspeaker response deviations as well as for correcting most response-related problems in program material. The Soundcraftsmen has separate controls for each channel, making it more flexible but also more complicated to use than units like one made by SAE which has ganged controls.

**Loudspeaker add-ons** like super-tweeters and bass extenders can often improve speaker performance, but they rarely deliver what they promise unless they alone are used to cover the range they're designed for. If the original speaker systems have distortion or response peaks within the range(s) of the add-on units, the add-ons cannot reduce these problems by one iota. Add-on speakers are at their best when used, as directed by their manufacturers, with the specific loudspeaker systems for which they were designed.

**Plug adapters and cables.** Most American-made audio components can be interconnected through the usual cables with standard RCA-type phono plugs at both ends; but the more components you have, the more often you'll encounter cases of mismatched interconnections. For these, there is an almost limitless selection of adapters available from Switchcraft, Audiotex, Robins and several other manufacturers. In fact, it is safe to say that adapters or adapter cables are available to mate any two standard receptacles you will ever encounter in your hi-fi activities. When, for some obscure reason, a component is equipped with nonstandard receptacles, you can always order suitable adapters directly from the manufacturer, if he doesn't automatically supply them with his products. As a matter of fact, one of the sure-fire ways of identifying a serious audiophile is by the variety of cable adapters he has among his lifetime accumulation of other audio gadgets. Chances are, he'll buy more of them in future. ◆

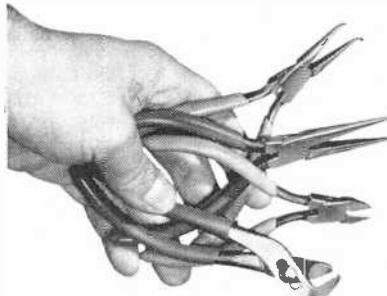
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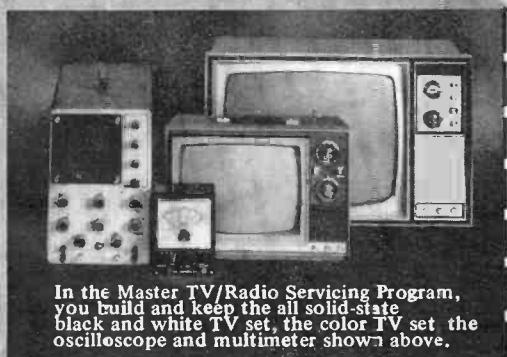
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# News Highlights

## Future Outlook for Engineers

According to the Manpower Report of the President delivered to the Congress early this year, there will be an average demand for 48,000 engineering graduates each year to meet the nation's manpower needs between now and 1980. On the other hand, studies by the Engineering Manpower Commission indicate that only about 43,000 bachelor's degrees in engineering were earned in 1971 and 1972. Beyond this year the number of graduates is expected to decrease steadily because fewer students are enrolled in the present sophomore, junior and senior classes. Hence, the gap between supply and demand is expected to widen as time goes on.

## New Underwater TV Camera System Demonstrated

For only \$10,000 you too can have a complete closed-circuit TV system that will work down to 650 feet below the surface of the ocean. We attended a demonstration of the new system recently at a pier in Brooklyn. We watched on TV monitors while a diver took the underwater camera down into the water in order to inspect the pilings supporting the pier. The TV camera, which is 7 in. in diameter and 16 in. long and weighs only four pounds in the water, is equipped with a handle grip for the diver and can be remotely controlled for beam, focus, target and iris of the camera lens. The demonstration was sponsored by GBC Closed Circuit TV Corp. (of New York City) which calls itself the country's largest supplier of CCTV accessories and equipment.

## New Amateur Radio Satellite Launched

The first in a new series of sophisticated satellites designed and built by hams in the U.S. and Australia was launched recently as a "piggyback" package aboard a NASA Delta space rocket. The main payload of the rocket is an advanced weather satellite, Oscar VI (for Orbiting Satellite Carrying Amateur Radio) differs from the previous five Oscars in several respects. It will have a comparatively long life —about a year with batteries recharged by solar power. It will operate in a circular polar orbit 900 miles out. The 38-lb satellite measures 7 in. by 12 in. by 17½ in. Receiving amateur signals on the 2-meter ham band and retransmitting them on the 10-meter band, Oscar VI will permit international communication on frequencies heretofore limited to short-range operation. It will be used by many more amateurs than before with relatively simple equipment.

## ABC to Distribute Cartrivision Video Cartridges

A subsidiary of American Broadcasting Companies recently announced the signing of a national distribution agreement under which ABC will distribute video tape cartridges for play on the Cartrivision video tape system. The video tape cartridge system, the first to be offered to American consumers, is now on sale at over 500 major stores in 20 large markets throughout the U.S. The tape recorder/

player is included in top-of-the-line color TV consoles from Sears Roebuck, Montgomery Ward, Admiral, Emerson, and Teledyne Packard Bell.

### **DeVry Institute to Move**

One of the leading electronics career education institutions in the nation, DeVry Institute of Technology, will move to a new \$7-million campus at Chicago's Riverview Park. The oldest and largest of eight Bell & Howell Schools and specializing in electronics technology, the campus will occupy 17 acres in the center of the new 71-acre industrial park located on the former Riverview Amusement Park site. A new, \$3.4-million building, now under construction, will be located at the southeast corner of the campus at Melrose and Campbell Streets. Formerly located at 4141 West Belmont, Chicago, the institute will open its new facilities to accommodate 3500 students at the start of the 1973 academic year.

### **KLH Acquired by Eastern Air Devices**

Eastern Air Devices, Inc. has announced the acquisition of the KLH Research and Development Div. of The Singer Co. for a total cash consideration in excess of \$6 million. KLH manufactures high-fidelity music systems and loudspeakers; Eastern Air Devices is a diversified manufacturer of home entertainment and other consumer electronic products and electrical equipment. For the year ended Jan. 1, 1972, KLH had sales of \$13.4 million and pre-tax earnings in excess of \$1.5 million. For the fiscal year ended July 29, 1972, EAD announced sales and net earnings of about \$27.9 million and \$1.4 million respectively.

### **IR Device Sees Heat Picture in Total Darkness**

A new, hand-held device, called "Probeye," detects infrared energy from objects within its fields of view and presents a visible image of the objects from their heat patterns. The device is a self-contained system, roughly the size and shape of a standard press camera. Giving off no light itself, the unit uses a collimated beam-scanning technique to scan a 7½ by 18-degree field of view. A six-element indium antimonide detector array, cooled to 87 degrees K by a self-regulating cryostat operating on compressed argon, converts the infrared radiation received by the optical system into electrical signals. After amplification and processing, these signals produce a reconstruction of the IR pattern in the scene, which is then viewed through the eyepiece as a visible image. The unit is made by Hughes Aircraft Co.'s industrial products division.

### **Largest, Most Powerful Computer**

Shipment has begun on Illiac IV, referred to by its builder, Burroughs Corp., as the largest and most powerful computer ever to be constructed. The system is located at NASA's Ames Research Center in Mountain View, Calif., where it will be used for long-range global weather forecasting, fluid dynamics calculations, signal processing, and oceanographic simulation. The super computer uses 64 high-speed processing units, working data simultaneously. As many as 200 million instructions per second can be processed, which is some 15 to 20 times faster than the largest conventional computers, and is equivalent to processing the names of New York's eight million people 25 times every second. The system was conceived six years ago by the University of Illinois under direction of Dept. of Defense. The contract was awarded in 1967.



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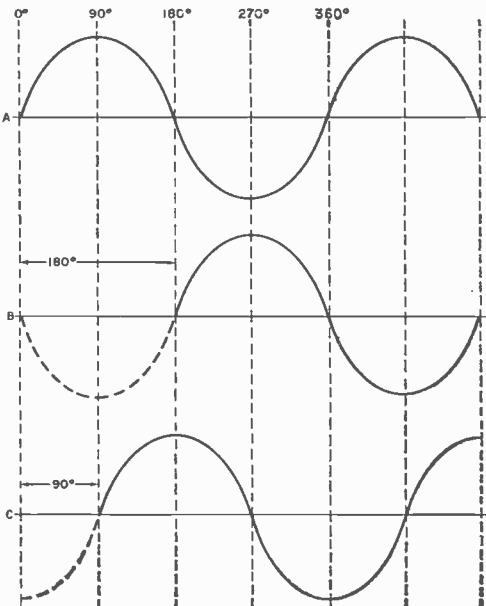
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# methods of matrixing

## *Comparing various matrix systems and how they work*

THE 4-channel stereo ball started rolling in 1970 when Peter Scheiber proved that he could use a "black box" to process two channels of stereo material to create a 4-channel "surround sound" illusion. Later, Electro-Voice demonstrated another black box that seemed to do the same thing in addition to enhancing many existing stereo programs. At about the same time, Dynaco performed the same trick with just a few resistors (as opposed to the somewhat more complicated Scheiber and E-V approaches) added to an existing stereo amplifier and a pair of extra speaker systems. Much later, CBS announced their "SQ" approach wherein four channels of sound are compressed down to two for recording in the

**Fig. 1.** Waveforms B and C are out of phase with basic sine wave shown at top.



conventional 2-channel format; the two channels could subsequently be decoded to yield the original four channels.

Meanwhile, several Japanese manufacturers were busily devising black boxes to do pretty much the same thing the U.S. boxes were doing. The "matrix race" was well under way. At one point, it appeared that the consumer might have to own as many black boxes as he owned records. Now, however, the early confusion has given way to a more or less ordered world of matrix sound.

The term "matrixing" is just an engineer's way of saying "mixing." Recording engineers have been matrixing for years, using many parallel tracks of recorded tape (up to 16) to record an original performance and then "matrixing" the results down to two musically balanced tracks to be transferred to discs. On the other hand, the new medium of 4-channel matrixing involves the mixing down of four tracks into two, using prescribed percentages of all four tracks in each of the two channels. For example, the new "left-total" channel might consist of a full measure of left-front, 20 percent of right-front, and 10 percent each of the right-rear and left-rear signals. During decoding at home, a further algebraic mix takes place, recombining the left-total and right-total channels in four different ways to yield four different outputs. These outputs are intended to be similar to the original or "discrete" four channels which existed at the start of the process; they can never be identical. Any high school math textbook will confirm that, with only two equations from which to work, one cannot solve for four unknowns; this is exactly the case with 4-channel matrix decoding. Consequently, the recovered

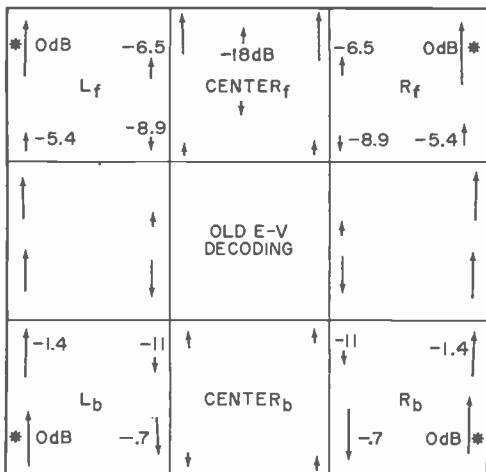
# for 4-channel sound

BY LEONARD FELDMAN

front-left signal ( $L_f$ ) may contain predominantly the original  $L_f$  sound track, but it will also contain some material from the other two or three channels which are present in the original 4-track version of the recording on tape.

In addition to choosing simple percentages in the mix or matrix, it is possible to vary the phase relationships of each channel with respect to the other channels. Examples of signal phase shifting are shown in Fig. 1. With these possibilities of varying percentages and phases, it is no wonder that so many variations in encoders and decoders appeared so quickly. Each proponent set out to vary the amplitude (percentage) and phase parameters of the four channels to create the "best"—according to the supporter—overall 4-channel illusion. Of course, there must be trade-offs in such an arrangement; it is these tradeoffs which differentiate one system from another.

Fig. 2. Outputs with first E-V decoding.



**First E-V System.** The choice of Electro-Voice's early parameters was based on two premises: first, that it is not necessary to have a great degree of separation between

DISCRETE 4-CHANNEL		"OLD" E-V MATRIX	
100	0	60	14
LEFT FRONT DESIRED		LEFT FRONT DESIRED	
DISCRETE 4-CHANNEL		"OLD" E-V MATRIX	
0	0	18	8
(A)			
DISCRETE 4-CHANNEL		"OLD" E-V MATRIX	
0	0	27	14
LEFT BACK DESIRED		LEFT BACK DESIRED	
100	0	32	27
(B)			

Fig. 3. Power distribution comparisons.

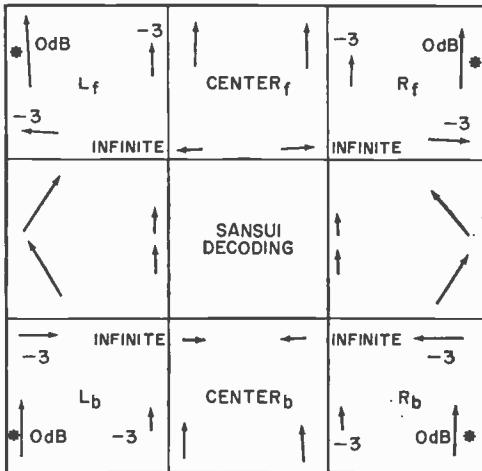
tween the front-left and front-right channels to perceive a good frontal stereo effect, and second, that a centered vocalist (centered between the two front speakers) should be positively pinpointed at that location and should not wander to the rear of the hall in a 4-channel presentation. Graphically displayed in Fig. 2 are the results obtained using the early E-V method. Arrows are used to represent amplitude (loudness) of the signals and phase. In this and all similar figures in this article, whenever an arrow points upward, the signal is in-phase with the original discrete 4-channel equivalent signal. Eight conditions or intended locations of sound around the listening room are shown. Each of the squares in the diagram is divided to show what will be heard from each speaker under a given condition.

When you examine the upper left-hand box, where it is desired to have sound coming from the left-front, you will note that the left-front arrow is longest (greatest ampli-

tude) as it should be, which means that the left-front signal is coming *predominantly* from the left-front speaker. The smaller arrows show that undesired left-front information of smaller amplitude is also coming from all three remaining speakers. The numbers beside the arrows denote how much in decibels (dB) a given signal is below the 0-dB reference signal (in this case, Lf). There is 6.5 dB of "separation" between the left-front and right-front signals, 8.9 dB diagonally across to the right-rear speaker, but only 5.4 dB from front-left to rear-left in the upper left box.

One shortcoming of this system will be noted if you examine either of the "rear" signals (lower corner boxes) in which are represented either a desired left-back or right-back signal. Notice that the opposite rear speaker in each case is only 0.7 dB lower in sound than the "desired" rear speaker. In the E-V system, this minimal separation is partly compensated for by the fact that the undesired rear signal under these conditions is out-of-phase with the desired one. Scanning the diagram reveals that there are other signals which are out-of-phase with respect to the desired signal. The desired signal in each box is denoted by an asterisk (\*). A point in favor of the first E-V system can be seen by examining the box called "center." In this case, when the recording engineer wishes to place a center vocalist, the two front speakers have large signals (the normal condition for placing a vocalist between them) while the rear speakers have very little sound coming from them, perhaps -18 dB with respect to the front. Under these conditions,

Fig. 4. Outputs with Sansui decoding.



DISCRETE 4-CHANNEL

100	0
LEFT FRONT DESIRED	
0	0

SANSUI MATRIX

50	25
LEFT FRONT DESIRED	
25	0

DISCRETE 4-CHANNEL

0	0
LEFT BACK DESIRED	
100	0

SANSUI MATRIX

25	0
LEFT BACK DESIRED	
50	25

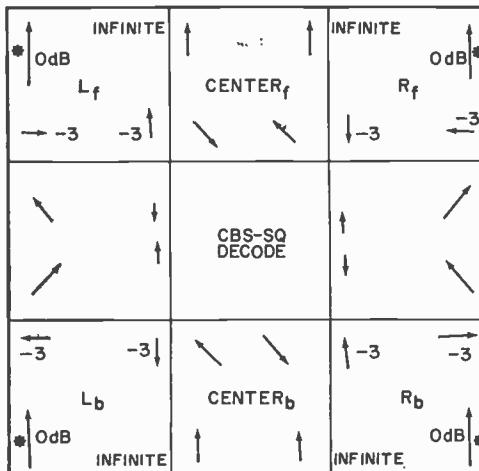
Fig. 5. Power compared for Sansui matrix.

the sonic illusion is quite impressive since the vocalist remains dead center front with the orchestral accompaniment surrounding him front and rear.

Another way of looking at this or any other system is to consider the power distribution in the various speakers when the program content calls for playing a single channel. In Fig. 3A we see the "ideal" power distribution for a discrete 4-channel system when only the front-left channel should be playing, and next to it we see the power distribution over the four speakers, using the old E-V system, for a left-front matrixed approximation. Similarly, for a left-rear-only signal. Fig. 3B depicts the condition in "discrete" playback compared to playback via the older E-V matrix.

**Sansui Matrix.** Sansui chose the encoding and decoding parameters to provide a more symmetrical degree of separation around the listening area. This means that there is less measurable separation across the front than with the E-V system, more separation across the rear, and a somewhat diminished

Fig. 6. CBS SQ decoding results.



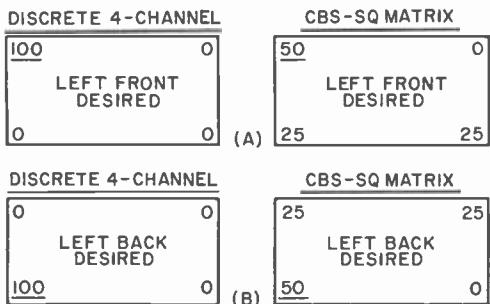


Fig. 7. Power outputs with CBS matrix.

"center vocalist" effect, all of which can be interpreted from the diagram in Fig. 4. Sansui has contributed the idea of a 90° phase shift to which the two rear speakers are subjected in both the encoding and decoding processes. According to them, this makes for better spatial definition, particularly with respect to the rear channels. In all other respects, the system corresponds very closely with the original Scheiber proposal in which the channel diagonally opposite the desired one always has zero output. This high degree of diagonal separation is offset by the fact that both channels adjacent to the desired one contain output signals of the desired channel content that are only 3 dB lower than that reproduced

important, more so than front-to-rear separation. Accordingly, in setting their matrix parameters, CBS chose combining numbers that would result in ideal side-to-side separation at the expense of front-to-rear separation. Also introduced are 90° phase shifts since both Sansui and CBS contend that phase shifting the appropriate signals enhances the perceived separation.

What happens when an SQ disc is played through an SQ decoder is shown in Fig. 6. Note, for example, that when a left-front-only signal is desired (upper left), there is no output of that signal from the right front (full front stereo separation). Similarly, when a right-rear signal is desired (lower right), there is no output of that signal from the left-back speaker. On the other hand, outputs of undesired signal from the remaining two speakers in each case are down only 3 dB (same as Sansui). Furthermore, when any attempt is made to place a vocalist dead-center front, the amplitude of the signal from all four speakers is identical and only phase differences prevail.

The full stereo separation capabilities of the CBS SQ system are further illustrated in Fig. 7. As before, a desired front-left or back-left signal is compared with the "ideal" power distribution of discrete playback of the same types of signals.

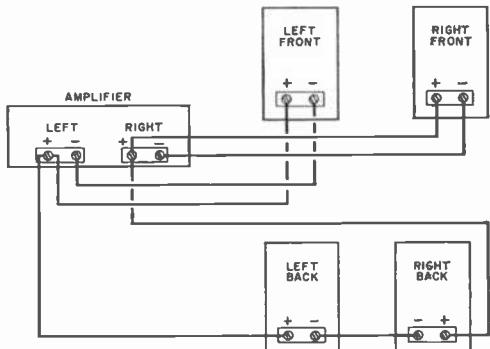


Fig. 8. Early Dynaco speaker hookup.

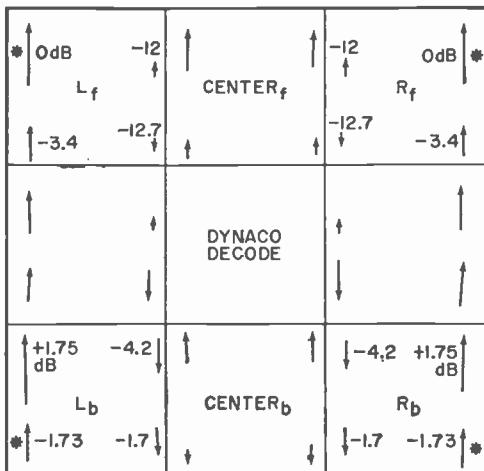
by the desired channel, as can be seen in Fig. 4 and the related decibel levels placed near the appropriate arrows.

Figures 5A and 5B compare the Sansui results, expressed in percentages, for a single left-front or left-back signal with those of discrete playback.

**CBS SQ System.** The major difference between the CBS SQ system and those previously discussed is based on CBS's belief that frontal stereo separation is extremely

**Dyna System.** The original Dynaco proposal for achieving a 4-channel effect from existing stereo discs involved no black box at all. All that had to be done was to connect two rear speakers so that they were fed the *difference* between the left and right stereo signals as shown in Fig. 8. When a

Fig. 9. Outputs with Dynaco decoding.



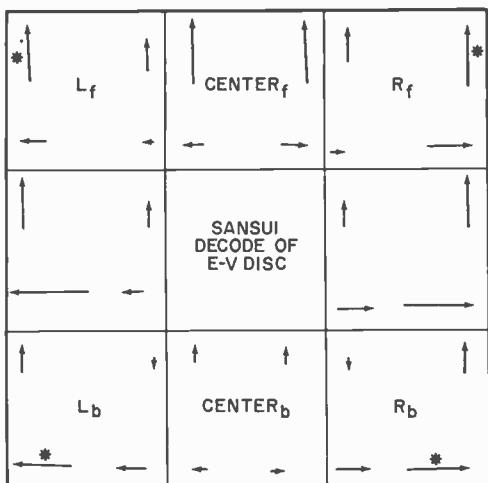


Fig. 10. E-V disc through Sansui decoder.

recording is made in a concert hall, many of the reverberant signals arrive at the microphones out-of-phase with respect to the direct sound waves. In Fig. 8, such signals would acoustically *cancel* in a normal stereo speaker hookup but are reinforced in the rear speakers which are hooked up to reproduce L-R signals. Of course, the effectiveness of this arrangement depended upon the amount of out-of-phase material contained in the original stereo recording.

After meeting with some success, Dyna altered the configuration by adding a resistive network which modified the amplitudes of the signals fed to the various speakers. The results produced a matrix extremely close in effects to that of the early E-V proposal as can be seen by comparing Fig. 9 (Dynaco) with Fig. 2 (E-V). As a result, records encoded by E-V's first formula sound just about perfect when played using the simple Dynaco black box sans extra amplifiers; and Dyna-encoded records sound fine when played through E-V's decoder.

**Compatibility.** There now arises the question of compatibility between the various 4-channel systems. Listening tests conducted using the Dynaco, early E-V, and Sansui systems confirm that, aside from a very slight shifting of instrument locations, these three systems offer a great measure of compatibility. To illustrate this point, Figs. 10 and 11 show what happens when an E-V encoded disc is played through a Sansui decoder and, conversely, what happens when a Sansui disc is played through an

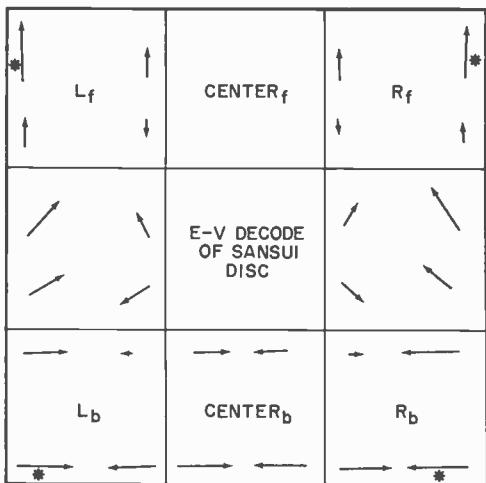
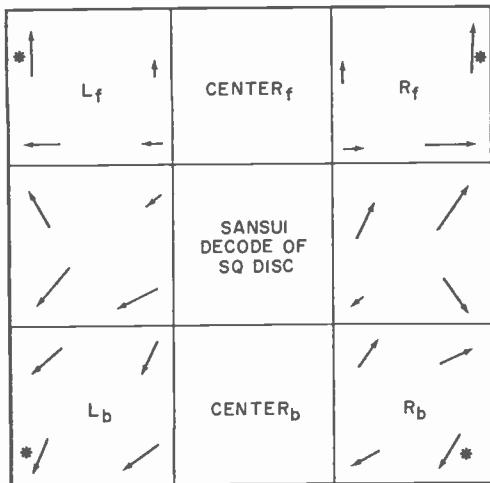


Fig. 11. Sansui disc through E-V decoder.

E-V decoder. By comparing Fig. 10 to Fig. 2 and Fig. 11 to Fig. 4, you can see that the differences are small.

A greater degree of incompatibility results when a CBS SQ-encoded disc is played through one of the other types of decoders. For example, a CBS disc played through a Sansui decoder results in sonic distribution as illustrated in Fig. 12. By comparing this result to the "proper" SQ results (Fig. 6), you can see that the stated goals of the SQ system (full side-to-side separation) have badly deteriorated.

**Universal Decoder.** Although by far the greatest number of 4-channel matrixed discs released to date are CBS SQ types, a good number of discs using other matrix systems are also available. Some manufacturers have elected to build decoders with several switch positions to handle the different decoding systems. This, of course, is a valid though somewhat expensive solution to the compatibility question. Electro-Voice, on the other hand, used a computer to design a decoding scheme that comes fairly close to being fully compatible with all of the popular encoding schemes. They have retained the original E-V amplitude coefficients in the encode and decode formulas but have added specific amounts of phase shift to some of the signals. The phase shifts used are neither 90° nor 180°, but carefully calculated angles that fall somewhere in between. To judge the effectiveness of this new circuit, Fig. 13 shows what happens when a CBS SQ disc is played through the E-V decoding system, and Fig. 14 shows

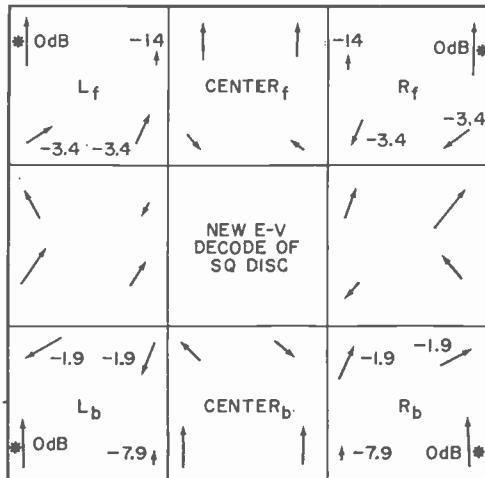


**Fig. 12.** CBS disc through Sansui decoder.

the power distribution. Comparing these two with Figs. 6 and 7, you can see that the results are very similar.

While this "Universal" E-V circuit does not offer "infinite" separation across the front or rear, power in the undesired channels is only 2 and 6 percent, a slight amount compared to an actual SQ decoder's results. It could not be perceived unless the listener was sitting right on top of the offending speaker. (Interestingly, in CBS encoders which do not contain extra logic "enhancement of separation" circuits, a certain amount of cross-blending in both the front and rear is now being incorporated anyway to assist in creating the center front soloist illusion that was virtually absent from the original SQ system.)

**Logic or "Gain Riding" Circuits.** We stated earlier that no matrix system offers the separation capabilities of a fully discrete 4-channel reproducing system. The immediate effect of this inherent limitation is a "narrowing" of the 4-channel listening "field." The listener's position in the room is somewhat more critical and he is not as free to move about—and still maintain good 4-channel effects—as he would be when listening to discrete 4-channel tapes or discs. To counter this limitation, most of the proponents of matrixed 4-channel systems have devised additional sensing or logic circuits which instantaneously detect the presence of a dominant channel and, either by increasing its relative amplitude or decreasing the instantaneous amplitude of the other three channels, increase the effective sep-



**Fig. 13.** CBS disc through new E-V decoder.

eration in the particular system. Obviously, such added sophistication increases cost.

**Advantages of Matrixing.** As every matrix proponent is quick to point out, the "matrix" approach to 4-channel sound offers distinct advantages which can be summarized as follows:

1. All matrix discs can be played using existing cartridges and stylii. Discrete 4-channel discs require cartridges that can reproduce up to 40,000 Hz signals.
  2. Matrix discs produce excellent results in stereo playback without loss of information or deterioration with repeated playings.
  3. Matrix 4-channel discs can be played by FM stations without changing any broadcast rules. It is likely to be several years before the FCC approves a means for broadcasting discrete 4-channel material.

SQ DISC THROUGH NEW E-V DECODER		SQ DISC THROUGH NEW E-V DECODER	
<u>51</u>	2	26	26
LEFT FRONT DESIRED		LEFT BACK DESIRED	
23.5	23.5	42	6

**Fig. 14.** Power relations with new E-V decoder.

4. Adapting your hi-fi system to matrix 4-channel is considerably less expensive than opting for discrete disc playback which at present requires a large capital outlay for such items as a new cartridge, a fairly expensive decoder/demodulator, etc. At the present time, the least painful way of getting into 4-channel stereo is via the matrix route.

# BUILD A PAIR OF SIMPLE ALARMS

## Low-cost vehicle protection

BY ANTHONY C. CAGGIANO

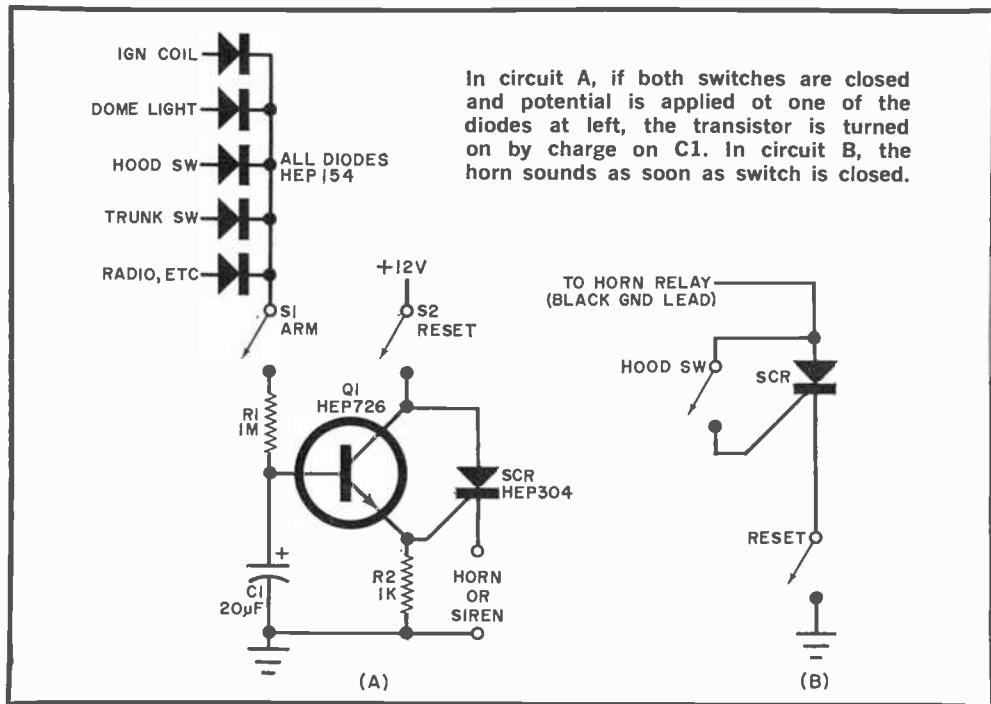
HERE are two simple automotive alarm circuits that can be assembled at very low cost, yet they work as well as many of the more complex systems currently available.

Circuit (A) uses a number of conventional silicon diodes whose anodes are connected to various points that have the 12-volt battery voltage applied to them when activated. These include the ignition coil, dome light, radio, tape player, etc. If normally open switches are installed also, the list can include the trunk, hood, or a pressure-sensitive switch under the floor mat.

The operation of the circuit is quite simple. If both the arming switch (*S1*) and the reset switch (*S2*) are closed and the ignition is turned on (either by a key or a jumper wire), current flows through the associated diode and *R1*, putting a charge

on *C1*. When the charge on *C1* is sufficient to cause *Q1* to turn on, the current through the transistor also turns on the SCR. The latter supplies current to a horn or siren. Once the SCR is on, it remains on regardless of the condition of the diodes or the transistor. Only the opening of the reset switch (which is concealed within the vehicle) will turn off the SCR. The values of *R1* and *C1* in the timing network are selected to provide sufficient delay for the owner to enter the vehicle. The arming switch is left open when the vehicle is in use and is closed when the vehicle is unattended.

Circuit (B) is used with a hood-latch cable installation (or an ungrounded trunk switch). In this case, there is no delay and the horn sounds as soon as the switch is activated. The SCR remains on until the reset switch is opened. ◆



# adjusting your TV set for best color

*Procedure used to get like-new picture*

BY DAVID J. WATERS

A NEW color-TV receiver, once properly set up, is capable of producing sharp, clear color pictures because the three beams from the electron guns strike the centers of their respective color dots on the picture tube screen. Light coming from each dot under these conditions is a pure color, uncontaminated by the other two colors.

As the months go by, however, things begin to happen to the sharp, pure color. Tubes begin to age and other components like capacitors and resistors begin to drift off value. The aging and drifting worsen as time goes by. Fortunately, all color TV receivers are designed to permit adjustments that will satisfactorily compensate for component deterioration and other causes of color imperfection. In this article, we will discuss how to make some basic adjustments.

**Purity Test and Adjustment.** One of the major causes of loss of color clarity is a loss of purity. To test for color purity, tune your receiver for the best possible color picture, working with the fine tuning, aft (if any), tint, color, brightness, and contrast. Tune through all channels, looking for areas of color "blotches" common to all channel settings. If you note any such areas, color purity must be re-established.

Degaussing is the procedure used for re-

storing color purity. The only tool needed is a degaussing coil with a 10'-12' line cord and a momentary-action power switch.

Plug the coil's cord into an ac receptacle so that you can bring the coil right up to the front of the picture tube and also back away 8' or 10' directly in front of the tube. With the TV receiver turned off, hold the degaussing coil parallel to the center of the picture tube and begin making small circular movements with the coil. While the coil is in motion, activate and hold the power switch and continue to describe ever widening circles until you have covered the entire screen area of the picture tube. Then, still depressing the power switch, back away from the receiver about 8' or 10' and let go the switch.

A word of caution: A degaussing coil develops a powerful electromagnetic field that can destroy the speaker or the convergence magnets, as well as ruin a non-antimagnetic watch. So, do not bring a degaussing coil near the speaker or the rear of the receiver, and remove your wristwatch.

After you have completed degaussing the picture tube, turn on the receiver and tune in a color broadcast. Carefully recheck all areas of the picture for color impurity. If any such areas still exist, degauss the picture tube again.

While you are examining the picture, take careful note of how the colors are converged. Do this with the color control set to a "natural" level—not to saturation. If the colors are improperly converged, the outlines of figures against a background of contrasting color will reveal color "fringing." The fringe may be red, green, or blue and, if present, indicates that reconvergence is necessary. Note, however, that some misconvergence is normal for all dot-triad picture tubes, especially at the corners and extreme top, bottom, and sides. So, if, at a normal viewing distance, the color fringing cannot be noticed, there is no need to reconverge the beams.

A note of warning is in order before proceeding. *Unless you are familiar with the procedures to follow when working around high voltages, do NOT perform the following steps—have a TV technician do them. Once the back is off of a powered receiver, dangerously high voltages are present at various locations; so, if you do not know what you are doing, don't gamble on getting a bad shock.*

Regardless of the need for convergence, purity adjustments must be made. Turn off the power from the receiver and remove its back. Turn the color control fully counter-clockwise. Then plug a cheater cord into the receiver's safety interlock and the other end into an ac outlet. Turn on the power and allow the receiver to warm up until a full raster appears on the screen. Prop a mirror up at a convenient distance and angle in front of the TV screen so that you can readily see the screen image while working behind the receiver.

Being careful to touch nothing else, go to

the back of the receiver and set the **BLUE SCREEN**, **RED SCREEN** and **GREEN SCREEN** controls fully counter-clockwise and the **BLUE DRIVE** and **GREEN DRIVE** controls to  $\frac{1}{4}$  clockwise.

Referring to Fig. 1, loosen but do not remove the three wing-nuts located on the yoke assembly at the back of the picture tube. Grasping two of these nuts, ease the yoke backward (toward you) until a red "blob" of color appears approximately in the center of the screen. (You may have to advance the **RED SCREEN** control.) Center the blob with the tabs on the blue lateral assembly. Then slide the yoke forward (away from you) until the red area just fills the screen and tighten the wing-nuts.

Set the **NORMAL/SERVICE** switch to **SERVICE** and the **KINE BIAS** switch to the lowest setting that will permit the following two steps to be performed. Adjust the **RED SCREEN** control until a low-intensity red line appears horizontally across the face of the tube. Back off on the control until the line just disappears. Repeat these two steps with the **BLUE SCREEN** and **GREEN SCREEN** controls. Then set the **NORMAL/SERVICE** switch to **NORMAL** and alternately adjust the **DRIVE** controls for neutral grey shades in the black and white picture on the screen. Note that the white areas appear at your viewing distance to be white and not reddish, greenish, or bluish.

**Color Convergence.** Having determined that your receiver requires convergence, place a color bar/dot generator atop the receiver cabinet (or any convenient location if this is not practical), plug it into an ac outlet, and connect its r-f output cable to

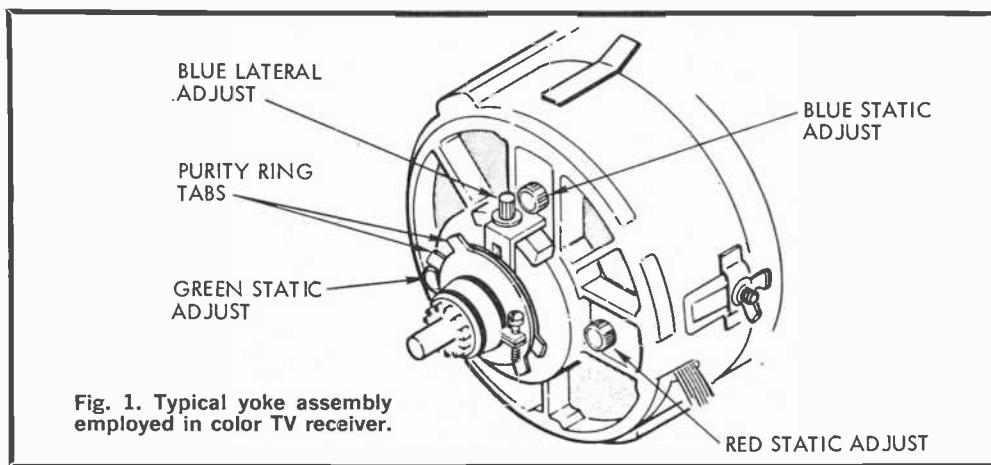


Fig. 1. Typical yoke assembly employed in color TV receiver.

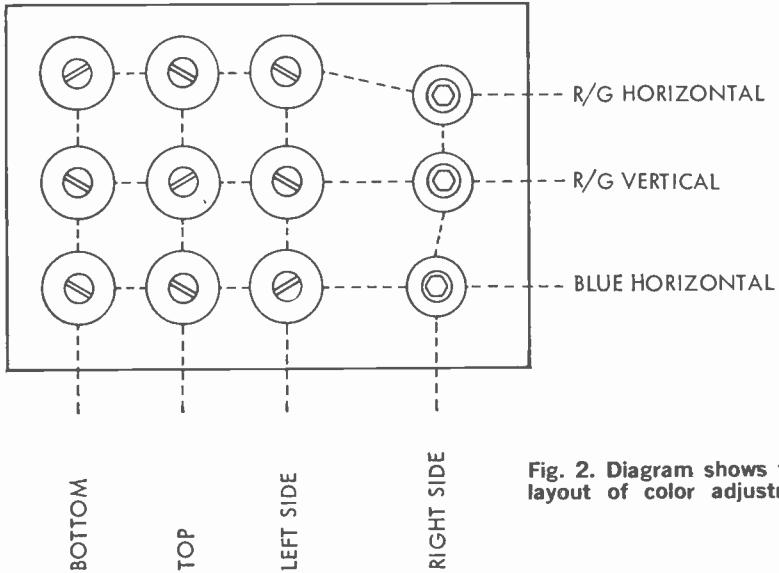


Fig. 2. Diagram shows typical layout of color adjustments.

the receiver's antenna terminals after first removing the lead-in cable. Tune the receiver to a vhf channel within the generator's range. Set the generator's pattern control to DOTS or CROSSHATCH and tune the channel control for a sharp, flutter-free display on the face of the picture tube.

Set the pattern control for COLOR BARS and adjust the COLOR and TINT controls on the receiver so that the fourth bar from the left is reddish-purple and the third bar is red. A green bar should appear at the extreme right on the screen. Switch to DOTS.

Locate the three static convergence controls on the yoke of the picture tube and adjust them so that the red, green, and blue dots merge into white dots in the center of the screen. Note that the blue control moves the blue dots up and down and the red and green controls move their respective dots diagonally in opposite directions. If the red and green dots converge and the blue dots are at the proper height but to the left or right, move the blue dots horizontally by operating the blue lateral control.

The dynamic adjustments are a bit more complicated to make since they interact, and each set is predominantly in control of only one quadrant of the picture tube's screen. Locate the convergence board and note the 12 controls with which you will be working, matching their locations with the layout drawing in Fig. 2. The three controls on the right are slug-tuned coils for which

you will need the appropriate tool for tuning.

The dynamic adjustment procedure is accomplished mainly through trial and error. Converging the dots at the bottom of the screen causes the convergence at the top to deteriorate, and vice versa. Accordingly, a little adjustment at a time (first one, then the other) will usually produce satisfactory results. In most cases, a compromise in misconvergence at the extremities will have to be made in order to keep the convergence in the all-important center of the screen as near to perfect as possible. You may also find that, to maintain perfect center convergence, you have to go back to the static (yoke) adjustments for touchup. Note, however, that perfect convergence will be obtained in only about  $\frac{1}{2}$  to  $\frac{1}{3}$  of the entire area of the picture screen. It will be progressively worse at the farthest extremes as mentioned earlier. This need not be an inconvenience, however; since, at normal viewing distance, the small error will appear to be slight, if not nonexistent. ◇

**Editor's Note:** The instructions for adjusting for color given here are generalized. Not all sets have the same adjustments or require the same procedure. If you can obtain the service data for your particular set, follow the instructions given there.

# THIN TV DISPLAY PANEL

*Zenith device has same apparent resolution as conventional CRT*

RESEARCH scientists from Zenith Radio recently unveiled their version of a thin TV display panel whose  $\frac{1}{8}$ " thickness produces a picture that, except for brightness, rivals that of a conventional CRT.

The experimental unit uses a Burroughs "Self-Scan" panel consisting of 80 columns and 212 rows of gas cells, at present producing a red picture due to the neon gas used. At the present state of development, the panel has a peak luminance of 8 foot-lamberts, and a contrast ratio of 40:1.

In operation (see below), a full line of cells is addressed at the same time and the incoming video is stored in 80 individual capacitors that control the current sources for each column. Modulating these currents produces a wide-range linear gray scale.

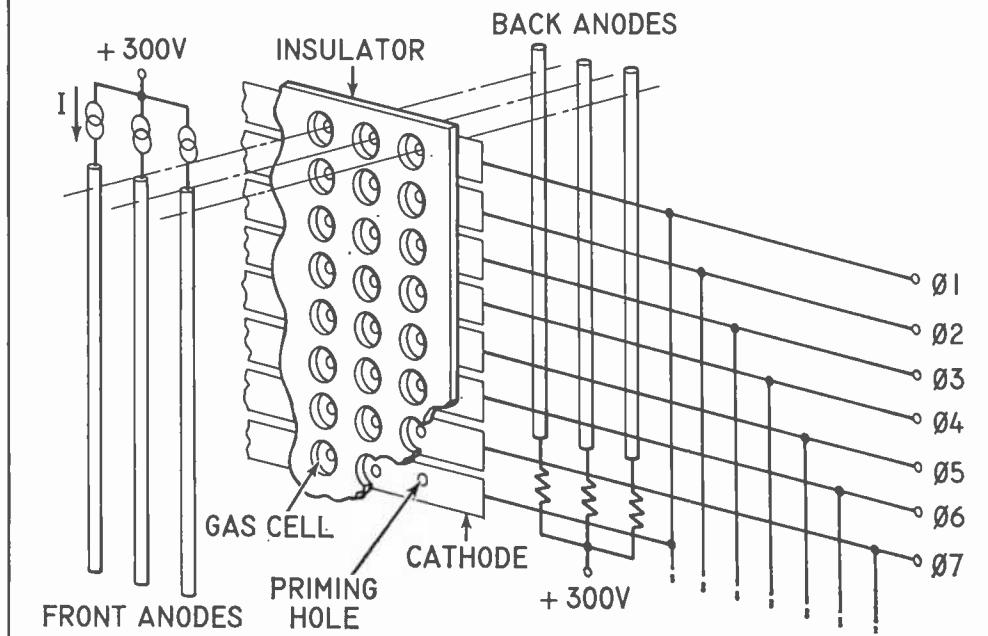
The illumination time of the full line of gas-discharge cells is 60 microseconds compared to the 100-nanosecond excitation time of each phosphor dot in a color CRT.

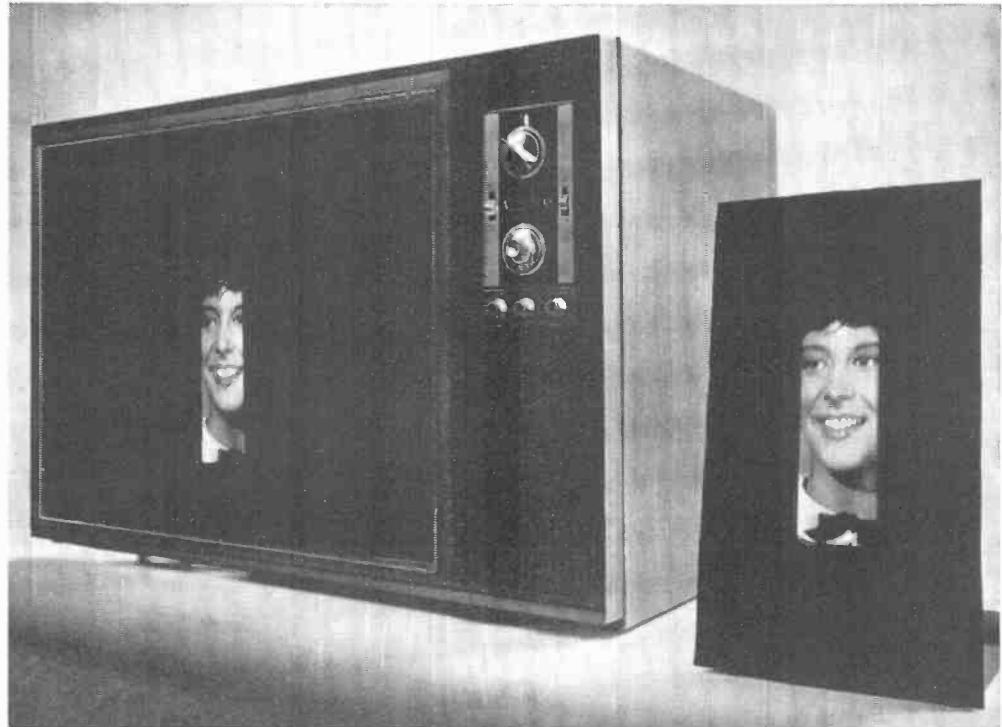
In the thin panel, light is emitted from each cell only as long as the current is applied, and there is no persistence.

In the test demonstration, the  $\frac{1}{8}$ " thick panel was 2.4" wide by 6.3" high and the 25" color CRT was masked to show a picture of the same dimensions. The apparent picture resolution was similar as the photos on the next page will show.

Dr. Robert Adler, Zenith vice president of research said, "What we have learned is encouraging. However, there are many problems to be solved before these panels can be considered for product use. The present panel produces a red monochrome picture, and three colors must be produced in the panel. Each column of the display requires a driver which in a commercial unit would mean 1500 separate drivers. This will require IC's that can handle the needed voltage. And, finally, much higher luminance and better power utilization will be required." ◆

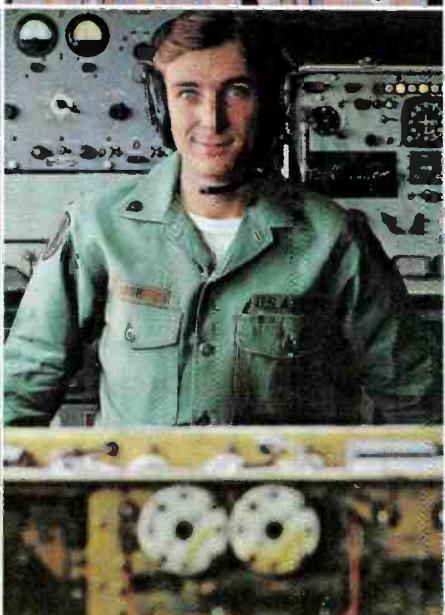
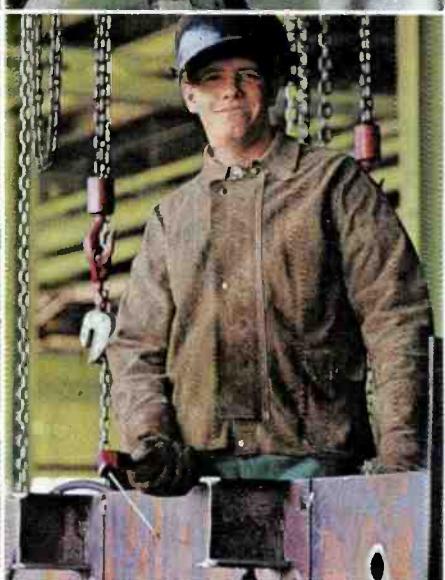
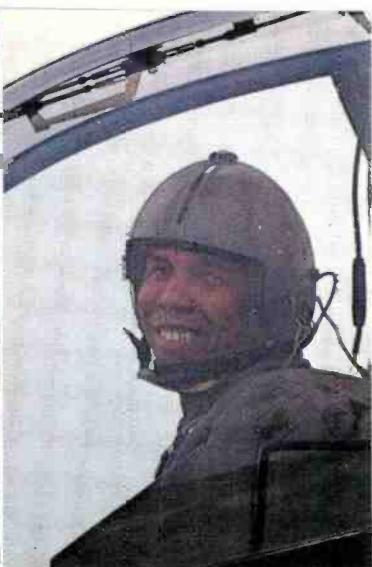
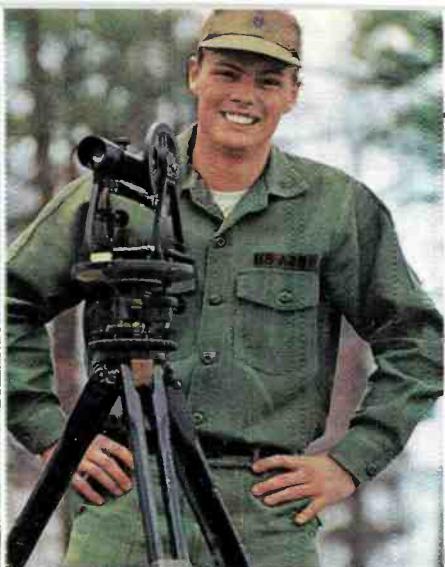
## GAS DISCHARGE TV PANEL





(Below) Without the associated electronics, the panel is only  $\frac{5}{8}$ " thick.  
(Above) Comparison between the thin panel and conventional color receiver.  
The receiver screen is masked to show same area as panel. (Right) Close-up of panel shows excellent resolution.





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# Build an ALPHA BRAIN WAVE FEEDBACK MONITOR

*You may be able to  
learn how to relax  
through electronics*

BY MITCHELL WAITE

**T**HREE is nothing quite so pleasant as being able to relax completely whenever you want to. Unfortunately, today's quick pace rarely leaves us the time to truly relax.

Perhaps for that reason, scientists have come up with an electronic approach to relaxation that might revolutionize the art of "calming down." Drawing on knowledge of general psychology, eastern meditation techniques, and, in particular, clinical electroencephalography, researchers in the field of alpha-wave feedback have progressed rapidly in the last few years and made many significant gains.

Unlike the older forms of meditation, alpha-wave feedback requires neither an avatar or guru. Researchers have found that the minute brain-wave frequency band between 7.5 and 13 Hz is continuously produced in meditative stages of Yoga and Zen. This is called the "alpha state." The assumption is that the length and intensity of alpha-wave production is an impartial measurement of the ability to reach a special state of "relaxed awareness," found in certain types of meditation.

People who produce continuous alpha seem to experience a generally heightened sense of well-being, with a parallel increase in clarity. Thus, alpha feedback allows one to prepare for demanding mental tasks by previously clearing the mind of distracting thoughts and ideas. It is precisely for this reason that some businesses are investigating alpha feedback. Researchers are also suggesting that the "pain" of education can be lessened if these procedures are used in attention control. There is the possibility, they say, that recall can be improved and mental blocks avoided during examinations, by the use of alpha feedback.

**Basic Approach.** In alpha feedback, high-gain, low-noise amplifiers detect the micro-volt signals of the brain and use them to modulate a sound or other stimulus. The person training for increased alpha completes the feedback loop by listening to the rise and fall of a tone as the brain waves come and go. Thus, by learning to produce just the elusive 7.5-to-13-Hz modulation, a person can experience the alpha state.

Actually, all brain waves have charac-

teristic mental correlates. For example, deep sleep produces the long slow waves between 2 and 4 Hz; problem solving and daydreaming give rise to the theta rhythms (3.5 to 7.5 Hz); while tension, worry, or surprise produce the beta frequencies (13 to 28 Hz). There is also evidence that creative and spontaneous moods occur most often when the frequencies between alpha and theta are active. This has led some researchers to speculate that creativity and insight might be facilitated by learning how to increase frequencies.

The important thing is to find out more of all this for yourself. With the circuit described, you may be able to influence and enjoy all of the brain-wave states. In addition, the project can be used to listen to such body signals as scalp tension and heart rate.

**About the Circuit.** Because of the rapid increase in the popularity of biofeedback, a large selection of feedback monitors have appeared on the market. Their complexity ranges from a device for alpha feedback using only one IC to research laboratory equipment costing thousands of dollars. The latter include such features as strip chart recorders, multi-channel amplifiers, highly controllable filters, percent time indicators, etc.

The circuit shown in Fig. 1 incorporates functions usually found only in more sophisticated equipment. For example: because the different brain waves are very close in frequency, a switchable 4-pole bandpass filter is used. Each filter is tuned to the center frequency of the theta, alpha, and beta bands. These filters obviously make recognition of a particular brain wave much easier and faster.

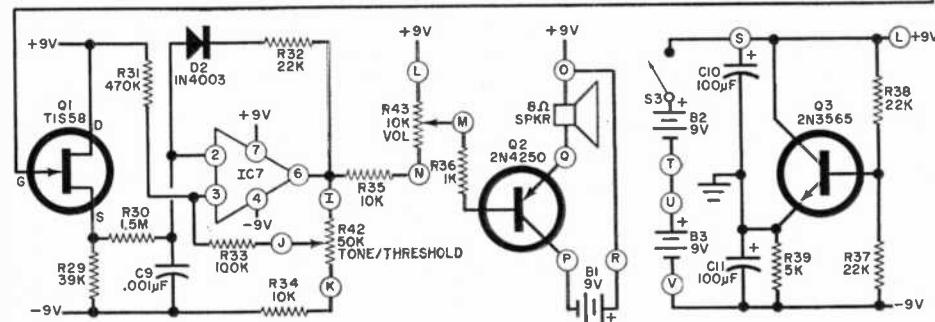
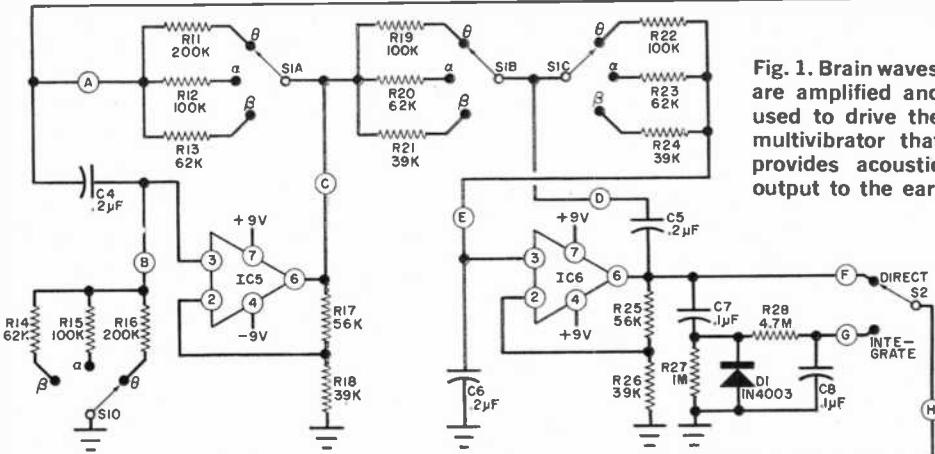
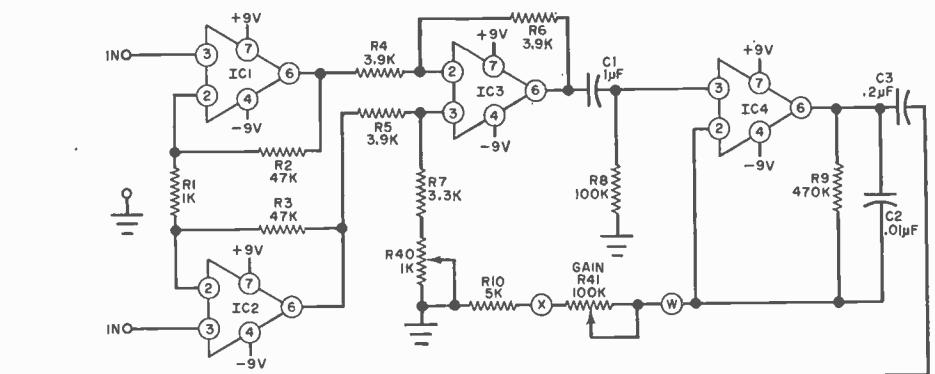
Another critical parameter of a feedback machine is its ability to reject strong common-mode interference—such as 60-Hz hum or erroneous signals from electrode movement—while presenting a high input impedance. An inexpensive solution to this problem is to use a single low-noise op amp in the differential mode. This solution is not completely satisfactory because of the inevitable tradeoff between input impedance, balance, and common mode rejection. Here we use an instrumentation amplifier for the front end, with two low-bias op amps (*IC1* and *IC2*) providing an almost infinite input impedance and excellent common mode rejection.

Electrodes, which couple the microvolt signals to the amplifier, are critical in two respects. They should not generate short-term voltages (tiny noise spikes) or long-term voltages (offset or drift). A number of low-cost commercial machines use an inert material such as stainless steel for electrodes. The difficulty with these electrodes is that they produce some noise spikes and (more seriously) generate a slow voltage offset, which (if the input stage is direct coupled) can eventually saturate the output. A better approach is found in laboratory applications where silver electrodes coated with a layer of chloride are used. Though these electrodes are free of noise and have no long-term voltage drifts, the chloride surface must eventually be replaced so the electrodes are disposable types. However, with proper cleaning, they will last for some time. The least troublesome approach is to use pellet-type Ag/Ag-Cl electrodes which, due to their special construction, last indefinitely.

Another more general consideration in designing an EEG monitor is the type of modulation used to produce the audio feedback. Most models use the amplified, filtered brain wave either to amplitude- or frequency-modulate a fixed tone. In the monitor described here, a unique combination tone-threshold control can be adjusted to produce either AM, FM, or a combination of the two.

It is also necessary to determine what aspects of the brain-wave envelope shall vary the tone. The two most common methods use either a direct or integrated waveform to modulate the audio. With the mode selector switch, *S2*, in the DIRECT position, the instantaneous waveform passing through the filter frequency modulates an adjustable tone. This mode creates an effect in which one seems to be tuning directly to the thought of the brain. If the continuous tone is objectionable, the oscillator can be set just below its threshold point so that only the peaks of the filtered waveform trigger the tone. The latter method integrates the filtered waveform over a fixed period of time.

In this monitor, depending on the setting of the threshold control (*R42*), the tone can be made absent when no signal is present. When the threshold is exceeded, the frequency of the tone is proportional to the envelope of the signals. This mode is better for biofeedback training since the



### PARTS LIST

**B1,B2,R3**—9-volt battery  
**C1**—1- $\mu$ F, 10% Mylar capacitor  
**C2**—0.01- $\mu$ F disc capacitor  
**C3-C6**—0.2- $\mu$ F, 10% Mylar capacitor  
**C7,C8**—0.1- $\mu$ F, 10% Mylar capacitor  
**C9**—0.001- $\mu$ F, 10% Mylar capacitor  
**C10,C11**—100- $\mu$ F, 2-volt electrolytic capacitor  
**D1,D2**—IN4003 silicon diode  
**IC1,IC2**—N5556 op amp (Signetics, do not substitute)  
**IC3-IC7**—741 op amp  
**Q1**—TIS58 field effect transistor  
**Q2**—2N4250 transistor  
**Q3**—2N3565 transistor  
**R1,R36**—1000-ohm, 1/4-watt, 5% resistor

**R2,R3**—47,000-ohm, 1/4-watt, 5% resistor  
**R4,R6**—3900-ohm, 1/4-watt, 5% resistor  
**R7**—3300-ohm, 1/4-watt, 5% resistor  
**R8,R12,R15,R19,R22,R33**—100,000-ohm, 1/4-watt 5% resistor  
**R9,R31**—470,000-ohm, 1/4-watt, 5% resistor  
**R10,R39**—5000-ohm, 1/4-watt, 5% resistor  
**R11,R16**—200,000-ohm, 1/4-watt, 5% resistor  
**R13,R14,R20,R23**—62,000-ohm, 1/4-watt, 5% resistor  
**R17,R25**—56,000-ohm, 1/4-watt, 5% resistor  
**R18,R21,R24,R26,R29**—39,000-ohm, 1/4-watt, 5% resistor  
**R27**—1-megohm, 1/4-watt, 5% resistor  
**R28**—4.7-megohm, 1/4-watt, 5% resistor  
**R30**—1.5-megohm, 1/4-watt, 5% resistor

**Fig. 1.** Brain waves are amplified and used to drive the multivibrator that provides acoustic output to the ear.

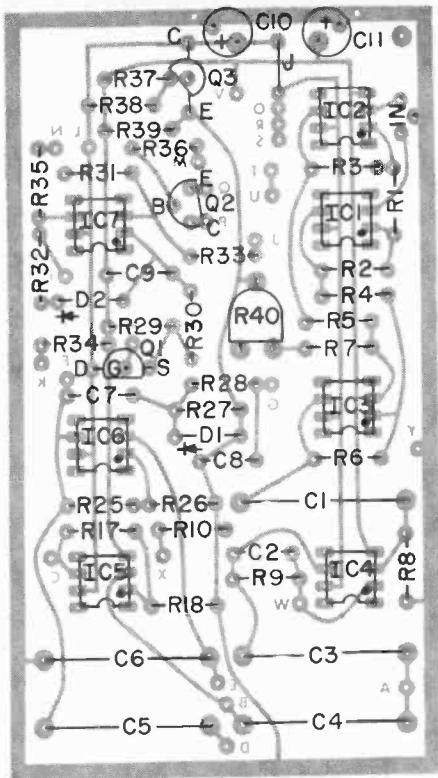
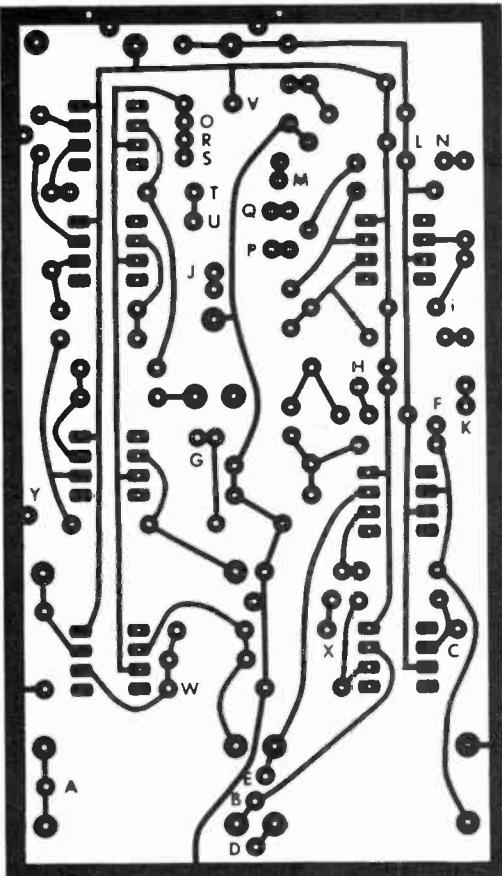


Fig. 2. Actual size foil pattern is at right with component layout above.



tone gives a direct indication of the desired result.

This monitor also has an audio amplifier with speaker and volume control ( $R_{43}$ ), so that a group can listen or the volume can be reduced to a quiet level.

**How It Works.** Integrated circuit  $IC_1$  and  $IC_2$  amplify the differential signal between

the two input leads while providing unity gain for the common mode signal. The residual common mode signal is removed by  $IC_3$  and can be nulled to zero by trimmer  $R_{40}$ . The signal is then coupled through  $C_1$  to  $IC_4$  and further amplified. The gain of this stage can be varied from about 5 to 95 by the setting of  $R_{41}$ .

Integrated circuit  $IC_5$  forms a two-pole

$R_{32}, R_{37}, R_{38}$ —22,000-ohm,  $\frac{1}{4}$ -watt, 5% resistor

$R_{34}, R_{35}$ —10,000-ohm,  $\frac{1}{4}$ -watt, 5% resistor  
(IPC type)

$R_{41}$ —100,000-ohm miniature potentiometer

$R_{42}$ —50,000-ohm miniature potentiometer

$R_{43}$ —10,000-ohm miniature potentiometer  
with attached switch for  $S_3$

$S_1$ —4 pole, 3-position shorting rotary switch

$S_2$ —Spdt switch

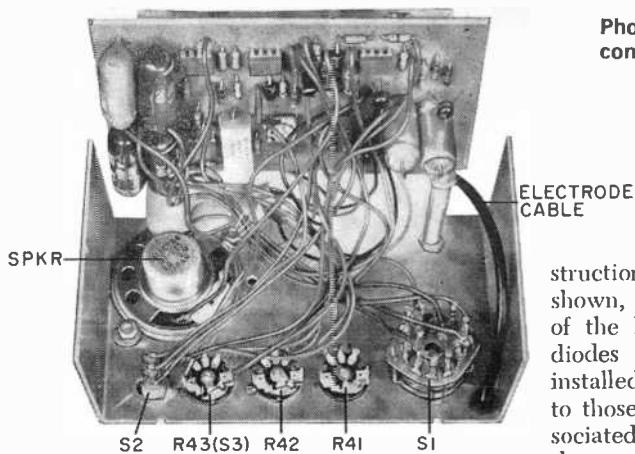
$S_3$ —Spst switch on  $R_{43}$

$SPKR$ —Miniature 8-ohm speaker

Misc.—Four feet of 2-conductor shielded flexible cable, metal enclosure, battery connectors (3), knobs (4), rubber grommet,

headband, electrode cream, electrodes, earclip, mounting hardware.

**Note**—The following are available (postpaid, but insurance extra) from Extended Digital Concepts, Box 9161, Berkeley, CA 94709: #PE2, etched and drilled PC board at \$4.49; #PE3,  $IC_1$  and  $IC_2$  at \$6.49; #PE4, set of stainless steel electrodes at \$1.49; set of disposable Ag/Ag-Cl electrodes at \$3.49; #PE6, set of reusable Ag/Ag-Cl electrodes at \$14.95; #PE1, complete kit of parts including sets of disposable and stainless steel electrodes, drilled and etched board, drilled and painted enclosure, elastic headband, electrode cream, and earclip at \$58.95. California residents, add 5% sales tax.



Photograph of prototype shows how components were assembled in box.

active filter which rejects signals lower than the frequency determined by capacitors  $C_3$  and  $C_4$  and  $R_{11}$  through  $R_{16}$ . Conversely,  $IC_6$  removes signals higher than its selected frequency. The net effect is a filter which passes only a narrow band of low frequencies.

With  $D_1$  as a shunt rectifier and  $C_8$  and  $R_{28}$  as a smoothing filter, the signal is passed to  $Q_1$ , a FET operating as a source follower with unity gain. Integrated circuit  $IC_7$  is connected in a multivibrator circuit and is normally saturated with the output voltage near the positive supply voltage. When  $C_9$  charges through  $R_{30}$  to a voltage higher than the level provided by the voltage divider made up of  $R_{31}$ ,  $R_{33}$ ,  $R_{42}$ , and  $R_{34}$ ,  $IC_7$  saturates due to positive feedback. Capacitor  $C_9$  then discharges through  $D_2$  until  $IC_7$  flips back to its previous state. The signal from  $Q_1$  varies the charge on  $C_9$  and thus modulates the tone.

Transistor  $Q_2$  is a source follower which provides a low impedance to drive the speaker without overloading the multivibrator. A separate battery ( $B_1$ ) is used for the speaker to avoid feedback.

Transistor  $Q_3$  is a source follower which creates a low-impedance ground about half way between the plus and minus supply voltages. This also permits the use of a single-pole switch ( $S_3$ ) to turn the monitor on and off. It is not necessary to disconnect  $B_1$  because its drain is negligible with  $S_3$  open.

**Construction.** The use of a PC board (foil pattern shown in Fig. 2) makes con-

struction easy. Mount the components as shown, observing the notch and dot code of the IC's. Also make sure that the two diodes and three transistors are properly installed. The lettered terminals correspond to those on the schematic. The resistors associated with  $S_1$  are connected directly to the terminals on the switch. Use fine solder and a low-power soldering iron.

The circuit board and batteries can be installed in any small enclosure. The three potentiometers ( $R_{41}$ ,  $R_{42}$ , and  $R_{43}$ ) and the two switches ( $S_1$  and  $S_2$ ) should be mounted on the front panel, with a small grommeted hole also on the front panel for the shielded cable. The speaker is cemented to the front panel with a few holes drilled in the panel for the sound to come through.

Prepare the electrode cable by removing about 12" of the outer insulation from the cable. Unwind the shield and twist it into cable form. Solder this shield lead to the earclip. Remove about  $\frac{1}{2}$ " of insulation from the two insulated leads and carefully solder them to the electrodes. When soldering to stainless steel, first lightly sand the metal surface with fine sandpaper.

**Testing.** Install fresh batteries, turn the circuit on, and adjust the tone/threshold control ( $R_{42}$ ) until a tone is heard in the speaker. Set the bandpass switch ( $S_1$ ) to its lowest range (3.9-7.9 Hz) and the mode control ( $S_2$ ) to direct. Using a small amount of electrode cream, clip the ground lead to an earlobe. Saturate the electrodes with cream, and steadily hold one electrode in each hand. The circuit should pick up your heartbeat, amplify it, and send it through the speaker. This is a noticeable beep, about one a second. The pulse signal is about 1 millivolt (10 times greater than alpha-wave level) so turn the gain control down. If you cannot hear your pulse, check the wiring.

If you have a signal generator and scope, the circuit may be further analyzed by clipping one input and the ground lead to the signal generator ground and feeding an attenuated signal into the other input lead.

The dc output of all op amps should be near zero.

**Balancing the Amplifier.** Potentiometer R40 is used to trim the gain of one side of the differential amplifier to make both gains exactly the same. When they are equal, common mode rejection is maximum. The best procedure is to feed a common mode signal of 3 to 4 volts into both inputs tied together, across a 10,000-ohm resistor. Put a scope or ac VTVM on the output of IC4 and adjust R40 for the smallest signal. If you do not have a scope or signal generator, hook the electrodes through the 10,000-ohm resistor to ground and touch the common leads. You will hear 60-Hz noise from your body. Adjust R40 for minimum noise or the clearest tone.

**Use of the Monitor.** First, a note of caution. The monitor, like most commercial machines of this type, is battery operated. This is to prevent a shock in the rare event that the 60-Hz power line shorts to the inputs. Therefore, for complete safety, avoid hooking the monitor to any ac-operated equipment such as scopes, battery eliminators, etc. When ac devices are hooked up to an EEG monitor in a laboratory, light coupling devices or fused fail-safe systems are used.

If you are sure the monitor is picking up EKG and properly balanced, you are ready to try EEG feedback. Place a small bit of electrode cream on the earclip and attach it to either earlobe. Wrap an elastic or soft cloth band around the head, aligned so that it is over the eyebrows and at the widest part at the back of the head. Pin the cloth to hold it on. Put a small amount of cream on each electrode and place one under the band just above the left or right eyebrow. Place the other in line with the first at the rear of the head. Spread the hair apart and add a little more cream. The electrodes will function best when they float above the scalp with electrode cream bridging the gap. With the electrodes placed in this manner, you should be picking up mostly what is called occipital alpha. In more advanced stages of meditation, alpha production increases in the frontal areas of the brain. You can experiment with this by placing both leads on the forehead.

Sit or lie down in a quiet, comfortable place. Turn the monitor on, place the hand-

pass switch in the alpha range (7.9-13.0 Hz), with mode in DIRECT, turn the gain all the way down, and adjust the tone and volume to a pleasing level. Blink your eyes and listen for a beep. Slowly turn the gain up. If the electrodes are correctly placed, no hum will be heard. Now, with the eyes open and focused on an object, adjust the gain for a fairly steady tone. Because you are producing mostly beta and the band-pass is on alpha, you should not hear the beta frequencies. Now close the eyes and listen for a rhythmic modulation of the tone. Do not *try* to produce this rhythm; let the mind go and just listen for it. The occasional fluttering of the tone will be the alpha waves.

Notice the types of thoughts that block the alpha. After you are sure you are producing alpha, switch S2 to INTEGRATE and adjust the threshold/tone control so that, when the eyes are open, there is no tone. Shut the eyes and practice increasing the number of times the tone is on (percent time training). Later try increasing the frequency of the tone (amplitude training).

In laboratory training, a usual alpha session lasts 10 to 15 minutes a day for about two weeks. If you stick to it, you may eventually notice a feeling of well-being and relaxation after each session. To experiment with the other brain-wave bands, simply repeat the procedure with the filter switched to the desired band. Try lowering the dominant alpha frequency toward theta in the direct mode and notice if spontaneous thoughts or ideas come more easily.

When you have finished using the monitor, carefully wipe the cream off the electrodes. If you are using stainless steel electrodes, sand them lightly and clean them with alcohol.

One final note: alpha-wave feedback has produced results similar to meditation, but it works much faster. It is still, however, a subtle effect and requires diligence and experimentation to obtain worthwhile results. ◆

**Editor's Note:** This article, which follows last month's story on principles of biofeedback training, describes an easily constructed project for experimentation. There have been many claims made for brain-wave monitors —some highly exaggerated. We make no such claims, other than that the circuit operates properly.

# Low-Cost Electronic Thermometer

INDICATES LOCAL OR REMOTE TEMPERATURES  
FROM FREEZING TO 302°F

BY JAMES R. SQUIRES

**E**LCTRONIC thermometers have proven to be not only more accurate than the old-fashioned mercury types; they are also far more versatile. They can have more than one sensor and the sensors can be mounted almost anywhere within reason with a cable connected to the readout.

A circuit for a good, low-cost electronic thermometer is shown below. The unit has both local and remote sensing and can operate between 32° and 302°F in two ranges.

Thermistors are used as the temperature sensing elements so keep in mind that these devices have a thermal hysteresis effect. That is, if you measure the ambient temperature, then immerse the thermistor in boiling water, after cooling, it will indicate slightly higher than the ambient.

The two scales on the thermometer (XI and X10) are equivalent to currents of 1 mA and 10 mA through the meter, as determined by the setting of S2. The X1 range is roughly equivalent to a temperature range of 0° to 50°C (32° to 122°F), while the X10 range covers 0° to 150°C (32° to 302°F).

In the circuit, most of the components are in series. The value of  $R_3$  is chosen so that the 1-mA meter will indicate 10 mA. For the meter used in the prototype, a value of 17.8 ohms was required for  $R_3$ . Odd values of resistance for  $R_3$  can be made by paralleling higher values.

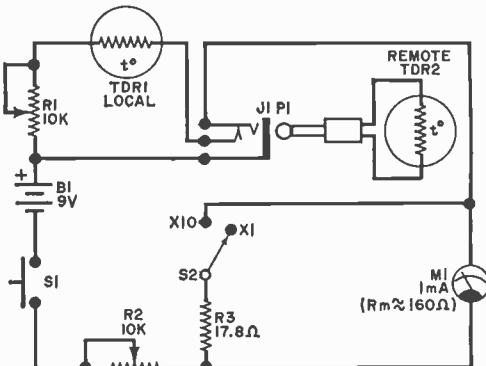
Any method of construction can be used (perf board, point-to-point wiring, etc.). Local thermistor *TDRI* can be mounted so that it just protrudes (about  $\frac{1}{8}$ "') from the chassis. The remote sensor is attached to the end of a length of two-conductor cable, with *P1* on the other end. The remote sensor is not necessary, of course, if you don't want to use it.

With S2 in the X1 position, plug the remote sensor into J1, depress S1 and adjust R2 until the meter indicates about half scale. Remove the remote sensor, and adjust R1 for a center scale indication with the local sensor. Hold the local sensor between

your thumb and forefinger and note that the meter indicates upscale. Do the same with the remote sensor. The two changes should be similar in value and any deviation will be due to slightly different resistance-temperature curves of the two thermistors.

The meter scale is calibrated by immersing the thermistors in ice water ( $32^{\circ}\text{F}$ ) and adjusting the appropriate potentiometer for the proper indication on the meter. Use boiling water ( $212^{\circ}\text{F}$ ) for the upper mark. To calibrate the remainder of the scale, keep the two thermistors in the hot water, along with a good mercury thermometer. Stir the water, and mark the other points on the scale as the water cools. Switch  $S1$  should be operated only when a temperature measurement is to be made. This conserves the battery and minimizes any self-heating of the thermistors due to current flow.

Resistance of either thermistor determines current flow through the meter.



## PARTS LIST

*B1—9-volt battery  
 J1—Miniature phone jack, normally closed  
 M1—1-mA meter  
 P1—Miniature phone plug to fit J1  
 R1,R2—10,000-ohm potentiometer  
 R3—See text  
 S1—Normally open pushbutton switch  
 S2—Spdt switch  
 TDR1,TDR2—Thermistor (Fenwall GB41P  
 Misc.—Suitable chassis, two-conductor cab  
 mounting hardware, etc.*

First step in noise reduction is noise measurement.



# How We Measure Noise

IMPORTANT FACTORS IN THE WAR ON NOISE POLLUTION

By CARL W. ALSEN, General Radio, Concord, Mass.

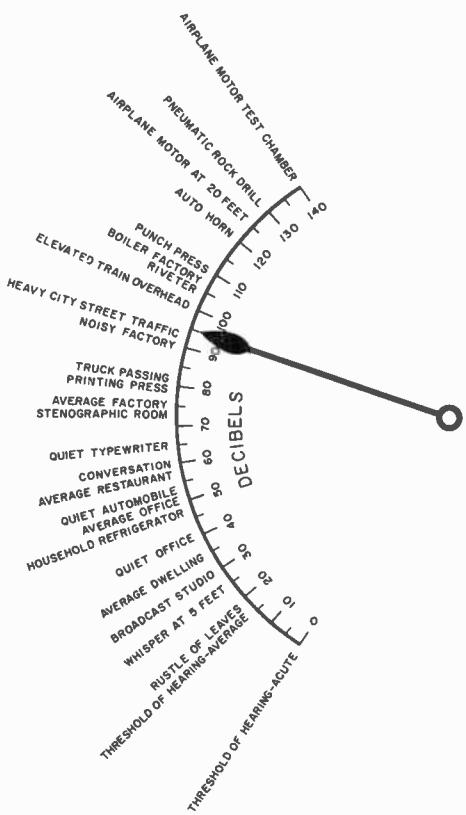
**S**TUDIES in acoustics—particularly psychoacoustics—require measurements of the effect of sound upon people themselves and their hearing. Since our hearing is decidedly nonlinear in response, so also must be the measuring instruments.

Over the years, a number of specialized sound measuring instruments have been developed for the acoustics specialist. Today, however, noise has become a common worry of a host of nonspecialists. The airport manager, plant engineer, and manufacturer of noise-generating snowmobiles, power mowers, and all manner of appliances must concern themselves with the noise problem and people's reactions to the noise

itself. To satisfy the consumer and the growing number of noise-control laws being passed, these nonspecialists must make noise measurements. Hence, what was once the specialist's instrument is rapidly becoming the nonspecialist's weapon in the battle against noise.

To understand how noise-measuring instruments operate requires some knowledge of the ear mechanism and how it behaves.

**The Intriguing Ear.** One startling fact about the human ear is that it can handle an immense variation in sound intensity. A high-level sound just short of the pain-threshold is 10,000,000 times as intense as



**Fig. 1.** Normal sounds fall in range from 0 to 140 dB. Instruments which are used to measure sound read in dB.

the quietest sound the ear can detect. The whole hearing mechanism responds to this wide range of sounds in an exponential manner such that noise increased three-fold appears to the human ear as though it only about doubled. Hence, by expressing sound level in logarithmic form, we have an approximate expression of loudness. For this reason, and because smaller numbers are easier to handle, the decibel, abbreviated "dB" in scientific notation, has been adopted as the unit of measure for sound level.

The decibel is defined as 20 times the logarithm of the ratio of sound pressure level to a reference level, or 0 dB. As shown in Fig. 1, normal sounds covering a ratio of levels of 10,000,000:1 can be expressed over a 140-dB range. About the smallest normally perceptible change in sound intensity is 1 dB. All sound-measuring instruments give readings in terms of decibels.

As concerns frequency response, human hearing is not as flat as even the poorest

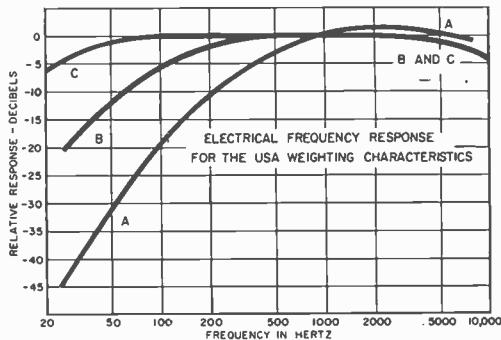
"high-fidelity" audio system, varying as much as 50 dB (a ratio of 300:1) from 50 Hz to 10,000 Hz. Even more perverse is the fact that this response changes with sound level; the response to high-level sounds is the best, but still not very good. A common evidence of this effect is the necessity of boosting the bass response of an audio system at low levels to keep the effect of flat, or at least pleasing, response.

Like any mechanical system, the human ear has an elastic limit beyond which temporary or even permanent damage can occur. Depending on many factors—the nature of the noise and the individual himself—this can occur at levels as low as 85 dB. Recent federal legislation has imposed limits upon the noise levels to which employees may be exposed in industrial plants. In a characteristically nonlinear fashion, permissible levels depend upon the duration of the exposure to the noise.

Finally, we find nonlinear effects the most unpredictable because the listener is a human being. The irritation a noise generates depends upon the emotional state of the listener at any given moment as much as it does upon the level or frequency of the sound itself. We are further confounded by the many other little-understood psychological facets of hearing, like our ability to sort out one voice in a general din.

**Earlike Instruments.** If measuring tools are going to be useful to the acoustician or psychoacoustician, they must simulate one or more of the peculiar nonlinearities of human hearing. The basic sound-measuring instrument is the sound level meter (SLM). The term "sound level meter" describes a very particular set of characteristics defined by the American National Standards

**Fig. 2.** The curves show weighted response characteristics specified by the American National Standards Inst.



Institute in Standard S1.4-1971. In simple terms, the sound level meter is an a-c voltmeter with a microphone to convert sound energy into an a-c voltage. The addition of a step attenuator, some special filtering networks, and a shaped-characteristic meter sets it apart as a sound level meter.

To simulate the logarithmic response of the human ear, the sound level meter is equipped with a meter movement designed to compress the reading so that the scale spans about 16 dB (a ratio of 40:1) and is approximately linear throughout its scale. The attenuator is adjustable in about ten steps of 10 dB each so that, with the range of the meter, a total measuring range of about 30 to 150 dB is attained. As a logarithmic voltmeter, the SLM has a range of about 5  $\mu$ V to 5 V rms. Many models can be adapted for use as audio rms voltmeters by the substitution of a connector for the microphone.

The ear's frequency response, depressing to an audiophile, is also a problem to the SLM designer. The ANSI standards for the SLM specify A, B, and C weighting curves (Fig. 2). These were originally designed to approximate human hearing frequency response at levels below 55 dB (A weighting), from 55 to 85 dB (B weighting), and above 85 dB (C weighting). Now, however, the A-weighted sound level is the most widely used regardless of the intensity of the sound to be measured. In fact, the industrial noise provisions of the Occupational Safety and Health Act of 1970 specify A-weighted, dB(A), measurements.

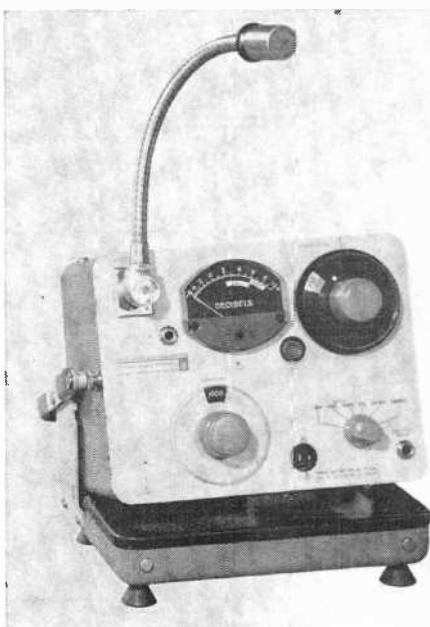
**SLM Circuits.** To achieve the required weighted responses in one sound level meter (Fig. 3), weighting networks are inserted into each coupling and feedback path. The feedback network in the main amplifier provides the 6 dB/octave rolloff at 8000 Hz required for each weighting curve. The C weighting, the most nearly flat of the weighted responses, has a specified low-frequency rolloff at 32 Hz, which is inserted in the coupling between the preamplifier and main amplifier. This is switched out for the B and A weighting. Low-frequency rolloff for B weighting is accomplished at the input to the preamplifier with a shunt resistance across the microphone capacitance for rolloff at 160 Hz. Response shaping at this point in the circuit helps reduce the likelihood of overloading the amplifier. A weighting, the most sharply modified re-

sponse, is obtained with the addition of a 733-Hz rolloff network in the main amplifier and continued use of the microphone capacitance for an even faster rolloff below 107 Hz.

Attenuation is introduced in two sections for best signal-to-noise performance and overload control. As attenuation is required, it is first added between the preamplifier and main amplifier, reducing preamplifier noise as well as the signal. Beyond 40 dB, attenuation is added at the input to the preamplifier to reduce the signal from high-intensity sound, preventing overloading. Through the distribution of both weighting and attenuation networks, each stage of the amplifier is able to operate on signals of optimum size.

The simple dc-to-dc converter circuit, which permits operation from a single 1.5-volt C cell, is basically a tuned self-biased Class-C oscillator operating at 130,000 Hz. The transformer output is applied to a full-wave voltage doubler rectifier consisting of diode D1, the transistor's base-emitter junction, and capacitors C1 and C2. Half of the dc output voltage biases the transistor in the cutoff region. This class C operation results in about 70 percent conversion efficiency and 50 hours of instrument operation from one C cell.

Octave-band noise analyzer permits a rapid frequency analysis of noise to aid identification and treatment of separate sources of noise components.



## PERMISSIBLE NOISE EXPOSURES

Sound Level dB(A)	Exposure in Hours
Slow Response	
90-92	6
92-95	4
95-97	3
97-100	2
100-102	1.5
102-105	1
105-110	0.5
110-115	0.25
Over 115	None

**Measuring Noise Danger.** Today's growing concern with noise pollution in industry centers on hearing damage and on annoyance that results in increased irritability and lowered productivity. The length of exposure to loud sounds must be considered in the evaluation of potential danger. The current laws state that any exposure to levels above 115 dB (A) is too much, while unlimited exposure is permissible to sound levels of less than 90 dB(A). Intermediate levels are permissible for limited periods of time, as shown in the Permissible Noise Exposure Table.

A sound level meter can be used to monitor noisy areas, but to determine the legality of the noise by these standards requires frequent measurements over a working day,

followed by calculations to combine the contributions of the various levels measured and their durations.

To eliminate the tedium of such measurements and the chance of calculation errors, a noise exposure monitor has been developed to operate unattended for a full working day, measuring and calculating under control of an internal timer. Once turned on, the monitor makes regular A-weighted measurements of the sound level, determines which band the noise falls into, and accumulates counts at a rate in proportion to the severity of the noise.

Monitors designed for in-plant installation display the accumulated counts as a reading of the percent of allowable total exposure. Small monitors designed to be worn when an employee moves from place to place hold this exposure information to be read out at the end of day on a combination indicator/battery checker/calibrator. Panel lamps on each indicate if the instantaneous level has at any time exceeded 115 dB for 0.5 second or longer, and if sounds in excess of 140 dB have been detected no matter how short their duration.

**Other Noise-Measuring Instruments.** For further analysis of sounds in a manner equivalent to human hearing, frequency analyzers are available with constant-percentage-bandwidth filters. Since we hear octaves as equal intervals of tone, it is

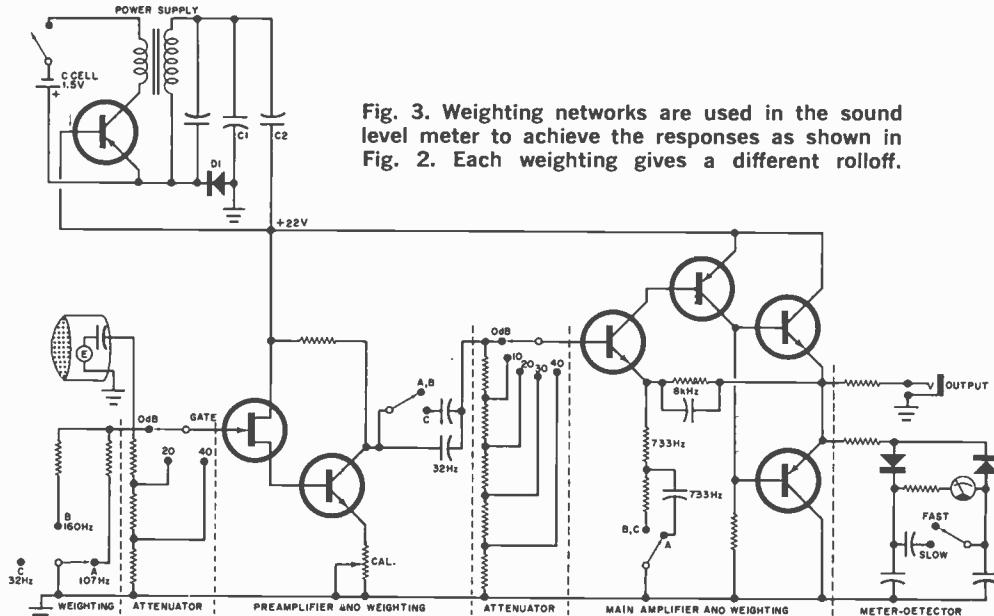
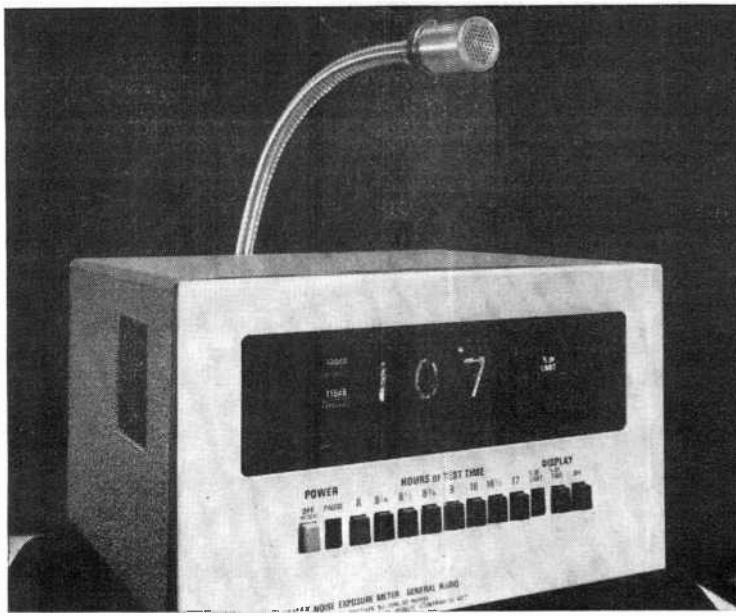


Fig. 3. Weighting networks are used in the sound level meter to achieve the responses as shown in Fig. 2. Each weighting gives a different rolloff.

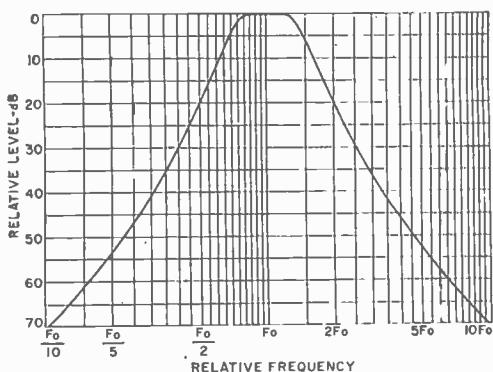


A noise exposure meter combines a sound level meter and an exposure calculator designed to provide unattended operation and a correct readout.

desirable in the analysis of noise frequencies to use filters that are an octave or fraction of an octave wide. These filters can be a single filter that is continuously tunable, a series of filters that can be switched in steps, or many filters in parallel. But the bandwidth is usually a fixed percentage of the center frequency, about 70 percent wide for octave-band filters (Fig. 4) and about 26 percent for  $\frac{1}{3}$ -octave bands.

Impulse noises, like those produced by explosions or punch presses, can have serious effects on hearing and, so, need to be measured. Meter movements are typically too sluggish to respond to brief noise impulses and the eye too slow to note accurately even the peak value. Storage oscilloscopes greatly aid in the analysis of

**Fig. 4.** In an octave-band filter, the 3-dB points are just an octave apart.



short-duration noises, but they do not provide simple numerical readings and are difficult to use in the field.

An impact noise analyzer has been developed to capture the fleeting characteristics of impulse noise with storage circuits. The "quasi-peak" integrator circuit with a 0.25-ms rise time responds very quickly to the rising level of an impulse. A built-in sluggish decay time (about 600 ms) permits the operator to "eyeball" an approximate peak value more easily. While this is happening, a "peak" storage circuit with a 50- $\mu$ s rise time holds a voltage, related to the peak sound level, to be read at the operator's leisure. Another storage circuit is charged from an averaging detector with a selectable time constant. A "time average" reading taken from this storage circuit will be proportional to the duration of the impulse. From these three quantities—quasi-peak, peak, and time-averaging—the impulse can be well defined and compared with the characteristics of other known noises.

The electronics industry has provided the field of acoustics with an arsenal of sophisticated measuring tools that do an excellent job of simulating the peculiar behavior of human hearing. But much still remains to be done. In medicine, transportation control, communications, and computers, the greatest challenge will be to ensure that human needs and peculiarities determine the performance of electronic systems—not the reverse. ◇

# AUTOMATIC AMPLIFIER SWITCH

CONVENIENT ACCESSORY FOR YOUR AUDIO SYSTEM

BY TOMMY N. TYLER

If you have put together a hi-fi system using separate components, the chances are that you may already have been bugged by the nuisance of having to switch on the main amplifier each time you want to operate the turntable, the tape recorder, or the FM tuner (or whatever you have). Also, if you are as absent-minded as most of us, you have probably forgotten more than once to switch off the amplifier after the last record—finding the amplifier still on a day or two later.

Here is a simple device you can add to your hi-fi system to control the power to the main amplifier automatically whenever one of the "front end" components (such as the turntable) is switched on or off. The automatic amplifier switch, whose schematic is shown in the diagram, can be built in one evening from a handful of components. The cost should be only about \$7.

**Circuit Operation.** Diodes D1 through D4 are connected in series with sockets S01 through S04 to the ac line. A load connected to either of these sockets will cause a voltage drop across D1 and D2 or D3 and D4, depending on the instantaneous polarity of the power line. This voltage is applied through R1 to the gate of triac Q1, causing full line voltage to be applied to controlled socket S05 where the main amplifier is connected.

The circuit operates reliably for any load of 5 watts or more connected to any one of sockets S01 through S04. With a smaller load, the limited triggering current available to Q1 will retard its firing angle so that full power is not delivered to S05.

Note that any suppression capacitors larger than about 0.01 microfarad installed across the power switches of equipment plugged into the controlling sockets may have to be removed if they supply enough reactive current to trigger Q1. Such capacitors are sometimes found in turntables to suppress the noise generated when the motor is switched off; but they are not indispensable.

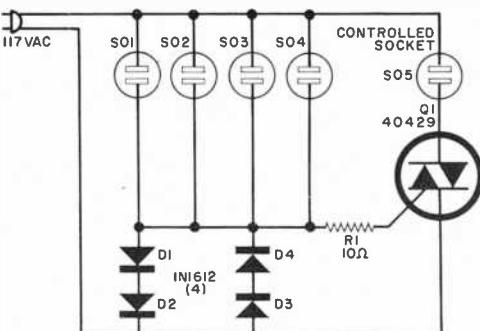
The effect of reactive current can also

be minimized by using a triac that requires relatively high gate current for triggering. To find out easily whether or not you will have a problem with reactive current, plug the turntable or other device into S01 and attach a 40-to-100-watt lamp to S05. If the lamp glows when the turntable is switched off, check for suppressors across the power switch.

Putting fuses in the circuit is optional. An overload or short circuit applied to S01 through S04 could ruin one or more of the diodes; but neither Q1 nor the load connected to S05 would be harmed. Conversely, an overload at S05 would damage Q1; but none of the diodes nor the units connected to the input sockets would be affected.

**Component Selection.** Diodes D1 through D4 are power rectifiers with sufficient current ratings to carry the maximum current of all the controlling devices connected to S01 through S04 simultaneously, in case

Simple circuit has 4 diodes and triac.



## PARTS LIST

D1-D4—50-PIV, 5-ampere silicon diode (IN1612 or similar)

Q1—200-volt, 6-ampere triac (RCA40429, SK3506)

R1—10-ohm, ½-watt resistor

Misc.—Chassis-mounted ac receptacle (5), mounting bracket, mounting hardware, suitable chassis, line cord, grommets, etc.

they are all turned on at one time. Since the diodes are connected in series and back-to-back, they never receive more than a couple of volts in the reverse direction. Therefore, silicon diodes (or silicon power transistors connected as rectifiers) with the lowest PIV rating can be used. Be sure the rectifiers are silicon or the forward voltage drop won't be enough to trigger  $Q_1$ . Triac  $Q_1$  must have a current rating only high enough to handle the main amplifier load connected to the controlled socket.

**Construction.** Since the amount of wiring and components required is small, a wide variety of construction methods is possible. If only one controlling socket is needed, the unit can be built inside a standard wall outlet box. Another technique would be to use a multiple power outlet box.

The prototype was constructed in a 4" ×

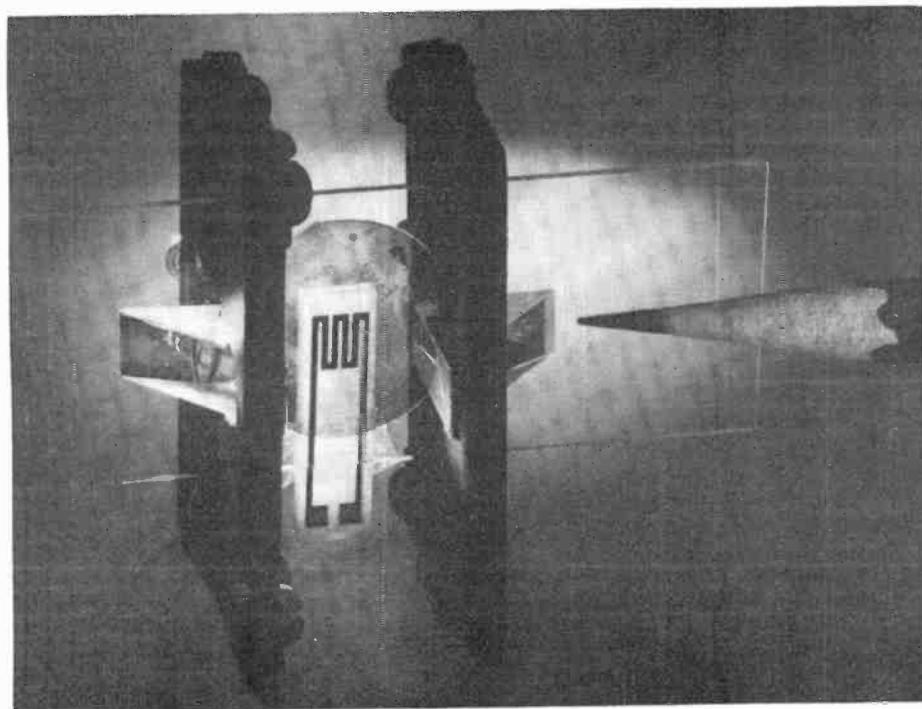
2½" × 1½" box, which is about the minimum size for handling four controlling input sockets. Use insulated mounting hardware for the diodes and triac and check carefully for leakage to the chassis to make sure there is no shock hazard. Use an ohmmeter to check for leakage. Make sure bare leads or terminals can't come in contact with the chassis.

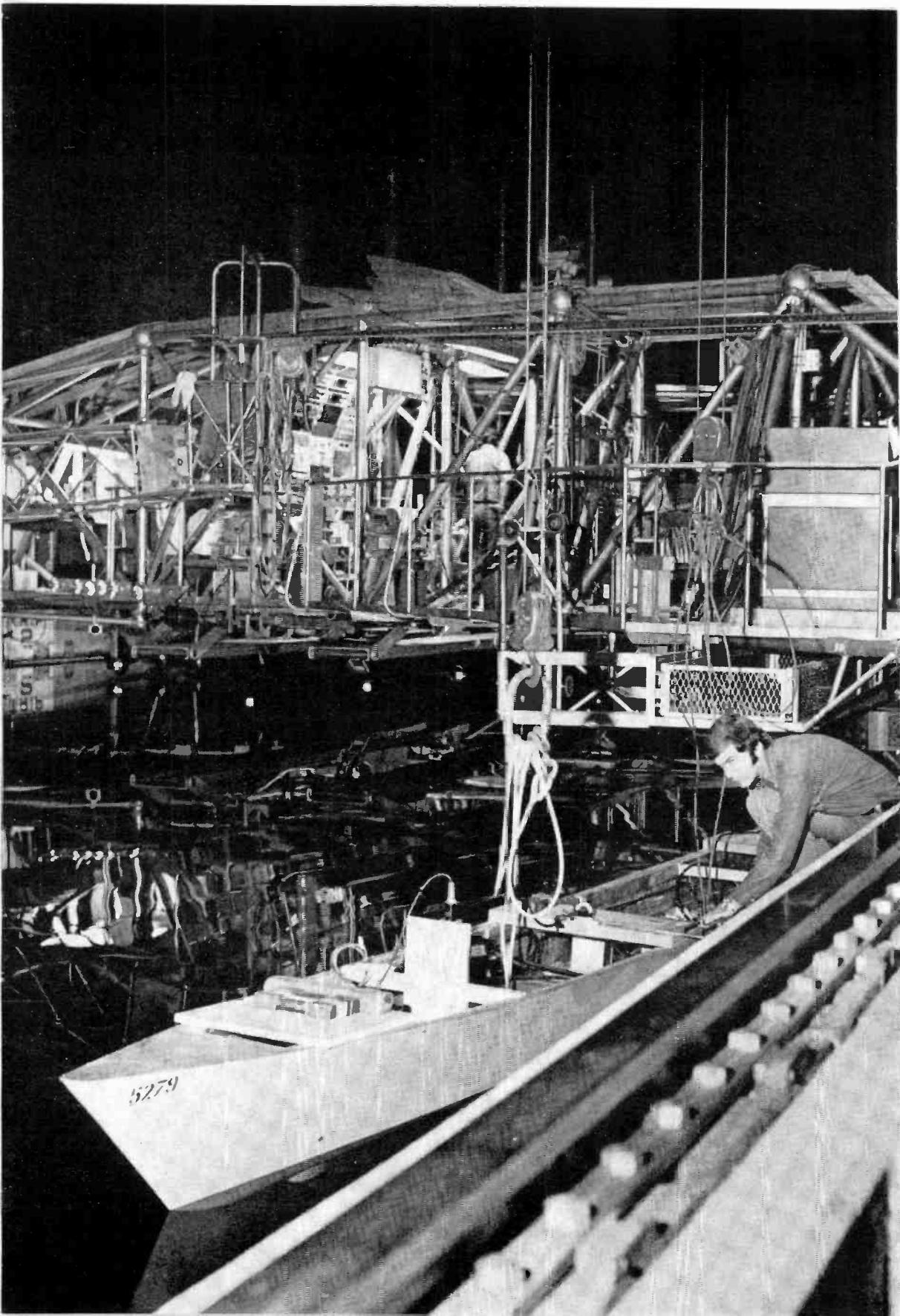
Test the circuit by connecting a 100-watt lamp to  $S05$ . With a small load applied to one of the controlling sockets ( $S01$  through  $S04$ ), the lamp should turn on to full brightness. If the lamp is dim, it might indicate a defective triac, which is firing only on alternate half cycles; in which case you will need an oscilloscope for further troubleshooting. With a little imagination, you can probably think of several more applications for this automatic switch in the ham shack or around the house. ◆

### THIN FILM LASER SWITCH

A new light switch for use with lasers has been devised by Bell Labs. It may be useful in future tiny optical circuits for putting phone calls and other information on a laser beam. Main components of the switch are a

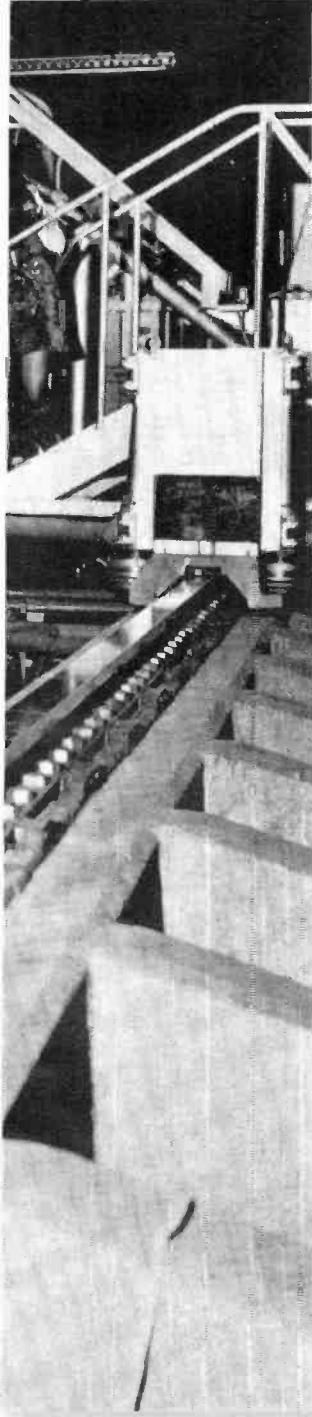
magnetic thin film of single crystal garnet in which the light is guided and a serpentine-like electric circuit which is used to impose the required information on the light beam by changing the beam's path.





5279

# If you're looking for a career instead of a job in electronics...



**I**t costs millions of dollars to build modern ocean going vessels. The final design of such ships is based on extensive testing with sophisticated electronic measuring equipment using exact models as shown in the photo of the Naval Research and Development Center. The engineering technicians who check out, maintain and repair such equipment have to be experts. Their work is not only interesting and exciting, they also enjoy top pay in their field.

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**WASHINGTON, D.C.**

*Inexpensive  
readout devices  
that get brighter  
with more ambient light*

# LIQUID CRYSTALS

**I**MAGINE a 7-segment readout device that requires only 280  $\mu\text{W}$  of power to operate and becomes more visible as the ambient light increases. Also imagine a cathode ray tube which appears normal in every respect, even to the image on the screen, except that the image has been stored there for more than a year with no electrical connection of any type and can be erased in milliseconds. Let your imagination run wild and conjure up fantasies of a panel light that costs only a penny, a flat-screen TV receiver, or a microwave fluoroscope. These devices either already exist or are anticipated to arrive on the scene in the near future. They are all possible as a result of liquid crystals.

As their name implies, liquid crystal substances exhibit properties of both a solid and a liquid. Depending on their viscosities, liquid crystals can be poured like water, easily assuming the shape of their containers. However, due to selective reflection, white light striking a film of these crystals causes a different wavelength to be reflected at different angles of incidence, resulting in the iridescent colors typical of liquid crystals. Furthermore, since the crystalline structure which produces selective reflection is inherently weak, any force that causes this structure to shift or realign itself causes a different structure to be produced.

This force can be thermal, acoustic, electrical, magnetic, or even mechanical.

Here, we will consider only thermotropic liquid crystals. These are compounds that exhibit a liquid/crystal phase, or "mesophase," at a temperature usually greater than the ambient. Thermotropic crystals can further be divided into three categories, two of which are of interest to us—cholesteric and nematic.

**Cholesteric Liquid Crystals.** Cholesteric liquid crystals, all derivatives of cholesterol, are the best known thermotropic compound. Currently, they are the most widely applied. The major property of these compounds is their ability to change color under the influence of different stimuli, notably temperature.

When a layer of cholesteric crystals has been properly applied to a surface and illuminated by an incandescent light, the crystals change from colorless to red, yellow, green, then blue, and, finally, violet, as the temperature of the surface to which the crystals are applied passes through the mesophase range. Raising the temperature even more turns the crystals colorless. The process is reversible, with the same spectrum of colors appearing in reverse order as the crystals are cooled through the mesophase range.

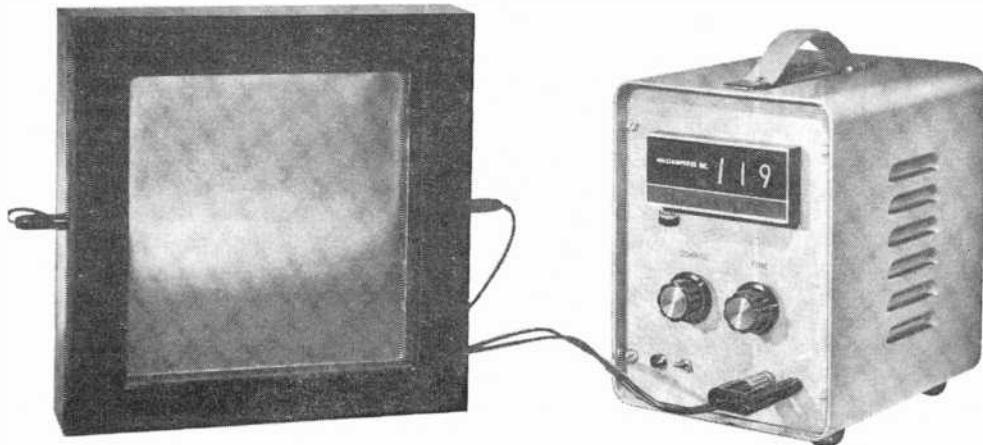
# FOR ELECTRONICS

Since the colors scattered by cholesteric liquid crystals under incandescent light are unique to a given temperature, measurement of temperature is possible to an accuracy of better than 0.1° C.

Liquid crystals either mixed with a solvent or contained within 20-micron spheres (encapsulated liquid crystals), which are suspended in a water slurry, are available if you wish to apply them to surfaces like transistor heatsinks. To work with the solvent-suspended or encapsulated liquid

crystals, a black background is a must. Some of the encapsulated types are sold in a blackened solution which leaves a black surface when dry. To use unblackened crystals, the surface to which they are to be applied must first be coated with a *water-base* black paint such as No. VL-447A available from Vari-Light (9770 Conklin Rd., Cincinnati, OH 45452) at \$1.00 for 50 cc. Edmund Scientific (300 Edscorp Bldg., Barrington, NJ 08007) stocks both the blackened and plain liquid crystals.

Fig. 1. Liquid crystal microwave power density meter made by Bendix.



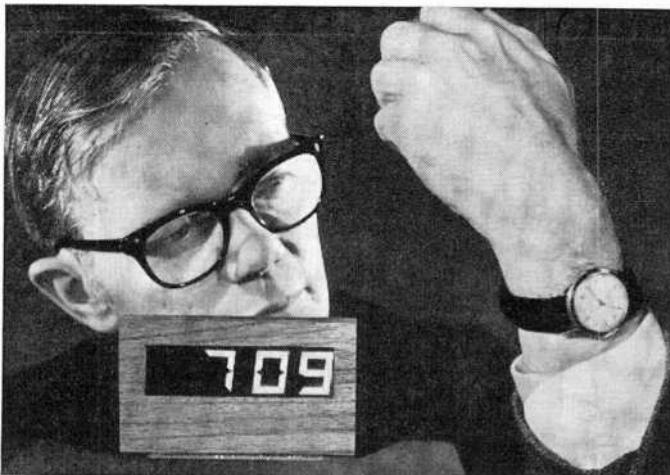


Fig. 2. Prototype liquid crystal digital readout for watches and calculators. (Photo: RCA Labs.)

The liquid crystal solution, a clear or slightly cloudy yellow solution, is designed to be air-brushed or aerosol-sprayed onto the painted surface, using a steady back-and-forth motion. An even coating about 1-mil thick will provide optimum results. Too thick a coating must be avoided. An excellent kit is offered by Liquid Crystal Industries (460 Brown Ave., Turtle Creek, PA 15145); it contains 12 bottles of pre-blackened liquid crystal solutions, a special aerosol applicator, and a Mylar hoop for indirect testing. Available in low and high temperature versions, the kits are each priced at \$75.00.

No color is visible until the spray coating dries and the surface being tested is at a temperature within the range of the liquid crystal being used. Dim colors mean the liquid crystal coating is too thin. If this is the case, put down another coat.

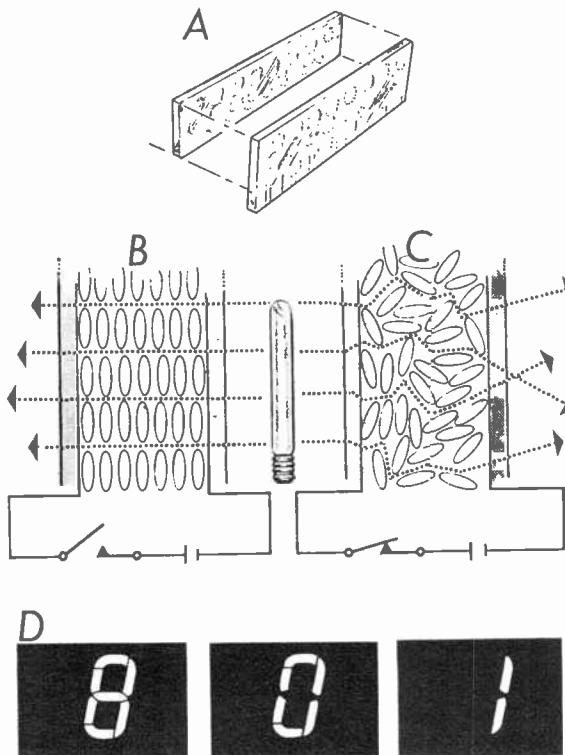
Instead of applying the liquid crystals directly to a surface, it is much easier to work with them in encapsulated sheet form so that they do not become contaminated and can be used over and over again. Memory liquid crystal sheets have been developed; they turn black wherever the surface has exceeded the critical temperature. When the temperature decreases, the black area remains black, but simple brushing of the blackened area restores the original color. Experimental kits of all types of sheet material are available from Edmund Scientific in a small kit, Part No. 60,756, for \$4.00 postpaid, or in a large kit, Part No. 71,143, for \$10.00 postpaid.

The property of cholesteric liquid crystals to exhibit different colors with changes

in temperature has many direct applications in electronics. For example, the alignment of infrared laser beams is a difficult task by traditional methods. In comparison, either a sheet of liquid crystal materials or a sheet of metal with a layer of liquid crystal on its rear surface will yield a good image of the beam size and operating mode of the laser.

The visualization of intensities in a microwave beam has also been easily accomplished by the use of cholesteric liquid crystals. A layer of liquid crystals is applied to a thin sheet of Mylar placed in a microwave beam so that energy transferred to the film heats up various segments in proportion to the amount of energy absorbed. Since the crystals indicate specific temperatures, distinct color lines form a two-dimensional plot of the microwave field intensity. An example of a device that uses this principle is shown in Fig. 1. In this instrument, built by Bendix Laboratories, the temperature range represented by the transition from red to blue is equivalent to a power spread of 7 dB.

**Nematic Liquid Crystals.** Nematic liquid crystals are currently causing a big stir in the electronics industry. Nematics are generally somewhat cloudy when viewed in bulk and tend to be a pale yellow in coloring. In small quantities or thin films, the haziness disappears. When placed under a microscope, the clear solution appears to have long wavy threads. If the liquid is probed or otherwise disturbed, the threads greatly multiply, slowly diminishing in number to the original quantity if no further



Microelectronic calculators such as those above with liquid crystal displays, are being manufactured in volume by such companies as North American Rockwell. In the display shown at (A), each digit has seven segments, each with an electrical lead, formed on glass plates with transparent tin oxide. Two glass plates are bonded together with about 1/1000 of an inch between them. This space

is filled with liquid crystal material. Magnified drawing at (B) shows how material's molecules are normally uniform; but when subjected to electrical field (C), molecules are upset so that they scatter light rays and the area appears to glow. Different numbers are formed (D) by subjecting selected segments to electrical field, which causes those segments to glow brightly.

disturbance takes place. These threads represent minute changes in the index of refraction between adjacent areas of the liquid. Under turbulent conditions, these area boundaries become many in number and tend to scatter light as the liquid turns an almost opaque white.

To harness this turbulence, a cell can be fabricated to contain a solution of nematic crystals between two electrodes. When a potential is applied to the electrodes, a flow

of ions is created which causes turbulence and turns the normally clear liquid crystal solution to a whitish color. This process is known as "dynamic scattering." The degree of whiteness and, correspondingly, the degree of reflected light, can easily be controlled by the voltage applied to the electrodes. Due to electrolysis depleting the liquid of ions, continued operation of the cell on dc will cause eventual failure of the nematic material. However, if an ac

driving voltage is used, ion depletion will be greatly reduced.

Like cholesteric crystals, nematic crystals have a mesophase that must be observed for proper operation. Until recently, nematic action was observed only in a narrow temperature band around 230° F. Continued research, however, particularly by RCA, is yielding nematic solutions usable over wider temperature ranges, including room temperatures.

One of the most obvious uses for a material that reacts as nematics do is the currently popular 7-segment readout. An RCA prototype of a 7-segment readout is shown in Fig. 2. Since there is so little force required to create turbulence in a nematic, minimal power provides a good indication.

Optel (P.O. Box 2215, Princeton, NJ 08540) was first to market a 7-segment liquid crystal readout device. Their No. 1003 display unit operates at 15-16 volts (ac for greater than 10,000 hours). The numerals form in 15-20 ms and decay in 100-200 ms. More important, only 40  $\mu$ W of power is required per segment. Although the rise times are noticeable, they are acceptable in digital electronic clock, voltmeter, and airport arrival/departure sign applications.

RCA has introduced a four-number 7-segment display and plans a matching COS/MOS IC for decoding and driving. Also projected are liquid crystal readout products from Display Tek of Dallas and from Texas Instruments.

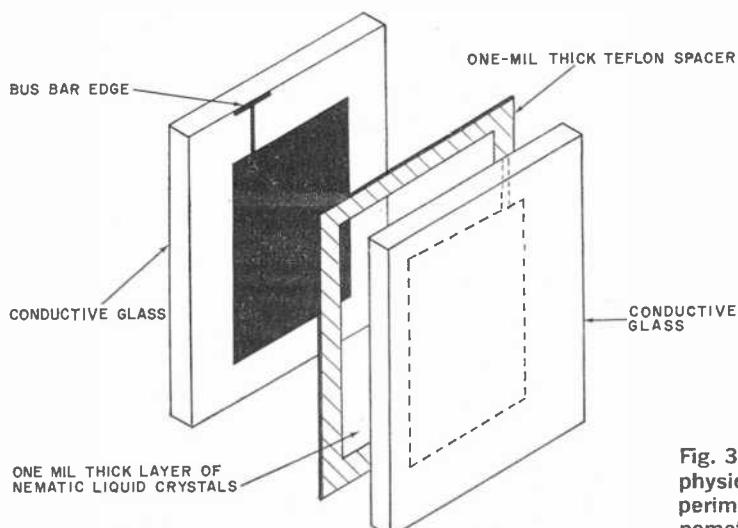
The Optel readout employs the reflective

mode for imaging, making indication in a dark room impossible without a light source but affording excellent image clarity in areas of high-intensity ambient lighting. Displays employing the transmissive mode have been built in prototype by several companies, but these require a power-consuming lamp behind the panel.

The uses for nematic crystals are not limited to readouts. Since the transmission of light can be controlled at will, it is possible to make automatically darkening windows, light shutters for optical systems, and many other similar devices.

If the front and rear electrodes of a nematic cell are formed into a grid-like configuration in which the front sheet of glass has vertically oriented electrodes and the rear sheet has horizontal electrodes, only the nematic material at the crossover point of the electrodes, when energized, reacts by turning opaque. With addressing electronics, such a device is easily capable of displaying diagrams and images.

**Making a Nematic Cell.** For experimenters who wish to obtain first-hand knowledge of the nematic cell, materials are available for making their own. These consist of a pair of glass sheets, each coated on one side with a conductive material, a spacer, and the nematic liquid crystal material. These items will permit fabrication of a transmissive cell. If a reflective cell is desired, one of the sheets of glass is omitted and replaced by a sheet of darkened metal (such as black-anodized aluminum).



**Fig. 3.** The diagram shows the physical arrangement of an experimental transmission-type nematic liquid crystal cell.

Transparent conductive glass sheets can be obtained from several suppliers. Vari-Light, for example, has  $2\frac{1}{8}'' \times 2'' \times \frac{1}{8}''$  sheets for \$2.40 (No. CG-80 tin-oxide coated) and \$1.50 (No. CG-75 gold coated) each. Larger sizes are available on special order. Although the gold coating has lower unit area resistance, the tin-oxide coating is slightly better since it transmits more light. When working with any type of conductive glass, the side with the conductive film should never be handled or otherwise contaminated. It should never be cleaned; to do so may damage the coating.

Once you have the conductive glass, a spacer of the same length and width must be prepared from some nonreactive material such as 1-5-mil sheet Teflon. Cut a hole of the desired size out of the center of the spacer material. Next, place a sheet of the glass, conductive side up, on a level, flat surface and place over it the spacer. Now, using a thoroughly cleaned medicine dropper, deposit some of the nematic solution on the sheet of glass within the confines of the cutout in the spacer. Make sure that the total amount of nematic solution deposited is no greater than the amount needed just to fill the hole and allow some room for expansion. Cover the assembly with the remaining sheet of glass. To finish assembling the cell, use a frame made from Plexiglas to hold it together. (Note: If you plan to cement together the cell parts, do not use an epoxy compound; it may react with the nematic liquid in the cell and ruin your efforts.) The procedure for assembling the cell is shown in the drawing in Fig. 3.

To make a 7-segment readout assembly, it is necessary to remove only part of the conductive coating on one of the glass sheets, leaving "islands" of conductor to make up the segments and narrow bands to bring out to the bus bar along the edge of the glass sheet. The Vari-Light conductive sheets have bus bars which can be cut into seven separate segments, each going to a separate segment of the display's conductive coating. To form the segments, a Dremel "Moto-Tool" with an abrasive rubber cone and a metal erasing shield can be used.

The nematic solution for your cell can be obtained from Vari-Light as Part No. VL-1047-N. It consists of a 5-gram bottle of liquid and sells for \$12.80. The operating temperature range of the solution is  $10^{\circ}$ - $47^{\circ}\text{C}$ , which includes normal room temperature.



**Fig. 4. Nematic storage-mode Reflicon tube and demonstrator. (Photo: Optel)**

Power requirements for your homemade nematic cell are minimal but will vary from cell to cell due to the assembly techniques used by different experimenters. If the nematic is from Liquid Crystal Industries (\$15/gram, 5-gram minimum order), there will be typically about an 8-volt threshold, with 22 volts optimum. Resistivity is about  $10^{10}$  ohms/sq cm, and the cell will yield a contrast ratio of at least 20:1. Although the cell will certainly operate on dc, the noticeable rise and decay times can be shortened by use of a 1000-Hz ac driving voltage. This experimental cell can be used as a light shutter, but the rise and decay times are still too lengthy to use it for modulating a laser beam with audio information.

**Storage-Mode Solutions.** By mixing a nematic crystal solution with a cholesteric solution (such as cholesteryl chloride), in a weight ratio of 9:1, a "storage-mode" liquid crystal solution is obtained. The solution is normally clear, but with 30 volts dc applied to it, it turns a milky white. Removing the voltage, the mixture regains its normal transparency only after several weeks. If desired, however, the material can be made transparent at any time simply by applying a 50-volt, 4000-Hz signal to the electrodes. With no power required to retain the image, the applications are virtually limitless.

One application has already appeared in the Model D-10 Reflicon® tube produced by Optel and shown with its demonstrator/driver package in Fig. 4. As can clearly be seen, the image shown on the screen of the disconnected tube is stored without attached wiring. The particular tube shown held its image for more than a year with little degradation. ◆

**H**OW would you like a CB accessory that can triple your transmitter power (legally), increase your range by several miles, and reduce interference dramatically?

Sound impossible? Well, in fact, we're talking about a CB antenna. Because antennas can do all of these things, their selection is every bit as important as the rig you buy. A poor antenna can make even your "Super-Gizmo XIII" work like the neighbor kid's walkie-talkie. And, conversely, a good antenna can make a reasonably priced CB set work amazingly well.

"Fine," you say, "but choosing that antenna isn't so easy. Why, there are hundreds of antenna shapes and sizes . . . not to mention claims like '5 dB gain' and so on."

True enough. But choosing your antenna can be fun, if you know just a few of the basics. Let's start with the base-station antenna for your home.

**Selecting a Base-Station Antenna.** Choosing your home station antenna will depend on what you want to do with your radio system, your individual preferences, and your pocket book.

The first choice a CB'er must make is between an "omnidirectional" and a "directional" (or "beam") antenna.

The omnidirectional antenna is the most convenient to use for the majority of CB operators. It's designed to receive and transmit equally well in any direction. So, whether you're talking to a station that's north or east makes no difference; and there are no adjustments to make. What does the typical omnidirectional base-station antenna look like? See Fig. 1.

The other general category of base-station antennas is the "beam" and, as its name implies, it can beam a signal in a particular direction. This has several advantages, as we'll see, but it also means that you have to direct the antenna toward the other station (by means of a remote-control antenna rotator motor, or electrically with the "electronic beam" antenna).

A few typical beam antennas are shown in Fig. 2. A beam is capable of more "gain" than an omnidirectional antenna, principally because it's squirming all your power in one direction. This also helps on receive, not only by making the other fellow's signal louder, but by cutting interference from stations in other directions.

Which kind of base-station antenna should you choose? Well, if you're interested in

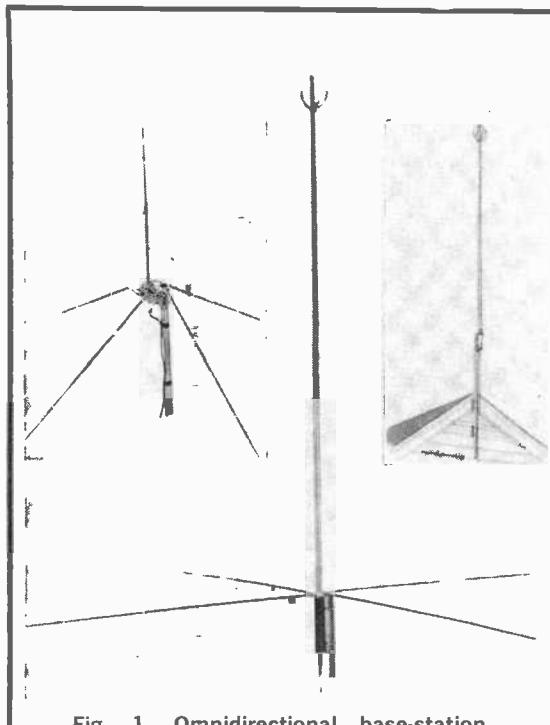


Fig. 1. Omnidirectional base-station antennas: (left to right) a ground plane; half-wave end-fed; colinear.

having the maximum range in a single direction at a time, then a beam is for you. For many of us, however, an omnidirectional antenna gives adequate range at a more economical price. And, for people like service-station operators who monitor channel 9 for emergency calls, an antenna that receives from all directions is a "must." If you'd like the advantages of both a beam and an omnidirectional antenna, you'll be glad to know that the electronic beam can provide them—at the flip of a switch.

Whichever type you choose, be sure that it will withstand the weather. Most quality antennas are made with a good grade of seamless aluminum tubing and hardware that resists rusting, such as stainless steel. Another material now being used is fiberglass—which, despite its somewhat higher price, can be a good investment, especially in high-corrosion coastal areas.

**Antenna Gain—What it Means.** Before long, every CB operator is confronted with antenna gain figures, like "4 dB," etc. Part of the confusion, of course, results from the fact that gain is measured in decibels (ab-

# WHICH ANTENNA FOR CB?

*How to select  
your most  
important accessory*

BY JACK CRAVEN  
The Antenna Specialists Co.

**Selecting a Mobile Antenna.** Probably the most important factor to be considered in selecting your mobile antenna is the way in which it is to be mounted. After all, you've got to figure out how to get it installed on your car.

By far the most popular type of mounting bracket today is a "no holes" mount which attaches securely to the trunk lid (Fig. 3). A more conventional mount, which requires drilling a small hole, is frequently used for antennas in the center of a car's roof (Fig. 4). For temporary installations, you'll find there are gutter-clip and magnet-mount types available (Fig. 5).

Originally, most mobile CB antennas were quite long (about 8½ feet), and you'll still see them in use. However, most CB'ers use a compact system that is more likely to get "wife approval." These antennas use a device called a loading coil, which maintains the electrical length of the antenna while shortening its physical length, usually to less than 4 feet.

How good are these shortened antennas? Usually they work as well or better than their full-size counterparts because they can be placed in better positions (such as the center of the trunk lid or center of the vehicle's roof) and they don't bend and gyrate as severely when the car is in motion.

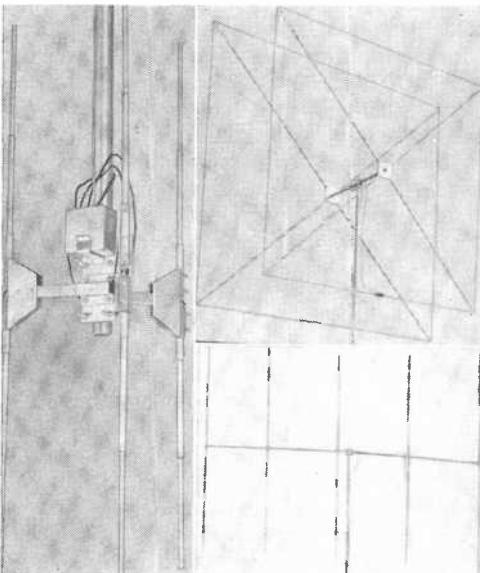
breviated dB). Here is what it really means:

Gain (dB) Over Flat Ground-plane Reference Antenna	Effective Radiated Power Multiplied By
0	1.0 (no change)
1.0	1.26
2.0	1.59
3.0	2.0
4.0	2.51
6.0	3.98

As you can see, a 3-dB gain antenna, for instance, can double your effective radiated power.

There's one other important thing to remember about gain figures: they are only meaningful when compared to a reference. Most antenna manufacturers use the industry's standard reference antenna, a flat ground plane. But a few manufacturers use an "isotropic" reference which inflates the gain figures by over 2 dB. This might sound good in their advertising, but it doesn't make the antenna work any better. In other words, when comparing antennas, always ask "gain over what?"

Fig. 2. Typical beam antennas: electronic type which is beam and omnidirectional (left); a quad (top right); and the familiar yagi (bottom right).



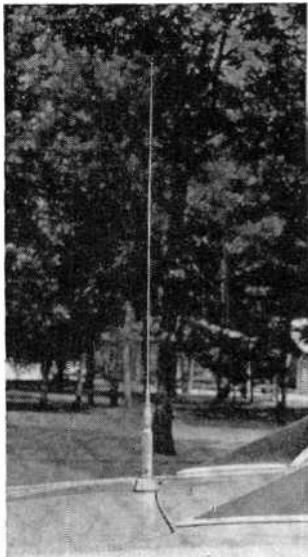


Fig. 3. No-hole mount is attached to the trunk lid.

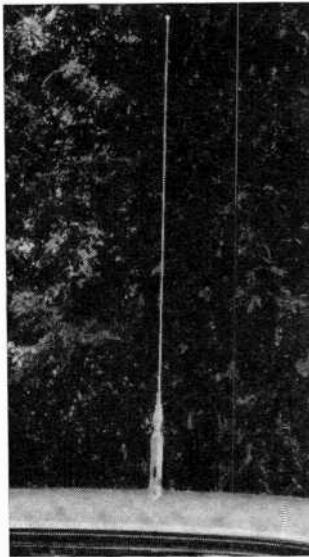


Fig. 4. Another arrangement is the roof-top mounting.



Fig. 5. Gutter and magnet types are temporary mounts.

**Installation Tips.** We've already mentioned how antenna manufacturers have made it easy for you to mount your mobile antenna without even drilling a hole. You'll find that most base antennas for your home are no more difficult to put up than installing a TV antenna. But there are a few things about installing CB antennas you should keep in mind.

First, be sure you have the correct type of cable. Most mobile antennas come with cable (type RG-58/U), so there's no problem there. You can purchase the same type of cable for your base-station antenna, but normally you'll want to purchase the heavier type RG-8/U. This is because in a long cable run, like 100 feet, the smaller cable will cause the loss of as much as 50% of your transmit power (as well as reducing reception). The heavier cable, on the other hand, would cause a loss of only about 25%, making it a wise investment.

But, above all, be sure that you've selected a cable with the correct impedance. Both RG-58/U and RG-8/U have an impedance of about 50 ohms to match CB antennas. Their counterparts, which look almost identical but carry the numbers RG-59/U and RG-11/U, are 70-ohm types which will cause a mismatch when used with most CB antennas.

Incidentally, some of us have trouble with soldering and/or shorting of the cable's small shield wires when installing the

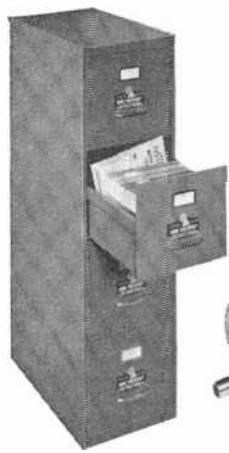
cable connectors—which can have disastrous effects. Fortunately, there's a good solution: pre-cut cables are now available in various lengths with connectors already installed.

Here's another tip that many CB'ers overlook, but which can make a world of difference in their system's range and performance: Buy or borrow an SWR meter. This little meter will tell you quickly whether or not you have antenna-line mismatches which could greatly reduce performance. If you have a mismatch, follow the antenna manufacturer's instructions (usually a simple element-length adjustment) until the meter shows an SWR of 1.5 or less on all channels. You will be surprised what a difference that can make.

With your mobile antenna, the ideal installation will be in the center of the roof. But, you'll find that most CB'ers use the type of antenna which clips on to the lip of the trunk lid, with very good results. It should, however, be centered—mounting on the left or right side of the trunk lid will tend to distort the antenna's radiation pattern.

For your base-station antenna, here are two rules of thumb: 1. Keep it as far from surrounding obstructions as possible. 2. Put it as high as possible. But watch that second suggestion. Current FCC rules limit antenna height to 20 feet above an existing structure (which may be why many a CB'er wishes his house were built on stilts).

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# flash tubes

**UNDERSTANDING  
AND GETTING THE  
MOST FROM STROBES**

**OPERATION & APPLICATIONS**

IT IS a simple device, the flash tube; but it is often regarded with awe—perhaps because many people don't understand just how and why it operates. A flash tube is nothing but a sealed glass or quartz tube, filled with an inert gas (such as xenon) and

tube and connected to a high-voltage pulse source. When a trigger pulse occurs, some of the xenon in the tube is ionized, allowing some electrons to flow through the gas. When this occurs, the remainder of the gas in the tube is ionized and the capacitor discharges quickly through the tube. The result is a flash of bright light.

The flash tube remains in the conducting state until the storage capacitor is fully discharged. Series resistor  $R_1$  prevents the power supply from providing enough current to keep the gas ionized after the flash. This avoids what is called "holdover", which can destroy the tube when it occurs.

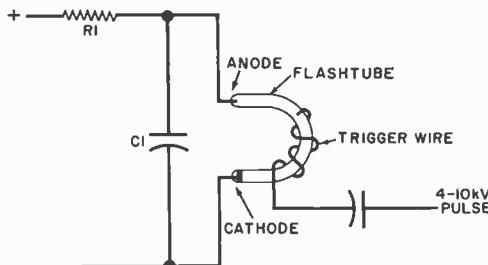


Fig. 1. In basic flash-tube circuit,  $C_1$  discharges through tube, after a trigger pulse partially ionizes gas.

having an electrode at both ends. The tube is unique in that it can provide a white light of high intensity for a very short time, which makes it ideal for use in vehicle and obstruction warning lights, high-speed photographic accessories, ignition timers and stroboscopes. It is also useful because it comes in a range of sizes: from a 1-inch tube for portable electronic flash attachments to 15-inch water-cooled units for pumping high-energy lasers.

So, how about the circuit that provides the driving voltage for a flash tube? It is also simple; a typical one is shown in Fig. 1. A high-voltage dc source (300 to 3000 volts) puts a charge on capacitor  $C_1$  through series resistor  $R_1$ . A thin wire (called the trigger) is wrapped around the

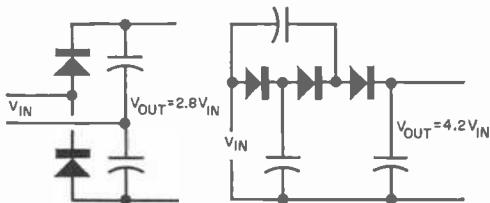
**Determining Flash Duration.** When the flash tube is in the conducting state, it has a very low resistance (about 6 ohms for a tube of short length) and this value is used to determine the flash duration. An approximate equation is  $T = RC/2$ , where  $T$  is the flash duration in seconds,  $C$  is the value of the storage capacitance in farads, and  $R$  is the equivalent resistance of the tube in ohms. The equivalent resistance of the tube depends largely on the distance between the cathode and anode electrodes, so the longer the tube, the higher the resistance.

For conventional photographic work, a flash duration of approximately 1 millisecond is required. For this application, then, a high capacitance and high flash-tube resistance are required.

When the xenon is ionized, an electron of a xenon atom is raised from its "ground" (lowest) state to some excited state. The atoms can only remain in the excited state for approximately 9 nanoseconds. When the atoms return to the ground state they radiate energy in the form of light or photons. According to Planck's Law ( $E = hv$ ), the

frequency of the photons is directly proportional to the energy state of the atoms. Since the excited atoms are in discrete, or "quantized" energy states, the resultant photons are of discrete frequencies.

Flash tubes are usually manufactured in three styles: linear, U-shaped, and helical. Parameters are generally specified according to: minimum-to-maximum voltage across the tube, minimum trigger voltage required to start gas ionization, maximum energy per flash, maximum average power dissipation per tube, and usable lifetime of tube. These parameters are determined by the tube's physical construction: arc length, tube diameter, type of electrodes, and gas pressure.

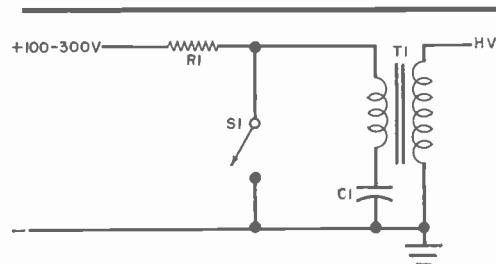


**Fig. 2.** To attain necessary high voltage, doubler and tripler circuits are used in the tube power supplies.

The amount of light energy released can be determined by knowing the potential energy stored in the capacitor. This can be found from the equation  $E = \frac{1}{2}CV^2$ , where  $E$  is the energy in joules or watt-seconds,  $C$  is the value of the capacitor in farads, and  $V$  is the voltage across the capacitor.

The total power dissipation of the flash tube is equal to the energy per flash times the number of flashes per second. However, the designer must be willing to trade off maximum energy per flash for the maximum number of flashes per second so that he does not exceed the power dissipation of the tube. If maximum ratings are exceeded, the shock waves in the gas could cause the tube to crack or shatter.

**Energy Supplies.** Between 300 and 600 volts dc are required to power the most common types of flash tubes. A voltage doubler (or tripler) such as that shown in Fig. 2 will serve the purpose well. Since the capacitor must discharge quickly, its internal resistance increases the flash duration and generates heat within the capacitor. Special flash-type capacitors are available, but conventional electrolytic capacitors may

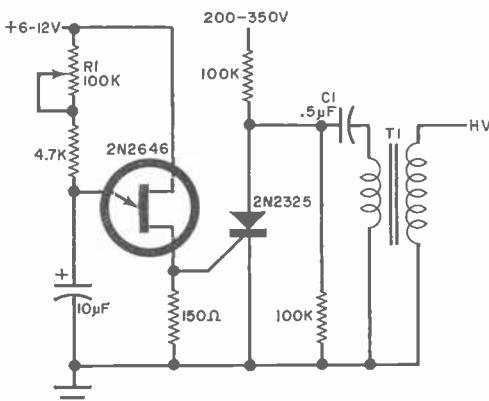


**Fig. 3.** When \$S\_1\$ is closed, \$C\_1\$ discharges through primary of transformer producing the high-voltage spike.

be used. (However, the latter require replacement since the heat eventually vaporizes some of the electrolyte.)

Like most light sources, the lifetime of a flash tube is limited. Each time the tube is flashed, ions bombard the cathode and cause some of the cathode material to be atomized and deposited on the inner surface of the tube. This deposited material forms a black area near the cathode; and, as the cathode element is used up, the black area grows. Eventually, the point is reached where the flash tube either does not fire or fires erratically. Depending on the tube's cathode structure, the operational life is between 5000 and 1,000,000 flashes. Of course, operating a flash tube below its maximum rating greatly increases its useful life.

**Trigger Circuits.** The basic trigger circuit is shown in Fig. 3. When switch \$S\_1\$ is open, the high-voltage dc charges capacitor \$C\_1\$



**Fig. 4.** Here, a UJT is used to control an SCR, which acts to discharge \$C\_1\$ through the primary of transformer.

through series resistor  $R_1$ . When  $S_1$  is closed, the charge stored in  $C_1$  rapidly discharges through the primary of step-up transformer  $T_1$ , generating a pulse on the secondary of 4000 to 6000 volts. An automatic pulser, using a UJT to trigger an SCR is shown in Fig. 4.

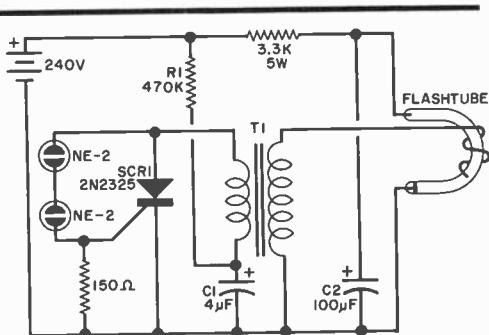


Fig. 5. In battery-operated flasher, two neon lamps flash over to turn on SCR.  $C_1$  and  $R_1$  set the firing rate.

The design of a portable strobe can be greatly simplified if a high-voltage battery is used instead of the line-operated supply. A #491 battery, rated at 240 volts, is used in the circuit shown in Fig. 5. This battery will last for several hours of flashing.

The triggering rate is determined by the time constant of  $R_1 C_1$ . As the charge on  $C_1$  approaches 240 volts, the combined ionization voltage of the series-connected neon lamps is eventually reached so that they turn on, thus triggering  $SCR_1$ . This

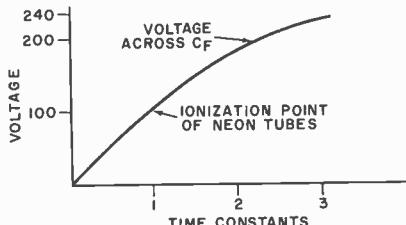


Fig. 6. Voltage across capacitor increases with time constant until the firing point of neon tubes is reached.

causes  $C_1$  to discharge rapidly through the primary of  $T_1$ . The pulse on the secondary of  $T_1$  triggers the flash tube.

The energy input to the tube is  $E = \frac{1}{2}CV^2$  or  $\frac{1}{2}(100 \times 10^{-6})(240)^2 = 2.88$  joules. The

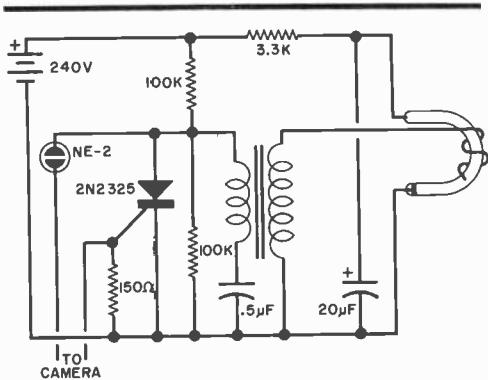


Fig. 7. Typical electronic flash for camera. Closing camera leads causes SCR to conduct, thus triggering tube.

time constant of  $R_1 C_1$  is  $0.47 \times 4$  or 1.88 seconds. As shown in Fig. 6, after a period of about 1 time constant, the voltage on the neon lamps is sufficient to turn them on, thus firing the SCR.

A typical camera strobe circuit is shown in Fig. 7, while Fig. 8 illustrates an ignition timer lamp.

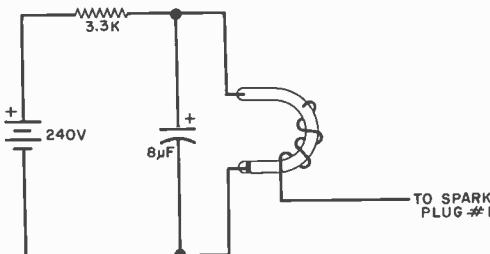


Fig. 8. In this simple engine timing light, the high-voltage pulse at the spark plug triggers the flash tube.

**Caution.** There is some medical evidence that exposure to strobe rates of from 6 to 10 flashes per second could cause an epileptic fit, even in a person without a previous history of epilepsy. Therefore, extreme caution must be used in building and operating strobes—not only by the builder but by any other observers as well.

From the electrical standpoint, caution must be used due to the high voltages involved in most strobe circuits. Be sure that all capacitors are fully discharged before making any circuit modifications or other changes in a piece of strobe gear. ♦

# ANTENNA TUNER FOR SWL's

LOW-COST FRONT END INCREASES SIGNAL STRENGTH  
AND IMPROVES SELECTIVITY

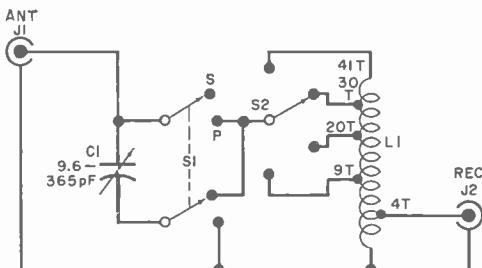
BY CARL C. DRUMELLER

**S**HORTWAVE receivers for serious listening are usually designed for use with a low-impedance antenna input; but the doublet antenna, which is normally used for low-impedance feedlines, works best over a narrow band of frequencies. So, if you have a general coverage (0.55 to 30 MHz) receiver, it is desirable to have a low-impedance input over a wide frequency range. For this, you need an antenna tuner.

The circuit shown here provides a low-impedance input over a wide frequency range and also improves receiver selectivity. The additional selectivity occurs before the first active stage (tube or transistor) of the receiver and thereby lessens the effects of image interference, cross modulation, and intermodulation. By omitting the 0.5-to-1.8-MHz range where most receivers perform quite well and by deleting the 15-to-30-MHz range where an amplifying preselector is often needed, the tuner design is very simple.

The tuner consists of a tapped coil (*L1*) and a variable capacitor (*C1*). The latter can be switched so that it is either in series or parallel with the coil. Connected to a random-length, end-fed antenna, the circuit can be tuned for resonance at the frequency of the incoming signal—with a low-impedance output. Its tuning is not critical, but it provides enough front-end selectivity to reduce appreciably the image interference. The apparent "gain" results from a resonant antenna and matched receiver input, which boosts the signal strength. Since it is passive, the tuner does not provide any actual gain, the increase in signal strength resulting from more selective use of the signal power.

The tuner is mounted in a small metal enclosure with the three operational controls on the front panel. Switch *S1* is used to select either series or parallel tuning of *L1*, while *S2* is used to vary the inductance. The antenna input and receiver output con-



Circuit resonates at desired frequency and provides low-impedance output.

nectors (*J1* and *J2*) may be conventional phono connectors or BNC-type devices.

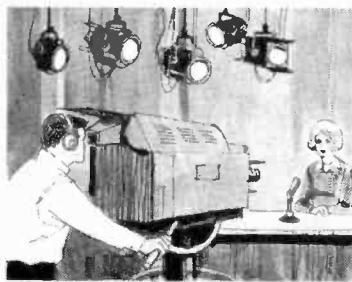
The shaft of *C1* must be cut down and an insulated extension shaft must be attached. This is because, when *S1* is in the series mode, the capacitor shaft must be above ground. The shaft also reduces the effect of body capacitance. The capacitor and inductor can be mounted on a small piece of perf board with spacers to stand the assembly off the front panel. The insulated shaft should protrude through the front panel for tuning.

Inductor *L1* consists of 41 turns of #26 enameled wire covering  $1\frac{1}{4}$ " of a  $1\frac{1}{4}$ " diameter plastic form (possibly a plastic pill container), tapped at 4, 9, 20, and 30 turns. The first tap, at 4 turns, is used to feed *J2*.

To use the tuner, connect a random-length antenna to the center portion of *J1* and the receiver to *J2*. Be sure a good ground exists between tuner and receiver and between receiver and ground.

Time in a fairly strong station between 1.8 and 15 MHz and try each position of *S2* with *S1* in series and parallel. Tune *C1* through its entire range until you notice a distinct increase in signal strength. Work your way across the various bands, adjusting the antenna tuner for a maximum signal at each point. Record each switch position with frequency for future use. ◇

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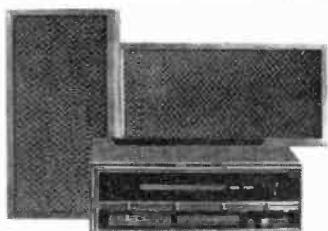
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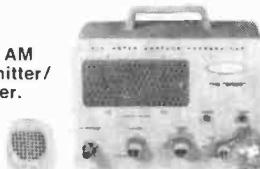
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# Product Test Reports

## TEAC AS-100 INTEGRATED STEREO AMPLIFIER (A Hirsch-Houck Labs Report)



BEST known for their high-quality tape recorders, Teac also manufactures other electronic components that go into a hi-fi system. An example of this is the new Teac Model AS-100 integrated stereo amplifier which the company styled as a companion to their Models 1230 and 1250 tape recorders. The AS-100 amplifier offers the same caliber of performance that has earned the company's tape recorders a reputation for excellence.

The AS-100 presents a somewhat stark, unglamorous appearance when compared to some of its competition. The lower portion of the front panel, finished in black with white markings, has simple switch levers for switching in and out tape monitoring, low- and high-cut filter, loudness compensation, and separate control of local and remote speaker functions. A pushbutton switch turns on and off power to the amplifier, while a small orange panel lamp just above and to the left of the power switch is softly illuminated when power is on. In line with the switch levers are input and output jacks for a tape deck and a stereo jack for 8-ohm headphones.

The upper portion of the panel is finished in satin aluminum, contrasting with the simple black plastic knobs set against them. Two large knobs at the left are used to select the program source and operating mode. The source selector has positions for two magnetic phono cartridges, a tuner, and two high-level AUX sources. The mode

switch provides the user with a choice of selecting either normal or reversed stereo, feeding left or right inputs through both speakers, or summing the left and right inputs to provide monophonic listening.

At the right side of the panel are concentric volume and balance control knobs. In the center of the panel are four smaller knobs for separate control of bass and treble in each channel. The tone controls are step-switch affairs, each providing five positions of boost and cut, flanking a center flat position.

In the rear of the amplifier are screw-type speaker terminals, speaker and line fuses, input jacks for the various program sources, and the tape recording outputs and inputs which parallel the jacks on the lower portion of the front panel. There is also a DIN-type tape recorder connector which is automatically disconnected when plugs are inserted into the front-panel jacks.

The preamplifier outputs and main amplifier inputs are brought out through separate jacks. A slide switch is provided to permit the user to bridge the jacks for normal operation or to separate the jacks for use with a 4-channel decoder, equalizer, or similar accessory. Finally, there are three ac outlets, two of which are controlled by the amplifier's power switch.

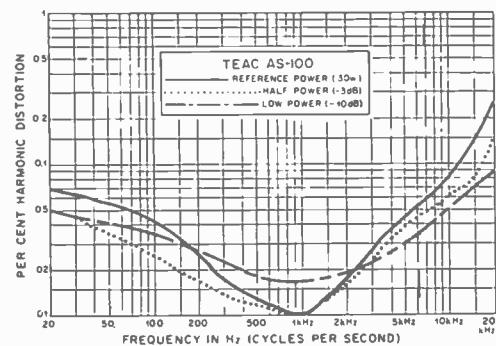
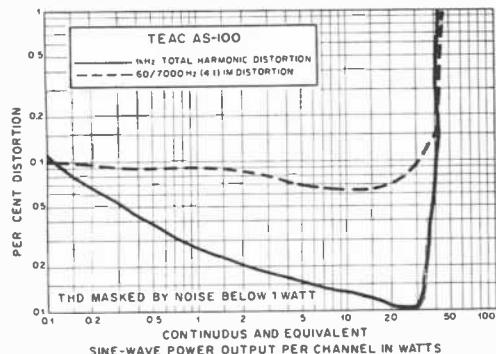
The amplifier is rated at 30 watts/channel into 8-ohm loads with both channels driven. Harmonic and intermodulation (IM) distortion are rated at less than 0.2 percent for any power level up to the rated maximum. The amplifiers employ direct-coupled differential circuits with low-noise IC's in the control amplifier section. A time delay muting circuit prevents current from flowing through the speaker outputs for a second or two after the amplifier is turned on, eliminating transient "thumps."

Weighing in at 22 pounds, the amplifier measures 16 $\frac{1}{2}$ " wide by 12 $\frac{3}{4}$ " deep by 5 $\frac{5}{16}$ " high. It is list priced at \$299.50. Optional teakwood side panels are available.

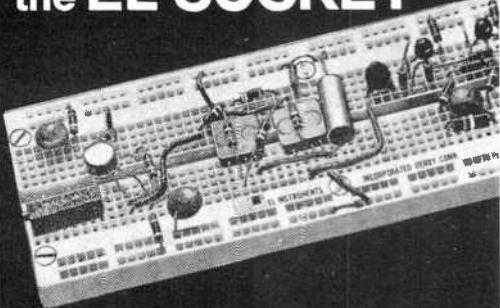
**Laboratory Measurements.** The Teac Model AS-100 integrated stereo amplifier proved that a simple exterior can be deceptive. Although the amplifier lacked the colored lights and fancy trim found on so many hi-fi equipment components, a brief exposure to our test bench made it obvious that we were dealing with an amplifier of superior quality.

The 1000-Hz harmonic distortion measured out at 0.027 percent at 1 watt, and below the noise level at lower powers. It decreased to 0.01 percent between 20 watts and 30 watts, and reached 0.1 percent at 40 watts/channel, just below the clipping level of about 42 watts. These measurements were made with both channels driven into 8-ohm loads. The measured IM distortion was between 0.065 and 0.10 percent at all levels from 0.1 watt to 30 watts output per channel. Into 4 ohms, the AS-100 clipped at 49 watts, and with 16-ohm loads, it delivered 27.5 watts.

Using 30 watts/channel as a reference full-power output, we measured the har-



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ic distortion over the full range of audio frequencies. It was 0.07 percent at 20 Hz, down to 0.01 percent at 1000 Hz, and increased smoothly to 0.29 percent at 20,000 Hz. At lower power, the distortion was not significantly different from that obtained at full-power.

At the high-level inputs, 65 mV (0.82 mV at the phono inputs) was required to provide a 10-watt output. The noise level, referred to 10 watts, was about 75 dB down on the high-level inputs and 71 dB down on phono, both well below audibility. Phono overload occurred at 115 mV, far above the maximum output level of any high-quality magnetic phono cartridge.

The loudness compensation was more moderate in its action (and, therefore, much more listenable) than in most amplifiers we have tested. The low-frequency boost at usable volume control settings was only 7.5 dB, accompanied by a 5-dB boost at 20,000 Hz. As a result, the sound was always natural, even with loudness compensation in use. The filters were not particularly effective with their 6-dB/octave slopes and -3-dB frequencies of 130 Hz and 5000 Hz. Accurate within 0.5 dB above 500 Hz, the RIAA phono equalization had a low-frequency rise of 4 dB between 70 Hz and 100 Hz; it fell off to -4 dB at 30 Hz.

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## LAFAYETTE LA-524 DECODER/AMPLIFIER (A Hirsch-Houck Labs Report)



**A**LTHOUGH compatible quadraphonic (4-channel) records can be played through an ordinary 2-channel system, their full impact can be appreciated only with 4-channel reproduction. A few 4-channel amplifiers and receivers are available, but most people who already have perfectly satisfactory stereo equipment are understandably reluctant to replace them with 4-channel components.

As we pointed out in last month's report on the Lafayette Radio Electronics Model SQ-M 4-channel decoder, almost any

We were surprised to find an appreciable (at least from a measurement standpoint) amount of crosstalk in the AS-100. At 1000 Hz, the crosstalk between the channels was -38 dB, while at 15,000 Hz, it was -16.7 dB. These figures are comparable to the stereo separation characteristics of many good FM tuners and phono cartridges. Although the amplifier will certainly not degrade the audible separation characteristics of any normal stereo system, it might cause problems in unusual installations where each channel carries a totally different program.

**Comments.** We enjoyed the "feel" of the AS-100 amplifier's controls. Everything worked with a light, yet completely positive, action. There were no clicks or thumps accompanying any switching operation. The brief turn-on delay was not noticeable in use but was nevertheless effective in its purpose of preventing turn-on thumps.

Needless to say, the audio quality of the AS-100 stereo amplifier was flawless. The amplifier is certainly powerful enough to drive almost any type of speaker system designed for home use. Anyone who thinks the appearance of the amplifier is a bit too functional should find the optional teakwood end panels a worthwhile investment.

system can be converted for 4-channel playback by adding a suitable decoder, a second stereo amplifier, and a pair of rear speaker systems. For some types of program material, such as some popular music and most electronic music, it is desirable to have four similar speakers and equal power capability in all four channels. However, in the majority of cases, a very satisfactory quadraphonic effect can be obtained with less expensive speakers and a lower power amplifier in the rear channels.

Lafayette has packaged the equivalent of their SQ-M decoder, together with a low-power stereo amplifier, in their compact Model LA-524 auxiliary stereo amplifier which measures 10%<sup>2</sup> x 8%<sup>2</sup> x 3%<sup>2</sup>. It sells for \$82.95.

The LA-524 is housed in a simulated wood-grain-finished metal case. Its FUNCTION switch allows selection of F+R (normal stereo reproduction through all speakers, with front and rear speakers on each side

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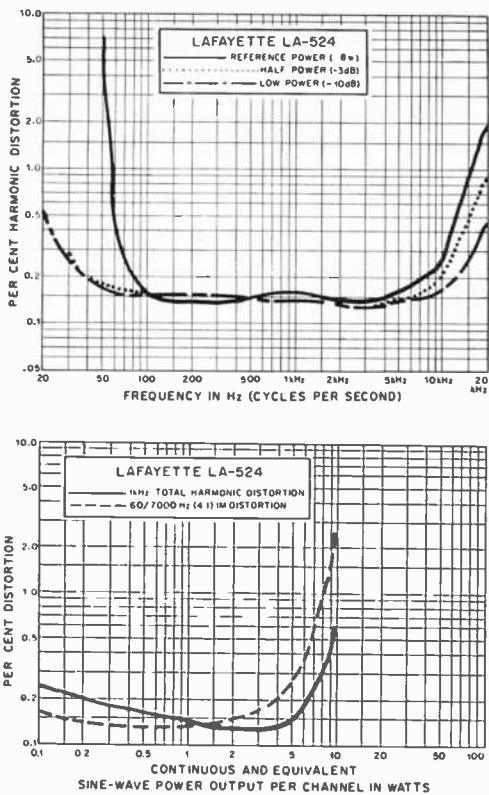
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carrying the same material), COMPOSER, SQ, or DISCRETE mode of operation. The COMPOSER mode derives a simulated 4-channel signal from 2-channel programs by feeding a difference (L-R) signal to the rear speakers. The SQ mode provides a decoding matrix for CBS SQ-encoded records. And the DISCRETE mode accepts 4-channel sources such as those provided by Q-8 tape cartridges and open-reel tapes.

The MASTER VOLUME control, actually separate concentric controls for the left and right sides of the room, serves all four channels simultaneously. The bass and treble tone controls, also concentric types, affect only the rear channels, while the regular stereo amplifier or receiver tone controls are used for the front channels. Along the bottom of the panel are rocker switches for a high-cut filter, stereo/mono selection, switching in and out the loudness compensation, and selection of main or remote speakers. A pushbutton switch controls ac power, and a headphone jack carries the rear-channel signals.

**Laboratory Tests.** In our lab tests, the

decoding functions were essentially similar to those of the Lafayette SQ-M decoder reported on last month. In the SQ mode, the two rear channels are driven with a constant phase difference of about  $64^\circ$  across most of the audio-frequency range, while the front channels had about a  $32^\circ$  phase difference. The phase shift from front to rear on the same side varies between  $75^\circ$  and  $90^\circ$ , and either front channel is about  $162^\circ$  from the diagonally opposite rear channel. In the COMPOSER mode, the rear speakers are driven  $180^\circ$  out of phase, with each rear speaker also out of phase with the front speaker on the same side.

Like the SQ-M, the LA-524 delivers up to 8.5 volts through its front-channel outputs without distortion. A small switch on the rear of the system changes the front-channel gains by 6 dB to match amplifier requirements; either 64 mV or 130 mV is required at the input for a 1-volt output.

The amplifier section of the LA-524 is rated at 60 watts ( $11\text{IF} \pm 1 \text{ dB}$  into 4 ohms). More realistically, at 1000 Hz, it delivers about 10 watts/channel into 8-ohm loads with both channels driven. With 4-ohm loads, the output was 11.2 watts. The low-frequency power capability of the amplifier, like most low-power amplifiers, is rather limited. Using 8 watts/channel as a reference full-power output, the distortion was quite low at about 0.15 percent over most of the audio range. It increased at the frequency extremes to 2 percent at 55 Hz and 20,000 Hz. At half power or less, the distortion stayed below 0.5 percent from 20 Hz to 16,000 Hz.

With a 1000-Hz test signal, the distortion was below 0.25 percent from 0.1 watt to 7 watts output, increasing to 0.6 percent at 10 watts. The IM distortion was less than 0.2 percent up to 4 watts, reaching 1.0 percent at 8 watts and 2.5 percent at 10 watts. Hum and noise were very low at about 75 dB below 10 watts.

The feedback-type tone controls had the desirable characteristic of varying the output at low frequencies with very little effect on middle frequency response. The loudness compensation was moderate in its action, as was the high-cut filter, which had a 6 dB/octave slope and a  $-3 \text{ dB}$  point of 4000 Hz.

**Listening Tests.** Listening to the LA-524, in combination with a stereo receiver, we obtained good quadraphonic reproduction

from a number of different types of records, including CBS SQ and others recorded with the Electro-Voice and Sansui systems. Most matrix quadraphonic disc systems are "compatible" in the sense that they produce enjoyable 4-channel sound even when the recording and playback matrices are different. Either the COMPOSER or the SQ mode can be used for deriving simulated 4-channel sound from 2-channel material. With any given recording, the chances are good that one or the other will sound better; so, a

little experimenting is probably in order.

For only \$38.00 more than the cost of the SQ-M decoder alone, the Lafayette Model LA-524 decoder amplifier gives the buyer a clean-sounding, flexible amplifier, albeit with relatively low output power. It is unlikely that a separate amplifier with comparable performance can be had for the same price, making the LA-524 one of the least expensive means of converting from a 2-channel stereo system to one capable of reproducing quadraphonic sound.

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### B&K MODEL 1440 OSCILLOSCOPE

**A**LTHOUGH triggered-sweep oscilloscopes are gaining in popularity, there are still plenty of uses for the conventional recurrent-sweep scope. One of the latest of these to arrive here, the B&K Precision Model 1440 solid-state oscilloscope with Cali-Brain®, which retails for \$299.95, shows some new approaches to this familiar scope design.

The new low-profile 1440 (only 16" deep with a 10" by 9" front panel) with its jet black front and sharp-contrast white lettering, excellent layout of controls, BNC-type vertical input connector, and flat-face 5" CRT, gives the appearance of a professional instrument. The scope's specifications further reinforce this first impression. Vertical bandwidth is from dc to 10 MHz (on ac, 2 Hz to 10 MHz). The rise time is specified as 35 nanoseconds, making the 1440 excellent for pulse work.

There are eight ranges of vertical attenuation, beginning at the low end at 0.1 volt full-scale and going on up to 300 volts full-scale. Input impedance is 1 megohm, paralleled by 35 pF, tilt is 5 percent or less, and overshoot is 3 percent or less. A concentric variable attenuator control provides continuous uncalibrated variation between the fixed ranges.

The horizontal section of the scope has a flat frequency response from dc to 800 kHz on dc and 2 Hz to 800 kHz in the ac mode at an input sensitivity of 400 mV peak-to-peak/cm. Input impedance is 100,000 ohms, shunted by 50 pF. The time base features five overlapping ranges plus TV-V at 30 Hz and TV-H at 7875 Hz. A sweep vernier control provides continuous control within each range. Synchronization is switch selectable between plus, minus, external, or line frequency (complete with a phase ad-



justment control). A built-in sync separator in the TV positions produces stable sync from a composite video input signal. The horizontal amplifier can also be driven from the power line or from an external source. Its gain control can be used to permit up to 2X trace expansion for close examination of any waveform. A pair of positioning controls completes the lineup.

Also located on the front panel is a test jack that delivers a 1-volt peak-to-peak square wave that can be used for both calibration purposes and for probe compensation. A test jack on the rear apron provides a means for Z (intensity) modulation. As an added feature, the vertical amplifier dc balance and the CRT astigmatism controls are accessible as screwdriver adjustments through the front panel. Since the 1440 can be switched to do double duty as a vectorscope, B&K supplies a plastic vector overlay that fits into the CRT's graticule bezel.

**Special Feature.** The greatest asset of the 1440 is its Cali-Brain feature, something

that we would like to have seen appear many years ago. Here is how Cali-Brain works:

The CRT has a special graticule on which are engraved two vertical scales. The left scale is calibrated from 0 to 1 in 20 steps, while the right scale is calibrated from 0 to 3 in 12 steps. Directly above each vertical scale, in a separate housing that is part of the bezel, is an illuminated number—100 over the 0-1 scale and 300 over the 0-3 scale. As the VOLTS FULL SCALE control (vertical channel sensitivity) is operated to set input sensitivity, a dial-cord-driven decimal point illuminator moves to indicate the range and scale in use. Hence, when the control is set to .3 volt, only the right scale is illuminated and the number above it is .300. Likewise, when the control is set to .1 volt, only the left scale is illuminated and the number displayed is .100. As can be surmised, as the control is moved through all of its positions in a clockwise direction, the numbers displayed will be: .100, .300, 1.00, 3.00, 10.0, 30.0, 100 and 300 as the left and right scales illuminate alternately. Note that only the decimal point locations move. Consequently, there is no doubt as to which range of the VOLTS FULL SCALE control is in use at any given moment.

As a further aid to reading peak-to-peak

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ac or dc voltages, the vertical positioning control has a "Pull To Read Volts" function that can be brought into play. Set to this function, the control disables the horizontal sweep to produce a single vertical line, the length of which depends upon the input voltage level. Furthermore, this line is automatically positioned at the correct right or left illuminated scale. All you need to do now is read off the peak-to-peak voltage on the illuminated graticule marker.

A dual-purpose, easily switched, 10:1 or direct probe with attached ground cable and a tilt stand under the case add to the convenience and versatility of the 1440 scope.

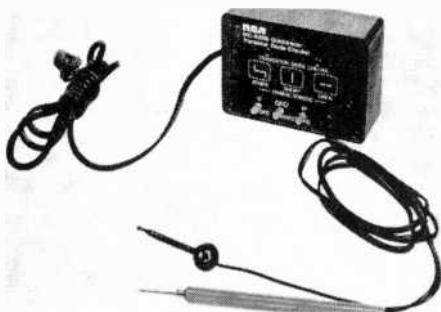
We have been using the scope on our bench for more than a month now, and during that time, it has done yeoman service. The Cali-Brain feature has been put to much use in comparing the circuit peak-to-peak waveform levels with those shown on schematic diagrams of the equipment we have in the house. The frequency response is excellent, the images, sharply defined and stable. As a bonus, we have been using the Cali-Brain feature as a high input impedance ac and dc voltmeter.

All in all, the B&K Model 1440 solid-state oscilloscope should prove a good addition—and investment—to any test bench.

### RCA WC-528A/B TRANSISTOR/DIODE CHECKER

WHY IS IT that almost every time a suspect transistor must be checked it is buried way down in a complex, crowded printed circuit board? If an attempt is made to remove the transistor from the PC board, it is almost certain that some damage will be done to the board. What is even more frustrating is to learn that the suspect transistor, after being removed, is in perfect condition (assuming that you have not succeeded in "frying" it with your soldering iron while taking it out of the circuit). It is no wonder, then, that in-circuit transistor checkers are so popular among experimenters and service technicians.

The latest in-circuit transistor checker we have used comes from RCA. It is their Model WC-528A or B "Quicktracer." Priced at only \$14.95, it fits neatly between the far more expensive curve tracer and the basic resistance-type transistor checker. Like most curve tracers, the Quicktracer is an accessory item designed to be used with an



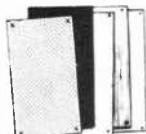
oscilloscope. When the two are paired together, the user has a handy means for checking all types of semiconductors except FET's. Too, it will even check many values of resistance and capacitance. The only difference between the A and B models is in the way they are mounted. The A model is plugged directly into the ac outlet (no cord), while the B version is attached to the side of the scope by a Velcro fasten-

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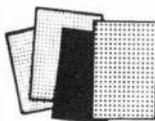
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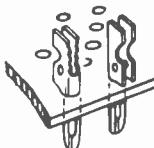
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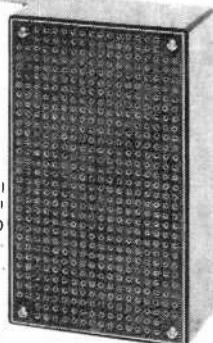
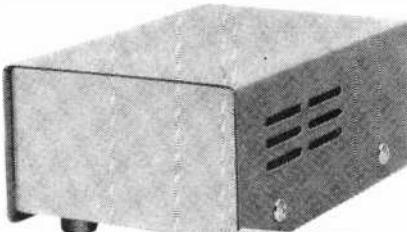


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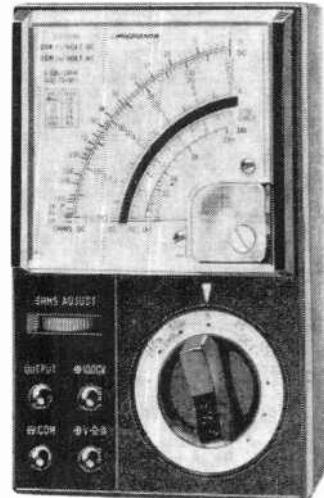
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ing, with a cord going to the ac outlet.

The Quicktracer provides horizontal and vertical signals for almost any scope (bandwidth is not important). Operation is based on the premise that, when a semiconductor fails, it fails catastrophically in such a manner that the junctions become either open or shorted. Unlike far more expensive curve tracers, the Quicktracer does not generate a family of curves. Its output, displayed on the scope's CRT, is just a single trace. And unlike many resistance-type in-circuit checkers that may or may not work, depending on what types of components are connected across the junctions, the Quicktracer also shows the conditions of the components connected across the transistor.

**Comments on Use.** After connecting the Quicktracer to the scope's vertical and horizontal inputs with the ground lead to the scope's ground, there will be two leads left over. One is a special clip lead, while the other is terminated in a needle-sharp tip on a conventional probe body. All the user does is connect these two leads to the semiconductor under test (polarity is not important) and observe the waveform displayed on the CRT screen. In the case of a transistor, the other junction must then be tested.

The shape of the displayed waveform

Circle No. 68 on Reader Service Card

changes with whatever circuit components are connected across the junction. This effect is put to use in testing many different types of resistors and capacitors. A built-in current-limiter resistor keeps current flow low so that only 75 mW or less must be dissipated by the device under test. This prevents accidental destruction of the test component.

The manual that accompanies the Quicktracer completely details the accessory's operation. RCA also provides a separate 12-page booklet that not only details the practical uses of the checker, but also discusses how to use it with the company's CTC-51, CTC-52, CTC-53 and CTC-54 solid-state color-TV receiver chassis. The application note shows actual base-to-emitter and base-to-collector waveforms for each transistor in the receivers. By comparing these waveforms with similar points in a receiver that is not operating, the service technician can quickly locate a defective transistor.

We have been using the checker for more than a month now and can attest to the fact that it has saved us a lot of service time and has been responsible for locating a number of faulty semiconductors. In a few cases, the Quicktracer helped in localizing faulty stages after which conventional troubleshooting methods pinpointed the bad component.

## CALIFORNIA INSTRUMENTS MODEL 8310 DIGITAL MULTIMETER

THE QUALITY, versatility, and good looks of digital test gear are constantly improving with the passage of time and each new model that is introduced into the market. Good examples of improvements in all three areas can be seen in the Model 8310 automatic digital multimeter (DMM) made by California Instruments Co. for \$345. This new DMM features a 3½-digit readout system, 100 percent overload capability, automatic zeroing and ranging, automatic polarity sensing and display, and dual-slope integration for maximum accuracy and noise rejection.

The dc volts mode has four ranges (2, 20, 200, and 1000 volts full scale) and is accurate to within 0.1 percent plus one digit. Polarity indication is fully automatic. The ac volts mode also has four ranges (2, 20, 200, and 350 volts full scale) and a frequency response of 45-20,000 Hz. The dc volts in-

put resistance and ac volts input impedance are both 1 megohm on the 2-volt range and 10 megohms on all other ranges. Resistance measurements are made in seven ranges from 200 ohms full scale to 200 megohms, with a 100-milliohm low end limit. Currents in the resistance mode range



from a maximum of 10 mA on the 200-ohm range to 10 nA on the 200-megohm range.

Among the optional accessories available for the Model 8310 are a high-voltage probe that extends the basic instrument's dc range to 26 kV, a high-voltage probe that extends the ac range to 1000 volts, and a set of current shunts that extend in six ranges from 20  $\mu$ A to 2 A on dc and five ranges from 200  $\mu$ A to 2 A on ac. The shunts permit the instrument to be used as a current-measuring device.

The reading rate for the electronics is two per second. Hence, there is no "blurring" of the gas-discharge readouts, and the resulting numbers pop up clearly and unambiguously. If required, an input connector located on the rear apron of the instrument case accepts a cable terminated in a switch that can be used to hold the indicated display until it is released.

Physically, the new DMM measures only 8 $\frac{3}{4}$ " wide by 8 $\frac{1}{2}$ " deep by 3 $\frac{1}{2}$ " high. It weighs less than 5 pounds. The cabinet has an appealing sloping-front design. All functions are selected by operating the appropriate piano keys located to the right of the

display window. Five function switches are provided, while a sixth permits the user to select a particular range when required, thus eliminating the need for numerous manual range selectors. Affixed to the sturdy all-aluminum case is a rugged carrying handle that can be adjusted and locked into any position to double as a variable-height tilt stand.

**Laboratory Tests.** As with all other DMM's, we checked the Model 8310 against our lab-standard dc voltage calibration source and some 0.1 percent precision resistors. The instrument came through with flying colors, well within the published specifications. The automatic ranging and polarity features came in very handy by eliminating the need to juggle test leads and range controls. The bright gas-discharge readout display was at all times easy to read, including the decimal points.

After two weeks on our test bench, we were satisfied that the Model 8310 digital multimeter lives up to its specifications. We make no conditions when we state that this new instrument would be a worthy addition to any lab or test bench.

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# HEADLIGHT REMINDER

SPECIAL ALARM FOR CARS AND MOTORBIKES

BY DAVID E. FAHNESTOCK

**H**OW MANY times have you driven through fog or rain, left your headlights on after parking the car, and returned to find the battery dead? On the other hand, how often have you started your car in a well-lit street and soon found you were driving with your lights off?

There is a definite safety advantage to driving with your headlights on during the day. Other drivers are less likely to pull out in front of you; and, when driving on a two-lane highway, oncoming traffic can see you at a greater distance and be less likely to pull out into your lane to pass. In the state of Florida, for example, motorcycles are required to keep their headlights on whenever the vehicle is in operation.

The circuit, as shown below, will sound an alarm if the accessory or ignition switch is turned on while the headlights are off or if the headlights are left on when the ignition or accessory switch is turned off. However, if ignition and headlights are both on, the alarm will not sound. In the first situation, operation of normally open switch *S1* (defeat) will shut the alarm off if desired; but in the second case, the switch has no effect.

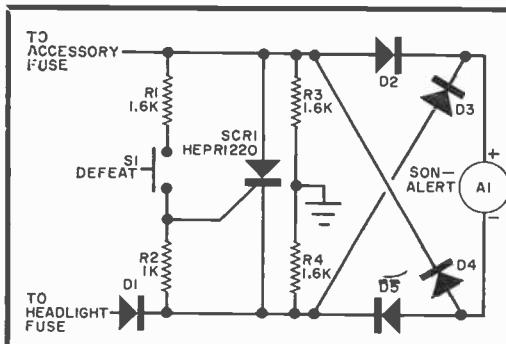
The circuit includes an OR and Exclusive OR function. If only the accessory (ignition) line is "hot," current flows through forward biased diode *D2*, the alarm, forward biased *D5*, and resistor *R4* to ground. Thus, the alarm sounds. The other diodes are reverse biased.

If only the headlight line is "hot," current flows through *D1*, *D3*, the alarm, *D4*, and *R3* to ground. This also sounds the alarm.

If both the accessory and headlight lines are hot at the same time, the potential across *A1* is zero and the alarm will not sound.

Operation of *S1* triggers *SCR1* if the accessory or ignition switch is on and the headlights are off. This applies the dc voltage to both sides of the circuit, as if both lines were "hot." In this case, *D2* is reverse biased and keeps voltage from turning on the headlights. The SCR will unlatch if either the ignition is turned off or the headlights are turned on.

**Construction.** The entire circuit can be assembled on a piece of perf board having the same diameter as the Sonalert, with the board electrically connected to, and supported by, the leads to the alarm. The three signal leads—one for the ignition-accessory, one for the headlights, and the ground—are made from lengths of color coded flexible insulated leads. The defeat pushbutton (*S1*) can be mounted in any convenient location near the alarm. All components are supported by small clips, making sure that the clips are secure and won't be dislodged by vehicle vibration. With 12 volts from the vehicle battery applied to the alarm, a sufficiently loud tone will be generated. ◆



## PARTS LIST

- A1*—Sonalert SC628 (Mallory) with mounting bracket.
- D1-D5*—Silicon diode (HEP134, IN458, HEP135, etc.)
- R1,R3,R4*—1600-ohm resistor
- R2*—1000-ohm resistor
- SCR1*—Silicon controlled rectifier (HEPR-1220, GE106Y1, GEX-5, GEC6B, etc.)
- S1*—Normally open pushbutton switch
- Misc.—Perf board, mounting clips, insulated wire, etc.

Variety of conditions can sound alarm.



# Modules and the Technician

By John T. Frye, W9EGV, KHD4167

MAC, Matilda, and Barney had been taking inventory most of the day, but now they were taking a break. Matilda had fixed hot chocolate, and they were enjoying this with some home-baked cookies she had brought in that morning. It was snowing hard outside, but inside the service shop all was cozy warmth and the good companionship of people who enjoy working together.

"Boss," Barney said, reaching for his fifth cookie, "I'm running into more and more color sets using snap-in modules. Before long, apparently, most new color sets will have these. I find I have sort of mixed emotions about this prospect. I wonder what you think of it."

"I've been thinking a lot about this, too," Mac admitted, "and I've been doing some reading about the different approaches to modular construction by the various TV manufacturers and of the philosophies behind these approaches. A *Business Week* article says the plug-in, plug-out modules were first introduced by Motorola, Inc., in 1967 models. This may be true as far as color sets are concerned, but we both remember Setchell-Carlson's 'unitized' B & W sets which used the same basic idea of easily removed circuit sections. Setchell-Carlson was simply ahead of its time. Tubes were still being used instead of transistors, and this made the modules large and bulky and required that the contacts to the rest of the circuit carry heavy currents to tube filaments, etc. The advent of transistors really made the modular concept feasible, for then the modules could be compact, light in weight, and of low current requirements.

"At any rate, other manufacturers started putting modules into a few of their sets as a sort of testing-the-water technique. Now,

in the 1973 models, almost everyone has modular color sets. Magnavox Consumer Electronics Co., for example, offers modules on almost half of their 1973 solid-state color receivers."

"Don't these sets cost more to manufacture?"

"Yes. When Motorola introduced the Quasar model, it asked for a \$100 difference in price over a conventional color set. Now it puts modules into models ranging from 14" portables to 25" units, and improved manufacturing technology has cut the price difference from \$25 to \$50 a set. GE, RCA, and GTE/Sylvania will not reveal the additional cost of modular inclusion. They prefer to mix the cost in with higher prices for costlier cabinets, remote controls, and touch tuning on models that use modules."

**Different Philosophies.** "What do you mean about there being 'different philosophies' with regard to the use of modules?" Matilda wanted to know.

"Well, there are at least three different approaches to the design, assembly, and servicing of color-TV modules. Motorola puts its components on six to ten relatively large modules and charges customers \$6.50 to \$18.50 for a new module, exclusive of labor. The technician can either fix the old module in his shop or send it to a Motorola factory and get a trade-in allowance. Motorola then rebuilds the module and mails it back to a distributor or technician. Motorola says that, without this arrangement, the unit would cost the customer \$25 to \$50. We have, of course, the same arrangement in the automobile industry with regard to fuel pumps, carburetors, generators and starter drives. Admiral and Panasonic employ a similar approach."

"So does the Heath Company," Barney offered. "For the first 90 days after purchase, they will repair any module free of charge and return it within two working days. After that, the repair service is equally fast, but they charge a flat \$5 fee for the repair up to two years. They, of course, deal directly with the customer; so there is no labor charge for installation."

"Right," Mac nodded and then continued: "GE and RCA want to get away from factory-rehandling costs and are working on the throw-away principle. By employing smaller, cheaper modules that contain fewer components they hope to trim module costs. RCA, which introduced three times as many modular sets this year as it did last, retails its modular units for \$7 to \$31 and does not give a trade-in allowance.

"Zenith uses a few large modules broken down by function. Lower cost components, such as transistors or integrated circuits, can be pulled out of the module and a new one snapped in once the trouble is diagnosed. Karl Horn, vice-president for engineering and research at Zenith, says about nine times out of ten the trouble can be identified by the technician on the spot, who can then replace the faulty component rather than the whole module. But having access to a set of modules is a great help in cornering the trouble. As you know, some kinds of instability can arise in the i-f section, the sync section, the age, or in one of the oscillators. Being able to replace whole modules with those known to be OK certainly facilitates knowing where to look for a bad component. As William Boss, GTE/Sylvania's marketing vice-president puts it: 'Finding a defective module should be a lot easier for the repairman than tracing through the 1200 parts of a TV set to pinpoint what's wrong.'

"It seems to me a common problem for the technician, distributor, and dealer is the necessity for stocking a multitude of different modules and the likelihood of being stuck with obsolete ones as the design is changed from year to year," Barney said. "We've been down that road with tubes."

Mac nodded agreement. "Motorola ran into that argument from their dealers when they introduced the Quasar, and they promised that modules would not be changed willy-nilly every year. Perhaps some kind of arrangement will have to be worked out in which obsolete modules can be traded in for new ones."

**A Threat to Servicing?** "I can't help worrying that modules are going to make a big dent in our service business," Barney confessed. "Maybe we ought to buck them."

"There can be no doubt that color TV sets require less service now than they did at first," Mac said. "Frank Moch, executive director of NATESA, says annual service calls on color sets have dropped from four to two since the introduction of transistors. He predicts modulars will lower this to 1½ calls a year. But knocking modules simply because they reduce service calls would be the worst kind of sabotage propaganda. In the long run, it would be about as effective as the French peasant's trying to hold back the Industrial Revolution by throwing his wooden shoe, or *sabot*, into the gears of the hated machine that was replacing him and his fellows. Featherbedding and other make-work practices represent waste that first seems to cost only others but eventually costs the featherbedder his job, because those paying his unearned wages, in desperation, find a way to replace the over-priced employee.

"However, I agree with you that the module poses a serious threat to servicing as we know it. First, modular sets are going to result in fewer, less-remunerative service calls. Second, most of those calls can be made by a quickly trained module swapper who knows only 'how' and not 'why.' On the other hand the module represents progress in the way of easier-to-service sets that benefit both the manufacturer and the customer. We must keep in mind that—distasteful as the idea is—service is a necessary evil. Ideally, from the manufacturer's point of view, a TV set would never need service—although I am sure the manufacturer would like a provision that the set would self-destruct at the end of a decent interval! From the customer's point of view, the set should *never* need service. Since this is not an ideal world, we are able to wedge ourselves in between the manufacturer and the owner and secure a grudging patronage from both.

"To my way of thinking, the only way we can keep our income up or even increase it is for us to increase our productivity. Service calls will take less time; so we increase the number of calls. For all these years we've been yelling for sets that are easier to service and now we've got 'em! It behooves us to make the most of having our wish granted."

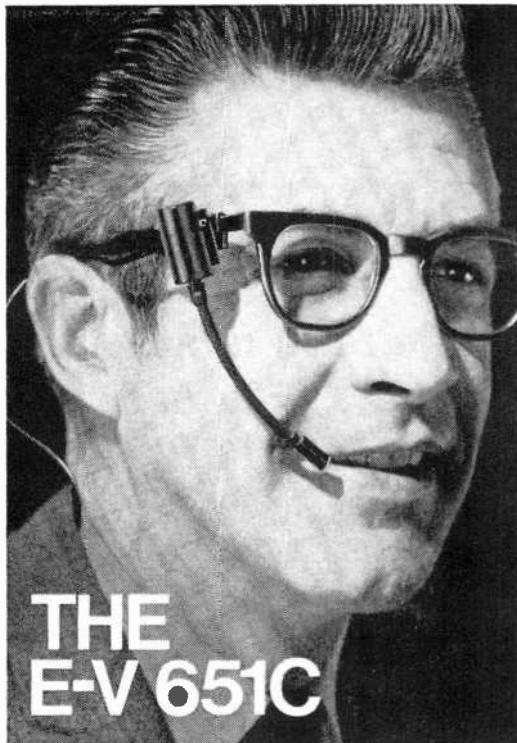
"Maybe we'll get some help," Barney said hopefully. "I can see right now that if we're going to be module repairmen instead of TV repairmen we're going to need module testers, just as we now have tube and transistor testers."

"I'm sure that once the dust settles, things such as that will be coming on the market," Mac agreed. "Eventually we may even see some standardization of module connections so that all will fit into two or three types of universal connectors, just as many different tubes fit the same socket."

**No Time to Panic.** Matilda slid off her stool and began gathering up the empty cups. "As I get it, Mac," she said, "you're saying this is no time to panic. Modules are here to stay—at least until something else replaces them—and the thing for the service technician to do is to figure out how he can go with the tide instead of against it. After all, ten service calls with a gross profit of ten dollars a call is just about the same as five service calls that bring in twenty dollars a call. The technician will have to push more doorbells, but he will not have to carry along so much equipment. Lowering the profit margin but increasing the traffic is what permitted the supermarkets to crowd out the corner groceries."

"That's the idea, Matilda. Some technicians will try to buck the trend just as they sneered at ac-dc receivers, pooh-poohed transistors, and finally took down their signs when color TV hit the market. But electronic servicing has never been a comfortable field for those who like things to stay the same. We are a tough breed who can roll with the punches. The fact that the average age of service technicians is over 45 years, according to what I was recently told, proves it."

"That brings up a final point," Barney said. "Very few young men are coming into the TV repair field. If they get enough training to be good service technicians, they are snapped up by other services using electronics before they ever get good and started in TV repair. The apprenticeship here is too long and the pay is too short to attract youth. Now, with modular TV sets, it should be possible to train young men to do what is necessary in a comparatively short period of time. Maybe that, plus the rising income level that has been mostly brought about by organization, will attract sorely needed young men into TV repair." ◇



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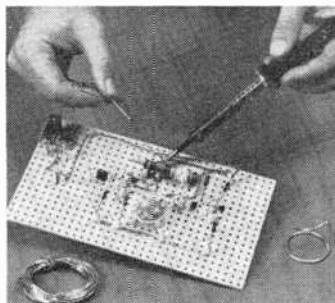
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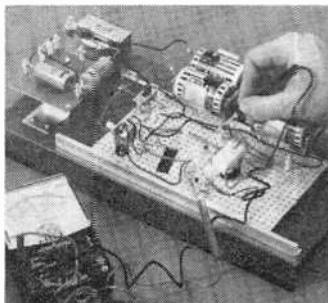
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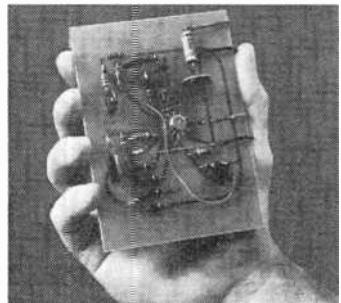
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Here's how two outstanding CIE students carved out new careers: After his CIE training, Edward J. Dulaney, President of D & A Manu-

### facturing, Inc., Scottsbluff, Nebraska, moved from TV repairman to lab technician to radio station chief engineer to manufacturer of electronic equipment with annual sales of more than \$500,000. Ed Dulaney says, "While studying with CIE, I learned the electronics theories that made my present business possible."

Marvin Hutchens, Woodbridge, Virginia, says: "I was surprised at the relevancy of the CIE course to actual working conditions. I'm now servicing two-way radio systems in the Greater Washington area. My earnings have increased \$3,000. I bought a new home for my family and I feel more financially secure than ever before."

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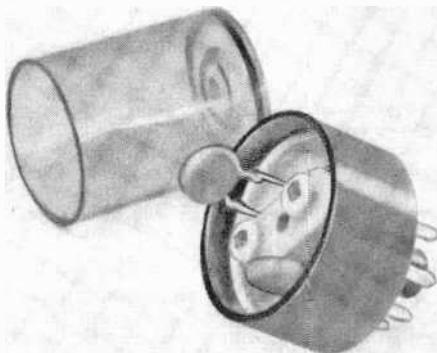
# Novel Temperature Control System

PTC Thermistor Opens the Door to Many New Ideas

BY W. L. GREEN

IT IS well known that there are two types of thermistors: those with negative temperature coefficients, and those with positive temperature coefficients. The former, whose resistance goes down as they are heated, are better known since they are widely used in temperature sensing and control circuits. The positive temperature coefficient (PTC) thermistor, however, also has some valuable uses—one of which will be described here.

The PTC thermistor used is made from modified barium titanate and it not only senses its own temperature, but generates its own heat to bring the ambient up to a specific value. Thus the thermistor seeks to maintain its own constant temperature, without any external equipment other than a power source.



Control chamber consists of an octal tube base, plastic pill container and cover, crystal socket, and two PTC devices. The latter are available at \$2.80 each from Alpha Research Corp., Box 1005, Merritt Island, FL 32952.

When power is first applied to the thermistor, it rapidly heats up to its own Curie Point (the temperature at which the internal resistance is five times that of the minimum temperature). Thus, if the Curie Point is 85°C and the PTC device is mounted in a small closed chamber, then the temperature within the chamber is also 85°C. At the Curie Point, the device resistance is very high, and very little power is consumed. The heating effect is then at a minimum. If the

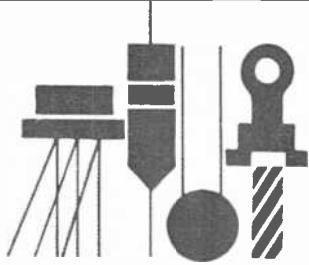
chamber temperature falls below 85°C, the device generates more heat to raise the temperature. If the ambient exceeds 85°C, the heat dissipation of the device decreases.

One good use for the PTC thermistor is to maintain a constant temperature in a small crystal chamber so that transmitters or other crystal-controlled instruments will remain on the correct frequency despite variations in room temperature. Power supply should be 12 to 28 volts ac or dc and should be capable of handling 1 ampere at the cold-start surge. The current then drops to about 50 mA in a few seconds.

To build a temperature controlled chamber for crystals, remove the base from a discarded vacuum tube (preferably octal) and remove the glass and lead wires from the pins. Obtain a plastic pill container whose cover is just wide enough to fit within the empty tube base. Cut a  $\frac{1}{8}$ " hole in the plastic cover and press it down into the base. Then solder a crystal socket and a pair of PTC devices to the pins. Cut the height of the plastic pill container to suit the height of the crystal to be used. Install the crystal and put the cover on the chamber.

Using a pair of 85°C PTC devices connected in parallel and a 12-volt supply, the crystal oven will maintain an internal temperature of 35°C in an ambient room temperature of 0°C. A pair of thermistors will adequately heat a volume of three cubic inches from -77°C to +20°C and since the temperature (low) crossover point of a properly cut quartz crystal is between +10°C and -20°C, this arrangement will work quite well in most applications. On the high end, the crossover point of a quartz crystal is about +75°C and, due to heat dissipation through the case, the internal temperature will not exceed 40°C with a 25°C ambient.

In designing with PTC devices, follow these rules: never connect PTC's in series; make the housing reasonably airtight; use a pair of 85°C PTC's for 3 cu. in. of volume; wire PTC's in parallel; use between 12 and 28 volts ac or dc; and be sure supply can withstand 1-ampere surge for a few seconds.



# Solid-State Scene

By Walter G. Jung

**A**CIVITY on the solid-state scene is expanding at a furious pace, particularly in the area of IC's. We are not referring just to premium price/performance industrial and military items either. The big news is in consumer electronics—the stuff you and I buy. Fresh new products with new ideas are here—at attractive prices. Take a look at the sampling here and see for yourself.

**Motorola and National Quad Op Amps.** These two companies have both introduced new types of op amps designed to fill the needs of single-supply systems normally found in industrial and automotive applications. However, these devices promise to go a lot farther than those uses, because of a rare combination of performance, versatility and economy.

Both manufacturers' devices are similar except for minor difference in certain specifications. All have the same pin configuration for the 4 differential input amplifiers as shown in Fig. 1. Motorola has devices in two temperature ranges—the MC3301P for 0 to 70°C, the MC3401P for -40 to +85°C. National's LM3900N is for 0 to 70°C.

All of the devices have internal compensation and simplified biasing for ease of applications.

Where can you use these new op amps? Virtually anywhere you would use an ordinary op amp, and in many unique ap-

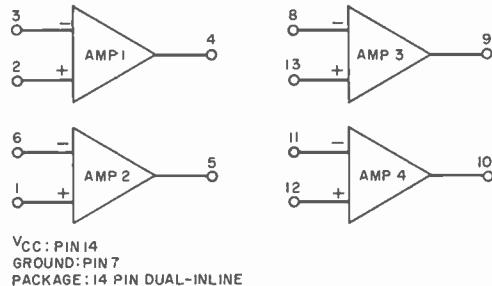


Fig. 1. Pin configuration for quad op amps MC3301P, MC3401P, LM3900N.

plications to boot. The manufacturers have such a wealth of applications already worked out; we could hardly begin to do them justice here in our limited space. Get the data sheets and application notes for the devices and you'll soon share our enthusiasm.

	Supply Range (volts)	Band-width (MHz)	Input Bias Current (nA)	Open Loop Gain
MC3301P	4 to 28	4	50	2000
MC3401P	5 to 18	5	50	2000
LM3900N	4 to 36	2.5	30	2800

As for prices: MC3301P is \$1.05 each for 1 to 24 units; MC3401P is \$1.10 each, 1 to 24; LM3900N is \$1.15 each, 1 to 99. For data and applications notes, see their respective distributors, or write to:

Motorola Semiconductor Products, Inc.

P.O. Box 20912

Phoenix, AZ 85036

National Semiconductor Corp.

2900 Semiconductor Drive

Santa Clara, CA 95051

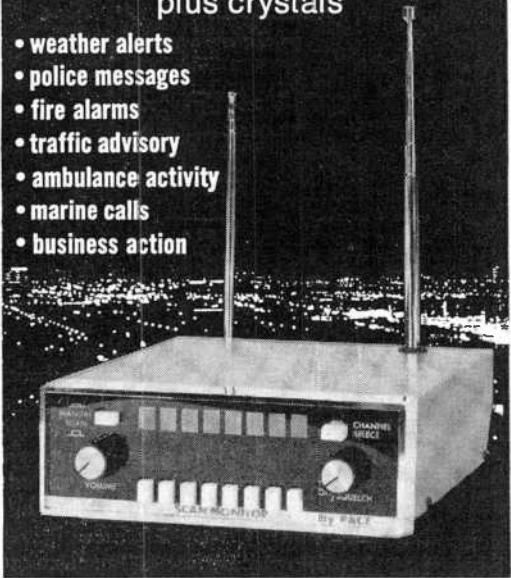
**Fairchild Three-Terminal Positive Regulator.** The  $\mu$ A7800 series, an extremely interesting IC chip, is now being marketed by

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Fairchild Semiconductor. The  $\mu$ A7800 is essentially a three-terminal "black box" voltage regulator—an unregulated voltage is applied at its input and a regulated voltage is obtained at the output. What could be simpler than the hookup shown in Fig. 2? The device comes with preset output voltages of 5, 6, 8, 12, 14, 18 or 24 volts, and can deliver over 1 ampere of current. Output impedance is well under 30 milliohms and line regulation is 0.0005%/volt.

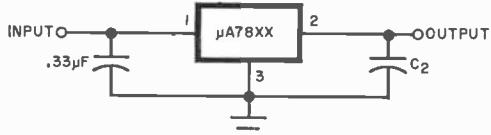


Fig. 2. Basic hookup for regulator.  
Output voltage substitutes for X's.

You can try, but you won't be able to blow out this regulator. It is internally current-limited, and has a thermal shutdown circuit and safe area protection for the pass transistor, making it quite accident-immune. The  $\mu$ A7800 is available in either a TO-220 plastic or TO-3 metal package.

Use of the  $\mu$ A7800 really takes the headache out of power supply design; however its use is not limited to this basic application. It can be used as a current regulator, adjustable output regulator, high-current regulator, part of a tracking regulator, pass element in a precision voltage supply, and even as an audio amplifier. You'll probably find this "no-hassle" approach to regulation attractive when you consider that the price of the  $\mu$ A7800 is \$2.20 for lots of 1 to 24. A data sheet and application note are available from your distributor or:

Fairchild Semiconductor

313 Fairchild Drive  
Mountain View, CA 94040

**Raytheon Low-Noise Stereo Preamplifier.** Good news for audio preamp experimenters is here from Raytheon in the form of the RC4739, a new dual-channel, internally compensated preamp IC. The RC4739 is designed specifically for improved signal-to-noise ratio in low-input-level applications such as RIAA phono preamps. In this application, it boasts a noise level 76 dB below a 10-mV input signal.

The RC4739 has a 110-dB open-loop gain, single or dual supply operation, high-level low-distortion output, short-circuit protection, and output swing of  $\pm$  13 volts into

2 kilohms, making it attractive as a low-noise general purpose op amp. An RIAA preamp abstracted from the data sheet is shown in Fig. 3.

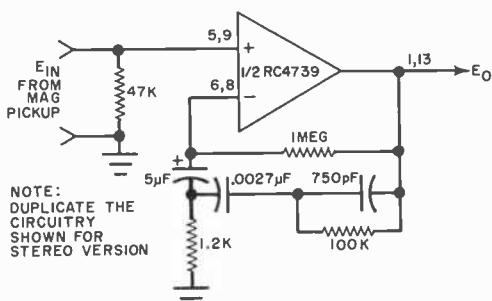


Fig. 3. RIAA phone preamp using the RC4739 has gain of 40 dB at 1 kHz, noise level of 1.7 microvolts referred to the input, S/N 75 dB below 10 mV.

By the time you read this, the 14-pin dual in-line unit should be on distributor shelves at a price in the neighborhood of \$1.00 in small quantities. Complete performance data and further application information are available from:

Raytheon Semiconductor  
350 Ellis Street  
Mountain View, CA 94040

**RCA Operational Transconductance Amplifiers.** RCA's pet new device, the operational transconductance amplifier (OTA) is a truly unique type of op amp. As its name implies, the OTA is an op amp that operates in the transconductance mode. Therefore, its output is a *current* (high-impedance) source as opposed to most op amps, which are *voltage* sources. The polarity of the output current is controlled by the differential inputs, as in a conventional op amp. But here is a second big difference. An OTA has a third input, an amplifier bias current terminal ( $I_{abc}$ ) which sets the maximum output current and controls the transconductance ( $G_m$ ). The voltage gain is simply  $G_m R_L$ . So an OTA is an op amp with an electronic gain control. We can vary  $I_{abc}$  to change  $G_m$  and thus change the voltage gain of the op amp—a rather neat trick.

The representative type of OTA is the CA3080. It operates from  $\pm 2V$  to  $\pm 15V$  supplies, has a typical  $G_m$  of 10,000 micromhos and a very linear range of gain control which is useful well over 3 decades (60 dB). The OTA is useful in modulators, multipliers, and switched amplifiers, or as

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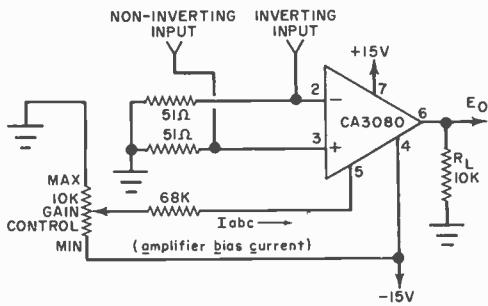


Fig. 4. OTA gain-controlled amplifier

a conventional op amp with low power (as little as 1 microwatt). Figure 4 shows the OTA's gain control capability, using the 10 kilohm gain control to vary  $I_{abc}$ . Either signal input may be used, depending on the desired output polarity, with best linearity below 50 mV peak-to-peak.

RCA has recently introduced another OTA with a husky power output stage following a basic CA3080 preamp. This is the CA3094. The preamp section has basically

the specs of a CA3080 but the npn output stage can handle 300 mA of peak current. It still has gain control and switching capability, as a basic OTA, but with the benefit of controlling the much larger currents.

Amplifiers built with the OTA's can have very good characteristics. For example, the circuit shown in Fig. 5 uses a CA3094 to drive a complementary output pair, with a feedback tone control built into the loop. This 12-watt amplifier has a total harmonic distortion of 0.1% or less, below its clipping level. It may be used with either standard high-level inputs or ceramic cartridges by changing those values noted.

Both devices come in 8-lead TO-99 packages. The CA3080 is available in quantities of 1 to 99 for \$0.97 each, while the CA3094 costs \$1.63 for comparable quantities.

For further information, consult your distributor or:

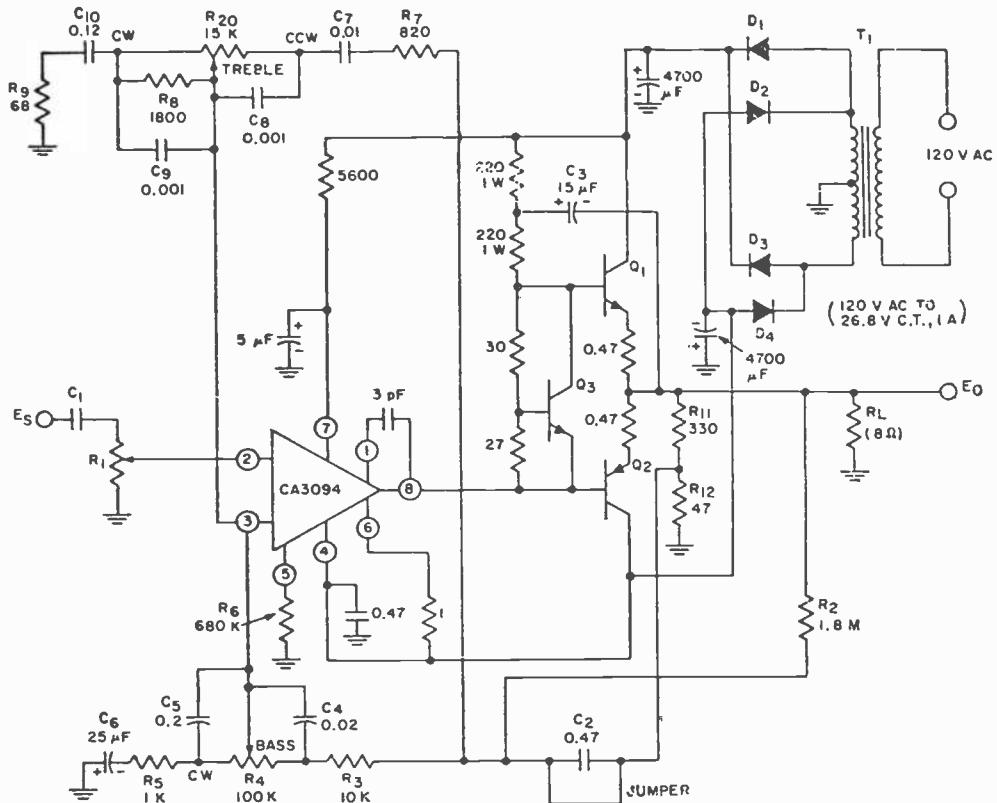
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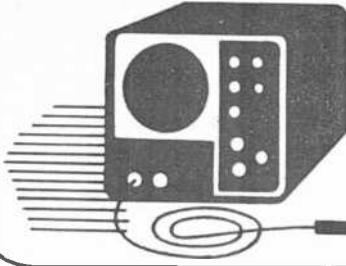
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Fig. 5. Complete power amplifier using CA3094. Q1 is 2N6292, Q2 is 2N6107, Q3 is 2N6288. For source of tuner or preamp output, C1 is 0.047 μF; R1, 250 K; omit C2 and R2. For ceramic cartridge, C1 is 0.0047 μF; R1, 2.5 megs; C2, 0.47 μF; R2, 1.8 megs.





# Test Equipment Scene

By Leslie Solomon, Technical Editor

A COMMON piece of test equipment on many benches is the audio signal generator. They are usually sine-wave generators, although other waveforms are also available. Let's find out how these instruments work—with an eye toward solving future test and servicing problems.

To start with, we'll consider the sine-wave devices since they are the most popular. These generators should have the following characteristics: low harmonic content, stable operating frequency, stable output amplitude, low spurious outputs (hum, noise, jitter, extraneous modulation), and good dial and range accuracy coupled with good dial and range repeatability. They should also have enough output (usually variable) to drive a broad range of loads. What about the frequency range? Well, they should cover more than the entire audio spectrum from below 20 Hz to above 30 kHz (with a maximum between 50 and 100 kHz probably a good choice).

Most of today's generators use a Wien-bridge circuit such as that shown in Fig. 1A. The network consisting of  $R1C1$  and  $R2C2$  determines the oscillation frequency. The resistors are usually made variable to "tune" the exact frequency, while the capacitors are usually switched to provide ranging. Interestingly enough, this basic

circuit will not oscillate properly with only these components providing positive feedback. It is necessary to introduce a nonlinear element into a negative feedback loop; in Fig. 1A, this element is  $R3$ . This resistance usually takes the form of an incandescent lamp whose resistance at startup is low, permitting the circuit to start to oscillate. As more and more current flows through the lamp, its resistance increases, which increases the negative feedback and reduces the oscillation level. After a few cycles, the resistance just "balances" the circuit for best oscillation. So that little lamp in your audio generator is not an internal chassis illuminator! If the lamp should need replacement, be sure that you use an identical substitute.

The low-frequency limit of a Wien-bridge oscillator is about 1 Hz due to the thermal "speed" of the lamp, while the upper limit is determined by the amplifier and is usually about 1 MHz.

The phase-shift oscillator (Fig. 1B) uses a three-section phase-shifting RC network and an amplifier having a gain of 29. Each section of the network has  $60^\circ$  of phase shift at the frequency of interest thus totaling  $180^\circ$ . When this is added to the  $180^\circ$  phase shift of the amplifier (plus its gain), the circuit is primed for oscillation. Actual oscillation starts with a small disturbance in the amplifier (usually the application of power). This disturbance is amplified, shifted in phase by  $180^\circ$ , and applied back to the input of the amplifier where it is amplified and shifted again by  $180^\circ$ . This circuit is used primarily for only one frequency (whose waveform is excellent), and can be "fine tuned" by making one of the resistors variable.

Some systems (especially home-made versions) use the twin-T approach as shown in Fig. 1C. This will be recognized as a

## Audio Generators: How They Work

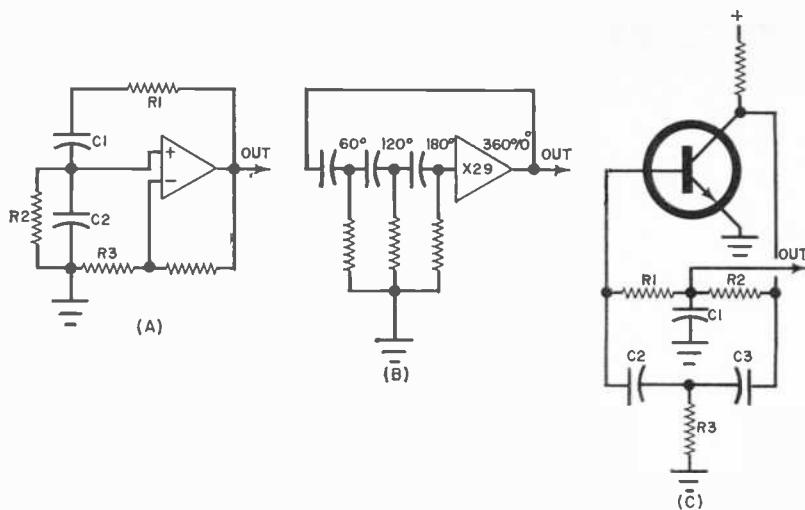


Fig. 1. Various methods of generating sine waves. The Wien bridge is shown at A; the phase-shift oscillator at B; and the twin-T configuration at C.

basic organ tone generator. In this circuit,  $R_1$ ,  $R_2$ , and  $C_1$  form a low-pass filter, while  $C_2$ ,  $C_3$ , and  $R_3$  are a high-pass filter. Since the phase shifts of these two networks are opposite, the only frequency at which the device can oscillate is where the total phase shift across the two networks is  $180^\circ$ . It is at this frequency that oscillation takes place. The best results occur when  $C_1$  is about twice the capacitance of  $C_2$  and  $C_3$  (which have the same value) and  $R_3$  is about one tenth the value of  $R_1$  and  $R_2$  (which also have the same value). The circuit is trimmed by  $R_3$ , and the output is taken from across  $C_1$ , where the harmonic distortion is lowest. The output of this circuit must be coupled through a high-impedance buffer to prevent loading. The transistor must have a high beta.

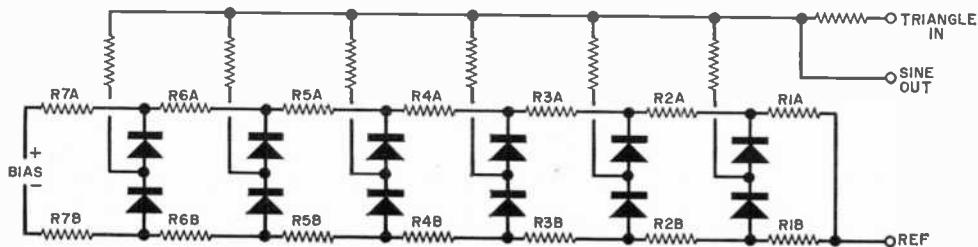
**Synthetic Sine Waves.** The synthetic sine-wave approach is used in some expensive laboratory types of generators. The theory

is to create a number of small straight-line segments joined together so that the result looks like a sine wave—but with a number of tiny steps in it. The wave is thus like the top of a picket fence whose tips have been cut to resemble a sine wave. Obviously, the more segments, the better the approximation to the desired waveform.

The circuit in Fig. 2 illustrates the use of 12 diodes and associated resistors to synthesize a sine wave from a triangle wave to within 0.25% rms error. Why a triangle wave? Because this is an easy waveform to produce with op amps—which are now being used extensively in test equipment.

The 12 diodes are arranged in pairs and connected to a bias network as shown. The input triangle waveform is applied to the common junction of each pair. The network consisting of  $R_{1A}$  through  $R_{7A}$  biases the upper row of diodes (with respect to the reference output) in a voltage progression that represents the positive peaks of each

Fig. 2. This diode circuit synthesizes a sine wave from a triangle wave. The bias arrangement determines at which point in the triangle each of the diodes comes in.



of the six segments for the positive-going portion of the synthesized sine wave. Resistors R1B through R7B bias the lower diodes for the negative peaks of each of the six segments that form the negative-going portion.

If we assume that the applied triangle starts with its positive-going edge first, then the sine-wave output will follow until the bias level of the first diode is reached, and the waveform is clipped. As the triangle wave continues to increase in amplitude, each diode step clips at its predetermined voltage. The triangle is thus converted into a series of clipped steps that resemble a half sine wave with bumps. The same thing happens on the negative-going portion of the triangle wave, except that the other diodes come into play. The resulting rough sine wave is suitably filtered to make it smoother.

**Sine-Wave Testing.** First, and most important, you have to know just how good your sine wave is. Do not automatically assume that a device marked "sine-wave generator" is putting out a pure sine wave. Actually, most devices come under the heading of "almost sinusoidal oscillator" in which some nonlinearity within the system plays an important role. In most cases, of course, the nonlinearity is small to avoid distorting the output. Unfortunately, there is little that the user can do with a finished generator. In our November 1972 column, we discussed active differentiation. A test circuit of that type, plus a few hours of "diddling" with components, may produce a better waveform.

**What to Look For.** First, make sure that the generator covers the frequency range of interest—with a little extra for further experimentation. Although sine waves are commonly used, both square and triangle waves are of great value (more about these in a future column).

Dial accuracy is a must, and the use of Lissajous figures with known frequencies (WWV for example) can be used to check accuracy. Repeatability is also important, as is frequency stability (both with line variations and temperature). With regard to stability, RC oscillators are the least stable, while Wien bridges are somewhat better than phase shifters. Output flatness is important and can be checked with an external VTVM or TVM if the generator does not have its own meter.

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# Volta and his



## “Electric Pile”

WHEN Alessandro Volta, Italian physicist and protege of Napoleon Bonaparte, announced the invention of his “electric pile” in 1800, he touched off an explosion of scientific discoveries and technological innovations that have shaped the world we know today. Volta’s pile, forerunner of modern primary-cell batteries, was a revolutionary device because it was the very first source of continuously flowing electrical energy.

Just prior to Volta’s announcement, scientists were preoccupied with the problems of understanding and applying the only kinds of electricity known at the time—static electricity and the mysterious “animal electricity” discovered by Luigi Galvani. Volta’s pile changed the course of electrical research, leaving the brief sparks of static

electricity behind as a specialized branch of physics and making Galvani’s discoveries into nothing more than a scientific curiosity.

As a professor of physics at the Italian universities at Como and Pavia, Volta spent the first thirty years of his career looking for ways to generate, measure, and control static electricity. His electrophorus and condensing electroscope both evolved directly from this line of work. When Galvani sent him a copy of a paper describing a new kind of “animal electricity,” Volta immediately dropped his work, and began reproducing the famous frog-muscle experiments. His primary objective was to help Galvani explain his strange observations.

Galvani, an Italian physician in Bologna, had accidentally discovered that touching the nerves in a frog’s leg with a pair of unlike metals made the muscles convulse. He thought that the living tissues, and not the metals, were the source of electrical energy. Galvani called this form of electricity “animal electricity” to distinguish it from static electricity, and he sincerely believed he had uncovered the secret force of life.

According to Galvani, the nerve tissue generated the electrical energy that made the frog’s leg convulse. In the light of modern electrophysiology, he wasn’t far from wrong. Where Galvani went off track was with his belief that the metals merely completed the circuit between nerve and muscle. As a methodical experimenter, Volta tried the experiment using two pieces of the same metal—something that never occurred to Galvani. The frog’s leg did not twitch. The discrepancy came as a big surprise to both men. Volta responded by re-evaluating Galvani’s theory. Galvani and his followers responded by criticizing Volta’s new-fangled experimental procedures.

At the time, it took a great deal of bold and creative insight to propose that the metals, and not the animal tissues, were behind this new kind of electrical energy. When Volta arrived at this notion, he began a series of experiments to show that a pair of unlike metals can produce electricity without the help of any kind of animal tissues. His first experiments used a single pair of metals bathed in either a brine solution or a dilute acid. Volta, by the way, was never able to explain the function of the brine or acid.

When Galvani heard about Volta’s new experiments, he responded by pointing out

BY DAVID L. HEISERMAN

the fact that an electric eel can produce large amounts of "animal electricity," without the help of any kind of metal. For the time being, this argument stumped Volta; but it didn't stop him.

The only research instruments at the time were those designed for studying static electricity—hardly the kinds of instruments a modern-day technician would use to study the nature of batteries. Thus, Volta had to juggle electroscopes, charged glass rods and slabs of resin to measure his "metallic contact electricity."

Volta determined the relative intensity of his electrical forces by charging an electro-scope with his brine-bathed metals. The farther the leaves separated, the larger the electrical tension. He determined the polarity of his potentials by first charging an electro-scope with a static charge of known polarity, then touching it with one of the metallic electrodes. If the leaves fell together, the electrode had a charge opposite that of the reference static charge. If the leaves separated even farther, the polarity had to be the same as the reference static charge.

His first experiments showed that different combinations of electrode metals produced different polarities and amounts of electrical tension. By mating all possible pairs of electrodes made from lead, zinc, copper, graphite, silver and gold, Volta constructed the first table of electromotive elements. He and other investigators later used this table to predict the voltages and polarities a certain combination of metals would produce.

While Galvani was quietly gathering supporting data for his findings, Volta had to work between bouts of accusations and "public insults" concerning his allegiance to Italy. When Napoleon and his armies stormed into northern Italy, making Volta's state of Lombardy part of the French Empire, Volta was one of the Italians sent to greet the noted conqueror. Being a resident of the little state, Volta wasn't overly enthusiastic about his mission; but, having met Napoleon in Paris several years before, Volta decided it would be wise to move with the tide of the times, and make the best of the political situations around him.

Volta wasn't a traitor in the usual sense because the people of Lombardy had always been sympathetic to the French cause. They looked upon Napoleon as one who could finally unify the separate states of their

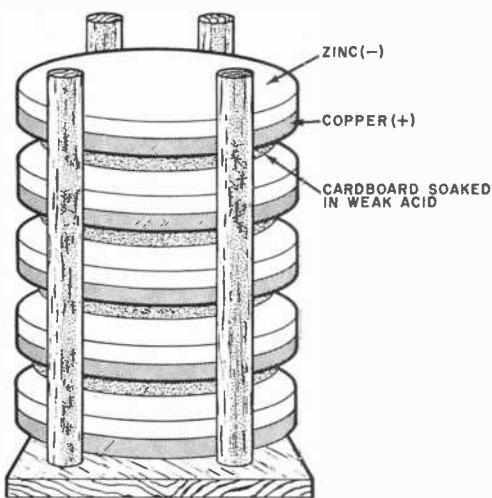
nation. Nevertheless, a few influential Italians living in other parts of the country began making trouble for the physicist. To add fuel to the animosities between Volta and Galvani, the physician stubbornly refused to pledge allegiance to the French flag. Volta's situation became so bad at one point that Napoleon, himself, intervened to save the neck of his favorite scientist.

When the political air finally cleared, Volta returned to the scientific tasks at hand. The only remaining problem was finding a way to get a more convincing amount of electrical tension from his contact metals. He came upon the idea of piling copper and zinc discs on top of one another, sandwiching a piece of brine-soaked cardboard between each pair. This "pile" of metals and cardboard actually formed what we now know as a series aiding circuit.

In 1800, Volta described the final results of his work in a long, two-part letter to Joseph Banks, President of the Royal Society of London. Banks prepared the letter as a formal scientific paper for the *Philosophical Transactions of the British Royal Society*. Published under the title of "On the Electricity Excited by the Mere Contact of Conducting Substances of Different Kinds," the world learned of Volta's source of continuously flowing electrical energy.

This famous paper clearly showed that a chemical action between pairs of brine- or acid-soaked metals produced the new form of electricity. Thus, Galvani's theory suffered a sudden and complete death.

Lower part of Voltaic pile. Most had 30 sets of metal and cardboard discs.



The first part of Volta's paper described the construction and effects produced by his electric pile: ". . . if the sets of triplets of the plates be added 20 or 30 more, disposed in the same order, the actions of the extended pile will be much stronger, and be felt through the arms up to the shoulders; and by continuing the touchings, the pains in the hands become insupportable."

Volta also noted that the "perpetual" electrical action stopped as the cardboard pieces began to dry out. To remedy this problem Volta invented the "crown of glasses"—glasses filled with a weak acid solution and containing a pair of unlike metals. By attaching wires from an electrode of one kind to an electrode of the other kind in another glass, Volta wired up what we now know as a series cell arrangement. This makes up a more familiar version of

wet-cell batteries that are employed today.

Although Volta and Galvani were bitter enemies, Volta gave Galvani full credit for leading him into the kind of research that resulted in the "pile" and "crown of glasses." Largely due to Volta's support, his "perpetual" current became known as "galvanic current." Electrical researchers later named the galvanometer after the unfortunate Italian physician.

Volta, however, could not resist taking one public jab at the man who had been his rival for so many years. When Napoleon invited Volta to demonstrate his inventions before the political and scientific leaders of the French Empire, Volta introduced his electric pile by unwrapping it from the skin of an electric eel—the animal that represented Galvani's strongest argument for "animal electricity."



## A PERMANENT 3.75-Volt SUPPLY

By FRANK H. TOOKER

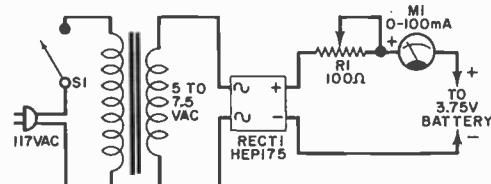
THOSE readers who have been passing up the 3.75-volt nickel-cadmium battery offered currently being made by *Edmund Scientific Co.* (300 Edscorp Bldg., Barrington, NJ 08007) are overlooking an especially good buy. These batteries are hermetically sealed in steel cases. They maintain a constant potential during discharge and have excellent charge retention properties. They are rated at 750 mA-hours. And they sell for only \$2.40 each. To top it all off, the Edmund people guarantee these batteries for at least 300 charges, provided the recommended charging rate is not exceeded.

Edmund's Stock No. 60,633 batteries can be used in any application where any other battery can be used—and in some applications where other batteries just can't hack it.

The charging rate of a nickel-cadmium battery is very important. Edmund recommends that their batteries be charged at a rate not greater than 75 mA over a period of 16 hours. In many applications, however, a charging rate of only 35 mA will keep the batteries charged.

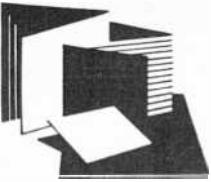
Charging can be accomplished by any dc source, the potential of which must be significantly greater than the nominal 3.75-volt rating of the battery pack. All that is necessary to assure a safe charging rate is a current-limiting resistor between the battery pack and the charging source.

A simple ac-powered charger for the Edmund battery pack is shown in the schematic diagram. Note that a step-down transformer capable of delivering between 5 and 7.5 volts at the secondary is connected to a full-wave bridge rectifier assembly. Potentiometer  $R1$  is the limiting resistor, while milliammeter  $M1$  allows the user to visually set the charge rate to the proper level. The output from the charger is unfiltered, which is perfectly safe and satisfactory for Ni-Cad battery charging.



For applications like continuous, 24-hour-a-day, operation of crystal oscillators, for portable test instruments employing digital RTL integrated circuits, and for alarm and surveillance service (to name but three), the battery is unsurpassed in performance and reliability. And Edmund's low price of only \$2.40 for the 3.75-volt battery pack makes it realistic and worthwhile to have several packs on standby, ready to go into service for any new application or emergency that should happen along.





## New Literature

### LITTELFUSE CADDY ASSORTMENT CATALOG

A short-form catalog featuring their extensive product line of exact replacement fuse and circuit breaker caddy assortments is available from Littelfuse. It describes the new "One-Stop Service Caddy" which provides a convenient two-in-one assortment of eight popular breakers and 30 of the most widely used fuses; "Serviceman's Favorite" basic caddy with 18 compartments containing 75 fuse ratings in both the Quick-Acting and Slo-Blo series, and more. For a copy of Catalog FCA, write to: Littelfuse, Inc., Dept. PR, 800 E. Northwest Hwy., Des Plaines, IL 60016.

### SEMICONDUCTOR CATALOG

A 92-page Semiconductor Supermarket catalog containing listings for transistors and integrated circuits by Motorola, RCA, Fairchild, National, and Motorola HEP is now available from Circuit Specialists. The catalog contains many device connection diagrams and how-to-use circuits for IC's. While featuring solid-state devices, the catalog also lists resistors, capacitors, and other parts as well as Midland CB gear, Jetco treasure finders, and assorted test instruments. Address: Circuit Specialists Co., Box 3047, Scottsdale, AZ 85257.

### PLATO PRODUCTS SOLDERING TIP CATALOG

An extensively revised 28-page soldering tip catalog (No. 0372) has been issued by *Plato Products, Inc.* Illustrated with dimensional drawings to facilitate accurate selection, the catalog lists tips to fit all leading brands and models of soldering irons, desoldering tips for connectors, 14- and 16-pin DIP packages and flat packs, tip wipers, iron holders, and desoldering wicks. Address: Plato Products, Inc., P.O. Box 1019, El Monte, CA 91734.

### BROOKSTONE HARD-TO-FIND TOOLS CATALOG

The *Brookstone Company's* latest "Hard-to-Find Tools" catalog, featuring 149 new entries is the usual bonanza of listings for the professional and hobbyist alike. Tools for all types of work—machinists, electronics hobbyists, cabinet makers, auto mechanics, etc.—are listed in this 56-page catalog. Address: Brookstone Co., Dept C, 11 Brookstone Bldg., Peterborough, NH 03458.



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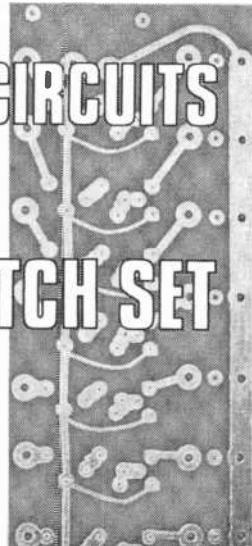
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## Electronics Library

### MODERN DICTIONARY OF ELECTRONICS, Fourth Edition

by Rudolph F. Graf

As new technologies evolve, new terminology must be developed to communicate, describe, and define the previously unknown concepts, components, and techniques. Here is where this book plays a vital role. It contains definitions of some 18,000 terms used in the various areas of electronics. About 2000 terms have been added, and hundreds of existing definitions have been updated in this edition. Illustrations are included to explain many of the definitions.

*Published by Howard W. Sams & Co., Inc., 4300 West 62 St., Indianapolis, IN 46268. Hard cover. 688 pages. \$12.95.*

### HANDBOOK OF LOGIC CIRCUITS

by John D. Lenk

As a good "handbook" should be, this is an all-round reference work for the beginner and the expert in logic design. After presenting basic logic symbols, equations, and circuits, the author shows how these are used in logic networks, decoders, encoders, function generators, flip-flops, counters, registers, shifting elements, etc. An appendix provides explanations of logic mapping systems, procedures for testing logic circuits, and various logic tables.

*Published by Reston Publishing Co., PO Box 547, Reston, VA 22090. Hard cover. 307 pages.*

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### HOW TO INTERPRET TV WAVEFORMS

by Forest H. Belt

This photo/text guidebook was created specifically to clear up many current mysteries about TV waveforms. More than 250 photos of actual waveforms on an oscilloscope display are large enough to show subtleties in shape. Scope settings in obtaining each waveform are explained and any unusual special requirements are listed. Not only does the book show what normal waveforms should look like, but —more importantly—it shows what happens to each key waveform under various component fault conditions.

*Published by Tab Books, Blue Ridge Summit, PA 17214. 256 pages. \$7.95 hard cover; \$4.95 soft cover.*

### ELECTRONIC ANALOG AND HYBRID COMPUTERS, Second Edition

by G.A. & T.M. Korn

Completely revised, expanded, and updated, this new edition makes available current practical information on analog and digital computers. Much of the material has never before been published. This book is unique in its emphasis on hardware information on new hybrid analog/digital computing devices for handling live instrumentation and controlling data. It will be of value to circuit designers, project engineers, and anyone else who must keep abreast of what is going on in computer technology.

*Published by McGraw-Hill Book Co., 1221 Ave. of the Americas, New York, NY 10020. Hard cover. 421 pages. \$21.50.*

### NORTH AMERICAN RADIO-TV STATION GUIDE

by Vane A. Jones

All the radio and television stations in the U.S., Canada, Mexico, and West Indies, nearly 10,000 in all, are listed in this up-to-date guide. The more than 5500 AM, 3000 FM, and close

to 1200 TV stations presently on the air, scheduled to start soon, or temporarily off the air are categorized by geographic location, frequency (or channel), and callsign. Important statistics, such as power by night and day, antenna height, time sharing between stations, and network affiliation, are given for each station. Educational stations are designated, as are FM stations broadcasting in stereo.

*Published by Howard W. Sams & Co., Inc., 4300 West 62 St., Indianapolis, IN 46268. Soft cover. 160 pages. \$3.95.*

### SIMPLE, LOW-COST WIRE ANTENNAS FOR RADIO AMATEURS

by William I. Orr, W6SAI

For the ham looking for an authoritative book on building tested wire antennas, only a few worthwhile ones are available. This new book is one of them. Designed with an eye toward economy and maximum performance, the antennas described are simple and inexpensive. Exact dimensions are given, thus avoiding the need for calculations and guesswork on the part of the reader. Many of the antennas work efficiently on two or more amateur bands.

*Published by Radio Publications, Inc., Box 149, Wilton, CT 06897. Soft cover. 192 pages. \$3.95.*

### MAGNETIC RECORDING

by Charles E. Lowman

This is an authoritative and practical guide to the technology of magnetic recorders used in such fields as audio recording, broadcast and closed-circuit TV, instrumentation recording, and computer data systems. The most up-to-date circuitry, newest techniques, and latest innovations are covered in basic language with a minimum of mathematics and many helpful illustrations. The text discusses the applications, advantages, and limitations of magnetic recording, its basic principles and theory.

*Published by McGraw-Hill Book Co., 1221 Avenue of the Americas, New York, NY 10020. Hard cover. 285 pages. \$14.50.*

### QUESTIONS & ANSWERS ABOUT COLOR TV, Second Edition

by Leo G. Sands

Answered in this book are 124 of the most frequently asked questions about color TV. The contents are divided into four parts. The first deals with theory and operation; the second with installation procedures and problems; the third with color TV servicing; and the fourth with how to make simple modifications of and additions to receivers to improve and extend their capabilities.

*Published by Howard W. Sams & Co., Inc., 4300 West 62 St., Indianapolis, IN 46268. Soft cover. 96 pages. \$3.95.*

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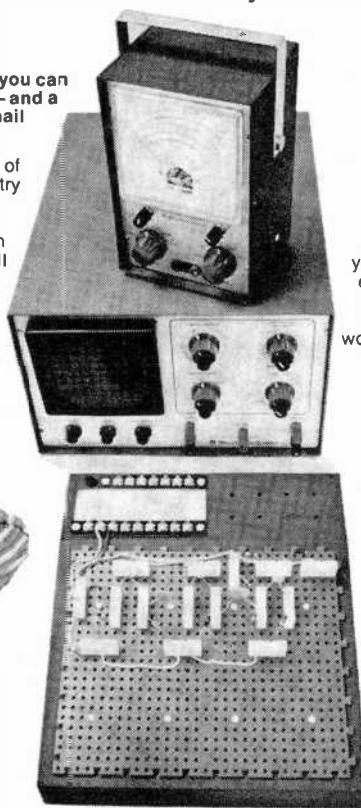
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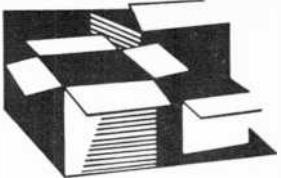
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## New Products

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Four new solid-state vhf-FM business band transceivers are being offered by Sonar Radio Corp. Depending on the model selected, the user has a choice of single- or four-channel operation and 10 or 25 watts output. All are designed to operate in the 148-174-MHz band, and all are specified at 2 watts (audio) output with less than 10 percent distortion. The single-channel/10-watt version is designated Model 2101, while the four-channel 10-watt version is Model 2102. The more powerful 25-watt ver-



sions are Model 2103 (single-channel) and Model 2104 (four-channel). Operating power is from a 13.8-volt dc, negative ground only, source. In the Models 2102 and 2104, channel selection is via a bank of pushbutton switches.

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### NEW GARRARD AUTOMATIC TURNTABLE

A new automatic turntable that gives the buyer a choice of either a Shure or a Pickering magnetic cartridge with elliptical stylus has been introduced by Garrard. The Model 42M/S contains a Shure cartridge, while Model 42M/P contains a Pickering cartridge. The turntable highlights a gimbaled low-mass aluminum tonearm with a fixed counterweight in correct balance for the particular cartridge selected. A damped cueing and an adjustable antiskating device are also featured.

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### MALLORY BURGLAR ALARM

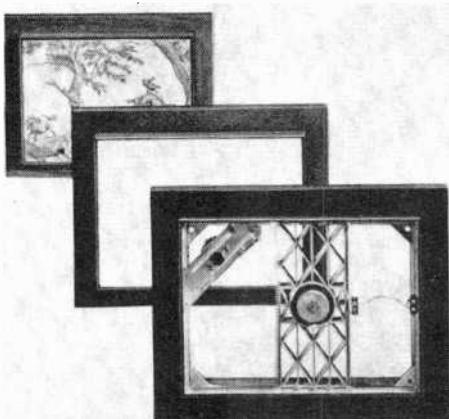
The "Bloc-Alarm" is a miniature battery-operated intruder alarm recently introduced by the *Mallory Battery Co.* Shaped like a door wedge, the alarm is placed at the foot of the entry door to be protected. Its wedge shape

physically prevents easy access. Almost any pressure on the actuating plate trips the alarm, setting off an almost deafening tone. Once tripped, the actuating plate must be manually reset to turn off the alarm.

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### FISHER "SOUND PANEL" SPEAKER SYSTEM

Fisher Radio has patented and is currently marketing a radically designed speaker system that can be used on the floor as a screen, hung



on the wall like a picture, or suspended from the ceiling. Called the Model PL-6 "Sound Panel," it measures 29 $\frac{1}{4}$ " by 23 $\frac{3}{4}$ " by a mere 2 $\frac{1}{8}$ " thick. The system consists of two drivers, each consisting of a large concentric magnet and voice coil, which convert electrical impulses into vibrations that are radiated through a high-density polymer diaphragm. The result is said to be true hi-fi reproduction with natural sound over a wide dynamic range in an omnidirectional radiation pattern.

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### ANTENNA SPECIALISTS' CB ANTENNA KIT

Antenna Specialists Co. has come up with an answer to two-way CB installations in motor homes and other RV's where a fiberglass roof makes it difficult to establish a "ground plane" for the antenna. It is their new Model M-246 Motor Home Antenna Kit consisting of a high-performance base-loaded mobile antenna, universal plate-type camper mount, stainless steel shock spring, and the company's exclusive ground plane kit with which an effective ground plane can be achieved on the roof surface by means of an interconnected tape grid. The mounting plate can be fastened to either the side or the top of the vehicle.

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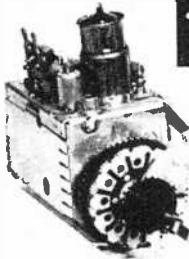
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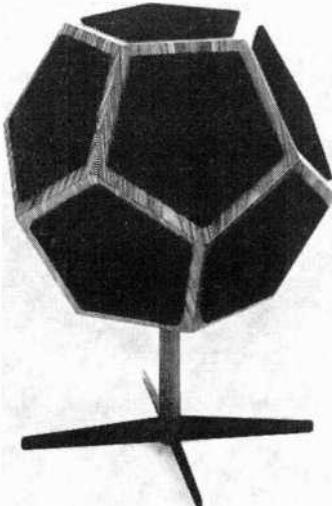
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ference that plague TV viewers. The new antenna series provides the highest signal sensitivity but concentrates on supplying high directivity needed to reject increasing amounts of electrical noise. The new Quantum Series is said to be the most highly directive antenna currently available, with front-to-back ratios up to 50 percent higher than those of the powerful Color Crossfire. The new line encompasses 7 vhf/FM and 8 uhf/FM/vhf models for metropolitan to deepest fringe areas.

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## DESIGN ACOUSTICS SPEAKER SYSTEM

Design Acoustics is a new company in the hi-fi speaker system field. Their specialty at present is omnidirectional speaker systems as represented by their Model D-12 system. This new speaker system uniformly disperses sound over a



full 360° in a given listening area. Its power response is given at ±2 dB from 30 Hz to 15,000 Hz. The system employs nine 2½" cone tweeters, a 5" midrange driver, and a 10" high-compliance woofer. A choice of wood finishes and grille colors is available.

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## INTECH HANDHELD MARINE RADIOTELEPHONE

The Intech Model V101 is the first completely American made, low-cost, handheld radio-telephone specifically designed for marine use. It is expected to extend the use of portable vhf radiotelephones to small pleasure craft as well as to satisfy portable communication needs for commercial vessels. The V101 has a 9-channel capability and operates on any of the simplex or duplex channels. It utilizes a unique frequency synthesizer that requires only one crystal per channel. A dual-gate MOSFET is used in the receiver to provide large signal handling capability, and IC's are used in the

transmit buffer, power amplifier, i-f amplifier, and audio power amplifier.

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### MURA QUADRAPHONIC HEADPHONES

Anticipating the trend toward 4-channel sound in hi-fi equipment over a year ago, Mura Corp.



went all out and recently introduced their Model QP-300 quadraphonic headphones. Full fidelity is achieved by the ingenious use of eight drivers, two woofers and two tweeters in each earcup. Acoustical porting enhances the tonal quality of the headsets to the maximum. Soft simulated leather headband and lightweight oversize ear cushions provide extra comfort for added listening pleasure.

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### WORKMAN SPEAKER GUARD

Stereo installers often overload their speakers with overamplification which can damage both the speakers and the driving amplifier. Workman Electronic Products, Inc., has devised a "Speaker Guard" which consists of a resistor and a circuit breaker for overcoming this problem. An overload in power from the amplifier's output activates the circuit breaker and prevents damage when the Speaker Guard is installed. The Speaker Guard is available in 18 different models with varying combinations of power (watts) and speaker impedance values.

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### SIMPSON HIGH-FREQUENCY PROBE

Designed for use with the Model 2795 solid-state electronic multimeter, Simpson Electric Company's Model 2791 high-frequency probe offers quite a number of features. It provides a wide measuring range of 0.1 to 25 volts rms and a frequency range of 10 kHz to 800 MHz. It can be used as an indicator up to 1 GHz. Rated accuracy is 15 percent through 300 MHz. In addition, the Model 2795 has built-in linearizing circuitry to provide direct reading on linear scales, and built-in temper-

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2. Date of filing: September 29, 1972.

3. Frequency of issue: Monthly.

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William L. Phillips, Assistant Treasurer

#### II. Extent and nature of circulation:

	Average No. Copies Each Issue During Preceding 12 Months	Actual Number of Single Copies Published Nearest to Filing Date
A. Total No. Copies printed (Net Press Run) .....	476,847	476,439
B. Paid Circulation		
1. Sales through dealers and carriers, street vendors and counter sales .....	58,238	55,182
2. Mail subscriptions .....	323,556	326,057
C. Total paid circulation .....	381,794	381,239
D. Free distribution by mail, carrier or other means		
1. Samples, complimentary, and other free copies .....	12,011	11,037
2. Copies distributed to news agents, but not sold .....	79,584	80,918
E. Total distribution (Sum of C and D) .....	473,389	473,194
F. Office use, left-over, unaccounted, spoiled after printing .....	3,458	3,245
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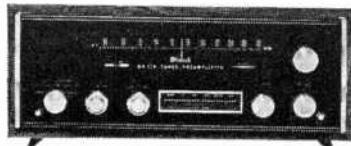
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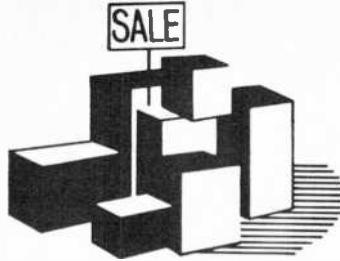
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# Surplus Scene

By Alexander W. Burawa, Associate Editor

## DEALERS IN THE BOSTON AREA

MOST Americans know Boston and environs as being a historical landmark, site of the Boston Tea Party and other rebellious acts against King George III of England. To most experimenters and hobbyists in electronics, however, the Boston area is equally important as a primary source of surplus parts and equipment and all types of solid-state devices. In the outlying districts, not far from downtown Boston, are located no less than three of the most active suppliers of bargain-priced solid-state components (among them diodes, transistors, and digital and linear IC's) and numeric readouts.

Longest on the Surplus Scene, Poly Paks (P.O. Box 942E, Lynnfield, MA 01940) offers the buyer a wide range of items ranging from a Philco 11-transistor AM radio chassis for only \$5.95 to a digital electronic clock by Scientific Devices for only \$57.00. Of primary interest to the experimenter is the wide variety of low-cost linear and digital IC's, transistors and diodes, and numeric readouts offered by the company.

Moving along to Peabody, we find B & F Enterprises (119 Foster St., Peabody, MA 01960), another big name in new surplus solid-state devices, especially the ever-popular 7400 series digital IC's and their associated numeric readouts. A very hot item currently in the B & F inventory is connectors, all types and sizes for modules and PC cards. The company is also moving into the kit area, offering no less than two calculators, a desk-top (\$99.00) and a pocket-size model (\$75.00), a digital electronic clock (\$57.50), a six-digit, 50-MHz frequency counter (\$97.50), and a quartz-crystal chronometer (\$59.50) for use in cars, campers, boats, etc. The current catalog lists all types of electronic components and hardware, computer memory stacks, power sup-

plies, and other hot items that can be had at very low cost.

Solid State Sales (P.O. Box 74A, Somerville, MA 02143) seems to have made a total commitment to semiconductor components, although their current literature lists a limited line of tantalum capacitors and miniature trimmer potentiometers. As its name implies, the company has a very broad range of semiconductor items that includes LED's, variable-capacitance diodes, low-current seven-segment DIP numeric readouts, transistors, rectifiers, triacs, bridge rectifiers, phase-locked loops, and a full lineup of the most commonly used 7400 series digital IC's and 700 series operational amplifiers. A decade counting kit consisting of a neon-glow readout tube and socket and 7490, 7475, and 7441 IC's is available at a low \$4.75.

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For industrial, government, and military surplus equipment of every description, an excellent source to try first is John Meshna, Jr. (19 Allerton St., Lynn, MA 01904). John is a hard-line old timer in the surplus business, limiting himself to buying up and selling true surplus gear. He has not gone into the IC and kit business, leaving that to the relative newcomers to the Surplus Scene, though he does from time to time feature hard-to-find semiconductor items.

While the Boston area dealers are basically mail-order companies, they do some of their business in walk-in trade. ◇

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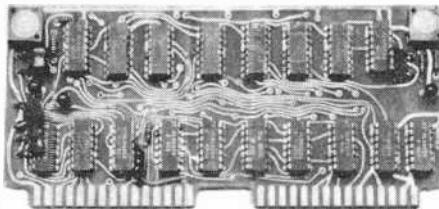
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7408	32	150	47	41	12	19	7457	162	153	115	126	120	119
7409	32	150	47	41	12	19	7458	162	153	115	126	120	119
7410	26	25	25	25	21	20	7459	120	114	107	100	95	89
7411	26	25	25	25	21	20	7460	120	114	107	100	95	89
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7429	32	150	47	41	12	19	7484	190	195	176	165	151	144
7430	32	150	47	41	12	19	7485	190	195	176	165	151	144
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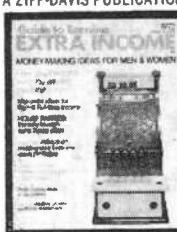
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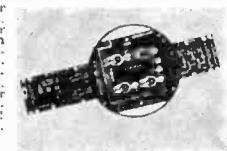
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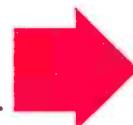
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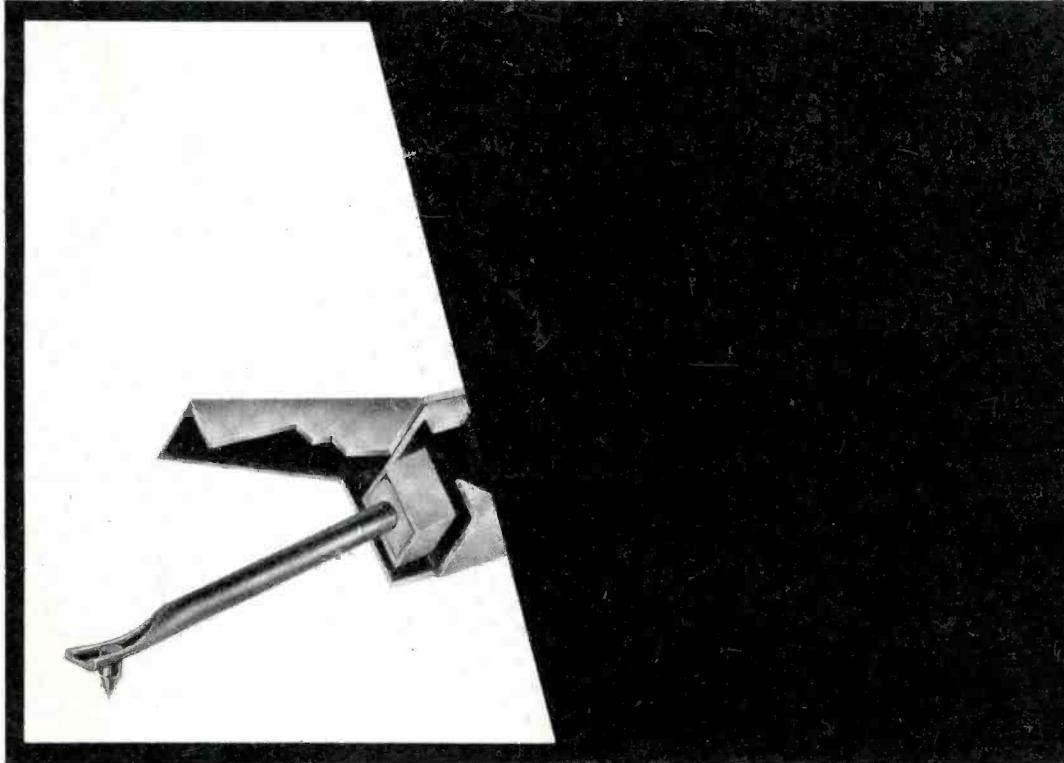


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