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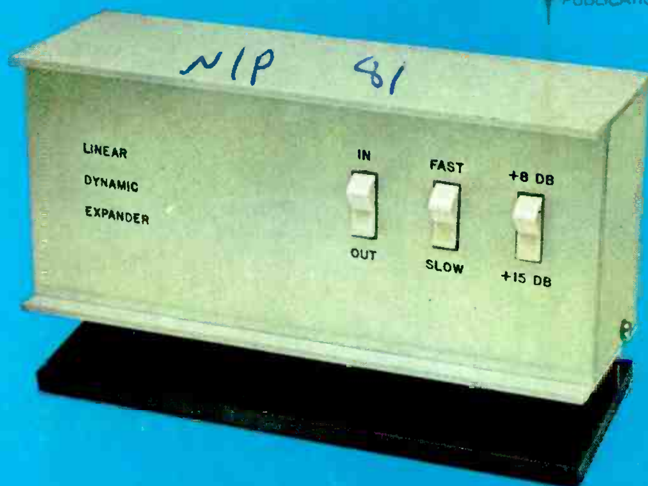

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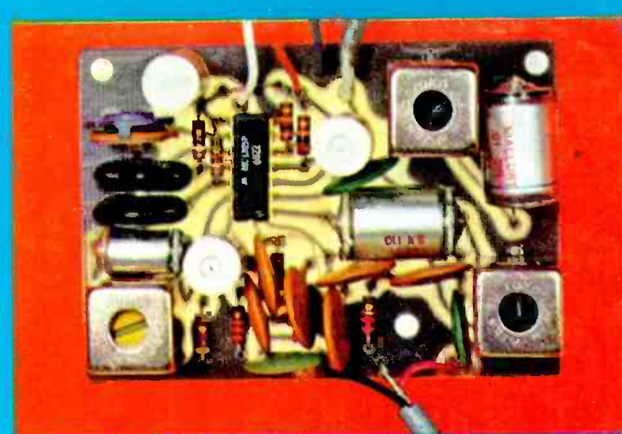

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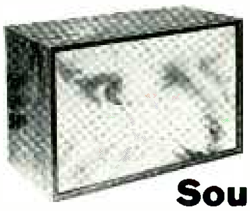

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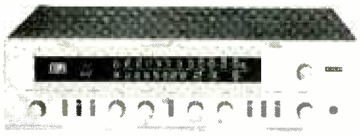

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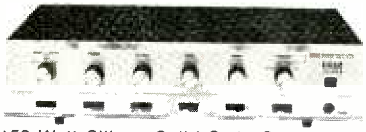

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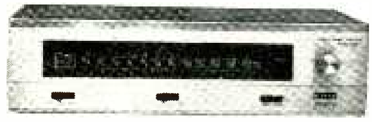

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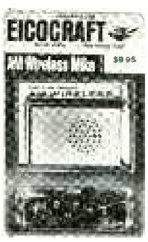

(lo band) $7.95; EC-2800 Aircraft Converter $7.95; EC-2900 Police & Fire Converter (hi band) $7.95; EC-3100 2-Station Intercom (with cases) $10.95; EC-3200 "Do-It-Yourself" PC Etching Kit $4.95; EC-2300 Audio Preamplifier $8.95; EC-2400 Bullhorn $8.95; EC-2500 Fuzzbox $8.95.

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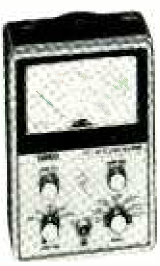

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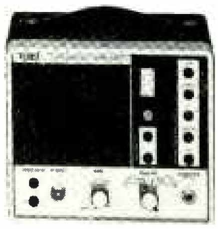

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You have heard and read, over and over again, about how important an FCC license is to your success in electronics. It is certainly true that an FCC license is important–sometimes essential – but it's not enough! Without further education, you can't make it to the top. Get your FCC license without fail, but don't stop there. To prepare for the best jobs, continue your electronics education and get your degree.

This kind of thinking makes good common sense to those who want to make more money in eleetronics. It also makes good sense to prepare for your FCC license with the School that gives degree credit for your license training – and with the School that can then take you from the FCC license level to the DEGREE level. The first *two semesters* of the Grantham degree curriculum prepare you for the first class FCC license and radar endorsement.

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NEW & TIMELY

Volume 41 Number 3 RADIO-ELECTRONICS March 1970

PLANE ANTI-COLLISION DEVICE IS DEMONSTRATED

BALTIMORE—An anti-collision device for aircraft that employs radio signals regulated by atomic clocks has been demonstrated. Airlines may begin to install the devices in 1971.

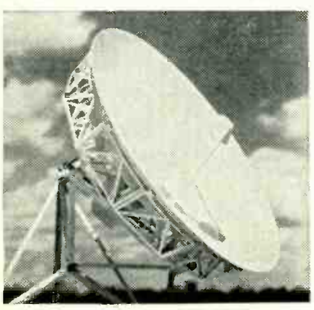
Each plane within an operational area would simultaneously transmit a digitally coded message every 3 seconds. Individual planes would be assigned one of 2000 time slots in a 3-second time base. Since all planes transmit at precisely the same time, each plane could compute the distance to other aircraft from the elapsed time of the transmissions.

Altitude information is contained in each plane's coded transmission. Closing rates can be computed from the Doppler shift in radio frequency.

A small panel is used to indicate when the plane should be flown level, climb or dive. The devices are made by McDonnell-Douglas, Bendix Avionics and Wilcox Electric, and will cost from $30,000 to $50,000 per plane.

ANTENNA IS TESTED FOR CANADIAN TV

OTTAWA—A 25-foot dish antenna is undergoing tests for use with the Canadian Domestic Satellite, scheduled for launching in 1972. Operating in the 3.7–4.2 GHz range, the

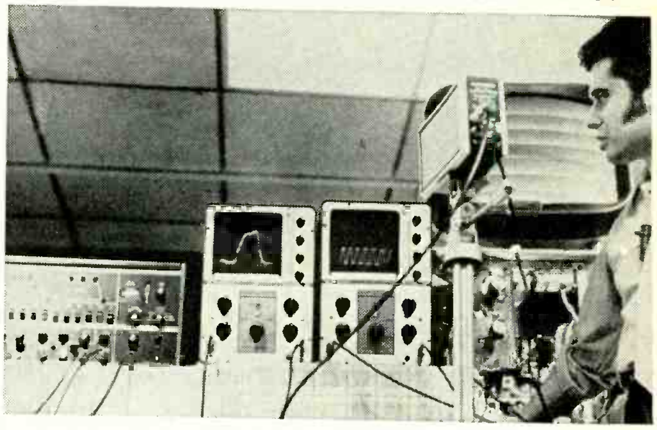


system is being designed to provide color TV reception in remote areas. Station electronics have been designed for unattended operation.

LUNAR TV 'SERVICE' GETS HAMMER AWARD

Astronaut Alan Bean was presented with a golden hammer mounted on a plaque for his attempt to repair the defective Apollo 12 color TV camera. Gene Ware, president of the Fort Worth TV service association who made the award, said, "We are proud of the initiative he displayed by trying to make it possible for the millions of TV watchers to view the moon-walk, even though it didn't work."

COLOR TV ALIGNMENT SPEEDED



CHICAGO—A demonstration of a new alignment procedure for color TV's—completed in less than 10 minutes—was held at a dealer service seminar sponsored here by Taylor Electric and Dynascan Corp.

A field engineer for Dynascan covered all phases of rf, i.f. and color-circuit alignment using the new B&K Sweep/Marker Generator, Model 415. He used a closed circuit TV camera so the audience could view the procedure easily. Various technicians used the generator to align the color set themselves.

(N & T is continued on page 4)

LOOKING AHEAD

by DAVID LACHENBRUCH
CONTRIBUTING EDITOR

New generation in color

Television set manufacturers are poised for what they consider the biggest model changeover since the introduction of the rectangular picture tube. The "new generation" is scheduled to start around midyear 1970, but some preview models could be forthcoming in the manufacturers' March and April introductions.

Highlighting the new generation will be the "new look" in picture tubes: squared-off corners and a 4-to-3 aspect ratio which shows more of what the camera sees than today's 3-to-2 tubes. Set manufacturers expect the new 25-inch (viewable diagonal) tube eventually to replace the current 23-inch version, the 21-inch to replace the 20-inch, and the 19-inch, the 18-inch. At first, the new tubes will be used only in higher-priced sets, but even with a midyear introduction, set manufacturers expect the new sizes to represent nearly 20% of 1970's domestically produced TV set sales.

At the same time, square-cornered 15-inch color tubes are being developed in Japan, with an eye to the US export market. These are expected to reach this country by fall.

In area, the new tubes are not much different from those they replace: The 19-incher shows 185 square inches of picture compared with 180 for the 18-inch; the 21-inch is 226 square inches vs 227 for the current 20-inch, and the 25-inch measures 315 square inches as opposed to 295 in the 23-inch tube.

This year will also see the first color tubes with 110° deflection, shaving at least a couple of inches from the depth of color sets—starting first, this spring, with a short 18-inch set, and followed, probably toward the end of the year, with a 19-inch square-cornered version. At present, there are no active plans for shorter tubes in the larger-screen sizes.

Another innovation scheduled by some major manufacturers this year will be the long-delayed, all-electronic

(Looking Ahead is continued on page 6)

IN THIS ISSUE

Radio-Electronics

March 1970 • Over 60 Years of Electronics Publishing

AUDIO—HI-FI—STEREO

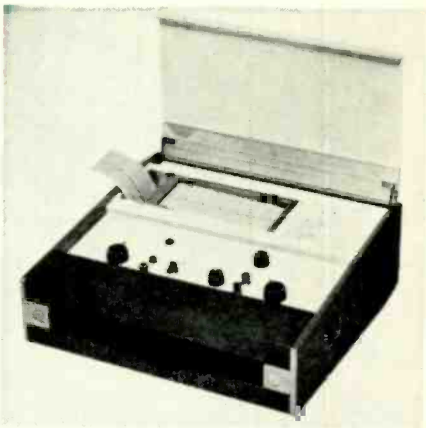
HI-FI STEREO BUILD-ITS

TELEVISION

BUILD THIS ONE

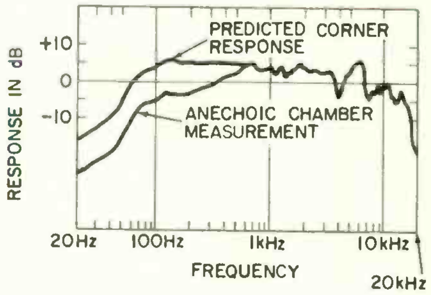
GENERAL ELECTRONICS

DEPARTMENTS



Solid-state electrocardiograph weighs only 22 pounds. For a look at the latest in medical electronics. . . . see page 61

Linear volume expander can make the faint background noises in your hi-fi system disappear. . . . see page 36



Low-cost acoustic suspension speaker provides smooth response. Build two for an extension stereo system. . . . see page 43

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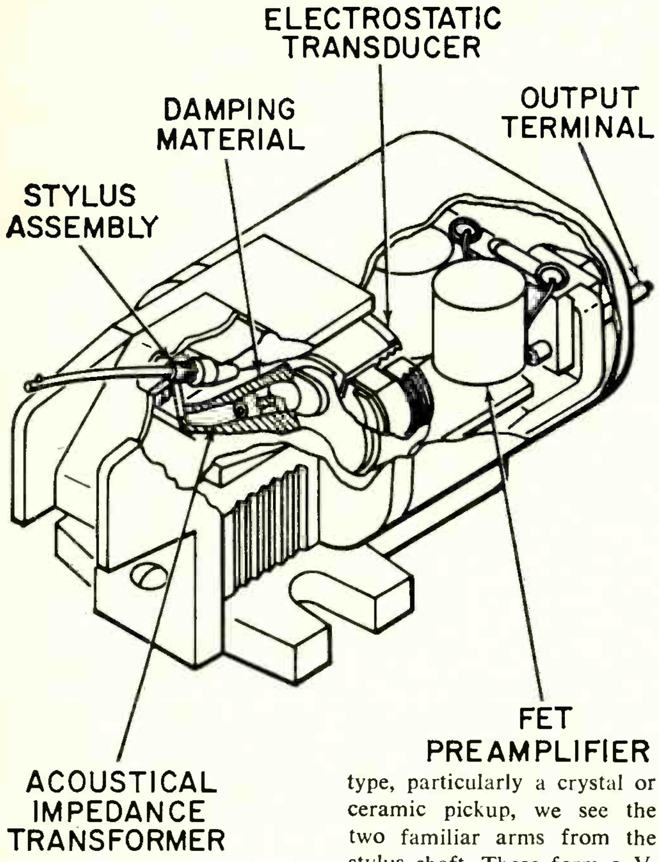


NEW PHONO PICKUP

Would you believe a pickup that converts the vibrations of the stylus to acoustic signals, picks them up with a microphone, amplifies that signal with an FET transistor amplifier in the cartridge, and puts out a signal comparable in level to that from a conventional magnetic phono cartridge. . . . .

by FRED SHUNAMAN

AT LAST WE HAVE SOMEthing absolutely new in phono pickups! If you're a hi-fi enthusiast, maybe you've heard that one before. But wait a minute before you say, "So what?" What would you think about a pickup that converts the vibrations of the stylus to acoustic signals, picks them up with a microphone (an electret microphone yet!) amplifies the signal from the microphones in a tiny FET transistor amplifier in the cartridge, and puts out a signal comparable in level to that from a conventional magnetic cartridge. Does that sound new?

But why the way-out approach? Because this new attack on the problem can produce a pickup with very high compliance, smooth frequency response, low intermodulation distortion and high trackability. At least so says its inventor, Hirotake Kawakami, of Sony, and the statement sounds reasonable.

What are the details of this amazing pickup? If we start at the stylus, which looks much like an ordinary type, particularly a crystal or ceramic pickup, we see the two familiar arms from the stylus shaft. These form a V, the ends of which are attached to a yoke. Here the resemblance ends. At the ends of the yoke are two bellows-like devices (Fig. 1) called canaliculi (little channels) by the inventor. The stylus vibrations move the ends of the yoke, pushing them against the ends of these bellows and setting up acoustic waves (sound or pressure signals) in them.

These canaliculi closed at one end by the yoke and at the other by the microphone diaphragms, are tapered (cone-shaped—see Fig. 2) with the ends at the microphones larger than the ends at the yoke. They thus form an *acoustic transformer* (as does the bell of a horn speaker). It is a puzzling principle of physics (Pascal's paradox) that if a piston of a given diameter is coupled by a gas or liquid to one of larger area, the pressure on the small-area piston will be transmitted exactly to *each* similar area on the large one.

If, for example, we were to make a bellows (square, for ease of measurement) with a small end 1mm square and the large end 5mm on a side, a pressure of 1 dyne on the small end would be transformed to a total pressure of 25 dynes at the large end.

To the pickup, this means that you can have a

Fig. 1

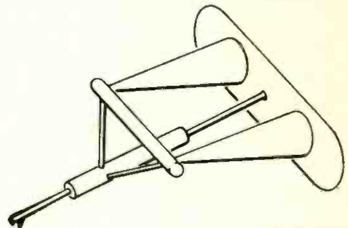
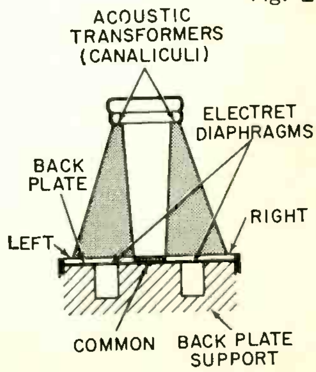


Fig. 2



SPECIFICATIONS

Output level	—26 dB at 1 kHz*
Channel balance	± 1 dB
Frequency response	10 Hz to 25 kHz
Channel separation	300 Hz—30 dB 1 kHz—26 dB 10 kHz—25 dB
Higher order resonance	26 kHz
Intermodulation distortion	1.0%
Stylus force	1.5 gram
Vertical tracking angle	15° ± 2°
Compliance lateral	20 x 10^{-6} cm/dyne
vertical	14 x 10^{-6} "
Type of equalization	Displacement type
Power supply	1 mA at 24 V dc
Dynamic range	90 dB

*0 dB = 1 volt at 5 cm/sec

(continued from page 4)

very decent pressure on the microphone diaphragm with very low pressure at the yoke end of the caniculus. This results in high compliance. The actual pressure ratio between stylus and diaphragm is 25 to 1, and the resultant compliance 20 x 10^{-6} cm/dyne. Since the exact length or size of the caniculus is not critical, mechanical design of the pickup is made easier.

The next new thing is further away from the fixed plate. This changes the capacitance, lowering and raising the voltage between the plates as the capacitance increases or decreases.

The capacitance (condenser) microphone is a very high-quality instrument, but the high-voltage supply is bulky, introduces hum, leakage and other troubles, so other microphone types have become more popular.

The electret is simply a

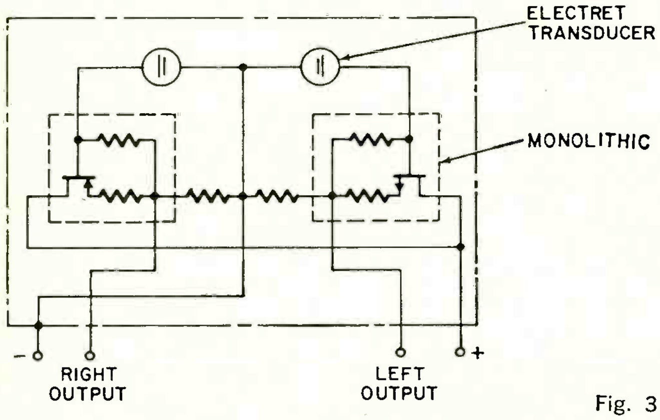


Fig. 3

the electret capacitor transducer. If you are not familiar with the "condenser" or capacitor mike, it's simply two plates (one very flexible) with a high voltage between them. Speaking (or otherwise applying pressure) into the capacitor mike causes the flexible "diaphragm" to vibrate, moving it closer to or piece of dielectric material (often thin plastic) with a permanent high-voltage positive charge on one side and a negative charge on the other. In the pickup, it is metalized on one side to serve as a diaphragm, as well as to supply the polarizing voltage.

As a pressure wave forces the diaphragm toward the backplate, the capacitance increases and the voltage drops; as it moves farther away the capacitance decreases and the voltage rises. These variations in voltage appear at the bases of the amplifier transistors (Fig. 3) and the characteristically low output of the capacitor microphone is brought up to the level of a normal magnetic pickup.

(N & T continued on page 12)

LOOKING AHEAD

(continued from page 2)

varactor tuning. Now in common use on the European Continent, it is currently featured in North America by only one manufacturer—Electrohome of Canada. Varactor tuning will make possible quick and silent channel changes and, by the elimination of mechanical parts and contacts, give designers new freedom in the location and design of tuning control panels.

Electrohome, for example, uses an 18-channel "touch-tuning" panel that changes channels when a finger touches a button; bodily resistance keys the channel change. The tuning panel may be removed from the set (to which it is connected by a flat cable). It also contains on–off, volume, color and tint controls. The latter three controls activate light bulbs within the set, with phototransistors substituting for the traditional potentiometers.

New tube type numbers

Ever since Jan. 1, 1967, when the Federal Trade Commission's decree that television screen sizes must be measured by viewable (rather than over-all) diagonal went into effect, service technicians have been putting 25-inch replacement tubes into 23-inch color sets. This interesting situation arose because the FTC's edict applied only to television sets themselves and not to unhoused picture tubes. The picture-tube industry continued to use the old "over-all" measurements to identify their products, while set manufacturers and retailers were required to use the new, generally smaller, measurements.

The situation has finally been corrected. The Electron Tube Council of the Joint Electron Device Engineering

(Looking Ahead is continued on page 14)

Radio-Electronics

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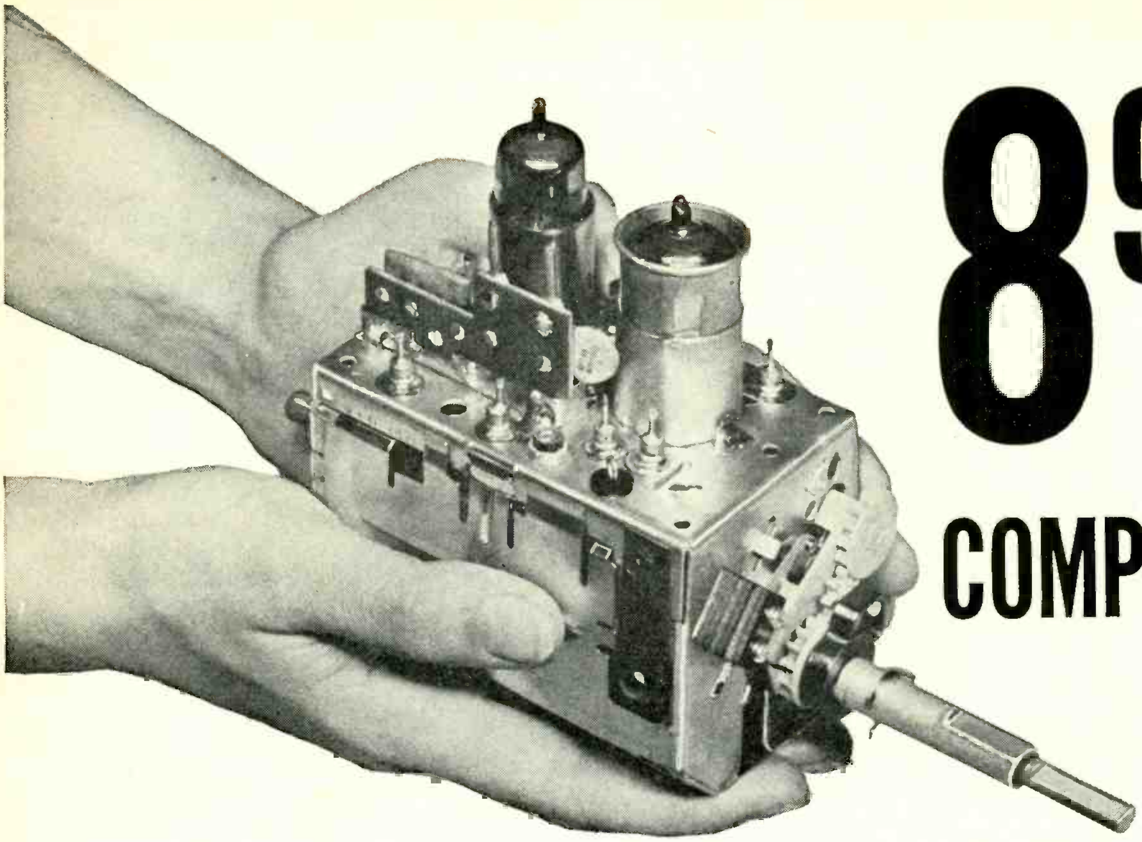

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CR7S	Series 600mA	1¾″	3″	41.25	45.75	9.50
CR9S	Series 450mA	1¾″	3″	41.25	45.75	9.50
CR6XL	Parallel 6.3v	2½″	12″	41.25	45.75	10.45
CR7XL	Series 600mA	2½″	12″	41.25	45.75	11.00
CR9XL	Series 450mA	2½″	12″	41.25	45.75	11.00

*Selector shaft length measured from tuner front apron to extreme tip of shaft.

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Circle 11 on reader service card

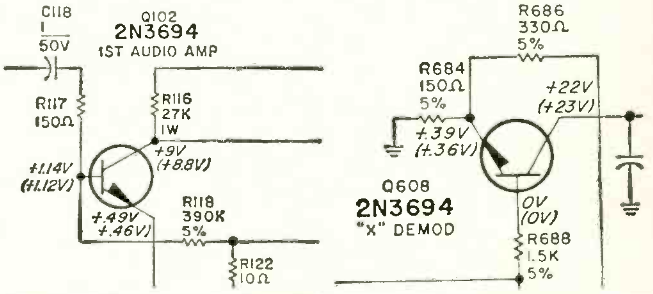
New & Timely

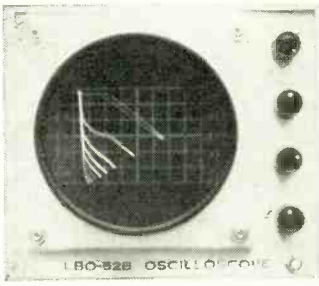
(continued from page 6)

NEW DYNAMIC CURVE TRACER SPOTS BAD TRANSISTORS "IN CIRCUIT"

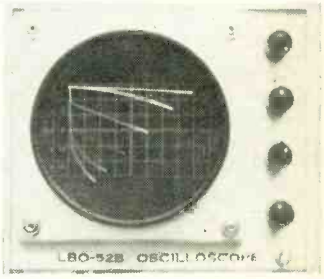
LONG ISLAND CITY, N. Y. —A new technique for servicing circuits using semiconductor devices has been announced by Jud Williams, Technical Director of Leader Instruments. It enables uncovering faulty semiconductors in circuit, rapidly and easily.

The procedure uses a new dynamic transistor curve tracer made by Leader that sweeps the device under test with 120-Hz pulsating dc voltage while





Curve family measured from 1st audio ampl (Sylvania Gibraltor).

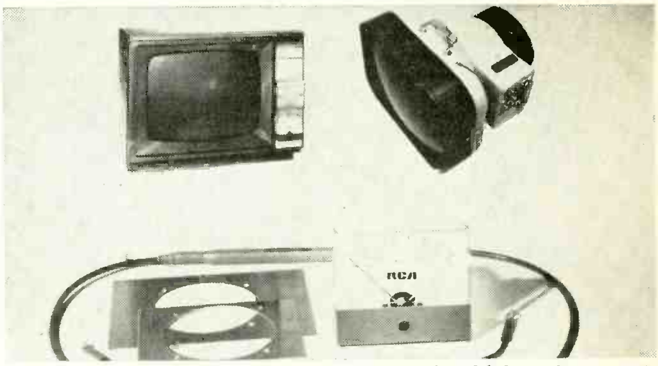


Transistor curves taken from x demodulator on Sylvania chassis.

current is applied to the base in steps. The result (see photos) is a family of curves displayed on a monitor scope.

According to Leader, the procedure can simplify replacement problems caused by the lack of a standard numbering system by transistor manufacturers. Universal replacement types may be matched directly with the tracer, reducing the number of devices required as stock.

HIGH-VOLTAGE METER KIT



A new kit for continuous monitoring of picture tube anode voltage of all color TV chassis has been made by RCA. The 10J110 kit has been designed for use with any of the RCA color test jigs, and can be adapted for mounting in other test jigs.

The meter kit enables service technicians to precisely adjust the high voltage output to manufacturers specifications, avoiding excessive voltage and possible abnormal X-radiation.

Included with the 3½-inch, 2% accurate meter is a multiplier and cable assembly with a resistor calibrated under operating conditions. The meter reads from 0–35kV. **R-E**

LOOKING AHEAD

(continued from page 12)

Councils (JEDEC), in charge of tube standardization and type designations, has announced a change in its tube numbering system that affects every picture tube sold in the U.S. The new numbering system uses the FTC-prescribed "viewable" diagonal as the key number, adding a "V" to differentiate it from the old system. Under the new system, for example, the former 25AP22A (a color tube with 25-inch over-all diagonal but 23-inch viewable diagonal) now has become the 23VAP22A. It still fits nicely into a 23-inch set.

TV fire furor

How many television sets catch fire each year? Nobody knows for certain, because no accurate records are kept, but the Government's National Commission on Product Safety estimates that the number could be as high as 10,000. Although that's still a small fraction of 1% of all sets in use, the commission has asked manufacturers to come up with tighter safety standards for new sets.

In response to the request, the manufacturers filed proposed new criteria to prevent burning or smoking sets. These were rejected by the commission as not stringent enough although a step in the right direction. The commission has urged the industry to adopt standards barring the use of any flammable components in flyback transformers, capacitors and yokes, and to make all other TV components either flameproof or self-extinguishing.

Two pictures, one channel

A TV multiplex system, which its inventor claims can double the number of channnels occupying the TV broadcast band, has been patented by Harold Walker. The first license to "DuoVision" has been granted to Cowles Communications Corp., a publisher and TV broadcaster. A standard TV set is used to receive the multiplexed pictures, but an adapter is placed between the antenna and the antenna terminals. By switching the adapter to "A" or "B" position, the viewer can pick up either of two telecasts on a single channel. The main program can be color or monochrome; the subsidiary program must be in black-and-white.

The invention has been proposed as one solution to the pay-TV problem, since the pay-as-you-see channel no longer would require the blackout of a "free" channnel. It also is seen as helping to increase the number of educational stations in big-city areas where no channels are now available.

A more novel suggested use is for three-dimensional TV. Some work has already been done on this by General Electronics and others, using the DuoVision system. Slightly different views of the same subject (representing the images seen by the left and right eyes) are broadcast simultaneously on the "A" and "B" subchannels and superimposed on the screen. A special lenticular faceplate covering the viewing screen directs the images to the left and right eyes.

Holographic 3-D movies

Another "no-glasses" 3-D technique—this one for movie theaters—has been patented by CBS Laboratories, which is now negotiating for a major test operation. Invented by Dr. Dennis Gabor, often called the "father of holography," the movie system uses a concave screen in which are embedded "holographic mirrors," designed to direct the proper image to the viewers' left or right eyes. Two projectors are aimed at the screen from different locations at the rear of the theater. CBS Labs claims the stereoscopic effect is visible from any seat in the theater. **R-E**

You pay for what you don't get

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Correspondence

ADD 4.5-MHz SIGNAL TO COLOR GENERATOR

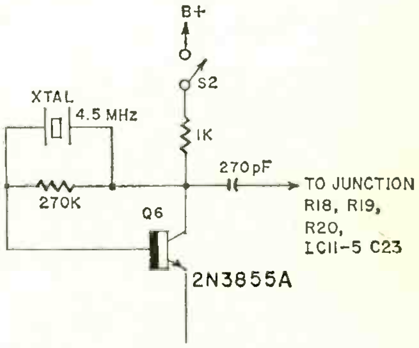
I'd like to add a 4.5-MHz signal output to my version of the color pattern generator you presented in your January 1970 issue. Can you give me any idea as to how it might be done?

WILLIAM V. GLOMB
Hawthorne, Calif.

Adding a 4.5-MHz signal is quite easy. The circuit is shown below. While it cannot be added directly to the existing printed-circuit board (there isn't enough room) it can be built on a piece of perforated phenolic board. There is ample space for the added circuit above integrated circuits IC4, IC5, IC6, IC7, IC8 and IC9. I will leave the details of supporting the board containing the added circuitry to your ingenuity.

Missing from the parts list with the article was the specs for switch S1. It is a 3-pole, 6-position non-shorting switch. Mallory 3236J or equivalent.

RAYMOND KOSTANTY



BONGOS SHORT A WIRE

I built the electronic bongos (Radio-Electronics July 1969) and they work fine. The schematic is correct, but the pictorial diagram of the parts layout needs one more wire—from the junction of R1 and C1 to the junction of R5 and R6.

VIC WILLIAMS
Austin, Tex.

Thanks for the note Vic. We're sure all the other readers who haven't yet put their bongos to work will appreciate it too.

(continued on page 22)

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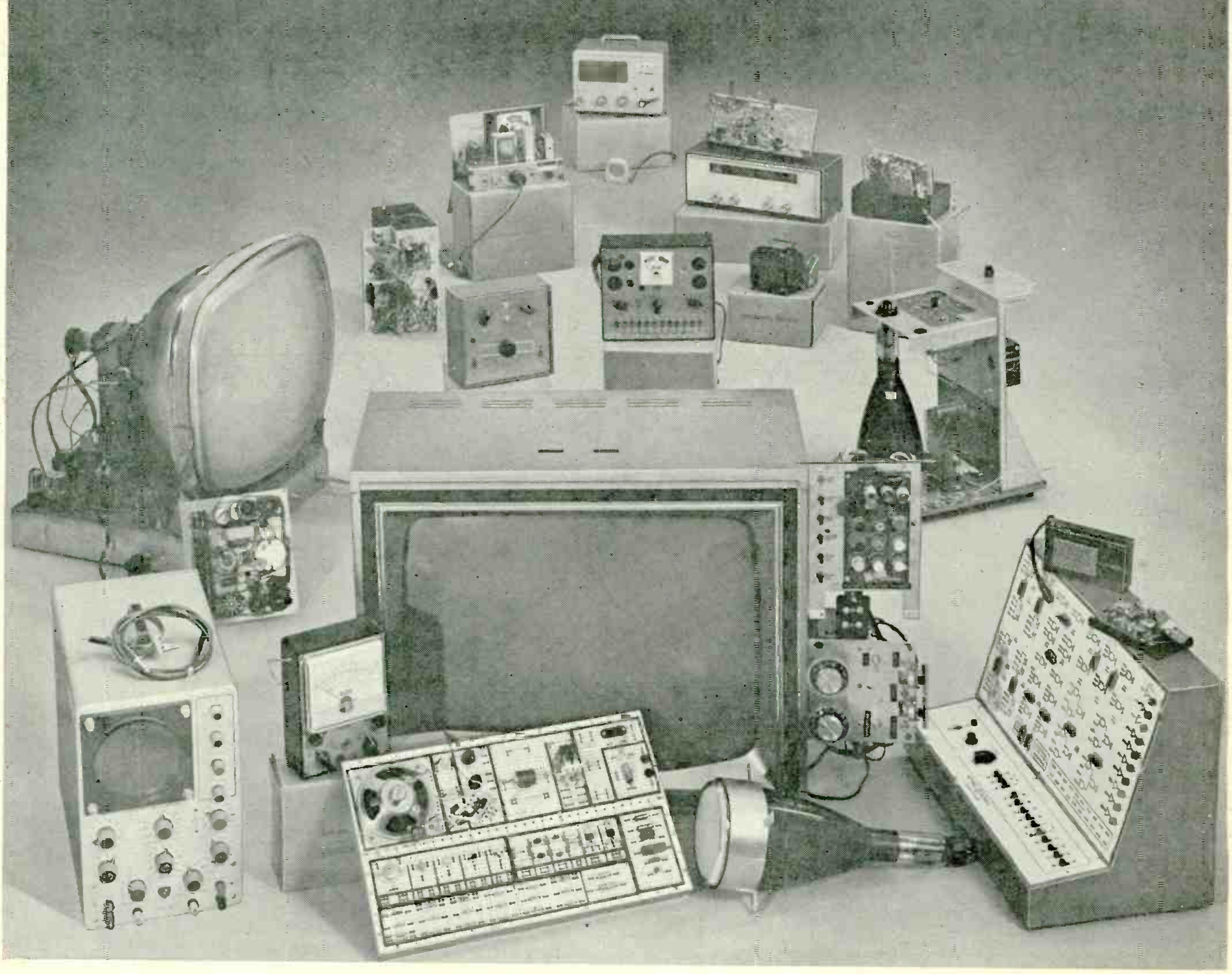

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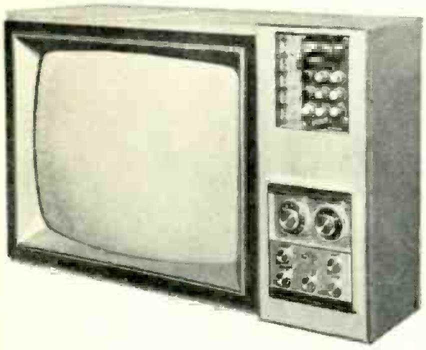

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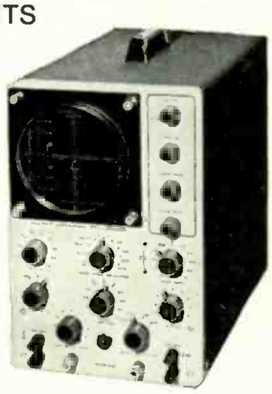

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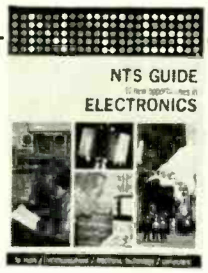

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Circle 18 on reader service card

CORRESPONDENCE
(continued from page 16)

CROSSOVER CROSSUP

I was very much interested in Norman Crowhurst's article, "Three-Way Crossover." However, I think that some points need to be clarified. How were the values for the capacitors at the input and output calculated? On p. 44, Fig. 6, the 200-2,000 Hz bandpass filter incorporates the 500 ohm emitter resistor. However, in the 20-200 channel this resistor is not used. Why? Finally, what exactly are safe impedances that can be used with this circuit? I don't believe Mr. Crowhurst was clear on these points. I would appreciate this information.

MICHAEL KUCYK
1733 Linden St.
Brooklyn, N. Y. 11227

Michael Kucyk's letter has drawn attention to an error that apparently escaped us all: there should be a 510-ohm resistor in the position to which he refers, on Fig. 6, page 44 of the October issue.

Had the board been assembled as drawn, a circuit check would quickly have found the empty space, and a 510-ohm resistor could have been dropped in and soldered, and then everything would have been fine. But one can't check a drawing quite that way! I used extra care making sure the etched circuit was correct and then, I suppose, became lazy when I reached the insertion (by drawing) of the very last resistor.

On the question about safe impedances, I presume he means from the viewpoint of achieving correct performance. The input is intended to work from a source impedance that is between zero and 500 ohms, while the output is intended to work into an impedance from 500 ohms to infinity (open circuit). Variation in these ranges will not materially affect performance.

The input and output capacitors, shown as electrolytics, outside the feedback loops, must have a reactance low enough at the lowest frequency each filter handles not to materially affect transmission: that is, less than about 4K on the input and it should be less than about 500 ohms on the output.

In the examples shown, the top two filters used 2 μF, on input and output, which would yield reactances of 400-ohms at 200 Hz and 40 ohms at 2,000 Hz. If full response at 20 Hz is vital, 50 μF may be substituted as output capacitor of this filter.

My thanks to Mr. Kucyk for drawing attention to these points.

NORMAN CROWHURST
Gold Beach, Oregon

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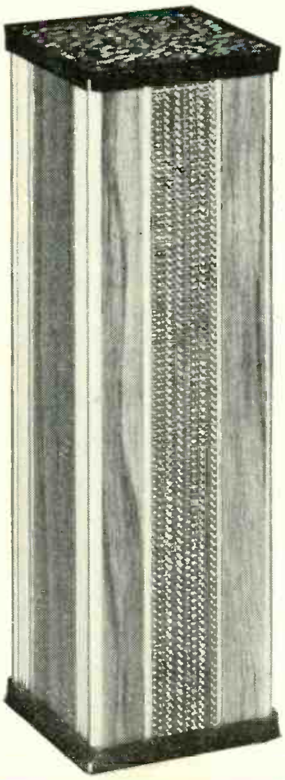

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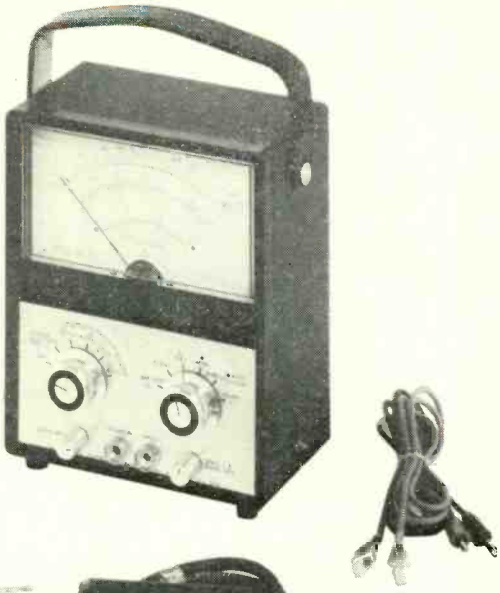

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Circle 21 on reader service card

In the Shop . . . With Jack

By JACK DARR
SERVICE EDITOR

PITFALLS WITH PARALLEL PATHS

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

If you're really stuck, write us. We'll do our best to help you. Don't forget to enclose a stamped, self-addressed envelope. Write: Service Editor, Radio-Electronics, 200 Park Ave. South, New York 10003.

THE SUBJECT WAS A MEDIUM-SIZE, Japanese color TV portable. One of my friends lugged it in one morning with a sad look on his face, and we set it up on the bench and lit the fire.

The trouble was obvious. The top 2 inches of the screen were blank. Turning the vertical height and linearity controls did nothing but make heads flatten out ludicrously. So, we pulled the back off and looked for the vertical output tube. To my surprise, there was a schematic inside the cabinet. How lucky can you get?

Not very. With the help of a powerful magnifying glass, we discovered the vertical output/oscillator tube was a 10GV8. "A 10-GV-what?" I asked. Without too much hope, we looked on the tube shelf. Nope. None of the five tube lists we had even *mentioned* such a tube. We looked in the tube substitution book and found the same thing—nothing.

"Well, let's peel it out and see what we can find, "I suggested. After locating the 10GV8 socket, we identified the pins of the pentode section and checked the dc voltages. Looked o.k., but since they had carefully managed to omit voltages on the original "bag-of-worms" schematic, this didn't help much. Without too much optimism, I looked in my Sams Photofact file. Lo and behold! There it was. Voltages and all. Things were looking up.

Screen grid voltage on the pentode was just a bit low. Grid voltage seemed to be o.k. Cathode voltage was +40 instead of the +20 volts called for. Hmmm. Was this tube good or was it weak?

"Look here," I said, "we've got 40 volts on the cathode instead of the +20 needed. This ought to mean the tube is drawing *more* than the normal plate current. If it is, it shouldn't be *weak*. The control grid voltage is close to normal, and the 55-volt peak-to-peak grid drive signal looks o.k., too. So, what's wrong?"

We located and removed the coupling capacitor, a 0.1-μF, which checked good—no leakage, of course. Then we tried bridging a big electrolytic capacitor from cathode to ground, with no perceptible results.

I turned the thing off, and checked the resistance from cathode to ground. About 2000 ohms plus. That didn't look right. There was also a great deal of trigger-work in there *beside* that resistor. In fact, the cathode circuit takes in quite a lot of territory.

We both looked at that ohmmeter reading of more than 2000 ohms, and I let him take out that 820 ohm cathode resistor. You guessed it, the resistor was wide open.

Since there was still a *complete* path to ground through the stuff on the convergence board, the vertical output tube could still try to make a raster. However, since it now had quite a bit more cathode resistance than the book called for, it was simply biasing itself off before it could sweep the full screen.

Putting in a new 820-ohm resistor cured the trouble, and the screen filled out nicely. The moral of a story like this, of course, is: "Don't stop when you've checked *only one part* of a circuit. There may be more than one path." **R-E**

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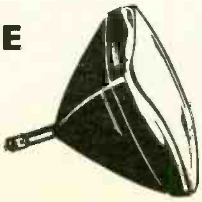

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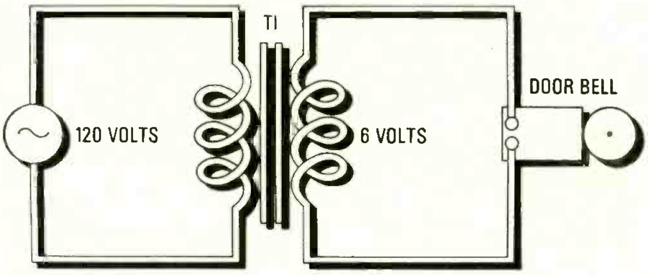
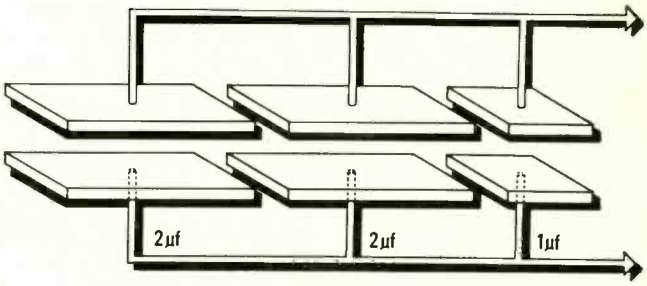


In this door bell circuit, which kind of transformer is T_1 — step-up or step-down?

Note: if you had completed only the first lesson of *any* of the RCA Institutes Home Study programs, you'd easily solve this problem.

This one is more advanced.



What is the total capacitance in the above circuit?

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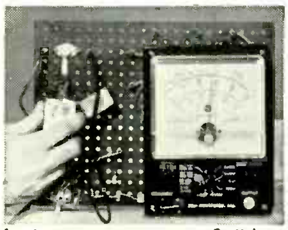

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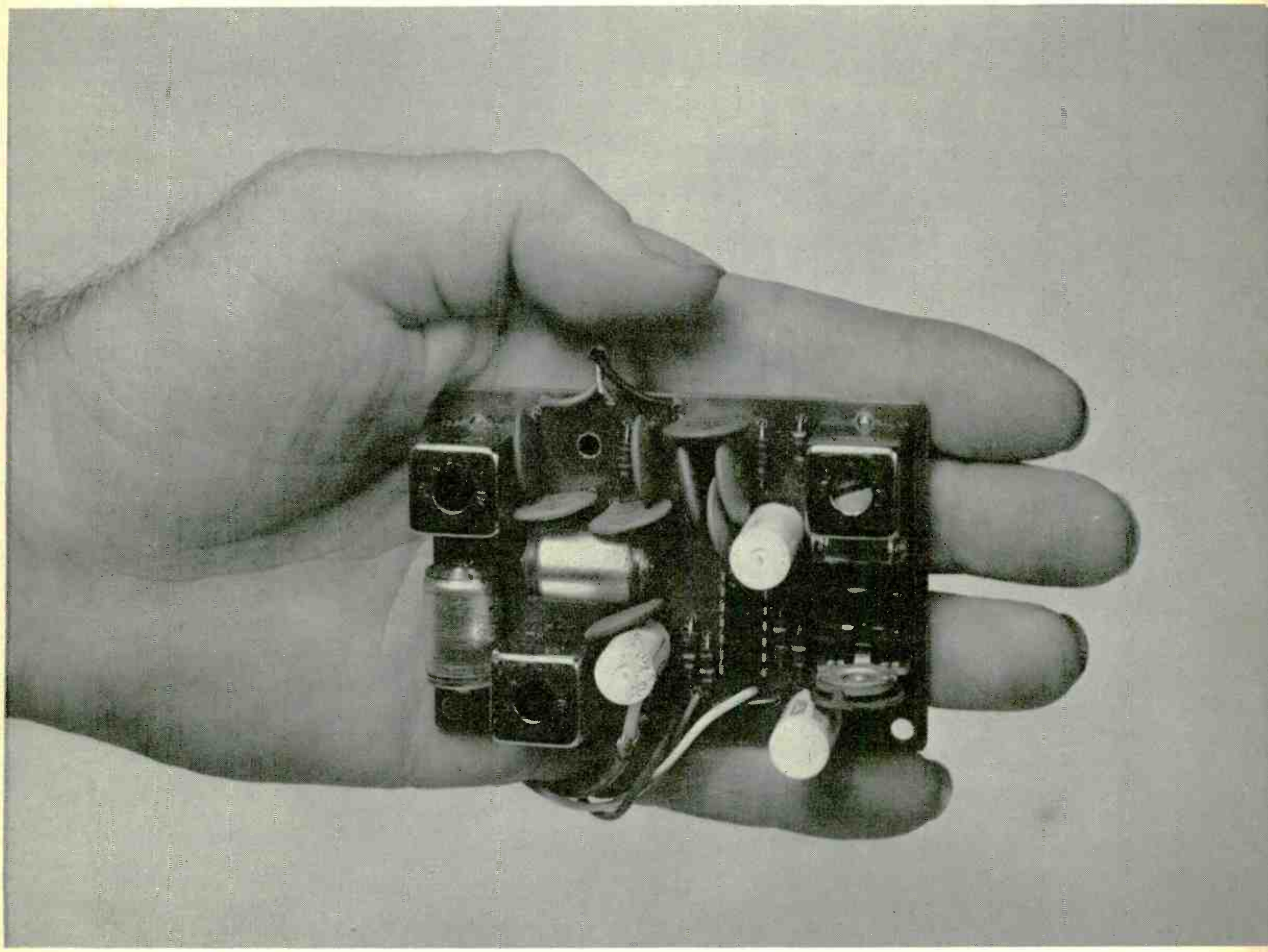


One-IC mini-multiplexer delivers 45 dB separation at midrange. Twin-T filter eliminates 'birdie' problems

by **KEN BUEGEL**

INTEGRATED CIRCUIT DEVELOPMENTS often seem to be aimed at exotic applications which are of little interest to the general electronic public. But Motorola's MC1304 and MC1305 are different: on one chip is a complete, advanced-design multiplex decoder. The MC1305, although identical in cost to the MC1304, provides for a separation adjustment and was used in this project.

The internal circuitry is formidable: 10 diodes, 31 transistors and 29 resistors. Even the block diagram for the 1305 (Fig. 1) reveals a level of complexity not often used with discrete-component multiplex adapters.

The IC uses the proven balanced time-switching technique with its inherent SCA rejection without filtering, and also provides a driver for a stereo indicator. Two separate additional inputs provide for stereo–mono switching and audio muting. And as if this weren't enough, a series of diodes with emitter followers serve as temperature-compensated voltage regula-

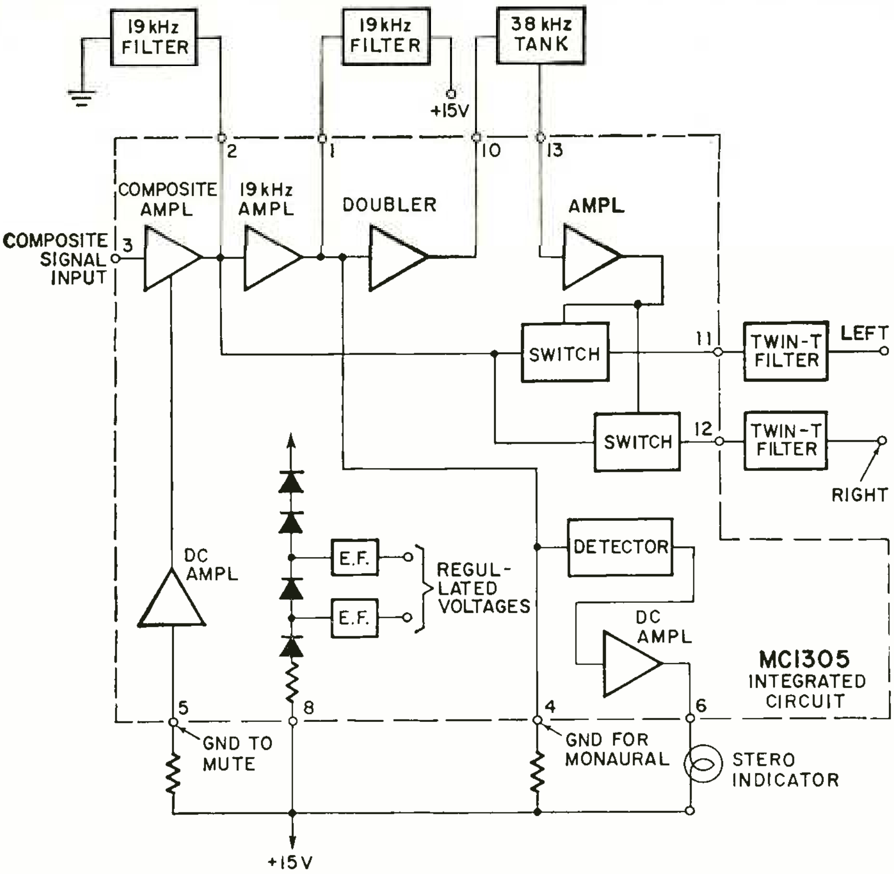


Fig. 1—Complex functions performed by 31-transistor MC-1305 (inside dotted line). Connections to pins 4 and 5 are optional.

tors for the circuits.

Performance of the chip is phenomenal in comparison to the very conservative Motorola specifications. A separation of 45 dB at 1 kHz is typical; three units constructed revealed a separation of 55 to 57 dB at 1 kHz, 44dB at 100 Hz., and 37 to 49 dB at 10 kHz. These figures are on a par with the very best multiplex adapters of conventional design. SCA rejection exceeds 55 dB and no interfering "birdies" have ever been audible with the device.

Channel balance is within 0.5 dB and total harmonic distortion is less than 0.5% at the recommended composite-signal input level.

The only drawback found in the design is the 19-kHz and 38-kHz rejection figures. Although a typical rejection is 20 dB at 38 kHz, this is not enough to prevent possible "birdies" when beating against a tape recorder bias oscillator. Therefore a 'Twin-T' filter has been added (Fig. 2) to each output to increase rejection another 20 dB.

Construction & alignment

You can build this project for under $21. The actual-size PC pattern for the decoder is included for do-it-yourselfers, and a complete kit of

PARTS LIST

All resistors ¼W, 5%
R1, R2—20,000 ohms
R3—4700 ohms
R4—500-ohm, ¼W trimmer (CTS type X201R50113)
R5, R6—3900 ohms
R7, R8, R10, R11—4300 ohms
R9, R12—2200 ohms

Capacitors
C1, C3—5-μF, 50V electrolytic (Mallory MTV 5CB50)
C2, C4—.01-μF polystyrene (Mallory SX110)
C5—.0022-μF polystrene (Mallory SX222)
C6, C7—.022-μF, 100V Mylar (Mallory PVC1122)
C8, C9, C12, C13—.001-μF ceramic (Centralab CE102)
C10, C11—.002-μF ceramic (Centralab CF202)
C14, C15—0.2-μF, 10V ceramic (Centralab UK-10-204)
C16—0.1-μF, 10V ceramic (Centralab UK-10-104)
C17—60-μF, 15V electrolytic (Mallory MTV 60CB15)

Other parts
L1, L2—J. W. Miller type 1361
L3—J. W. Miller type 1362
IC1—Motorola MC1305P

The following parts may be ordered from Transitek Co., P.O. Box 98205, Des Moines, Wash. 98016. All prices include postage. IC1, $7.20. L1, L2, L3 (set of three), $5.40. PC board MPX, $2.95. Complete kit of all listed parts and drilled PC board, $21.00.

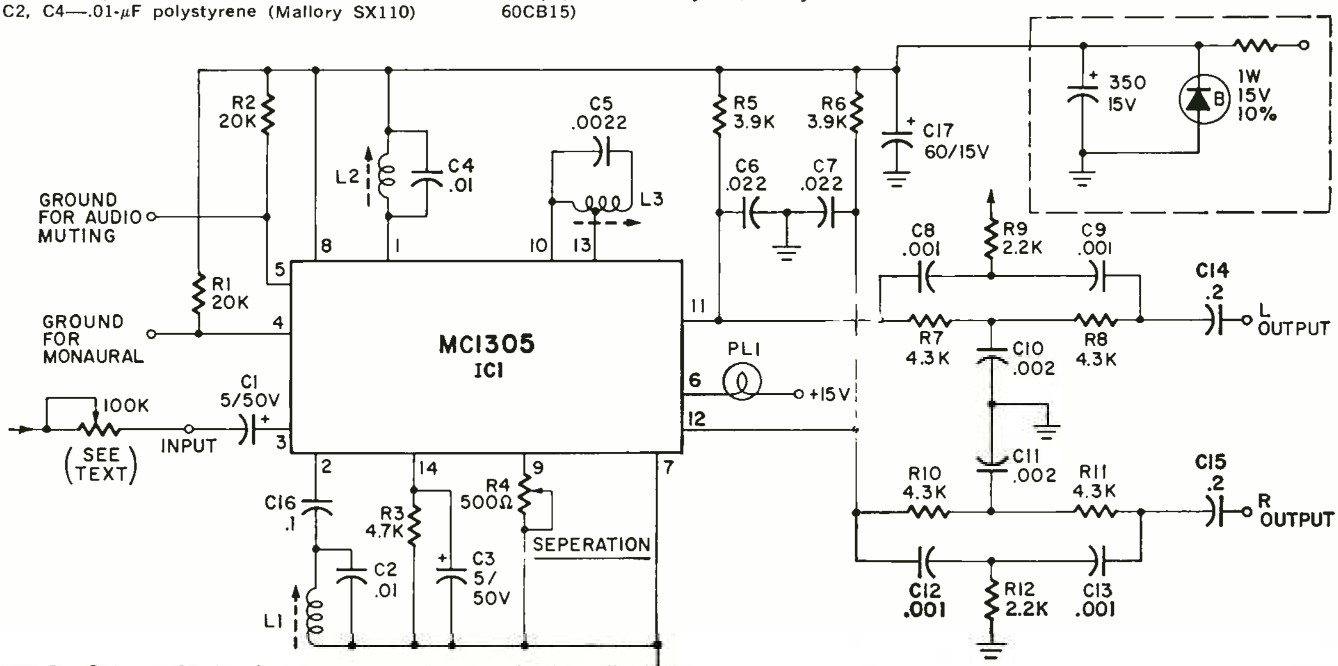
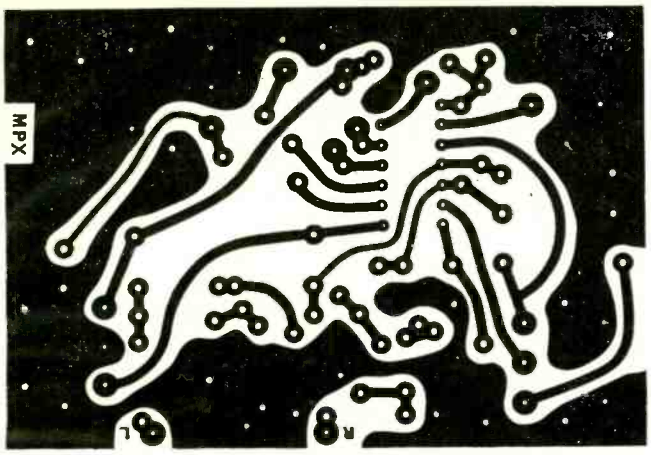
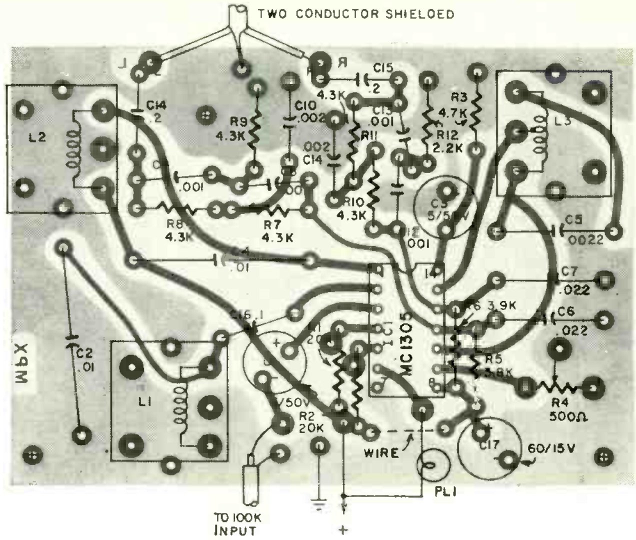


Fig. 2—Schematic showing components mounted externally to the 1305. Use a 12ES (12V, 40 mA) lamp for the lamp PL1.





Use the same-size printed circuit pattern above to make your decoder. Components specified will fit on the board. Component-side drawing on the right shows where to mount the parts. Some of the wiring to the unit is optional.

parts and drilled PC board is available. Please use the components listed, as the circuit board was laid out for them.

Construction of the project is simple, as is the alignment procedure. A 2.2 x 3.2-inch PC board provides enough component space without crowding. Recommended coils for this circuit are available only in a PC mounting style.

The best technique is to insert the IC and then add other parts outwards from the IC. *Don't* bend the leads on R4, IC1, or the transformers. After all parts are properly soldered, add the required external wires. If you do not plan to use audio muting or mono-stereo switching, wires are not connected to pins 4 and 5 of IC1.

Although a multiplex generator is the easiest alignment method, this unit can be aligned with a broadcast signal. Input level should be about 0.75 volt p–p to achieve maximum channel separation.

Each output should be connected to a 22K load to provide the proper terminating impedance to the Twin-T filters.

Connect an oscilloscope or ac vtvm to the junction of pin 1 and C4. Peak L1 and L2 for maximum 19 kHz as seen on the scope. This waveform should be about 1.6 volts p–p with a +15-volt supply. Move the scope probe to the junction of C5 and pin 4 of L3 and peak L3 for a maximum 38-kHz trace. This should be about 22 volts p–p. Caution: if you do not use a low-capacitance probe, the circuit may be slightly detuned when the probe is removed. This detuning will be slight and is corrected in the next step.

Connect the scope or vtvm to the *right* output and set up the generator for a *left-only* output. Set the wiper of R4 to midposition. Carefully peak L1, L2, and L3 for a *minimum* output on the *right* channel. Then set R4 for a minimum output.

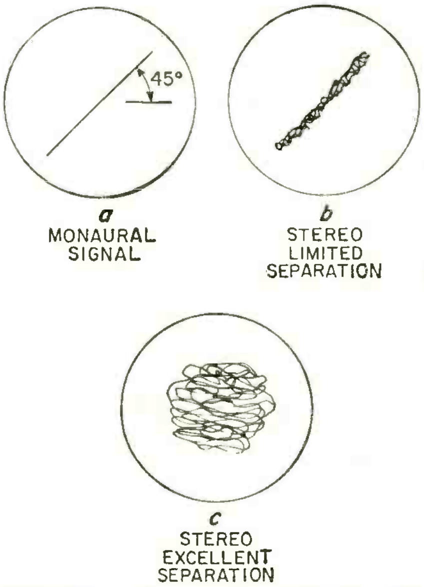
Now set the generator for a *right-only* output and read the output level on the right channel. Then set the generator to a *left-only* output. The difference in readings is the channel separation. It will not be as high as the figures given earlier since the residual reading also includes 19-kHz and 38-kHz components. An elaborate filter can remove these components for true separation readings, but the separation will not be increased.

FM station alignment

If you do not have access to a multiplex generator, connect the input to your tuner output. First peak L1, L2 and L3 for maximum output waveforms as described earlier. Connect the scope vertical input to the left output and the horizontal input to the right output. Tune to a monaural station and set the scope gains until the trace is a straight line at a 45° angle (Fig. 3-a).

Tune to a stereo broadcast and you will probably see something like Fig. 3-b. This indicates limited separation. Now, while watching the scope face, slowly tune L1, L2, L3, and R4 until you get a trace most like Fig. 3-c. If you can connect your amplifier to the adapter and also hear the output—preferably in headphones—so much the better.

Some stations have stereo programs which feature highly directional microphone pickup, this type of program material is the easiest to use for alignment. When the output looks like Fig. 3-c, you must identify the channels. It is possible to tune the unit so that the output labeled L is actually the right channel. Careful tests do not show any difference in separation or other specifications, however, so if you wind up with the channels interchanged, simply reverse them when you plug them into your preamp.



Figs. 3-a–c show scope patterns with vertical scope input to left output of the decoder and horizontal input connected to the decoder right output.

Most tube tuners will have more than 0.75 volt p–p output. This adapter will have decreased separation and increased distortion at higher input levels. The input impedance is around 20K so a 100K pot inserted in series with the input may be adjusted until the input is correct.

An interesting feature of this IC is its 8–22-volt supply specification. If the adapter is aligned at 15 volts and the supply voltage decreased, separation stays almost unchanged. This is not true if the adapter is aligned at a lower voltage which is then increased. In no event should the supply exceed +22 volts. Operation at +15 volts is highly recommended, since no performance characteristic was improved at higher voltages. As the supply voltage is not critical, a relatively inexpensive Zener diode with capacitor filtering will provide very stable operation. **R-E**

BUILD IC VOLUME EXPANDER

Improve apparent S/N ratio in your hi-fi system. Hot carrier diodes and IC's make it work

by KENNETH E. BUEGEL

THE MUSIC LOVER HAS NEVER HAD such an excellent range of equipment to choose from as he has today. Frequency response of the electronics extends far past the limits required and distortion levels are almost at the vanishing point. Signal to noise (S/N) ratios of 70 db or more are common. (At least on the specifications!)

These S/N ratios, however, start deteriorating as soon as the equipment performs its primary function—music reproduction. This is caused by the characteristics of the recorded medium. In tapes it is oxide irregularities which cause the familiar tape hiss. In records it is surface blemishes which continually increase through the useful life of the vinyl impression.

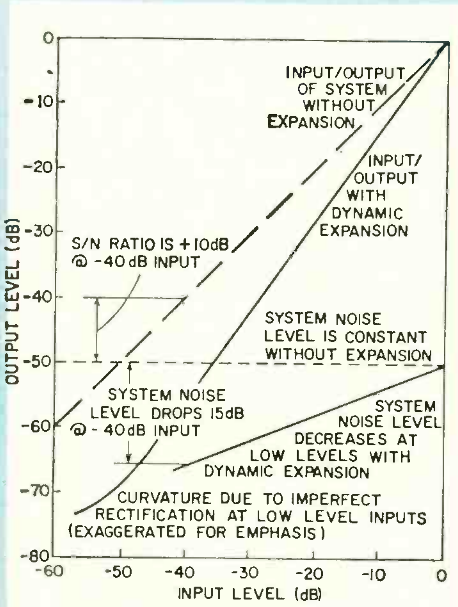


Fig. 1—Graph shows shift of input/output levels with linear expansion.

To alleviate these surface noises the recorded signal is artificially compressed when it is recorded. The loudness range experienced by the listener is thus decreased from what he hears at a live performance. In fact at least one major recording studio which claims to have reduced surface noise to new lows has only increased the compression until a solo violin has almost the same level as the full orchestra in a recording.

A device that would *linearly* expand the reproduced signal would more faithfully recreate the original performance. However, the effect of this expansion on the listener cannot be expressed only by electronic measurements of the signal.

In Fig. 1, the long dashed line shows the fixed linear relationship between input and output levels on an amplifying system without expansion. Note that at some low level near the −40 dB input point, the output signal is only 10 dB above the system output noise. (This noise is from the recording, tape or disc, and will be constant.) We hear the output signal, as it decreases from a high level to a low level, approaching a fixed background noise level.

The solid lines represent the performance of the same amplifying system with linear dynamic expansion included. With a +15 dB expansion characteristic added to our original 40 dB input range our output level now covers a 55 dB change. Even more important, the S/N ratio is *still* +10 dB at the lower input level.

If we had attempted to get this range of levels without expansion, our signal would have been 5 dB less than the noise level. Not easily depicted on a graph is the subjective response of the ear. Although the S/N ratio is still the same +10 dB at the −40 dB input point, the ear interprets this response as that from a system with much lower overall noise level, the same 15 dB that was added to the dynamic range.

When shopping for tape recorders we are continually faced with a S/N specification which, more or less truthfully, varies around 50 dB. Imagine what it would be like to see this read 65 dB. And this is precisely what it sounds like—with linear dynamic expansion.

You can have these benefits without throwing out your entire system and starting over. This project has been designed so that the device is placed between the preamplifier and power amplifier.

All expanders described in the literature to date have used a regen-

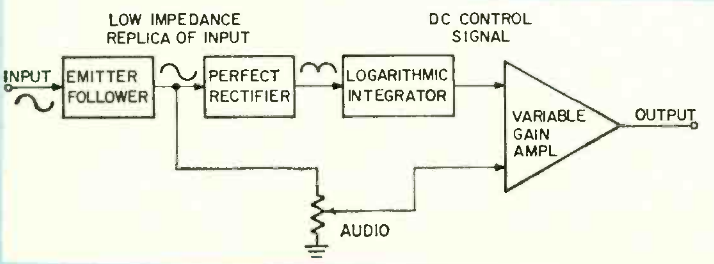


Fig. 2—Circuit of expander amplifier gain to vary directly with the input.

Expander specifications are:

Nominal maximum input and output levels:	1V rms. (This may vary from 0.2V to 3.0V.)
IM and THD @ 1V rms output:	0.2% (Decreases at lower output levels)
Frequency response:	
−1 dB points	30 to 20,000 Hz
−6 dB points	20 to 40,000 Hz
Signal/Noise ratio	
@ .01V rms input	85 dB
@ 1V rms input	45 dB

Expansion Linearity:

@ +15 dB: less than ±0.5 dB deviation from straight line in any 10 dB segment between 0 to −50 dB input (O d B = 1V rms).

@ +8 dB: less than ±0.3 dB deviation from straight line in any 10 dB segment between 0 to −50 input (O d B = 1V rms).

erative technique—the amplifier output signal has been used to determine its own input signal. While this type of device actually can increase the dynamic range, it is far from linear.

Assembly has been simplified and the only equipment needed to calibrate the unit is a dc voltmeter or scope, an audio generator and an ac vtvm, or scope. The design of several earlier models has been thoroughly evaluated and this version reflects the stress placed on performance as well as ease of calibration.

How it works

All signals used in the expander are derived from the input signal (see Fig. 2). The input signal is applied to the high input impedance of an emitter follower. The follower output is applied to a pot, used to adjust the audio level applied to the variable-gain amplifier. The total follower output is applied to a "perfect" rectifier which rectifies signals lower than 1 mV rms. This full-wave rectified signal is then integrated into a dc voltage. The dc voltage varies as the logarithm of the input signal. (Remember that the gain of an amplifier is expressed in decibels according to the formula:

$$\text{dB gain} = 20 \log \frac{e_{out}}{e_{in}}$$

This dc control signal is applied to the control element in the variable-gain amplifier so the gain of the amplifier varies directly with the input signal. Thus, as the signal input increases, the dc control signal rises and the output of the variable gain amplifier corresponds to:

$$e_{out} = e_{in} + K \log e_{in}$$

The schematic, Fig. 3 shows how we get these functions. IC1 is the "perfect" rectifier. Since D1 and D2 are inside the feedback loop of the op amp, the diode threshold voltage is

PARTS LIST

*T1—26.8VCT fil trans., Triad F90X or equiv.
RECT 1—1A, 50V bridge rectifier
C18, C19—250 μF 25V elecrolytic, Mallory MTV250DN25 or equiv.
C20, C21—500 μF, 15V electrolytic, Mallory MTV500 DN15
D5, D6—1W, 15V, 5% Zener diodes
R28, R29—½W, 220Ω, 5%
R30, R31—½W, 33Ω, 5%
PC board—PS-1, Transitek

Expansion Channel (for stereo, 2 of each are required)

All resistors are ¼W, 5%
R1, R2—220,000 ohms
R3—470 ohms
R4—2500 ohms, ¼W trimmer, CTS type X201R252B or equiv.
R5, R7, R9—20,000 ohms
R6—3600 ohms
R8—1800 ohms
R10, R23—10,000 ohms
R11, R20, R27—1500 ohms
R12, R15, R17—560 ohms
R13—1000 ohms, ¼W trimmer, CTS type X201R102B or equiv.
R14, R16—75,000 ohms
R18, R19—2200 ohms
R21, R25—180 ohms
R22—220 ohms
R24—100,000 ohms
R26—6800 ohms
C1—150 μF, 15V electrolytic, Mallory MTV150CK15 or equiv.
C2—0.1 μF, 10V ceramic, Centralab UK-10-104 or equiv.
C3—25 μF, 35V electrolytic, Mallory MTV25CB35 or equiv.
C4—68 pF ceramic
C5, C9, C14—22 pF ceramic
C6, C13—470 pF ceramic
C7—100 μF, 15V electrolytic, Mallory MTA100E15
C8—50 μF, 15V electrolytic, Mallory MTV60CB15
C10—.0012 μF ceramic
C11—500 μF, 6V electrolytic, Mallory MTV 500DJ6 or equiv.
C12—0.2 μF, 10V ceramic, Centralab UK10-204 or equiv.
C15—220 pF ceramic
C16, C17—0.1 μF, 20V ceramic, Centralab UK20-104 or equiv.
D1, D2—IN4154, G-E
*D3, D4—Hot carrier diodes, HP5082-2800
Q1—2N3391, G-E
*IC1, IC2, IC3—709 C Operational Amplifier
*S1, S2, S3—4pdt custom rocker switch
*PC Board—EXP-3
*Items available from Transitek; D3, D4 $1.25; IC1, IC2, IC3 $2.65; S1, S2, S3 $1.40; PC Board EXP-3 $2.75; Board PS1 (pwr), $1.00; PS1-K (pwr supply board with all components but T1), $7.00; EXP-3K (all items for 1 expansion channel), $26.00; Two EXP-3K's, $48.00
Transitek Co.
P.O. Box 98205
Des Moines, Washington 98016

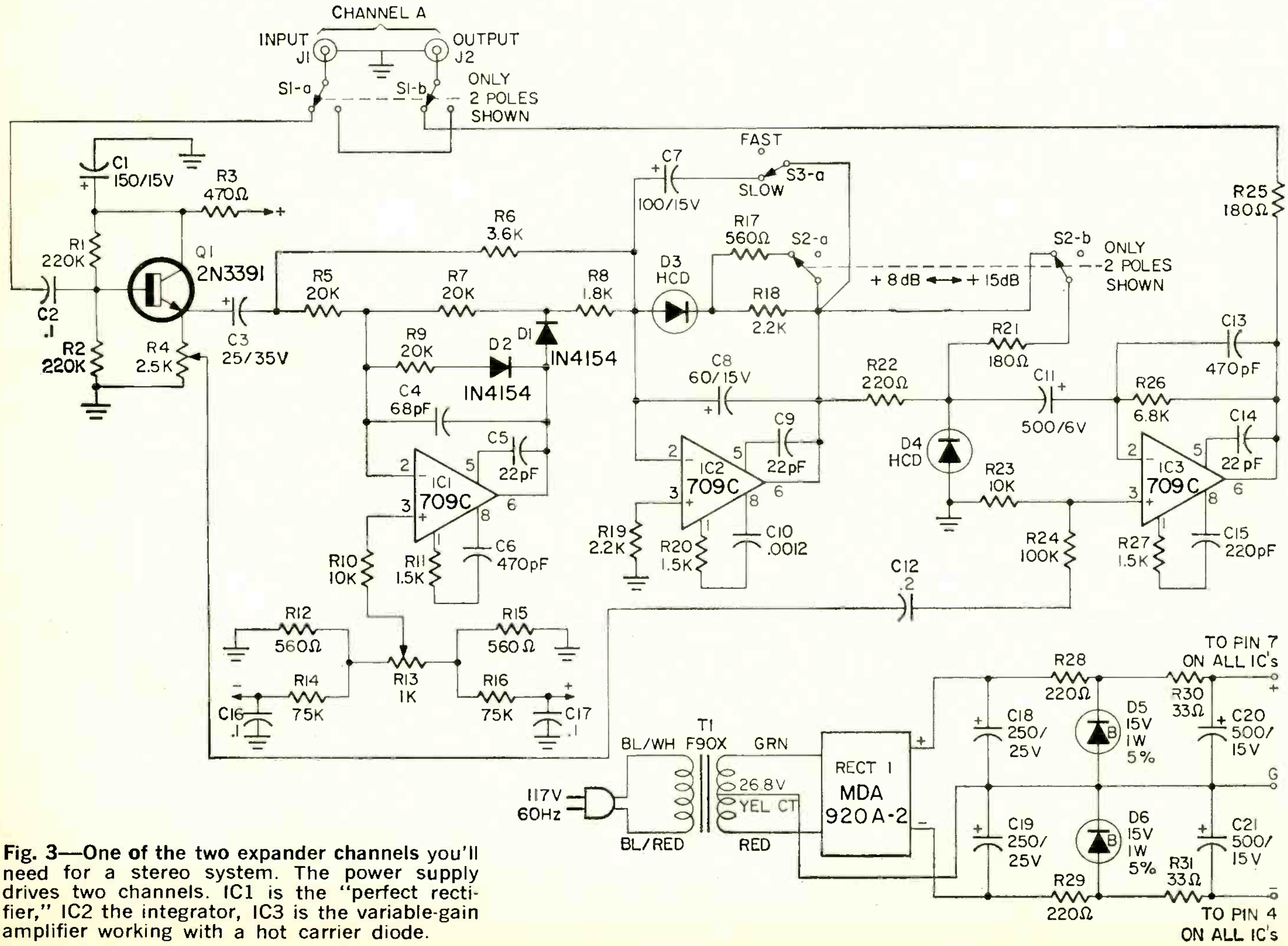


Fig. 3—One of the two expander channels you'll need for a stereo system. The power supply drives two channels. IC1 is the "perfect rectifier," IC2 the integrator, IC3 is the variable-gain amplifier working with a hot carrier diode.

reduced by the open loop gain of the amplifier—typically 7,000 to 15,000. Capacitor C8, in the feedback loop of IC2, integrates the rectified signal. The value of C7 and C8 determines low-frequency distortion. If the time constant chosen is extremely short, the expander tends to increase gain on the positive and negative peaks of a low-frequency input signal.

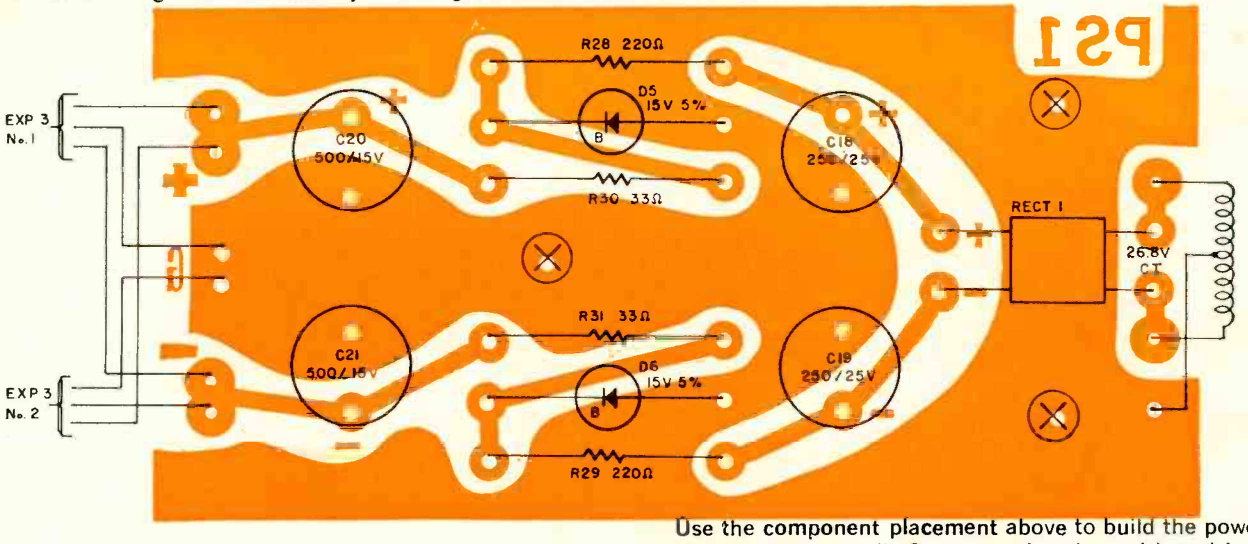
Increasing C7 excessively increases the time constant and causes a noticeable "pumping" action on the volume. However, unless you are a devotee of large pipe organs, for most music the fast position of S3 is best. D3 and R18, in another feedback loop of IC2, provide a modified logarithmic dc feedback. Diode D3 is a hot carrier diode with a much lower threshold voltage than ordinary diodes. The ac gain of IC3 is determined by:

$$\text{gain} = \frac{Z_F + Z_R}{Z_R}$$

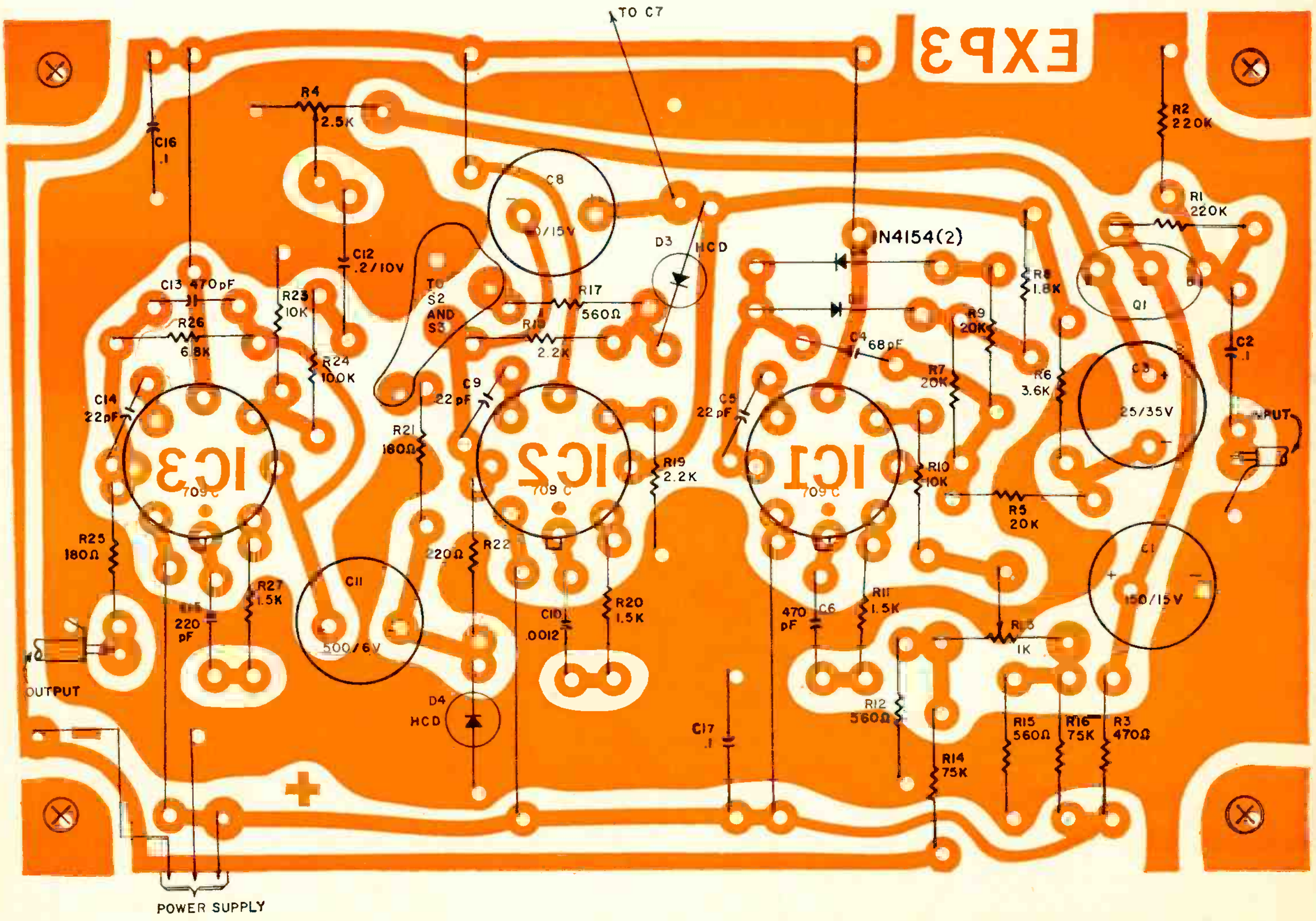
where Z_R is the impedance of C11 and D4 and $Z_F = 6.8k$. Capacitor C11 is large so its impedance, even at low frequencies, is much lower than the impedance of D4. Thus the gain of IC3 becomes:

$$\frac{Z_F + R_{D4}}{R_{D4}}$$

(continued on page 39)



Use the component placement above to build the power supply for a stereo unit. One expander channel board is below. Mount components on the expander like this. Use low-wattage iron to solder in the IC's, or install IC sockets for 709's.



The modified dc control signal of IC2 varies the current through D4 and thus the dynamic resistance of D4. Since C11 isolates the dc output of IC2, IC3 operates with a dc gain of unity and the output can never have a dc voltage of more than 5 mV. Resistor R13 sets the dc voltage applied to D3 and D4 so even without an audio input signal these diodes do not operate at extremely low current levels where their dc resistances could show wide variations from unit to unit. As a result the low-cost hot-carrier diodes provide nearly ideal results for the circuit.

The power supply is a full-wave center-tapped bridge rectifier providing ±15 volts to the operational amplifiers. Although the op amps do not require extremely low ripple supplies, the base supply of Q1 is sensitive to ripple and the additional filtering provided by C1 and R3 reduces the remaining ripple to negligible values.

Switch S1 either connects the expander or completely removes it from the system. Switch S2 selects either a +8 or a +15 dB expansion range, and S3 selects the fast or slow time constant.

Now let's build one

The device built for this article is in an extruded aluminum cabinet. The only parts mounted to the front cabinet panel are the switches. The power transformer, power supply pc board, and two expander pc boards are arranged along the rear cover plate. Other arrangements are possible for mounting the parts used to construct a dynamic expander.

Use the circuit boards as templates to determine the locations of the mounting holes. The easiest method of construction is to first place all the resistors on the boards in the positions shown on the component layout sheets, then the ceramic capacitors, next IC1 through IC3 and Q1, and finally the upright electrolytic capacitors. Add the external wiring to the expander boards before mounting them with ¼-inch spacers.

The length of the shielded leads to S1, S2, and S3 may be 6-feet long, thus allowing the switches to be placed on an existing panel with the expander itself tucked away in some hidden corner. Use of a 1/16-inch tiplet in a small 37½-watt soldering iron is recommended. A larger tip may be used in soldering leads to the ground foil. Note that each expander board has its own ground return to the power supply. Arrange your board mountings so you have access to R4 and R13 for the calibration adjustments. No switch is used in the power supply line since most systems provide switched ac line outlets.

Calibration techniques

Follow these steps in sequence to calibrate the expander.

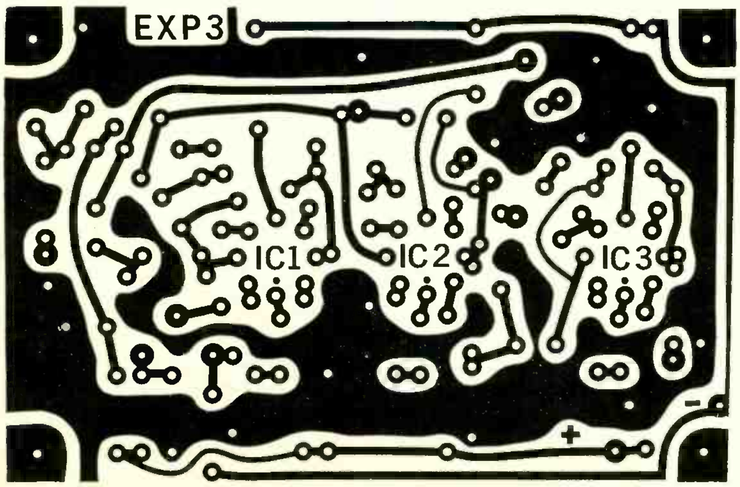
1. Check the outputs of the power supply. These should read plus and minus 15 volts ±5%.
2. Apply a short to J1 on both channels. Set S1 to the expander IN position and S2 to +15 dB. Set S3 to the FAST position.
3. Adjust R13 in each channel until a dc voltmeter or scope reads −0.2V at the output of IC2. (This voltage at pin 6 may be read most easily at one of the contacts of S2-a.) Adjust slowly, this is an integrator!
4. Apply a 1 kHz, 1V rms signal to J1 on both channels and adjust R4 on each channel until the outputs read 1V rms.
5. Reduce the input to 0.01V rms and measure the output on each channel. One channel will probably have slightly higher output than the other. Readjust R13 on the lowest channel until its output is the same as the highest channel.
6. Repeat steps 4 and step 5.

When calibration is complete the unit is ready to use. If your preamp output is low impedance, as virtually all preamps are, you may run 20 feet of shielded cable between its output and J1 on each channel. 40 feet of cable may be used between J2 and the power amplifier.

Expansion ratios can be adjusted by varying the values of R17, R18, R21, and R22. These particular values have been chosen so that the output level does not change significantly when switching S2.

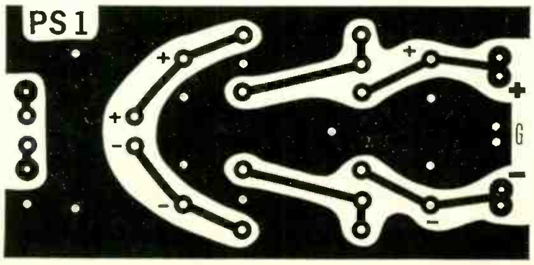
The pot connected between the IC2 outputs on each channel is of doubtful use. When it is used it forces the channel with the lowest input signal to operate at the gain of the loudest channel—which brings up the noise level of the lower channel. Since noise reduction is one significant advantage of linear expansion, this type of connection can only defeat its purpose.

Listeners report that the music in the expanded system sounds more like a live performance, although the rustling of programs is absent! The most convincing demonstration is to play a favorite tape or record with the expander in the circuit, then to remove the expander and play the same music again. In just the few minutes you have listened to the music without the noise background your ears will become accustomed. Without expansion you will immediately notice the noise which appears during softer passages. The difference is similar to going back to black and white after watching color television. **R-E**



ACTUAL-SIZE PRINTED CIRCUIT PATTERNS

Here's how the PC patterns look from the copper side. Reproduce them photographically to build your dynamic expander. You'll need two of the expander boards (left) for stereo, but only one power supply (below). Parts placement for the boards is on the preceding page.



All about tape recorder bias

Modern biasing techniques continue to improve audio fidelity

by NORMAN H. CROWHURST

THE FACT THAT TAPE SPEEDS AND CORRESPONDING FIDELITY achieved by off-the-shelf equipment today would have been considered impossible a decade or so ago testifies that changes have been occurring in both tape and tape recording. The variety of changes has led to some confusion, and sometimes to failure to achieve expected performance. To clarify the whole situation, let's examine the purpose and needs of high-frequency bias.

Original need for high-frequency bias

Every text on tape recording explains this. Without high-frequency bias, the waveform recorded was highly distorted because of the inherent nonlinearity of magnetic materials. The initial effect of high-frequency bias, before considering all the other factors, is twofold:

1. It saturates the tape at high frequency and virtually "demagnetizes" the material, leaving the instantaneous value of the audio waveform virtually free of this nonlinear distortion (Fig. 1).
2. It enables a wider recording gap to be used than would be possible without this high-frequency bias. This achieves deeper penetration of the magnetization into the tape, particularly at high frequencies where gap dimensions are important (Fig. 2).

Kinds of tape

In the early days, it was pretty remarkable that we could put a ferrous oxide onto a plastic base that would take magnetization at all. In those days, control of molecular size and the magnetic properties of the material was a long way off. By today's standards, the product was crude, although this was not easy to see, because magnetic properties and molecular size are not visible to the naked eye or even under any ordinary microscope.

In tnis article, we'll not get into chemistry and methods of preparing and applying magnetic material to tape. That's a specialist's job, and it's enough that we can go out and buy a whole variety of tapes. But modern techniques permit the production of material with smaller molecular structure, enabling more miniscule "magnets" to be formed on the tape. Also, magnetic properties have been changed, so "better" magnets can be made.

The quality of a magnetic material is reflected in its hysteresis loop, which is what happens as it passes through a whole cycle of magnetization. Three properties are of importance in any magnetic application: saturation density, remanence and coercivity. These are illustrated in Fig. 3.

These quantities are all relative, and vary from material to material. But taking the sequence relative to the parameters of one particular material, as magnetization is applied, the magnetism induced in the material responds slowly at first (region A). Then it rises much more rapidly (region B), until it reaches saturation (region C).

When this magnetization is removed, much of the magnetism remains (point D), and the amount remaining is known as the *remanence* of the material. At first sight, this would appear to be what gets left on the tape when making a recording—or the maximum level, at least. But this ignores the fact that the tape must leave the magnetizing head and transfer this magnetism to a playback head before it can be considered to have done its job.

This means that, unless this remanence is accompanied by another property called *coercivity*, it won't do much good. So modern tapes are rated on their coercivity. Note that coercivity is also related to the magnetization that has to be applied in the first place to reach saturation. The steep rise (region B) approaching saturation is not reached until the magnetizing force approaching the material's coercivity is neared.

So improvements in magnetic material have advanced through coercivity changes, while at the same time diminishing molecular size, so smaller magnets can be formed that will hold their magnetization through playback. Saturation density and remanence have both been increased somewhat, but coercivity and molecular size have been the important changes.

Early materials had what today would be called low coercivity. In turn, this meant that a lower bias current would push them to saturation. It also meant they were more subject to precise values of bias current.

At lower frequencies (up to, say, 1000 Hz) increasing bias current reduced distortion up to a point of diminishing returns. Actually, the loss that occurs with too much bias current at these audio frequencies is a loss of output, rather than an increase in distortion. But at higher frequencies the

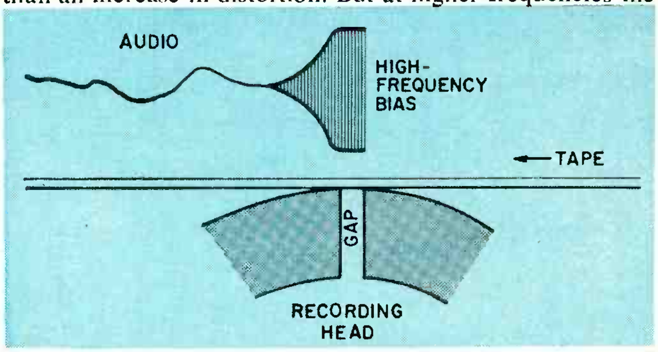


Fig. 1—High frequency bias, superimposed on audio signal, "demagnetizes" tape to instantaneous audio waveform value.

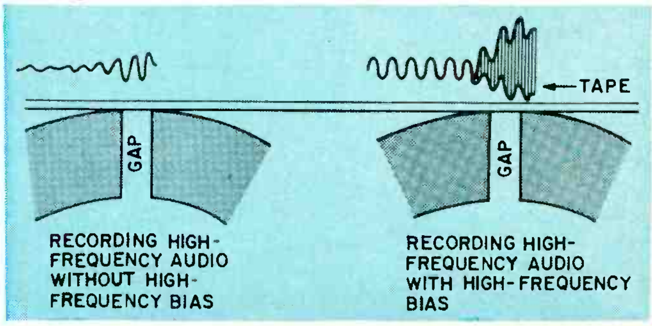
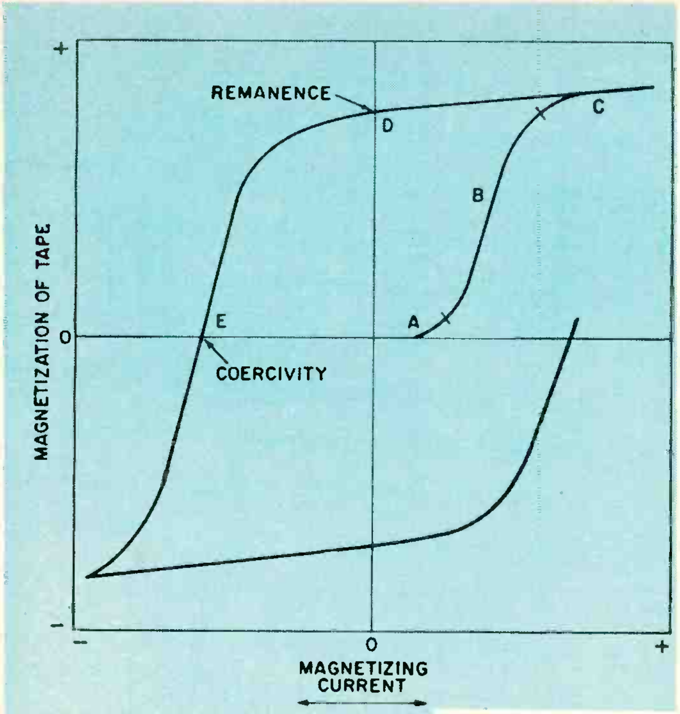


Fig. 2—Another function of high-frequency bias is to improve high-frequency response, even with a wider recording gap.



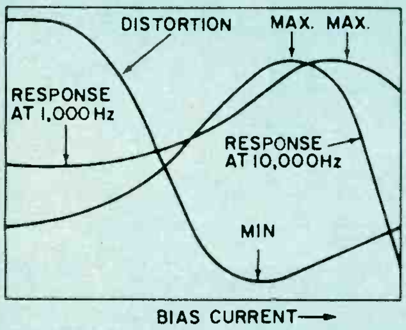


Fig. 3—Opening magnetizing cycle shows essential features of a magnetic substance in a hysteresis loop.

Fig. 4—Optimum bias for low mid-range distortion is inconsistent with good high-frequency response in low-coercivity tape.

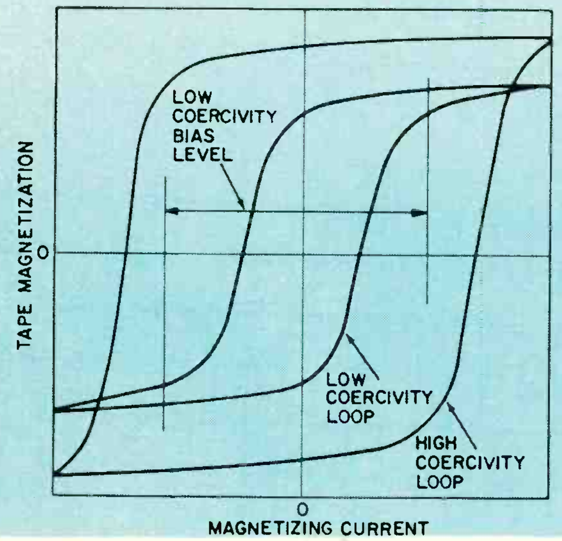


Fig. 5—Hysteresis loops of low- and high-coercivity tapes, showing the different bias levels needed for magnetization.

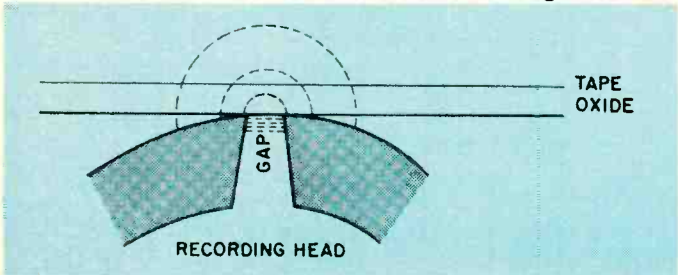


Fig. 6—Due to rapid decline of magnetic field strength with distance, the magnetizing field may not penetrate oxide layer.

loss of output begins at a much lower bias current.

At the bias frequency and tape speed, combined with the gap dimensions, several periods of bias oscillation occur while the tape is passing the gap. Recording occurs as the tape leaves the gap. At upper audio frequencies to be recorded, loss would occur in the absence of high-frequency bias because gap width is commensurate with the audio wavelength being recorded.

Thus at the higher audio frequencies, the frequency being recorded begins to behave in a manner similar to the bias magnetization. Because of this, too much bias current reduces the "headroom" for recording these upper audio frequencies.

So it happens, with low-coercivity tapes, that optimum bias for reducing distortion at mid-range frequencies does not coincide with optimum bias for achieving high-frequency response (Fig. 4). As good quality is usually defined in terms of both low distortion *and* good high-frequency response, a compromise bias setting was usually chosen such that neither distortion nor high-frequency response suffered too much.

Then, came high-coercivity tapes. Larger bias currents are needed to saturate them and to utilize the higher coercivity. For a first-time recording, the quality may be as good as with low-coercivity tapes, but unless bias current or erase current is raised from the value that suits the low-coercivity tapes, it will be impossible to reuse high-coercivity tapes because they will not fully erase.

This is shown by comparing the properties of the two kinds of tape (Fig. 5). A bias current that will easily saturate a low-coercivity tape does not even approach saturation in the high-coercivity tape. Conversely, if a head is set to saturate high-coercivity tape, it will considerably oversaturate low-coercivity tape if it should ever be used on the same recorder, resulting in considerable loss of performance.

This means that any good recorder should be adjusted to work with a specific tape or type of tape (similar types from different manufacturers could be used) and then always used with that type. This applies particularly to recording. Playback is not so critical. In fact, once the recording is made, it can be played back on any recorder equipped for playing the particular track configuration impressed on the tape.

Using finer playback heads merely insures that a better rendition of what is on the tape is retrieved. The limitation

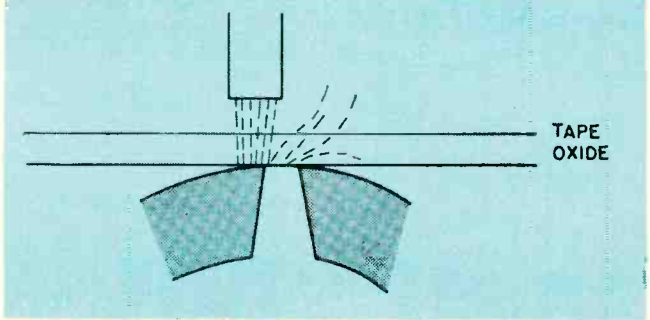


Fig. 7—Addition of a "back pole" can change shape of magnetic field through tape in vicinity of head, aiding penetration.

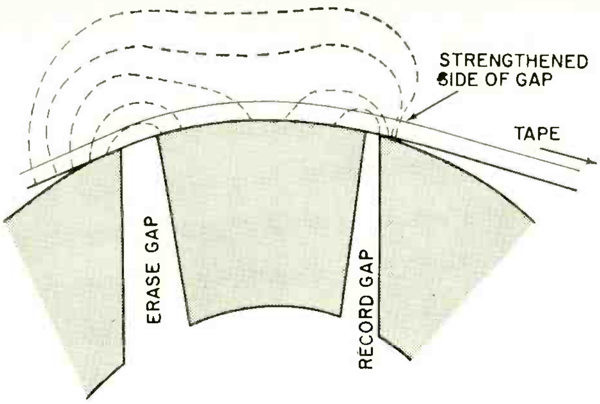


Fig. 8—Single assembly combining erase and record heads boosts field near record gap just as extra crossfield pole does.

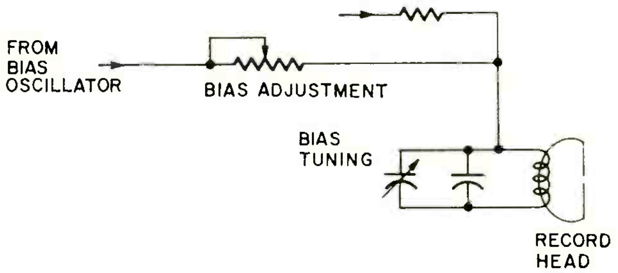


Fig. 9—Typical setup for high-frequency bias adjustment. Head bias current is first maximized, then set for tape type.

is the quality of recording on the tape, which comes back to the recording end.

Cross-field heads

The quality and intensity of signal on the tape is a function, not only of the input signal into the tape, but of how far into the oxide layer the signal extends. Although the oxide layer is quite thin, it does have finite thickness. Particularly at the high-frequency end, this thickness is an important factor.

Fig. 6 shows the magnetic field in the proximity of a recording gap. It gets rapidly weaker with distance from the gap, which is shown tremendously magnified. So, unless the field is very strong, especially with high-coercivity tape, magnetization may not extend even all the way through the oxide layer. Thus the effect is weakened by a magnetic "short-circuiting effect" of the unmagnetized portion behind the magnetized portion.

To achieve penetration, the important part of the field is the high-frequency bias. If an extra pole is put behind the tape (Fig. 7), the field in the proximity of one pole is strengthened, while the other is correspondingly weakened. The important effect—the part used to effect an improvement—is where the field strength is increased by the crossfield pole.

While the basic concept of an extra head behind the tape is fairly simple, its application could get quite involved: getting the extra head accurately positioned laterally across the tape to coincide correctly with track positions, and longitudinally along the tape so the field takes the correct shape—which cannot be seen, of course.

The tracks are only hundredths of an inch wide, the oxide is only fractions of a thousandth of an inch thick, and the gap width has similar dimensions. So accurate positioning of a head behind the tape requires extremely precise engineering, along with facility for inserting and removing the tape that will not disturb this accuracy.

So a further improvement (Fig. 8) achieves the same purpose by combining the record and erase head in such a way that a leakage field from the erase gap passes through the tape and returns to the record-head gap vicinity in the same way that a crossfield pole would produce. This puts all the engineering problems into a single, fixed block of construction. The needed precision can be built in, and head adjustment is no more critical than in the conventional recorder.

Use of crossfield magnetization does reduce the criticalness of bias adjustment. This means that a recorder, adjusted for optimum performance with one tape, will not be so seriously below optimum performance with another tape as would be the case where ordinary instead of crossfield heads are used.

Bias adjustments

The foregoing nas discussed adjustment of bias current for optimum performance in general terms. One more thing is important in all cases: The waveform of the bias oscillator should be good, as close to a perfect sine wave as possible. If the oscillator waveform departs from sinusoidal, it transfers its onlinearity, or departure from sine-wave form, to the program signal recorded.

So the first thing to do in checking bias adjustment is to be sure the waveform is good, whatever the current. Tuning the head inductance with a shunt capacitance will always improve it, as well as get more bias current by using more efficient coupling. But the waveform generated by the oscillator should be good before this improvement is added. It is not sufficient to rely on this method of improvement.

Having made this adjustment, the next step is to adjust the actual bias current to achieve optimum performance with the tape being used (Fig. 9). The method of making this adjustment will vary, according to the recorder facilities. A recorder that has full playback facilities, head and electronics, in addition to the record facilities can use the playback to monitor recording as the adjustments are made.

A recorder which uses the same electronics and/or head for playback as for record must employ a different, somewhat more protracted method of adjustment, but the end objective is the same. In the first, the adjustment is made while watching the playback monitor directly for the desired indication. In the second, a succession of adjustments are made, carefully noting the settings and using voice announcements on the tape to identify them. Then the tape is played back to determine the results. If necessary, a further series is tried, until the optimum is achieved.

Some manufacturers specify a way of adjusting the bias current in terms of output level at a specified high frequency, such as to adjust for a maximum output, then back off by a quarter turn on the adjusting screw, or by so many mA on the bias current reading.

This is a method of approximating ideal overall performance based on setting for maximum high-frequency response, and then modifying it to improve distortion properties.

If you want to actually measure distortion, as well as high-frequency response, you'll need to find a way of making this kind of measurement on tape, which is not so easy as measuring distortion in amplifiers. Fluctuation in level, not large enough to matter, due to variation in tape characteristics along the tape, or fluctuation in speed, insufficient to be significant as flutter or wow, can invalidate conventional distortion measurements that use highly sensitive frequency-selective circuits to eliminate the fundamental.

A method of measurement that is not sensitive to these fluctuations but will detect the forms of distortion sought must be used. The CCIF form of intermodulation distortion measurement detects only second-harmonic distortion. But by using the same basic method, with different test frequencies, the method can be adapted to finding the forms of distortion that are important here, and measuring them independently of small flucttutations in speed or amplitude. These we will describe in a future article. **R-E**

Walnut-veneer finish can make a handsome extension speaker for any hi-fi.

Build bookshelf speaker system

by ALEXANDER N. RETSOFF

This compact acoustic suspension system delivers clean sound with excellent response. Use it for main or extension speakers in your system

WHAT I WANTED WAS A COMPACT speaker system with a wide, smooth frequency response, low distortion and sufficient power-handling capability to fill at least a small room with realistic sound.

The requirement for smooth response and low distortion in a small cabinet calls for an acoustic suspension system. Although horn-loaded speakers provide excellent response and low distortion, the laws of physics being what they are, it is impossible to have a "small" horn-loaded speaker that extends to 50–80 Hz. That being the case, the choice was between a bass-reflex system and an infinite baffle.

Bass-reflex speakers

The bass-reflex approach includes all systems in which the sound emanating from the rear of the speaker is allowed into the room. Such a system may go under the name of "bass-reflex," "tuned-port," "ducted-port," "distributed-port," "Helmholtz resonator" or some other title. In all cases, a hole somewhere in the cabinet allows the rear sound wave from the speaker to enter into the room. These systems boast relatively high efficiency and extended low-frequency response.

In general, every dynamic loudspeaker exhibits a primary resonance at the lower end of its frequency response. The frequency at which the resonance occurs depends upon the mass of the moving system, i.e. the cone and voice coil, and the compliance of the suspension.

For a speaker in free space, the suspension is made up of the flexible spider, which supports the voice coil end of the cone, and the rim support at the large end of the cone. The system is analogous to a weight on the end of a spring. Once the weight is set in motion it bobs up and down at a rate or frequency that depends on the mass of the weight and the compliance of the spring. By increasing the size of the weight and/or picking a softer spring, frequency can be lowered. The converse is also true.

The point is that a speaker's output drops off very rapidly below its resonant frequency. Also, at its resonant frequency the cone likes to move and does so very readily, resulting in a peak in the response curve. Just like the weight on the spring, once in motion at its resonant frequency, the speaker tends to keep moving even after the signal has disappeared. This "hangover" causes poor transient response and muddy sound.

The degree to which the peak appears in the response curve and the transient response is impaired is determined by the "Q" of the resonant system. This in turn is controlled by the damping or friction in the moving system. The chief causes of damping are the air loading on the speaker cone, the friction in the suspension system and the damping factor of the amplifier.

If damping is high, there is only a mild peak in the response curve, since the energy is rapidly dissipated in the friction; the cone quickly comes to rest after the excitation is removed. An underdamped system will exhibit a large peak and long "hangover." Obviously this is to be avoided.

What has all this to do with the choice of a speaker enclosure? Well, the speaker and its enclosure must be designed for one another. It is the combination of the two, the speaker *in* its enclosure, which must be tested for resonance, response, etc.

Now, a bass-reflex enclosure is a box with a hole in it, and a box with a hole in it is a resonant system itself. It is called a Helmholtz resonator. A soda bottle is a Helmholtz resonator if you blow across its mouth.

The design philosophy behind a bass-reflex enclosure is to have the box resonate at the same frequency as the speaker mounted in it. This can be accomplished by properly controlling the volume of the box and the port size and ducting.

When two resonant systems are coupled together like this an odd thing happens. Instead of getting twice as big a resonance as you might suspect, you get *two* resonant peaks, one higher in frequency than the original and one lower in frequency. A dip appears where the original resonance was. The spread between the two peaks depends on the degree of coupling between speaker and box. This in turn depends upon the size of the box and the amount of damping material in it. In this way, one can extend the low-frequency response of the speaker system to the lower of the two resonance peaks.

This sounds like a terrific idea, and indeed the bass-reflex system was widely used several years ago, and still is in many smaller enclosures. There are certain disadvantages to this system: (1) increased distortion, especially near the resonant points, since the system is somewhat uncontrolled near resonance; (2) less than optimum transient response, leading to muddy sound; (3) irregular response in the bass region formed by the two resonances and the trough.

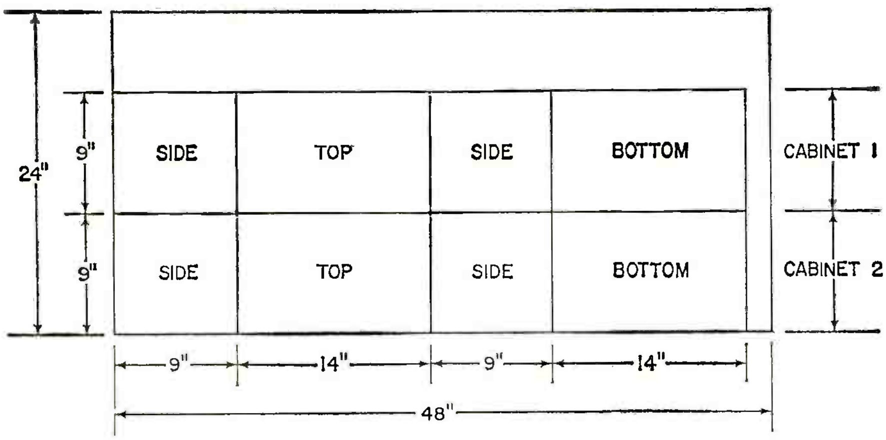


Fig. 1—Cutting diagram shows you how to cut two speakers from a single board.

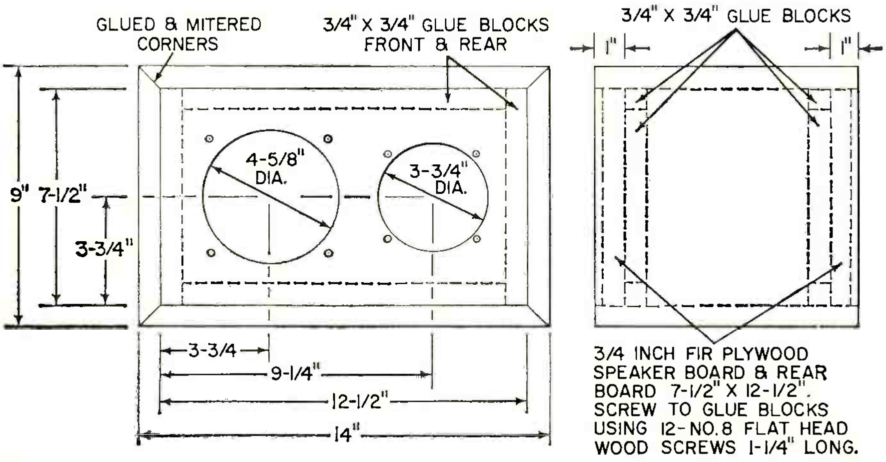


Fig. 2—Use good cabinet assembly techniques when constructing your speaker.

Why an infinite baffle?

This leaves us the infinite baffle. The infinite-baffle enclosure includes any type which prevents the sound from the rear of the speaker from getting into the room. In its simplest form it is an infinitely large wall in which the speaker is mounted.

In a more practical form, it is a completely sealed box filled with fiberglass or felt mats to absorb the rear sound energy. The walls of the box are strong and rigid enough so they do not vibrate in sympathy with the speaker. The infinite baffle performs the primary function of the speaker enclosure: preventing the rear sound wave from blending with the front wave. Since the two waves are out of phase, they cancel each other if allowed to meet. (The sound emanating from the port of the bass-reflex enclosure is delayed by the enclosure design enough to emerge in phase with the front wave in the bass reinforcement region. At higher frequencies all rear energy is absorbed by the damping material in the cabinet, and in this region the bass reflex acts as a sort of infinite baffle.)

Early infinite-baffle enclosures were made very large. Since the air trapped in the cabinet acts as a spring behind the speaker cone, system compliance is reduced and the resonant frequency of the speaker system is raised above that of the speaker alone. Since the output of the system drops below the resonant frequency, it appeared advantageous to use a very large cabinet for minimal increase in the resonant frequency.

The acoustic-suspension system is basically an infinite baffle in which the compliance of the trapped air is counted upon to provide some of the speaker suspension. Such a system uses a speaker with a very light (compliant) suspension that has a very low free-air resonance. It is put in a relatively small sealed enclosure. The trapped air decreases system compliance and substantially raises the resonant frequency by as much as an octave.

Thus one can see the necessity for starting with a very-low-resonant-frequency speaker. The acoustic suspension provided by the trapped air has one very distinct advantage: it lowers the harmonic distortion of the system. The main cause of nonlinear distortion in a speaker system is the nonlinearity in the suspension. The typical spider and rim-surround suspensions do not provide a linear restoring force at extreme cone excursions.

The "spring" provided by the trapped air, however, is extremely linear. In a well-designed acoustic-suspension system, the air cushion provides the majority of the restoring force. For example, if the resonant frequency of the system is one octave above (twice as high) the free-air resonance of the speaker alone, three-quarters of the restoring force is provided by the air cushion and only one-quarter by the speaker suspension. Thus, the effect of the nonlinear suspension, that is the distortion, is reduced three times.

In addition, the air cushion is provided by making the enclosure small instead of large. Further, the response is relatively smooth—assuming good damping to an acceptably low frequency—if the original speaker is of the high-compliance type. We pay for all these advantages with a decrease in overall efficiency.

In choosing a speaker for use in an acoustic-suspension system one must look for a low resonant frequency. Next, you need a good, powerful magnet, which implies good damping and the capability of long speaker excursions. The latter, although they give rise to Doppler distortion, are unfortunately necessary to get a reasonable sound-pressure level from a small cone.

How to build it

Probably many speakers will fill the bill. I chose to build the system around one available for $8.95 from Lafayette Radio Electronics (catalogue No. 99E01554). It is a 5-inch unit with a 1½-lb magnet and resonant frequency of 40 Hz. It is rated at 16 watts (peak). For a tweeter I chose another Lafayette unit (catalogue No. 99E01562) at $2.95.

The enclosure is 14 x 9 x 9 inches and is constructed from ¾-inch plywood. I chose to construct it from single-sided walnut-veneered plywood, available from several firms. Following the cutting diagram of Fig. 1, two speaker enclosures can be made from one 24 x 48-inch sheet of plywood.

Other veneers are also available. If you like oiled walnut, two or three coats of boiled linseed oil rubbed in with cheesecloth and the excess removed will give you a better finish than you can expect on commercial cabinets. Let each coat dry overnight and rub lightly with the grain using *fine* steel wool. The recessed front and back of the cabinet will not show and can be made from ¾-inch fir plywood available from any lumber yard. A two-conductor barrier strip is mounted on the recessed rear wall.

Fig. 2 shows how the cabinet is put together. Be sure to make it airtight. Seal all cracks with glue, filler or caulking. The inside of the cabinet should be loosely filled with Tufflex or a similar sound-absorbing material. Such materials are readily available from most parts dealers.

The wiring diagram is shown in Fig. 3. A 4-μF, 50-or 100-volt capacitor is used as a highpass filter to the tweeter. This capacitor should be a paper or mylar type. Aluminum or other electrolytics should *not* be used.

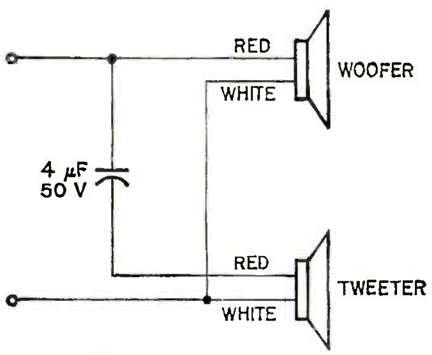


Fig. 3—Wiring diagram for speakers. Do not use tantalum electrolytic capacitors.

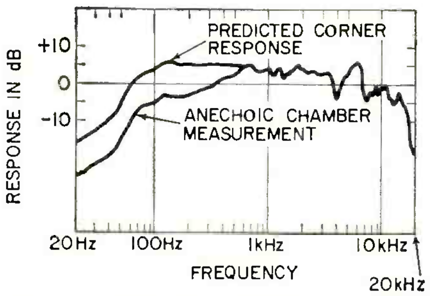


Fig. 4—Anechoic chamber curve is smoothed by placing unit in corner.

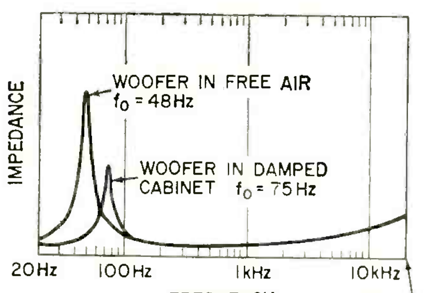


Fig. 5—Impedance curves for the woofer in free air and damped in the cabinet.

When wiring the speakers be sure to observe polarity. If you use the speakers recommended, you will find one terminal on each insulated with a red fiber washer and the other with a white one. Connect the whites together as the common return and the reds with the capacitor.

More exotic crossover networks could be used with this speaker system, but they are really unnecessary. The woofer used in this system handles itself so gracefully at the higher frequencies that there is no real reason to prevent it from reaching them.

When you're through, connect them to a good amplifier with at least 5 watts per channel capability into 8 ohms and listen. As is true for all speaker systems, bass response is affected by placement of the units in the listening room. As much as 9 dB boost in the low end can be achieved from corner placement.

Fig. 4 shows the response of the system, measured in an anechoic chamber, and the response expected in a corner placement, the recommended location for this system. Placed in a corner, a speaker sees a much reduced solid angle of radiation at low frequencies. Thus, its efficiency is greatly increased. This is especially important for small-size systems. You can experiment with various placements in your home. You will probably be quite surprised at the difference positions can make.

Impedance curves of the woofer in free air and in the damped cabinet are in Fig. 5. You can see that the resonant frequency rose from 48 Hz to 75 Hz, almost an octave. In addition, the height of the peak is substantially reduced. As explained, the acoustic response of a speaker system falls off at about 12 dB per octave below the resonant frequency. From Fig. 5, you can see the resonant frequency is at 75 Hz, and, sure enough, from Fig. 4, the response starts to fall off at just about that point.

The results of this little system will amaze you. The sound is surprisingly clean and live. The instruments of the orchestra are well defined and project into the room. This is attributable to the smooth mid-range. Except for a dip and peak in the response at 4 kHz and 6 kHz, the response throughout the critical mid-range is extremely smooth and well balanced compared with *any* system. Couple this with adequate response, again without any sharp variations, out to the limit of audibility (16 kHz), and solid bass response down to 60 Hz or so, and you have a system to put many of its larger and more costly brothers to shame. **R-E**

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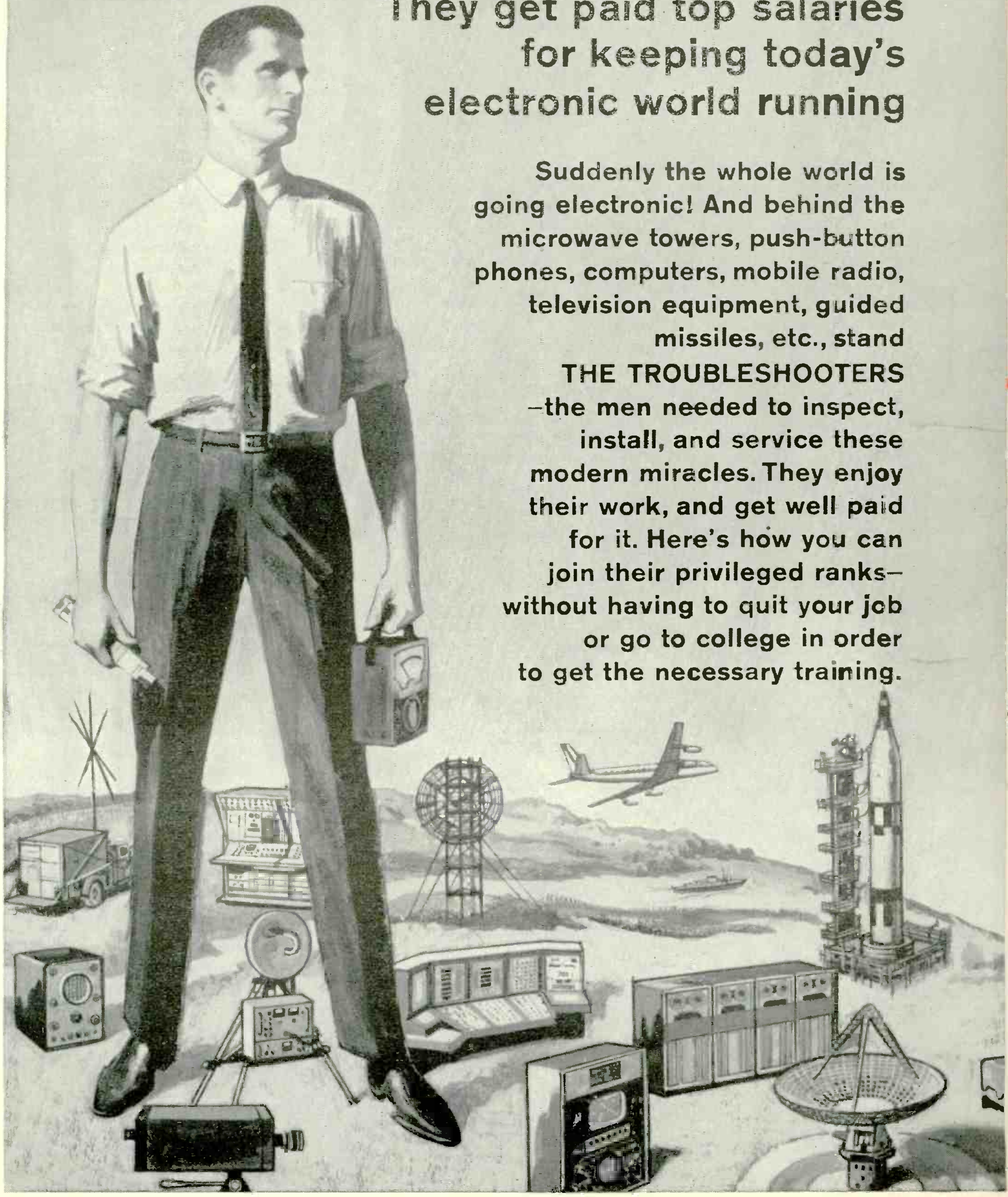

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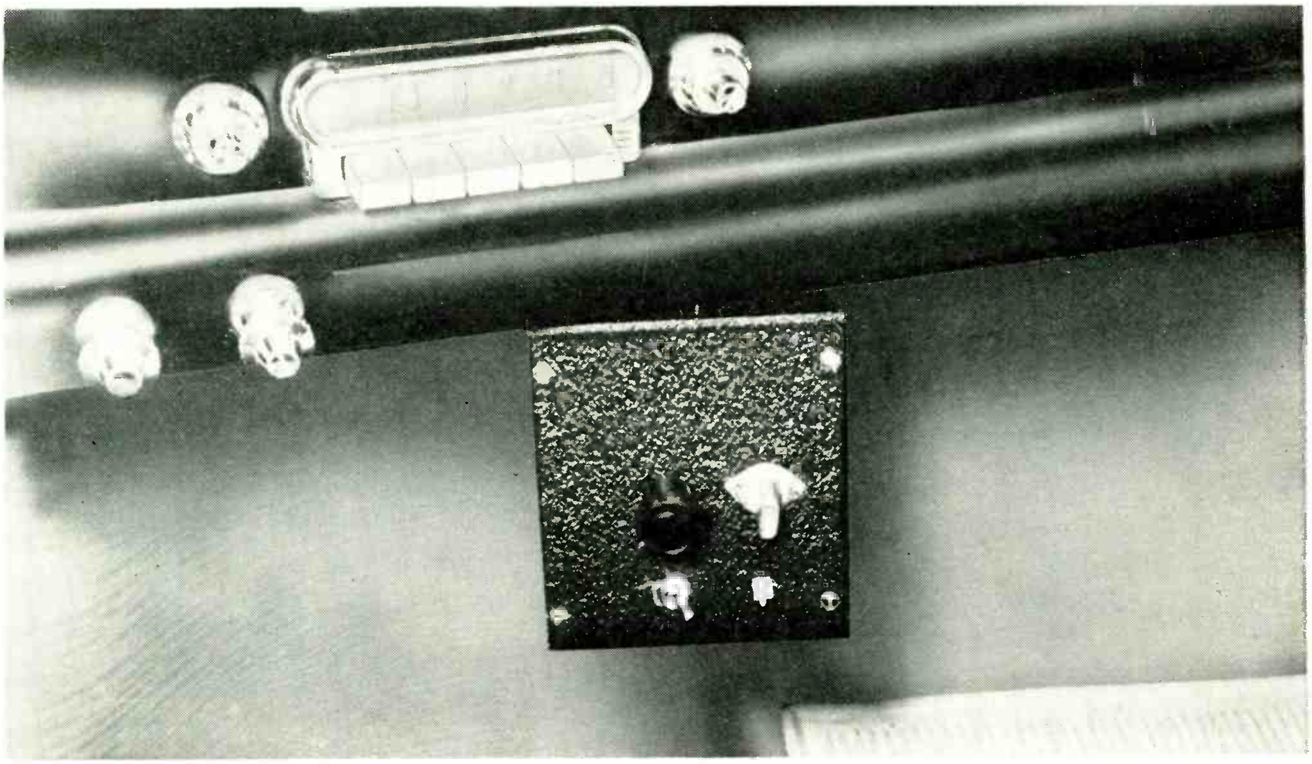


Crystal-controlled, double-conversion setup added to your car radio lets you tune in the world

by LARRY LISLE, K9KZT

GETTING A LITTLE TIRED OF THE sound-alike stations on your car's AM radio? You're not alone, judging by the soaring sales of FM radios, tape players and other electronic gear for in-car use. If you've been putting off getting something better for your car, why not invest $10 and a few hours this weekend and try the short waves?

The short-wave broadcast bands are unmatched for variety. You can hear the details of the latest world crisis direct from the capitals where headlines are being made, relax to a program of light comedy, enjoy Leonard Feather's latest jazz pick on Voice of America and match wits with a quiz program panel—all in a single evening. And on a long trip, nothing seems to make the miles pass as

PARTS LIST
Tube Converter

C1—220-pF ceramic-disc capacitor
C2—365-pF variable capacitor
C3—220-pF ceramic disc capacitor
C4—500-μF, 25-volt, electrolytic capacitor
C5—.005-μF ceramic-disc capacitor
C6—220-pF ceramic-disc capacitor
R1—2.2-megohm, ½-watt resistor
R2—33,000 ohm, ½-watt resistor
L1—13 turns of ¾-inch diameter, 16 turns per inch coil stock, (B&W 3011, or Air Dux 616,) or 13 turns of No. 20 solid, plastic-covered hookup wire, close wound on ¾-inch form.
RFC1, RFC2—2.5-mH radio frequency choke
RFC 3—10-mH radio frequency choke
S1—spst switch
S2—dpdt switch
V1—12AD6 tube
XTAL—See text and Table I
MISC—Cabinet (Premier CA-1403, etc.) coaxial cable, plugs and sockets to match car radio and antenna, tube socket, crystal socket, wire, solder, etc.

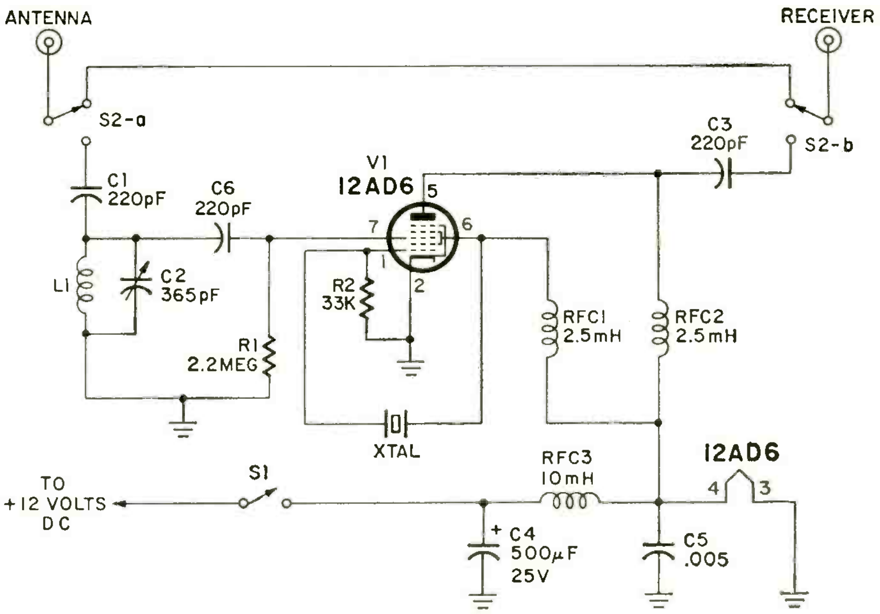


Fig. 1—Pentagrid converter circuit, with crystal-controlled oscillator section. C2 and the car receiver's tuning capacitor are used for tuning international short-wave broadcasts.

quickly as an edge-of-the-seat whodunit program.

Converters intended for the commercial short-wave broadcast bands need not be elaborate since many stations use extremely high power and have very good directional antennas beamed at North America

The two converters described were designed for maximum simplicity and ease of adjustment. I was pleasantly surprised at their performance—in spite of their elementary nature—and regularly use the transistorized version instead of an 8-tube communications receiver for casual listening at home. The tube version resides under the dash of the family car. Both were included to satisfy the personal preferences of builders.

Operation and construction

The tube model in Fig. 1 is a conventional pentagrid converter with a few unusual features. First, the oscillator portion of the circuit is crystal controlled. This eliminates one tuned circuit, and adds tremendously to the converter's stability when subjected to varying voltages and vibration during mobile operation.

With a crystal-controlled oscillator, the incoming short-wave signal is beat against the fixed crystal frequency and the i.f. is *variable* (Fig. 2). Capacitor C2 peaks the short-wave input to the mixer. The mixer's i.f. difference signal (840–1250 kHz for the 19-meter example shown) is then tuned on the car radio, where the variable local oscillator signal is heterodyned with the 840–1250-kHz variable i.f. signal to produce a *fixed* i.f.

Another feature is the rf choke instead of a tuned circuit in the output. Several arrangements of coil and capacitor were tried, but none increased performance enough to justify the need for retuning when changing frequency. Components C4, RFC3 and C5 form a filter to reduce electrical noise from the car's ignition system; they are unnecessary if your power source is lantern batteries or other noise-free sources. In an exceptionally noisy car it may be necessary to add another rf choke and .005-μF capacitor between this filter and the electrical system.

Neither parts layout nor component values are especially critical, although mechanical solidity in mounting parts and soldering connections is a must for mobile equipment. Good shielding, including coaxial cable for input, output, and power leads, will reduce broadcast feedthrough and ignition interference.

The transistorized version in Fig. 3 functions similar to the tube model. Transistors found to work well include International Rectifier's TR-20, Motorola's HEP-3, and RCA's SK3007. These transistors are universal replacement types, and should be readily available. Other transistors with a sufficiently high cut-off frequency will also work well [Readers may wish to try JFETS or MOSFETS.]

Since battery drain is low, dry cell operation is recommended; this also eliminates the need for the filter described for the tube model. An antenna switching arrangement has been omitted from the schematic in Fig. 3, and can easily be included if desired.

Some increase in performance may be obtained by substituting different values for bias resistors R1, R2 and R3, since transistors may vary somewhat in electrical characteristics. The tap on L1 may also be adjusted for maximum performance, as can C1 and C3.

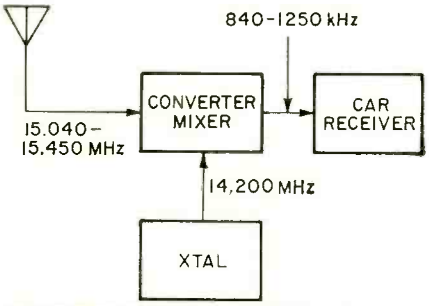
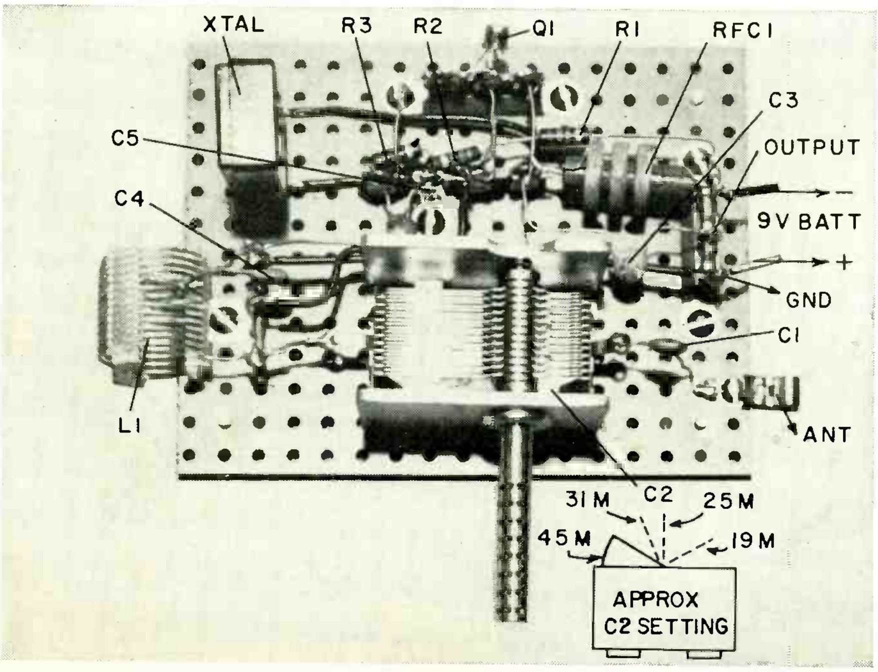


Fig. 2 — Peaked short-wave signal is heterodyned with selected crystal frequency. Variable i.f. is then tuned in on your car radio.



Solid-state construction used by the author at home. A number of high-frequency transistors are suitable. Performance may be improved by varying R1–R3 and other component values for transistor used.

How to tune

Using the converters is easy. After connnecting antenna, car radio and applying power, set the broadcast radio to the portion of the dial into which the short-wave signals will be converted with the crystal you're using.

Adjust C2 until signals are heard, then retune the broadcast receiver to a strong short-wave station and adjust C2 for best reception. At first it may be necessary to perform a bit of two-handed juggling between the two controls until the correct position of C2 is located for each band. The best time to tune up the converter is during the evening hours.

By choosing suitable crystals, the 49-, 31-, 25- and 19-meter broadcast bands can be covered with just two crystals as shown in Table 1. Before buying new crystals, however, check those already in the junk box, since many combinations are possible. For instance, a channel 10 Citizens-band-crystal (27.075 MHz), when operated in the converter on its fundamental frequency of 9.025 MHz, enables you to tune most of the 31-meter band.

Since there is only one tuned

TABLE I

SAMPLE CRYSTAL FREQUENCIES

49 Meter Band (5.950–6.200 MHz)—Crystal frequency:7.100 MHz, output:1150–900kHz
31 Meter Band (9.400–9.840 MHz—Crystal frequency:10.7 MHz, output:1300–860 kHz
25 Meter Band (11.700–12.095 Mhz)—Crystal frequency:10.7 MHz, output:1000–1395 kHz
19 Meter Band (15.040–15.450 MHz)—Crystal frequency:7.100 MHz (2nd harmonic at 14.200 MHz used), output:840–1250 kHz

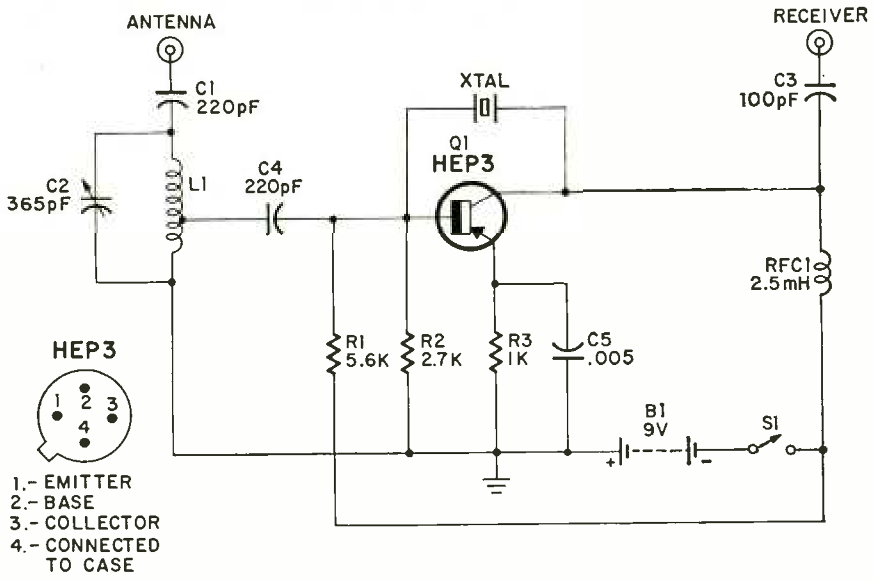


Fig. 3—**Transistor version** of the converter. Filter is not needed.

PARTS LIST
Transistor Converter

C1—220-pF ceramic-disc capacitor
C2—365-pF variable capacitor
C3—100-pF ceramic-disc capacitor
C4—220-pF ceramic-disc capacitor
C5—.005-μF ceramic-disc capacitor
R1—5600-ohm, ½-watt resistor
R2—2700-ohm, ½-watt resistor
R3—1000-ohm, ½-watt resistor
L1—13 turns of ¾-inch diameter, 16 turns per inch coil stock, (B&W 3011, or Air Dux 616) or 13 turns of No. 20 solid, plastic-covered hook-up wire, close wound on ¾-inch form, tapped midway between center and ground end.
RFC1—2.5-mH radio frequency choke
Q1—See text
B1—9-volt transistor battery
S1—spst switch
XTAL—See text
MISC.—Cabinet, fiber circuit board, coaxial cable, plugs and sockets to match those on car radio and antenna, crystal socket, battery connector, battery clip, wire, solder, etc.

circuit resonant on the short-wave bands, some problems may be encountered with "images." These will seldom be a serious problem, however, because of the high power used by the broadcast stations. If your favorite station happens to be on the weak side, though, shifting the crystal frequency slightly, or installing a trap circuit tuned to the image frequency between the antenna and converter should reduce the interference.

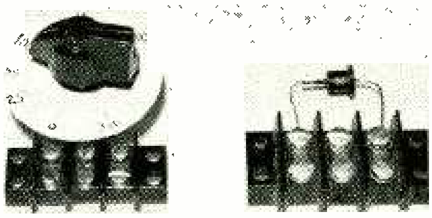
Broadcast feedthrough may be a problem with strong local broadcast stations, and it is wise to take this into account when selecting crystal frequencies. The converter may be used to monitor WWV, the 40 or 20 meter amateur bands, or other segments of the short-wave spectrum if suitable crystals are used. **R-E**

SMALL-COMPONENT BREADBOARDS

The problem of breadboarding experimental circuits is becoming more acute as transistors and other miniature components shrink towards the vanishing point. The short leads on T0-18 type cases and epoxy-bead transistors admit to one-time only soldering, if that.

The following system is based upon Bakelite screw terminals of the Cinch-Jones variety, and has proved very satisfactory in conserving leads and heat-sensitive components. These terminal strips come in three sizes: Series 140, 141, and 142. The first two, using 5-40 and 6-32 binding head screws, are the most convenient, and cost around twenty cents for a three-terminal unit.

A three-terminal Series 140 strip used to mount small-signal transistors. A white card is cemented to the bottom of each strip, covering the screw holes against accidental contact



from metal table tops, etc. The emitter, base, and collector terminals are identified with India ink. The pair of holes at each end of the strips allow easy fastening to breadboards or to metal chassis.

The use of these terminal strips is by no means limited to transistors, as shown in the photo. A 1N561 rectifier is mounted on a Series 141 strip, with a 300,000 ohm potentiometer attached to a 140 strip. The pot is an Ohmite type AB unit and its leads conveniently fasten under the 5-40 binding-head screws. A calibrated card dial gives resistance values at a glance.

These handy terminal strips are available with up to twenty-one terminals in the 140 Series. Whole families of transistors can be set up, as well as decade resistors, condensers, and multi-tapped transformers.—*F. W. Chesson* **R-E**

TOOLS FOR ELECTRONICS

by TOM HASKETT

This issue, starting on the facing page, is the next part of our new series of articles on tools for electronics. It starts our description of soldering tools. Next month we will continue the series with the next section of the article on soldering tools. We believe you will find all of this material a handy, practical addition to your R-E Reference Manual.

If you wish you can purchase a special hardcover binder to keep your Reference Manual pages together. It has a dark blue fabric cover and is gold stamped Radio-Electronics Reference Manual. The cost is $1.00, postpaid. Order from N. Estrada, 17 Slate Lane, Central Islip, L.I., N.Y. 11722.

SOLDERING TOOLS

Nearly as old as civilization itself, soldering was used as early as 2800 BC to construct silver jewelry. The ancient Romans soldered lead water pipes together (a technique still used today), and throughout most of recorded history some form of soldering has been used.

It is doubtful that the electronics industry could exist without soldering, for it makes possible the rapid, convenient and efficient connecting of the various components which constitute every electronic assembly.

The earliest crystal sets and spark-gap transmitters were constructed with Fahnestock clips and wooden breadboards, but since about 1920 most electronic circuits have been connected with solder joints.

This section of the series describes the tools and techniques you can use to perform good soldering.

Electrical connections

There are two general ways to make electrical connections between conductors—mechanical and metallurgical. The mechanical methods are **crimping, screwing** and **wrapping** the connectors. The metallurgical methods are **soldering, brazing** and **welding.**

Soldering is the bonding together of two similar (or dissimilar) metals by means of a third which has a much lower melting point (about 500°F) than the first two. The third metal is called, of course, solder, and it usually consists of an alloy of lead and tin. When melted, solder adheres to the other two metals, and when cooled, it makes a secure electrical connection between them by the creation of a new alloy.

In electronics work, most people use wire solder 1/16 inch or 1/32 inch in diameter, furnished in a coil or on a spool. Wire solder is most useful because you can feed it into a joint conveniently, and its small cross-sectional area allows it to be melted easily with low-heat tools. Bar solder is also available for large jobs, but is seldom used in most electronics work.

Solder alloys

The diagram of Fig. 1 shows the liquid, solid and plastic conditions of various solder alloys of lead and tin. Pure lead melts at 621°F, and

50/50 Type, Rosin Core (414°F)
- Alpha 53505 (solid core)
- Ersin 50/50
- Kester 50/50

Copper Loaded Type **(419°F)**
- Ersin Savbit

40/60 Hard, Rosin Core **(453°F)**
- Alpha 51406
- Ersin 40/60
- Kester 40/60

Silver Solder (565°-574°F)
- Alpha 53500
- Ersin HMP
- Jensen U-3

Aluminum Solder
- Alpha 53718 Brazing Wire and Flux
- Alpha 35003 Fluxless bars
- Chemalloy 504 Fluxless bars
- Jensen 121 Fluxless

Stainless Steel Solder
- Alpha 53982

and are therefore useful for transistor and printed-circuit work, where more heat might damage components; 50/50 solder is a general-purpose type.

When ordinary solder is used with a copper iron or gun tip, some of the tip copper is absorbed into the solder, wearing down the tip. **Copper-loaded solder** minimizes this wear by preventing such absorption to a great extent.

Hard and **silver solders** are used for connections which must operate in high ambient temperatures without melting, such as motors and projector lamps. Hard solders also have greater mechanical strength. Silver solder (which contains about 1% or 2% silver) is useful where corrosion is a problem, as when joining a copper ground strap to a spike or rod set in the earth.

Solderability, oxidation & fluxes

Certain metals are easily solderable with low- or medium-temperature solder alloys. These include gold and tin-plated metals. Copper, silver and cadmium plate are fairly easy to solder, but usually require a hard (high-temperature) solder. Metals which cannot easily be soldered include nickel plate, brass, steel, stainless steel, chromium plate and aluminum. More about joining these metals later.

When exposed to the atmosphere, metal usually **oxidizes;** that is, a surface film forms on the metal. If not removed, this oxidation film prevents solder from adhering to the metal and making a good bond between pure tin at 450°F. Note that in each case the metal goes from solid to liquid form sharply. Lead-tin alloys melt at various points, depending on the proportions of lead and tin. The lowest melting point, called the

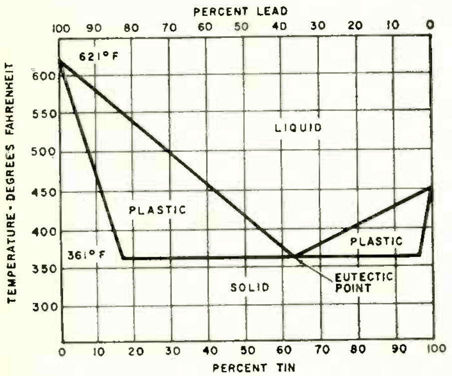


Fig. 1—This graph shows the effect of increasing temperature on various percentages of lead-tin solder alloys.

eutectic point, is 361°F for an alloy of 37% lead and 63% tin. At this temperature, the solder alloy goes sharply from solid to liquid.

But note that at all other points on the chart, the alloy changes from solid to plastic form as heat is increased. Evenually the solder becomes a liquid. The heat furnished to the solder joint must be sufficient to take the alloy through the plastic region and into the liquid region, or a poor joint will result.

Table I lists the most popular solder types used in electronics. The low-melting, eutectic and soft types melt at relatively low temperatures

Table I: Solder Types

Low Melting Point, Rosin Core (354°F)
Ersin LMP (62% tin, 36% lead, 2% silver)

63/37 Eutectic (361°F) Rosin Core
Ersin Eutectic

60/40 Soft, Rosin Core (370°F)
Alpha 13460
Ersin 60/40
Kester 60/40

the elements of the joint. To remove the oxide layer, **flux** is used.

The most common flux used in electronics is made of **rosin** (or resin), a dark-brown, butterlike paste which works well with the tin- or solder-dipped metals commonly used for wires, lugs and connectors. In fact, most electronics solder in wire form is made with one or more cores of rosin flux, so you don't have to use external flux. When you heat the joint, the flux flows on the surface and removes the oxide. Then, provided you have sufficient heat, the solder flows and displaces the flux. If you don't heat the joint sufficiently, the solder never displaces the flux and the result is a rosin joint—a poor connection.

You can use rosin flux to clean certain other metals only under certain conditions. Silver-plated surfaces must not be corroded or tarnished. Cadmium-plated brass, bronze or copper solders well with rosin flux. Copper, brass and phosphor-bronze can be cleaned with rosin flux only if they are not tarnished.

To solder nickel plate, galvanized steel, beryllium copper, silicon bronze, zinc and zinc plate, monel, nichrome and stainless steel, you must use aniline phosphate or zinc chloride fluxes. Unfortunately, these are **acid fluxes** and leave a corrosive residue which causes damages to joints, conductors and insulation. Acid fluxes should never be used in electronics work.

Aluminum soldering

Aluminum oxidizes so rapidly that you cannot solder it with ordinary solder and flux. One way of overcoming this phenomenon is to coat the aluminum with high-viscosity oil or grease, which protects the surface from the oxygen in the atmosphere. A more popular method is to use aluminum flux and solder, which does the same job. Several types are listed in Table I.

Other hard-to-solder metals are often joined with hard solder or brass and high heat, a process known as brazing.

When two metals are placed in physical contact and heated until both melt and fuse, the process is called welding. Unlike soldering, welding makes a very strong physical bond between the joined metals.

Brazing and welding are seldom used in electronics, for the usual need is an electrical, rather than a physical, connection of conductors.

Preparing the solder joint

Normally you should strip a wire end and wrap it around the lug or connector about three-quarters of a turn. Be sure the connector and wire cannot move. By Murphy's law, if a wire **can** move during soldering, it **will**, and you'll get a cold solder joint. Some technicians wrap wires all the way around a lug or connector. While this makes a very secure connection, if you later must remove that wire, you have a problem. The solder joint itself provides a secure mechanical bond, often stronger than the wire itself. But a partial turn of wire provides the mechanical immobility you need for the soldering operation.

Leave about 1/8 inch bare wire between the connector and the wire insulation. Often it helps to tin the wire end before using it, especially when working with stranded wire. (**Tinning** is cleaning and heating a connector, then flowing solder onto it. Once a wire has been tinned, it solders easily.) When you tin stranded wire, you prevent individual strands from splaying out and shorting to an adjacent terminal. Hookup wire and some terminal lugs are often supplied tinned and you can solder them without further preparation. But dull (oxidized) copper wire or brass connectors should be made shiny before soldering.

Usually it's best to connect all wires to a point before you solder it. But if you have to add another wire at a later time, heat the joint carefully until you see the existing solder liquefy. Then add a small amount of fresh solder.

Don't wire resistors, capacitors, diodes or any components with pigtail leads so they are taut. Make small bends or kinks in the wire leads to relieve mechanical stress. When a component is wired tautly from point to point, a mechanical strain exists on the component and it can be damaged by vibration. Also, such an arrangement sometimes produces microphonics.

When you solder a transistor, solid-state diodes or a small resistor, use a heat sink (or other thermal shunt) on the component lead to avoid overheating and damaging it. If you don't have clamping pliers, use a rubber band on the handles of long-nose pliers to hold them in place on the work as a temporary sink. Be sure to use a heat sink on the pins of polystyrene coil forms and similar components; otherwise the heat will melt the adjacent plastic and misalign the pins.

solder to a hot joint, the solder should shrink inward toward the center of mass of the joint by capillary action.

4. Allow the joint to cool without disturbing it. Don't pull wires, move the chassis or allow any vibration to shake the work table or bench. Vibration during the cooling period usually produces a cold solder joint.

If you are making a critical connection, clean the joint after it's cooled, by brushing with isopropyl alcohol, which removes flux residue without leaving any contamination. Sometimes this technique is very useful in high-frequency connections which might otherwise become noisy. It's also helpful in PC-board work, where connections are very close.

Poor soldering

What began many years ago as an art has now become a science. Only the best possible soldering is permitted for the millions of connections required in NASA and similar spacecraft electronics, which must have 99.99% reliability. Military electronics equipment is soldered with almost the same degree of perfection. Industrial and consumer electronics products are manufactured by processes in which soldering practice is somewhat less perfect, but still quite reliable. At the field-maintenance level, soldering quality drops sharply, and the soldering done by hobbyists and kit builders is often very poor.

While you may never equal NASA soldering perfection (partly because it may not be worth your while to invest time and money in the extremely painstaking and critical techniques and inspections they use) you **can** avoid gross soldering pitfalls. Poor solder joints are particularly annoying because they usually cause intermittent troubles which are difficult to track down. Here are a few solder-joint troubles you should avoid:

- Insufficient solder: Each part of the joint should be at least partially covered by the solder globule.
- Cold solder: This is a gray, mushy appearance without high luster, usually caused by hasty work, too little heat, or moving the joint before it has solidified.
- Rosin joint: Dirt on the parts, excessive flux or low heat may leave rosin flux between parts in the joint. All rosin must be boiled out so the joining is done by the solder.

Mechanics of soldering

To make a solder joint, you need three things: a heating tool (iron or gun), the solder itself and a positioning tool. The best way to make a good, secure solder joint is this:

1. Clean the work mechanically. Solder makes a good connection only with clean, bare metal. If the metal is dirty or grimy, you should clean it with a wire brush, steel wool or sandpaper. Manicurists' emery boards (sandpaper on narrow, stiff cardboard) are inexpensive and available at most drugstores. They make excellent throwaway solder-cleaning tools. If the wire or connection is new you may not have to mechanically clean it. A flux of rosin should be applied; when it heats, it removes the film of oxide which any metal has on its surface, and which prevents a good solder joint. Since most solder today has a rosin flux core, you can often omit this step. When you apply solder you also apply flux. But remember that flux will not remove paint, dirt or oil.

2. Heat the work where you want to apply solder. It's very important to heat the work first, before applying solder. Pure tin melts at 450°F and pure lead at 621°F, as you learned earlier. Most alloys of the two metals melt at some temperature below 621°F. But most solder alloys resolidify at about 361°F. If the temperature of the joint never goes higher than the liquid point, you will get a cold solder joint—a connection which has resistance or impedance, or which is intermittent. To prevent this, apply the tip of the soldering tool underneath the joint, if possible, as heat rises. If it's not possible for the tip to contact all wires and terminals in the joint, make sure it touches and heats the largest piece of metal involved. An experienced technician knows about how long it takes to heat a joint to the point where the joint (not the iron or gun tip) melts the solder. But don't overheat the joint, or the solder itself will oxidize and make a poor connection.

3. Apply solder, letting it flow by gravity and capillary action between the parts you want joined. If the joint won't melt solder, wait until it will. Don't feed the solder into the opposite side of the joint from the iron, for this will require more heat on the joint, and might overheat and damage nearby components. Apply enough, but only enough, solder to make a smooth, globular joint, with the solder filling all spaces and crevices. Too much solder is bad, but it is also bad practice if the solder doesn't flow freely on all elements of the joint. Ideally, when you apply

• Burned insulation: Caused by too much heat, a slip with the iron, or by dripping solder, this is not merely poor workmanship. When insulation is burned away, the possibility exists of a short to a nearby component. And if the iron or gun tip burns the insulation, some debris remains on the tip, which must then be cleaned before using it again.

• Wicking: If you overheat the joint too much or use too much solder, some creeps up the wire under the insulation, weakening or destroying the insulation, and stiffening the stranded wire and reducing its flexibility.

Transformer-type gun

Three basic types of heating tools are used in electronics: the **transformer type gun,** the **pencil** or **iron** and the **gas torch.**

In Fig. 2 are some typical guns. The handle contains a trigger switch which turns the device on; under the twin barrels is a pilot light. The tip is

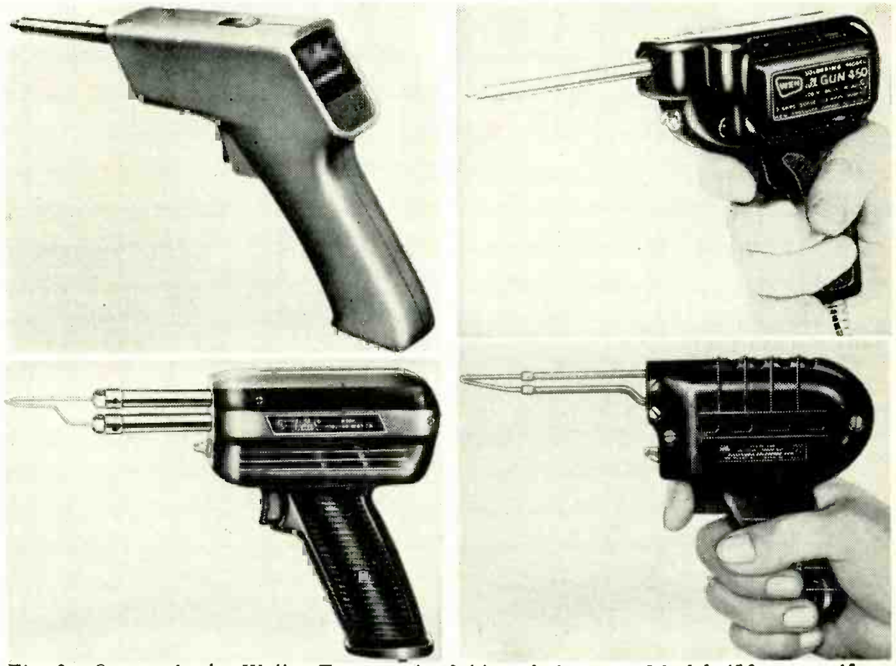


Fig. 2—On top is the Weller Tempmatic (left) and the Wen Model 450 guns. Above is the Weller Model 8200 (left), and the Wen Model 100 soldering guns.

removable so you can replace it when it eventually corrodes and becomes unusable.

(continued next month)

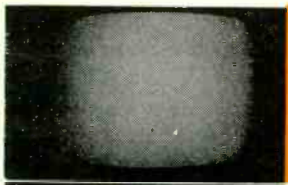
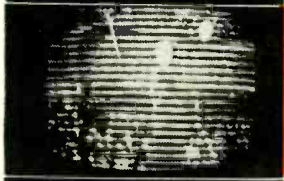
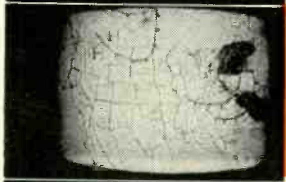
6GH8A reactance-controlled color oscillator

NEW R-E EXCLUSIVE

Kwik-Fix™ picture and waveform charts

by Forest H. Belt & Associates*

SCREEN SYMPTOMS AS GUIDES — WHERE TO CHECK FIRST

SYMPTOM PIC	DESCRIPTION	VOLTAGE	WAVEFORM	PART
	Color killer won't stop confetti	not any help	not any help	R1 C2
	Pic purple and monochrome, or no color if killer set deep	Screen-pin-3 Plate-pin-6	not much help	C9 R7 R8
	Color makes bars intermittently	not any help	not any help	R1 C2
	Color makes bars across the screen	plate-pin-1 screen-pin-3	WF1	C1 C3 C5 R3 R4 R5
	Color makes many fine bars across screen	not any help	WF3	C7
	No color regardless of killer setting	not much help	not much help	crystal tube
	Phase toward green end	not any help	not any help	C5
	Phase toward blue end	not any help	not any help	C3

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

Study the screen and the action of the Color Killer control. The most helpful clues to the fault are found at the key test points indicated.

Make voltage or waveform checks when indicated for screen symptoms.

Use the Voltage Guide *and* Waveform Guide *to analyze results of those tests.*

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

THE CIRCUITS

THE CW OSCILLATOR IN A COLOR SET PROVIDES AN ACcurate 3.58-MHz subcarrier for reinsertion at the color demodulators. The chroma sidebands need something to beat against.

This 3.58-MHz oscillator is a popular pentode version. It's a form of electron-coupled Pierce circuit, characterized by crystal feedback from screen to grid. Although the 3.58-MHz crystal sets approximate frequency, precise frequency and phase are determined by the reactance-control triode and its plate inductance, L1. They act as a variable load on the crystal, warping its frequency to lock it in on the color-sync signal from the transmitter. The control stage gets a dc voltage from the color-sync phase detector whenever any phase error exists in the oscillator.

SIGNAL BEHAVIOR

The only signal directly involved here is the one generated by the oscillator stage. The screen grid (pin 3) of the pentode acts as the plate of the Pierce oscillator. Some of the signal is fed back through the crystal and C6 to the pentode grid to sustain oscillation. The feedback path is frequency selective because of the crystal. So, the stage oscillates only at 3.58 MHz.

The control stage (sometimes called *reactance stage*) is dc operated. Its only effect on signals is through its loading of the crystal. It varies the apparent value of L1 and "fine tunes" the crystal frequency.

Bypass capacitors C5 and C3 keep L1 and the tube decoupled for signals. C1, C2 and R1 are an anti-hunt network. Their time constant keeps the control stage from being oversensitive to inconsequential variations that come from the phase detector.

The plate is the output element. That isolates the output from the oscillator feedback circuit. However, C9 feeds a signal sample back to the phase detector. (There, it is compared with the color-sync burst; the resulting dc controls the triode-reactance stage.) Tuned transformer T1, decoupled by C8, couples the phase-accurate 3.58-MHz signal to the color demodulators.

The capacitor at screen-pin-3 isn't for decoupling. It isn't large enough. It's merely part of a signal divider that holds the amount of feedback down to a stable level (C6 and the crystal make the other part of that divider)

DC DISTRIBUTION

Both tubes get operating dc from a 320-volt dc line. Plate voltage for the triode stage comes through R5 and L1. For the pentode oscillator, plate voltage comes through R8 and T1 and screen voltage comes through R7.

Bias for the pentode develops through grid-leak action across R6. The cathode is grounded.

The triode is self-biased from current through R3. Most of that current is what flows through the tube; a small amount of it comes from R4, which makes a dc voltage divider with R5 and R3.

You can't see the dc return for the triode grid. It is through R2 and the phase-detector stage; the latter isn't shown.

SIGNAL AND CONTROL EFFECTS

The station signal has little measurable effect on dc voltages and waveform amplitudes in these stages. Of course, it does affect the *phase* of the cw signal, but you can't see that on your scope.

When a trouble occurs, the color killer has a certain bearing on what screen symptom you see. Leave the control turned (usually clockwise) so chroma can get through to the demodulators. The voltage and waveform clues from the charts mean more if you do that.

Sometimes turning the tint control helps you diagnose a fault from the screen symptom. The main thing to notice is whether it alters color on the screen.

QUICK TROUBLESHOOTING

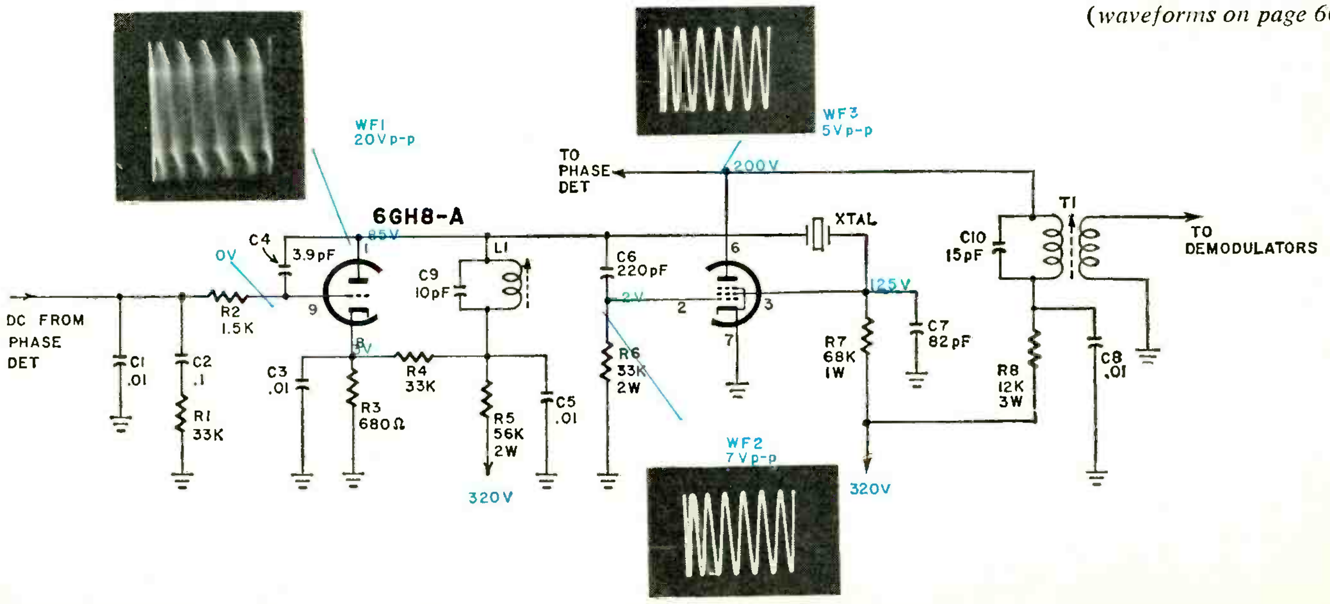
Clip a shorting jumper from pin 9 to ground. That isolates the color oscillator and control stages from the effects of the phase detector. Turn the color killer control down and then up. Try adjusting L1 and T1. Horizontal bars of color should float slowly or stand still in the picture

Then use your scope to check the output of T1. You can sync the scope at its TV-horizontal rate (about 5 or 8 kHz) or so it locks in several cycles of 3.58-MHz sine wave. Output should be 10-15 volts p-p.

If the oscillator is dead, and the only dc clues on the pentode are those caused by the oscillator's quitting (low plate and screen voltage), try a new crystal. It and the tube are the most likely causes of a dead or intermittent oscillator.

If the color bars are there, but tuning L1 can't stablize them, try a new crystal; the old one may be off frequency. Or, check C5; it may be open. Or, check C9 and C10 by substituting good capacitors. Beyond these hints, use the dc voltage troubleshooting charts; they're more helpful in this stage than signal waveforms. **R-E**

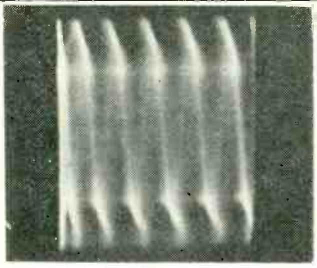
(*waveforms on page 60*)



Voltage change	to zero	very low	low	slightly low	slightly high	high
Plate-pin-1 Normal 85V	R5 open C5 shorted L1 open		C4 leaky C5 leaky C6 leaky	R3 low	C5 open	R3 open, high R4 open R5 low
Cathode-pin-8 triode Normal 3V	R5 open C3 shorted C5 shorted L1 open		R3 low C3 leaky C5 leaky C6 leaky	R4 high C5 open, leaky	R4 low C4 leaky	R3 open, high R5 low
Grid-pin-2 pentode Normal −2V	C4 leaky *C6 leaky	R2 open R7 open C1 open C6 open, leaky	R6 low R7 high C6 open XTL dead	R4 open	R5 open C5 open	R3 open
Screen-pin-3 pentode Normal 125V	R7 open C7 shorted		R2 open R6 low R7 high R8 open C6 leaky C7 leaky C8 shorted T1 pri open	C1 open C4 open, leaky C6 open XTL dead	C5 open	R7 low
Plate-pin-6 pentode Normal 200V	R8 open C8 shorted T1 pri open	R7 low	R7 low R8 high C6 open C8 leaky XTL dead	R2 open C4 open C6 open	R8 low C7 leaky	R7 open, high C7 shorted
	*or positive					

Use this guide to help you pinpoint the faulty part.
Measure each of the five key voltages with a vtvm.
For each, move across to the column that describes the change you find.
Notice which parts might cause that change.
Finally, notice which parts are repeated in the other voltage changes you find.
Test those parts individually for the fault described.
NOTE: For more guides to narrow down the faulty part further, see Waveform Guide.
NOTE: Dc voltages at other points in this stage are misleading for diagnosis, so are not a part of this guide.

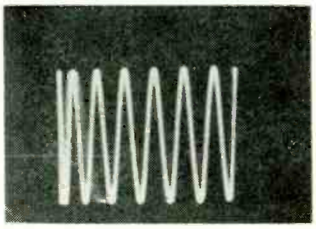
WAVEFORMS AS GUIDES



WF 1 Normal 20 V p-p

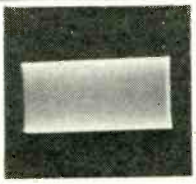
This is taken at plate-pin-1 of the control triode. It is the 3.58-MHz sine wave from the oscillator, with some modulation that comes from the phase detector. The waveform is locked in with the scope sweep near 500 kHz, which most modern service scopes can manage. Sometimes, schematics show this waveform as you see it below, with the scope set at the TV-horizontal rate-near 5 or 8 kHz. The cycles are not distinguishable, but you can see the "overlap" caused by the modulation.

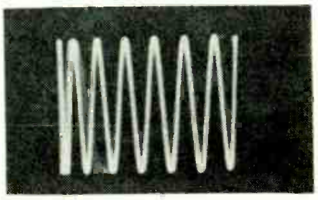
V p-p low	V p-p high	V p-p zero				
C4 leaky C7 open	R8 open, high C8 shorted T1 pri open	R6 v. low R7 open, high R7 v. low C6 open C7 shorted, low XTL dead	 Scope at horizontal	 20 V p-p C1 open	 7 V p-p C4 leaky	 25 V p-p R3 open R5 open C4 open



WF 2 Normal 7 V p-p

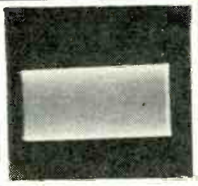
This is the 3.58-MHz sine wave made by the pentode oscillator, taken at grid-pin-2. As you can guess from the absence of waveforms with changed shapes, this waveshape doesn't alter much when trouble occurs anywhere in either stage. With the scope sweep at about 500 kHz, the sine waves are clearly defined. At the scope's TV-horizontal sweep rate, you see the cw waveform below. For troubleshooting, be more concerned with amplitude than with shape.

V p-p low	V p-p high	V p-p zero	
R4 high C1 open	R3 open R8 open R8 high C4 open C8 open C8 shorted T1 pri open	R2 open R6 v. low R7 open, high R7 v. low C4 leaky C6 open C7 low, shorted XTL dead	 Scope at horizontal



WF 3 Normal 5 V p-p

This is the output waveform at plate-pin-6 of the crystal-controlled Pierce oscillator. The output is electron-coupled. That is, the screen is the true oscillator plate and the tube's electron stream is modulated by the 3.58-MHz oscillations. This waveform isn't much of a troubleshooting aid when there's trouble. But it does offer a sure clue to an open C7, as you can see from the strange waveshape below. For other faults, you get more clues from other waveforms.

V p-p low	V p-p high	V p-p zero	V p-p zero		
	C7 open	R2 open R6 v. low R7 open, high R7 v. low R8 open, high C1 open C4 open, leaky C6 open, leaky	C7 low, shorted C8 shorted T1 pri open XTL dead	 Scope at horizontal	 18 V p-p C7 open

Use this guide and the Voltages Guide *to help you pin down fault possibilities.*
Use the direct *probe of the scope. Connecting the scope alters whatever symptom you see on the screen, but ignore that when you're checking waveforms.*
Check the three key waveforms. The scope sweep should be set at about 500 kHz, to show six or seven cycles of the 3.58-MHz sine wave.

Note amplitude. If it's low or high, check parts under those columns.
Note waveshape. If there's a change that matches one shown, check the parts indicated.
NOTE: Only waveforms that help most with diagnosis are included in this guide.
NOTE: All waveforms in this guide are taken with a color program from a local station tuned in.

New patient-monitoring systems and 3-D X-ray machines may one day save your life.

Photo courtesy Hewlett-Packard

The system trend in medical electronics

by **FRED W. HOLDER***

IN 1895, PROF. WILHELM ROENTGEN GAVE THE MEDICAL profession one of its most valuable diagnostic instruments when he discovered the "X-ray." Less than a decade later, in 1903, Prof. William Einthoven's experiments with electrical currents in the human heart led to the development of today's electrocardiograph (ECG).

Dr. Hans Berger applied the principle of the ECG to the measurement of brain waves in 1929 when he built the first electroencephalograph (EEG) and made tracings of the brain-wave patterns of himself and his family. His invention came before its time; the medical profession wasn't ready to accept the theory that the brain could send out electrical impulses. As late as 1941, Dr. Berger's machine was still considered only "a promising tool" for diagnosis of cerebral diseases.

Although these first machines were hardly electronic in operation, their present-day versions are totally electronic. They were made possible largely because the human body is a complex electrochemical machine. The brain, in operation, generates electrical signals and sends them out along the telephone lines (nerves) of the body to initiate complex bodily actions. A tiny nerve shoots electrical impulses into the heart muscle to maintain the rhythmic beat of the heart. If this nerve is damaged, the heart slows down or stops.

The transistor and other solid-state devices have boosted development of complex instrumentation in our space program, and have had a tremendous impact on medical electronic instrumentation. Telemetry, used extensively to return data from spacecraft, now transmits data on a patient's well-being to distant locations for diagnosis. Instrumentation techniques developed over the past few years allow the handling, monitoring and recording of many vital physiological parameters.

Before the doctor can prescribe treatment for a patient, he must first determine what is wrong. In most cases this is done with a few simple instruments. In more complex illnesses, however, the doctor may need information that can be obtained only in a laboratory or hospital. Let's see how some of these electronic devices are helping the doctor to do his job.

X-ray systems

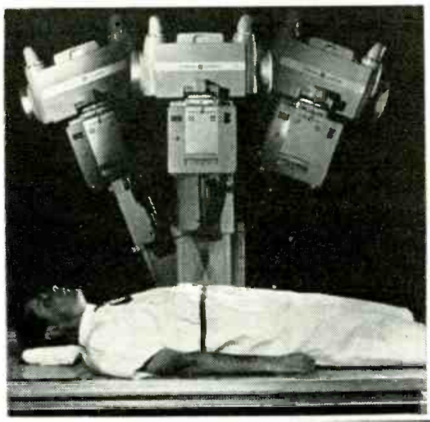
X-rays are high-frequency electromagnetic radiations with an extremely short wavelength (less than 1/10,000 of the wavelength of light). They pass through certain substances more readily than through others. Thus, when X-rays pass through the human body, they cast shadows of its various structures and organs onto a sensitized plate (generally a photographic negative or fluorescent screen). These internal bodily structures may then be studied by the doctor or specialist, known as a radiologist.

X-ray operations fall into three general categories: (1) radiography in which X-rays expose a photographic plate; (2) fluoroscopy in which X-rays activate a fluorescent screen; and (3) tomography, or X-raying of selective sections of the body, in which the X-ray source moves through a given arc in one direction during exposure while the film moves in the opposite direction to eliminate shadows of body structures before and behind the section un-

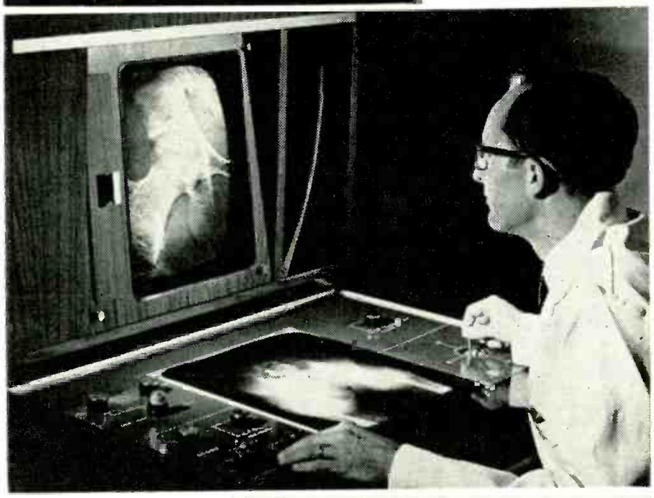
*Bendix Field Engineering Corp.

der scrutiny by the x-ray specialist.

General Electric's Telegem diagnostic X-ray system combines fluoroscopy and radiography as well as tomography. This system consists of a fully shielded, pivoting control console, a 90° to 15° table with powered lateral and longitudinal patient movement, and a closed-circuit TV system and monitor for fluoroscopy. The X-ray tube is mounted over the table on a telescoping stand; the tube may be tilted with respect to the table to permit radiography and fluoroscopy at oblique angles, or angulated for tomography. This system is the first remote-control diagnostic X-ray system available in the US that incorporates linear tomography. To accomplish tomography, the X-ray head passes through an arc of 40°, from – 20° to + 20° (photo). The radiologist can also select a – 5° to + 5° angle; depth range is from 0 to about 8.6 inches.



Triple exposure shows how GE's Telegem X-ray system moves through 40° arc so doctors can "see around" bone structures.



Enhancing and magnifying areas of X-ray film is possible with the GE Explorex radiograph, aiding difficult diagnoses.

Portable electrocardiograph can be carried to patient's home. Solid-state circuits guard against hazardous currents. This is Hewlett-Packard's Model 1500A.

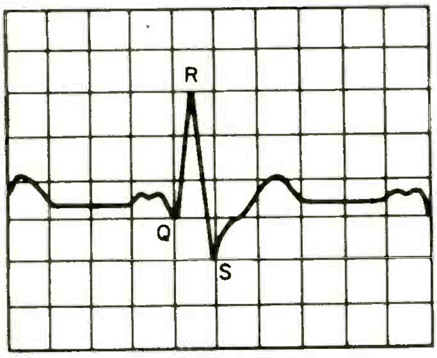


Fig. 1—Typical ECG waveform for healthy heart. The small, rounded pulse prior to the dip at Q indicates auricular contraction, while the QRS waveform relates to ventricular contraction. The small rise after point S corresponds to the end of the ventricular systole action.

Fluoroscopy has an advantage over radiography in that the radiologist can watch bodily functions in action. In earlier versions of fluoroscopes, observations had to be made in a dark room because the shadow images were too faint for eyes accustomed to daylight.

By applying the techniques of closed-circuit TV to the Telegem fluoroscopy functions, this problem is largely eliminated. In this application, X-rays are shot through the patient to a television camera, available in either standard 525-line or 875-line scan rate, with a contrast-improving circuit. The area to be X-rayed can first be viewed through the fluoroscope and then quickly switched to radiography for a permanent photograph.

GE's CFPD (Cine Fluoro Physiological Display) device permits simultaneous display of both the fluoroscopic image and patient physiological data on a television monitor. The data may also be recorded on motion-picture film or video tape.

Physiological data are presented in the lower right-hand corner of the TV image area and may contain up to four channels of monitored physiological data such as ECG, phonocardiograms and differential blood pressure readings.

Traditional methods of correlating monitored data with film are difficult and inexact, because it is difficult to obtain exact synchronization between the film frames and the physiological data. GE predicts CFPD will find clinical applications in cardiovascular procedures. In determining valve damage, for example, differential pressure readings are directly correlated with specific phases of the heart cycle, an important aid in identifying the location and extent of damage. Normal and abnormal patterns of contraction are directly compared with film frames.

GE's new Explorex radiograph intensifier permits a radiologist to enhance and magnify critical areas of an X-ray film. With full control of the enhancement techniques at his fingertips, the radiologist can now extract information from film that previously could not be obtained by other means of illumination or magnification. The new system can be used to study all types of radiographs, and may be useful in difficult diagnoses such as detection of tumors, vascular anomalies, gallstones, kidney stones and thoracic disorders.

Another form of X-ray photograph enhancement is being developed from space program techniques. For several years NASA's Jet Propulsion Laboratory in Pasadena, Calif., has been using digital computers to enhance the clarity of pictures returned from spacecraft. Early in 1966, JPL, in cooperation with the NASA Technology Utilization Division, began investigating the technique to clarify medical and biological X-rays. The results have been very promising, enabling doctors to get clearer views of details that otherwise might be lost or overlooked.

Electrocardiograph

The electrocardiograph, normally referred to as an ECG, measures bioelectric currents generated by a beating heart and records them as a graph on moving recording paper. Information is gathered from electrodes placed on various parts of the body and fed into the recording device where they are combined, amplified and used to drive a pen-type plot recorder. The plotted output recording is the electrocardiogram (ECG). Fig. 1 shows a typical QRS (ventricular contraction) complex ECG waveform of a healthy heart.

When a patient's normal ECG is compared with his abnormal ECG, the cardiac diagnostician can learn a great deal about the patient's heart condition. Even without the normal ECG, the diagnostician can interpret the tracings on the ECG and partially diagnose the patient's heart condition if necessary.

Early versions of the electrocardiograph were so bulky they could not easily be moved to a patient's bedside. The transistor has helped to solve this problem by reducing the size and weight of the units. Small portable units such as the Hewlett-Packard Model 1500A portable electrocardiograph (photo) weigh only 22 lb, and the physician can take the unit to the patient's home.

Another member of the ECG family is Hewlett-Packard's Cardiotocograph. This unit continuously monitors and records fetal heart rate to indicate fetal distress during labor activity. At the same time, the unit records on a strip chart a second trace that corresponds to labor activity, showing the relationship between stresses caused by uterine contraction and fetal heart rate.

A single 1-lb transducer capsule, held in place on the mother's abdomen by an elastic strap, contains two transducers: a microphone that picks up fetal heart sounds, and a spring-loaded plunger that responds to abdominal tension.

Electrical filters remove most of the interference and other sounds that often obscure fetal heart sounds. The electronic circuits then measure the time intervals between four successive beats; only beats establishing definite time relationships are used for the measurement. The inclusion of an indication of labor activity makes it possible for the physician to diagnose fetal distress from heart patterns that may appear normal when considered by themselves. The new unit may be used as early as the sixth month of pregnancy to help diagnose potentially critical cases even before labor begins.

Patient-monitoring instrumentation

Patient-monitoring instrumentation plays its greatest role in the coronary care unit, the intensive care unit and the recovery room. Intensive care, aided by electronic monitoring instruments, does not replace the nurse or any member of the hospital staff. Actually, it supplements the staff and increases the nurse-to-patient ratio.

Also, in terms of patient care, such instrumentation greatly decreases the mortality rate of patients. No two patient-monitoring or data-acquisition centers are exactly alike. Fig. 2 illustrates a typical patient-monitoring and recording system. A particular installation may have more or less capability than that shown, since the systems are generally modular in nature and structured to meet particular requirements.

For example, one Honeywell patient monitoring system is designed to monitor the basic body functions of a patient such as ECG, heart rate, blood pressure, temperature respiration and related biomedical information. It displays this information in several forms (ECG's on oscilloscope and recorder) to permit the medical staff to determine quickly the condition of the patient.

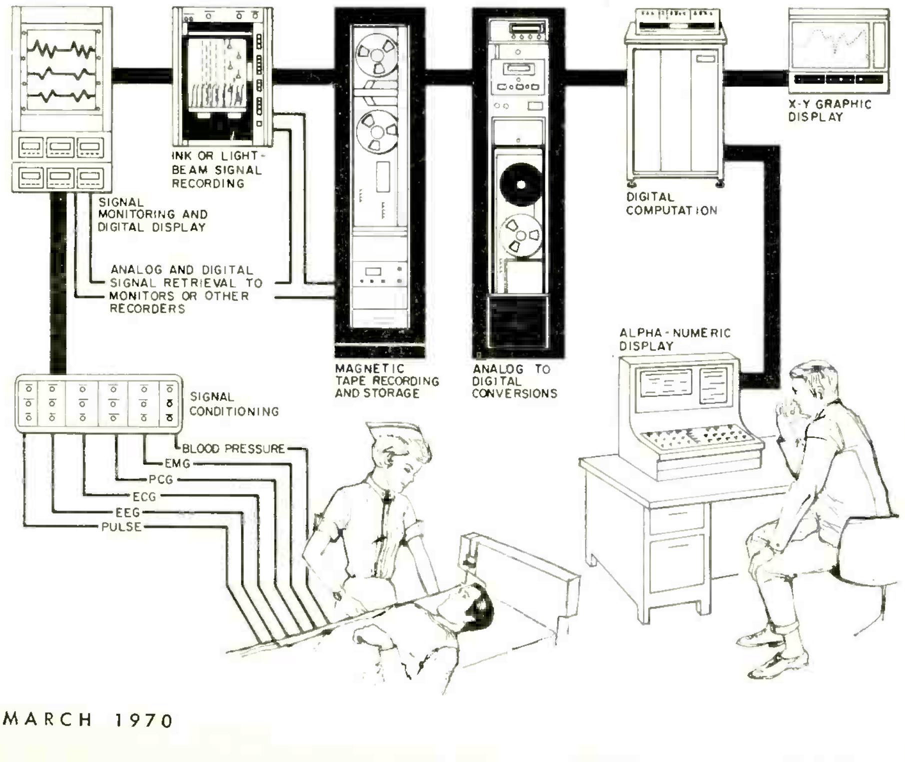
The complete system consists of one or more bedside units, a central station and related accessories such as leads, electrodes and transducers. The basic bedside unit contains an ECG monitoring channel and oscilloscope for data display, cardiotachometer to detect beat-to-beat heart rate, a precision-meter display unit with high and low adjustable alarm settings and a keyboard containing indicators and controls.

Alarm circuitry in the bedside unit sets off a visual (or audible) signal when a patient's heart rate exceeds preset high or low limits. An indicator button flashes with each heartbeat and can be activated to provide an audible beep with each QRS portion of the ECG waveform. The central station of this system consists of one or two large multitrace oscilloscopes to display data from up to eight individual bedside units simultaneously, a direct-write recorder with automatic selection, and keyboard indicators and controls identical to those in each bedside unit.

A recent Honeywell development, the mobile "shock cart," contains electronic monitoring and measuring equipment to gather information vital to treatment of patients suffering from shock (see photo). The unit consists of multiple transducers to measure blood flow, intravascular blood pressure, electrocardiogram and other parameters associated with shock. Also included are a multichannel oscillograph for immediate and permanent recording of the physiological information and a variety of signal-conditioning equipment required for measuring critical data.

Both General Electric and Hewlett-Packard manufacture highly flexible, modular lines of patient life-protection equipment for cardiac and general intensive care units.

(*continued on page 94*)



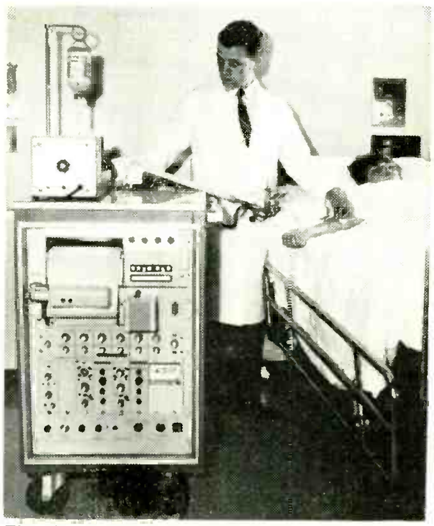
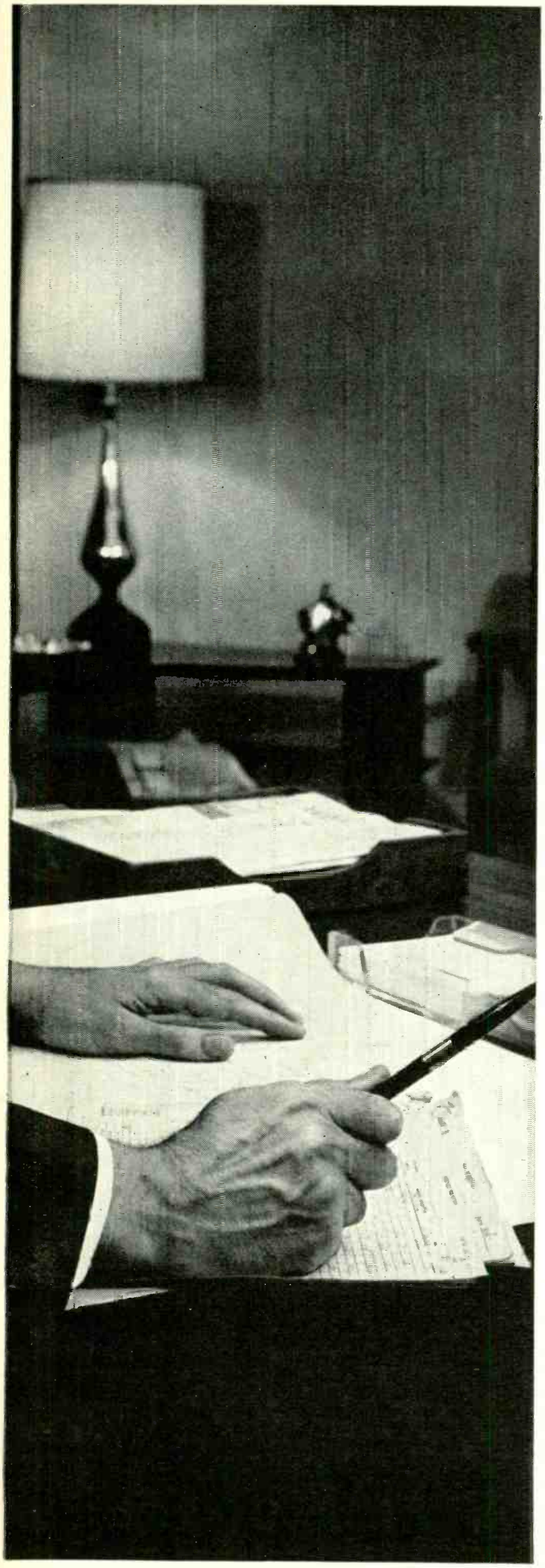


Fig. 2—Patient-monitoring systems like this one are saving many lives by spotting small but critical changes in patient life functions. System are modular.

Mobile "shock cart" made by Honeywell can monitor information vital to treatment of patients suffering from shock.



These solid-state modules automatically detect and display body temperature, venous blood pressure, arterial pressure characteristics and heartbeat rate and rhythm. Therapeutic treatment can also be automatically performed through electric stimulation (or pacing) of heart muscles to restore and maintain normal heartbeat.

A unique feature of the GE system is QRS detection and display which minimizes "false alarms" by filtering out false signals of both physiological and electrode origins. It incorporates a detection circuit which recognizes only the QRS-complex waveform and rejects all other ECG waves. The detection circuit is tuned to recognize the dominant frequency of the QRS waveform in much the same way a radio receiver is tuned to a particular radio station.

A new twist in coronary-patient monitoring has grown out of our space program. The Schaefers Ambulance Service in Los Angeles has adapted for ambulance use NASA's technique for measuring heart-rate information of test pilots. If the patient gives permission, attendants attach small bare wires to the patient's chest with a special gun that sprays and drys a silver-glue combination. This process takes about 2 minutes and eliminates the need to shave the chest and attach bulky electrodes.

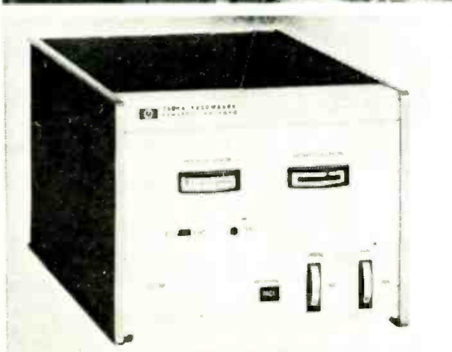
Measurements of the patient's heartbeat are picked up by the instrumentation in the ambulance and relayed, as an audio tone, via short-wave radio and telephone to the UCLA Medical Center.

A nurse in the emergency room at the medical center receives the information and feeds it into a standard ECG recorder where it is visually displayed for the doctor awaiting the patient's arrival. This advance information allows the doctor to make necessary hospital preparations and save valuable seconds after the patient arrives.

Cardiac pacemakers

The human heart beats 37 million times a year, or during a normal activity level 68 to 70 times a minute. The heartbeat rate is controlled by the brain. A tiny nerve pulses the heart muscle with an electrical impulse for each heartbeat. If this nerve is damaged or destroyed, the heart will slow down or stop completely. The latter case, known as Stokes-Adams disease, was once inevitably fatal.

These machines monitor, control and record the temperature in the incubator for infants.



Pacemaker aids or substitutes for heart nerve impulses. This HP 7804A can record how many pulses have been demanded in a set time.

The cardiac pacemaker has enabled life to continue for many individuals who otherwise would have died. The pacemaker shoots electrical impulses into the heart to maintain its proper beat. This electronic signal replaces the electrical signal which the heart-rate nerve normally produces.

When the patient is in the intensive-care ward, a cardiac pacemaker such as Hewlett-Packard's 7804A may be used. This unit not only delivers pace pulses "on demand" (that is, when the heart nerve fails to provide a pace pulse), but will keep track of how many pace pulses have been demanded during a given period of time. The counter is graduated from 1 to 15, because clinical experience has shown that if more than 15 pace pulses are required within a period of several hours, the patient needs continued use of the pacemaker.

If the patient requires heart pacing continuously for the rest of his life, a tiny pacemaker is generally implanted in his body. The first such device was installed in a human in 1960. Since then, as estimated 25,000 units have been installed in people ranging from a 6-month-old infant to a 94-year-old man. A housewife, who has had a pacemaker since she was 17, recently gave birth to a normal, healthy daughter.

The tiny pacemakers, manufactured by GE, consist of a generator with the necessary electronic circuitry to produce pulses at the correct rate and two electrodes which are attached to the heart muscle. The units, powered by long-life mercury batteries, are generally set to pulse 70 times a minute for older patients; however, GE also makes a unit which can be adjusted up to 85 pulses per minute for younger or more active heart patients.

Until recently, installation of these units required a major operation in which the patient's chest was opened, electrodes attached directly to the heart muscle, and leads run under the skin to the generator unit. The generator usually was located either in the stomach area or under the arm. Such an operation can be quite serious if the person is elderly or very ill.

A new installation technique has been developed which allows the unit to be installed with only local anesthesia and without opening the chest cavity. The electrodes are now inserted through a vein into the heart cavity and then connected to a generator implanted under the arm. The tiny electrical pulses from the generator are transmitted through the blood to the heart muscle to stimulate a regular beat.

According to GE, doctors believe the pacemaker principle may eventually be applied to regulating such common ailments as high blood pressure, diabetes and gall bladder disorders.

Servicing medical electronics equipment

Service on medical electronic equipment is a major problem. The number of suppliers is large (over 1200) and the market area covers the entire world. Large companies having an extensive product line can support a field service organization. GE, for example, has a staff of 600 technicians to service their X-ray equipment. Where such service is not available locally, hospitals and doctors must either attempt repairs themselves, bring in factory technicians with attendant costs and lost time, or return the unit to the factory. In the first two cases calibration is usually not accomplished even though the fault is repaired.

Bendix Commercial Service Corp. has opened medical service centers near Beltsville, Md., and Chicago. These centers offer a three-phase maintenance program to hospitals: (1) periodic inspection and servicing of equipment to prevent breakdowns and improve operation, (2) periodic certification and calibration to manufacturer's original specifications, and (3) 24-hour, short-notice, emergency repair service. **R-E**

TV On A Chip

Servicing receivers with integrated circuits requires special troubleshooting knowhow and techniques. An expert describes some current and experimental circuits on a 'chip'

by **ROBERT L. GOODMAN**

IC's—THOSE MICROMINI CIRCUITS spawned by the space age—are rapidly being applied to consumer electronics. Television manufacturers can now go directly from tubes to IC's, skipping "ordinary" transistor circuits.

For the set owner, this type of receiver will mean cooler operation, compact size, more reliability, and eventually a less expensive product. But what will this drastic change mean to the electronic service technician?

One good "spin off" is that the days of the tube jerkers and the "diddle stick" jockey will be numbered. New techniques and troubleshooting methods will have to be developed for IC testing.

Testing the IC 'chip'

Because many components in devices using IC's are on the "chip" fewer tests can be made. Most voltage, resistance and capacitance checks, for example, won't be efficient or practical.

One way to troubleshoot devices containing IC's is to use an oscilloscope for signal tracing and a pulse or square-wave generator for signal injection. In the modern electronics shop, the triggered scope and pulse generator replace the voltmeter and sine-wave oscillator of yesterday as detector and source. A television analyst can also be used to inject pulses into sync stages using IC's.

IC's are more reliable than vacuum tubes, have no cathodes to wear out, vacuum to lose (if a plastic encapsulated unit), or any mechanical electrode structures to vibrate. However, even though better processing and more reliability checks are being performed, IC's can and do fail.

IC defects can be caused by both electrical circuit and mechanical abuse. Tests on IC's are unlike those for other components, because an IC is not a component but a functional circuit in itself. Manufacturing faults may become apparent after a few months of operation. For example, an internal short may be caused by a slow chemical reaction or inadequate activation. Contamination is another defect that may not show up for months.

The external electrical circuit can cause IC failure if some outboard component defect causes excessive voltages or insufficient bias. Obviously, IC's cannot be repaired, so it's no use trying to locate the defective internal component. The technician's job is to positively determine that the IC is defective, and whether the defect was caused by an outboard com-

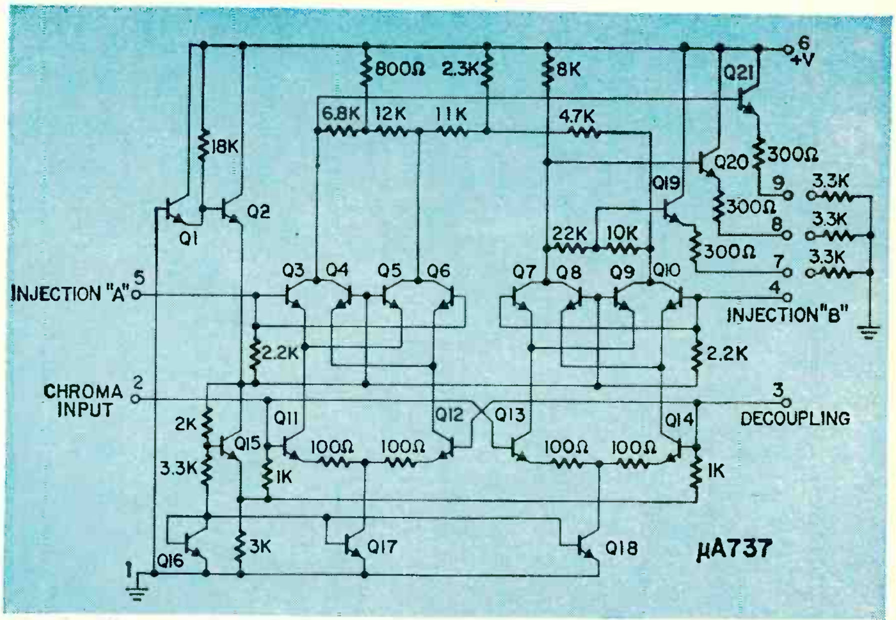
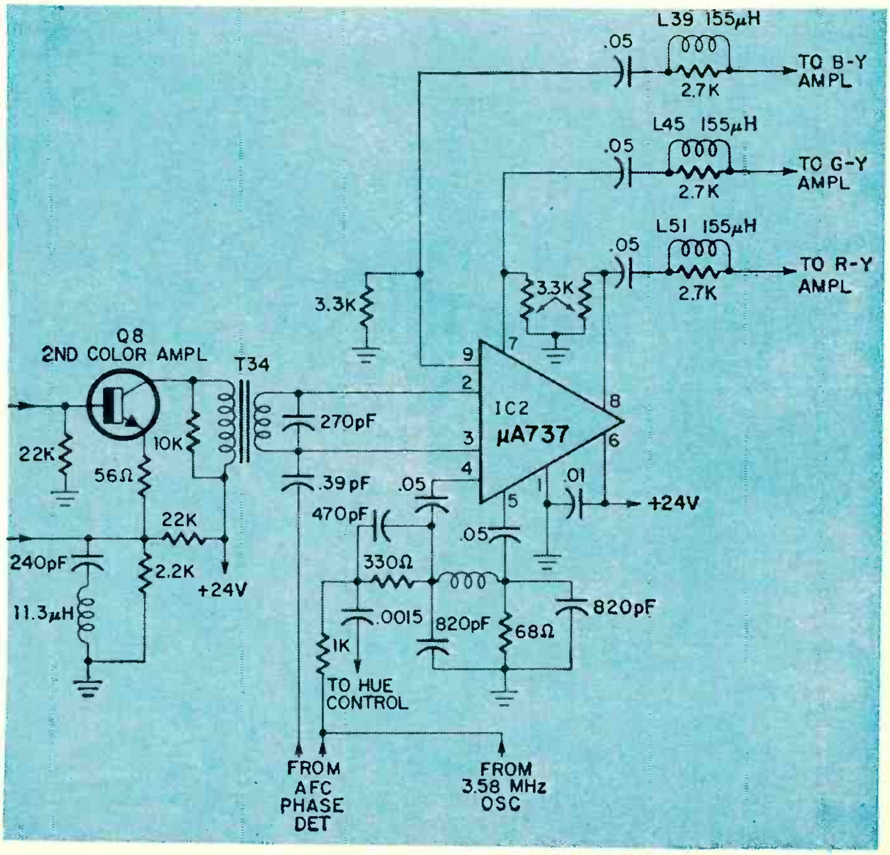


Fig. 1—**Circuit of the μA737** demodulator used by Zenith. Opposite-phase color signals are applied to amplifiers Q11–Q12 and Q13–Q14. Q3–Q6 and Q7–Q10 receive the 3.58 MHz reference. Q19, Q20 and Q21 are emitter followers.

Fig. 2—**Color demodulator circuitry** utilizing the μA737 with its two double-balanced synchronous detectors. Faulty color difference signals at pins 7, 8 and 9 may indicate the IC is faulty. Bad IC may also have incorrect voltages on pins.



ponent malfunction in the circuit.

IC chips, field effect transistors (FET's) and unijunction solid-state devices cannot be accurately tested and may be damaged by transistor checkers most service shops now use. Check out these devices in the operating circuitry by injecting a test signal and tracing the pulse through different IC stages with a triggered scope. This is a fast and positive troubleshooting method.

An IC color demodulator

Fairchild has developed an IC, designated μA737, for Zenith color receivers. It contains two double-balanced synchronous detectors that couple to a matrix in which the desired color difference signals are developed (Fig. 1). Note in Fig. 2 that the output of the second color amplifier is coupled to IC2, providing a stable, double-balanced demodulator and amplifier for the color signal. The "chip" is mounted in a case that plugs into a conventional 9-pin miniature tube socket, and is keyed with pin numbers accordingly.

Two chroma signals of opposite polarity (0.2 volt) are coupled to terminals 2 and 3 of IC2. Color difference signals of G – Y, R – Y and B – Y appear at terminals 7, 8 and 9, respectively. Oscillator injection reference (3.58 MHz) is injected at terminals 4 and 5. A scope will tell you if the IC or some outboard component is defective. Also, if the IC is faulty, you may find incorrect voltage readings at the terminals.

Although the chroma output of second color amplifier Q8 at the collector is approximately 6 volts, the stepdown for impedance matching of the second color amplifier transformer (T34) results in approximately 0.2 volts to terminals 2 and 3 of IC2. A power input supply of 24 volts is applied across terminals 6 and 1.

Amplification of the IC is greater than 10, providing adequate signal amplitude at the color difference amplifier grids. The operation of the IC is such that the second harmonic (7.2 MHz) of the 3.58-MHz signal is trapped in the output circuit by coils L39, L45, and L51 in the output circuit, which provide a high impedance at 7.2 MHz. (The 3.58-MHz fundamental is automatically cancelled within the IC.) Although a detailed description of the μA737 circuitry is unnecessary for servicing, it is interesting to note the following.

- Chroma signals of opposite phase are coupled into the parallel connected inputs of amplifiers Q11, Q12 and Q13–Q14.
- The color oscillator reference signals are coupled to the two sets of "switch" transistors Q3 through Q6 and Q7 through Q10.
- The color difference output voltages from the matrix are coupled through emitter followers consisting of

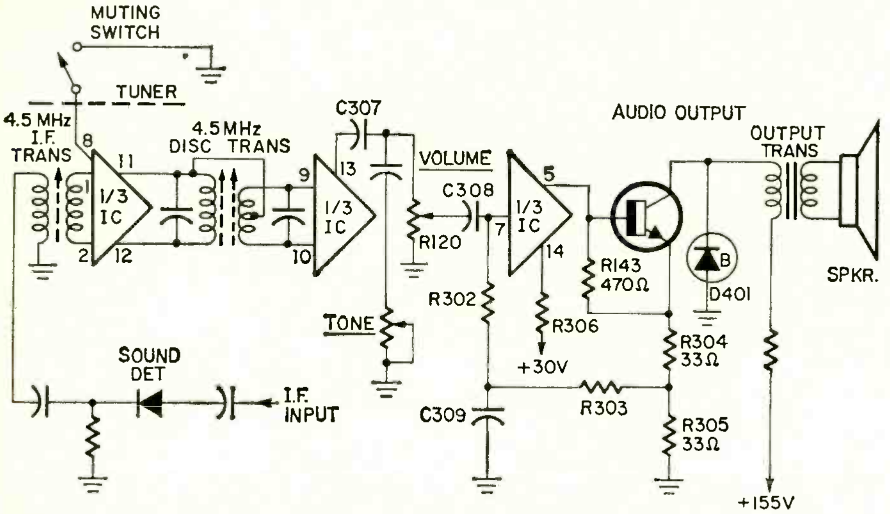


Fig. 3—Audio circuit in RCA CTC 40 color chassis with a single IC for i.f. amplification, detection and predriver. Triangles represent functions, respectively.

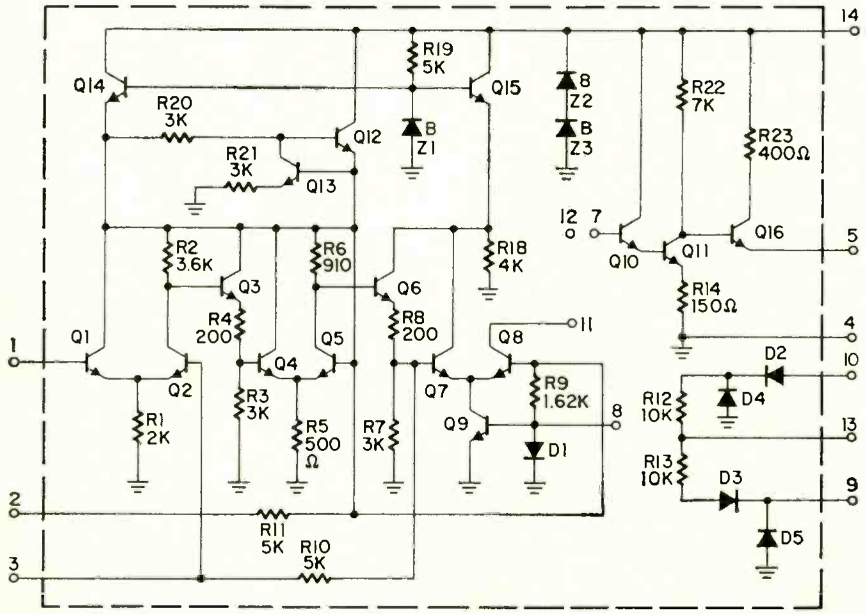


Fig. 4—Internal circuitry of the RCA audio IC. See Fig. 3 for pin connections to each of the three audio functions. D2–D5 are the ratio-detector diodes.

Fig. 5—Basic automatic fine tuning system used in the RCA CTC 40 chassis.

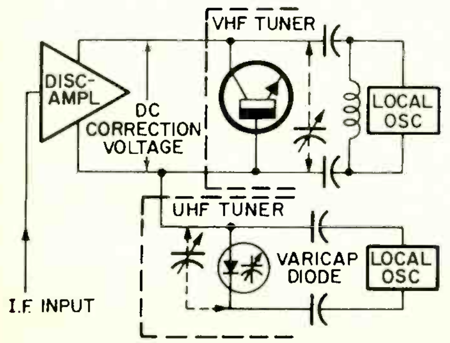
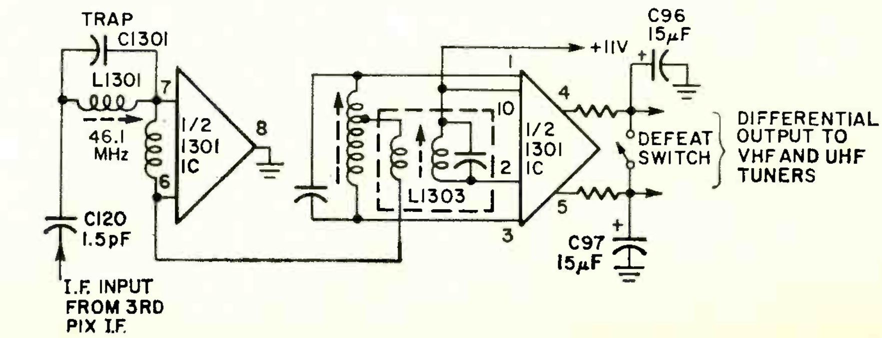
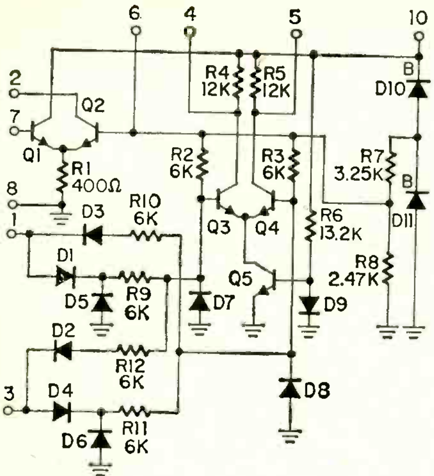


Fig. 6—Discriminator/amplifier of the aft system shown in Fig. 5.





DIODES D5 AND D6 ACT AS CAPACITORS AND ARE USED TO BALANCE THE DETECTOR SUBSTRATE CAPACITANCES.

Fig. 7—Internal circuit of the CTC 40 discriminator/amplifier IC.

transistors Q19, Q20 and Q21.

- Remaining transistors provide voltage division and regulation (Q1 acts as a Zener) for stability of the IC's operation.

RCA CTC 40 IC's

Sound circuitry in RCA's solid-state CTC 40 color TV chassis features a newly designed integrated circuit. The integrated circuitry includes the sound i.f. amplifiers, demodulators, preamplifiers and audio driver stages.

The IC may be considered as being divided into three sections (Fig. 3). The first operation is amplifying the 4.5-MHz i.f. signal from the sound detector. The amplified i.f. is then detected by another third of the IC and applied through the volume and tone controls to an audio driver section, which in turn provides power to the discrete audio output stage.

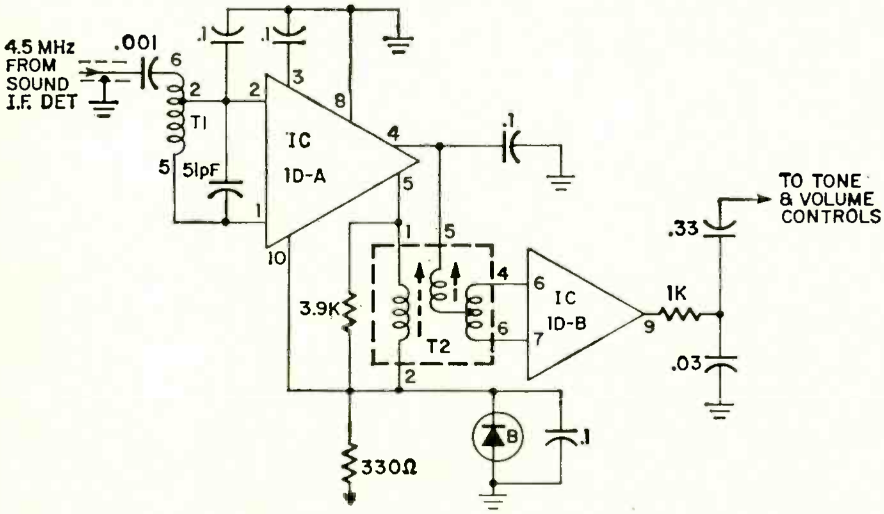


Fig. 8—Portion of the audio circuit in Motorola's TS 915/917 color chassis between the 4.5-MHz detector and a three-transistor audio output circuit. Signal injection techniques tell whether IC is spoiling TV audio.

RCA CTC 40 chassis is shown in Fig. 5. An IC discriminator/amplifier produces a differential voltage proportional to the applied i.f. frequency. This voltage corrects local oscillator frequency errors (mistuning), utilizing a special variable capacitance transistor in the vhf tuner and a varicap diode in the uhf tuner.

The IC system used for the aft (Fig. 6) has an internally regulated power supply. The circuit requires no external reference (bias) voltage for uhf defeat action; automatic degeneration of the output amplifiers totally eliminates all aft correction voltage when the output terminals are shorted for the defeat action. Fig. 7 is the schematic diagram of this IC.

Motorola's audio IC

Part of the audio system for the Motorola TS 915/917 color chassis is shown in (Fig. 8). Inside the IC, 12 transistors, 12 diodes and 16 resistors are direct-coupled to perform the various functions. A short or open in one of these internal components will affect total IC current drain.

A dynamic check is the only positive way to determine if the IC is operating properly. Feed a frequency-modulated 4.5-MHz carrier into the input and measure the recovered audio at the output.

With this many functions housed in one device, it's a sure bet a number of sound trouble symptoms can be the fault of the IC; for example: no audio, audio drift, distorted audio, noisy audio, weak audio and poor sound sensitivity. Finally, transformers T1 and T2 play important roles in IC performance. Here again, the best check is with signal injection and the oscilloscope for detection.

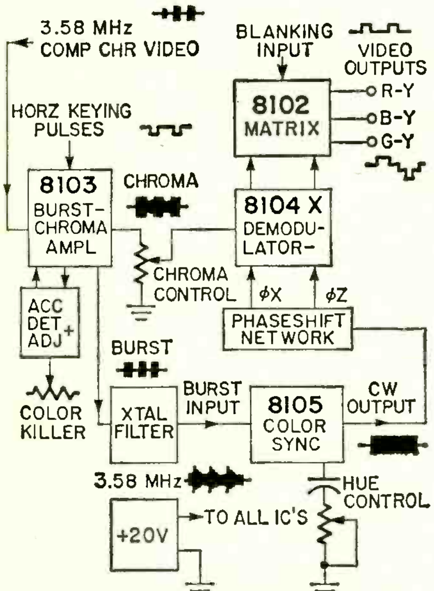


Fig. 9—Complete color processing circuit made on four IC chips.

Let's look at the process in more detail. The output of the i.f. amplifier is fed to the discriminator transformer and is next applied to the IC ratio-detector (D2-D5 in Fig. 4). The resultant audio signal is coupled through C307 to the tone and volume controls. Capacitor C308 couples the audio from the volume control to the driver section of the IC. This section provides the current gain necessary to drive the output audio stage. A 275-volt Zener diode, D401, protects the output transistor from high transient voltage spikes.

Resistor R143 coupled between the base and emitter of the output transistor, provides an additional load for the driver section, minimizing the undesirable effects of output transistor leakage current.

Automatic-fine-tuning IC

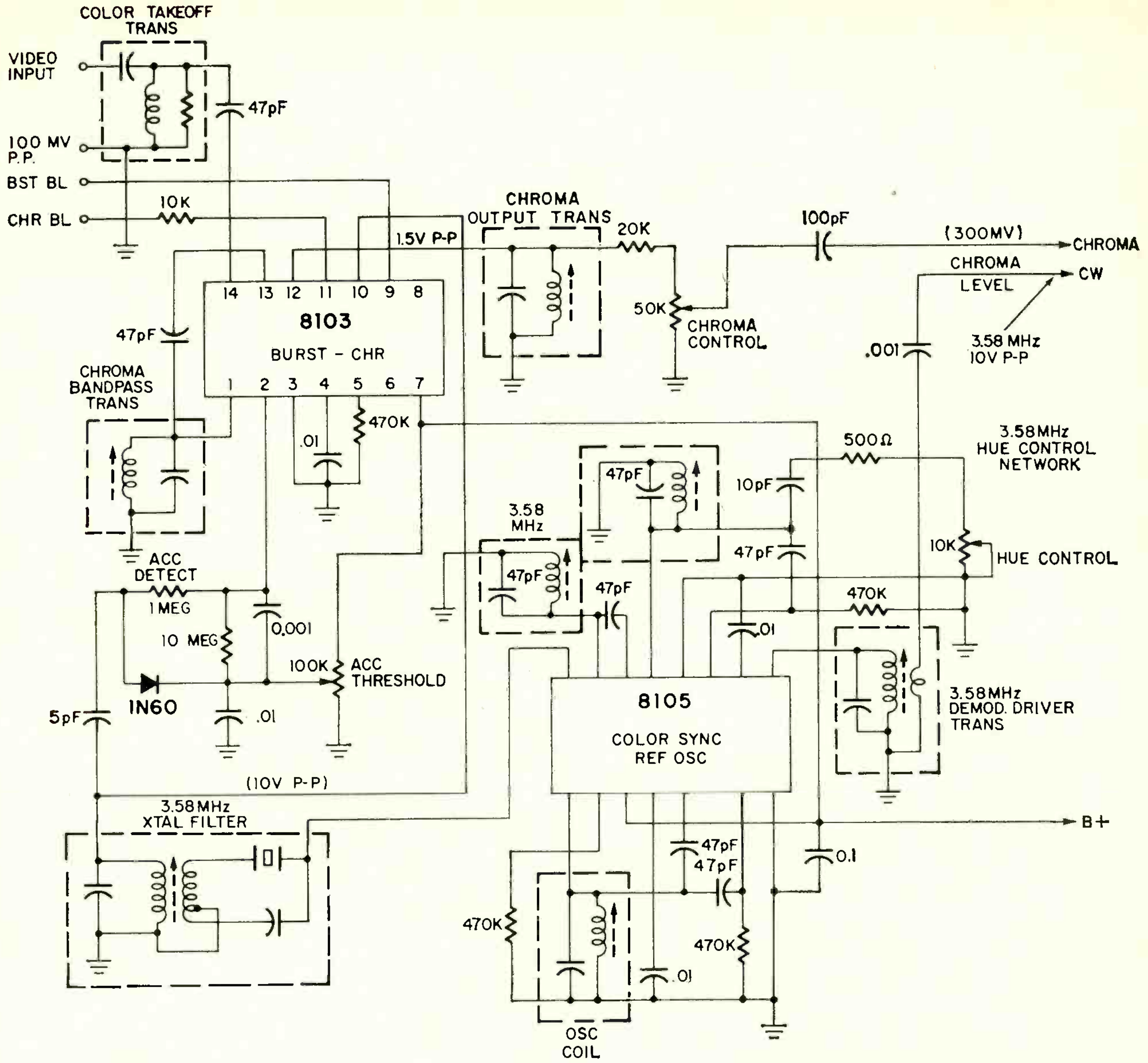
The basic aft system for the

Color-processing IC's

General Instrument Corp. is now working on a complete color-processing circuitry using integrated metal-thick-oxide silicon (MTOS) techniques. The design uses four MTOS chips to perform the following functions:

1. Chroma-burst separator, amplifier, keyer and color killer. 2. Color demodulator. 3. Color matrix. 4. Color synchronization.

The system (Fig. 9) is now integrated into four chips. Further refinements combining the functions into three, two or even one large chip are possible. The 8103 keyed chroma and burst amplifier and the 8105 color synchronization chip with outboard components is in Fig. 10. The 8105 contains an integrated two-stage amplifier operating at 3.58 MHz, a locked oscillator and limiter



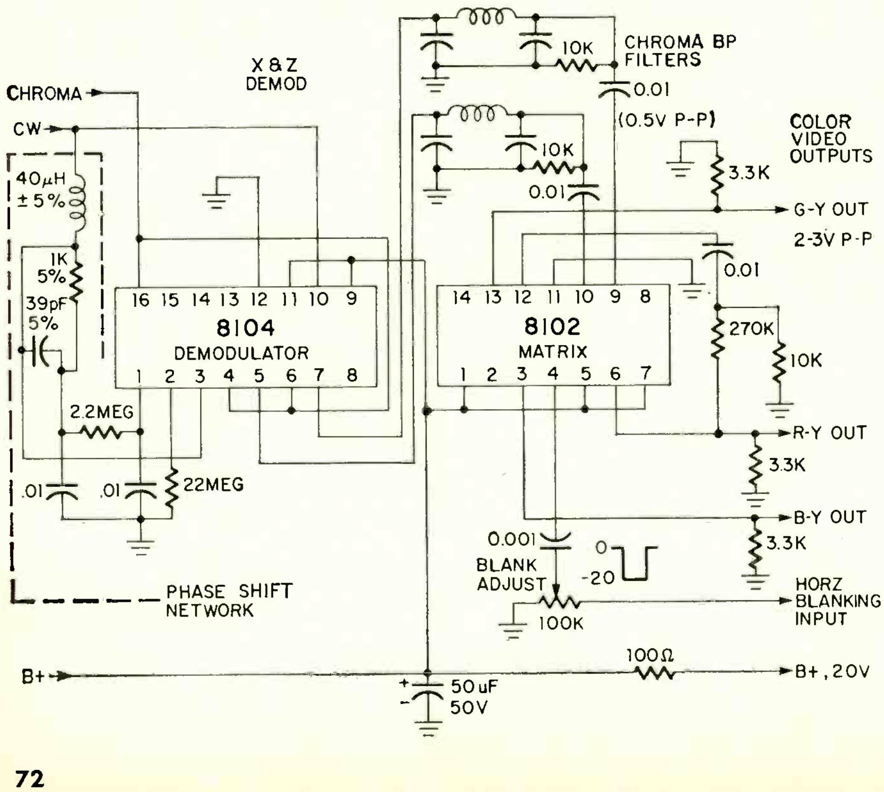


Fig. 10 (above)—This IC system could cut color TV circuit components 50%. Complete color-processing circuits are on four chips. The 8103 part provides keyed chroma and color burst, while the 8105 operates with an external crystal as a 3.58-MHz oscillator.

Fig. 11—Remaining two IC sections, 8104 and 8102, serve as a dual demodulator and x-y matrix, respectively. The four separate IC's may be combined into a larger single chip.

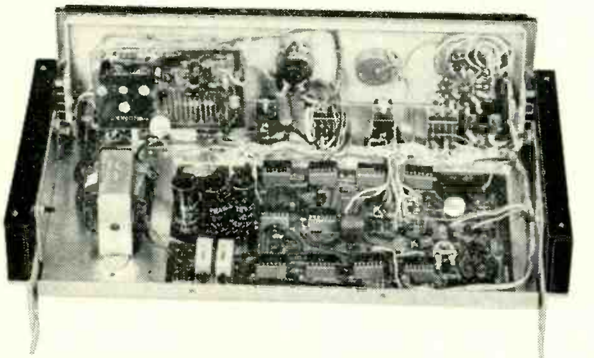
stage. The 8104 demodulator and 8102 matrix is shown in Fig. 11. The 8104 is a dual demodulator and an integrated switching-type demodulator with built-in bias supplies. The 8102 is an integrated version of the three-triode, cathode-coupled X and Z matrix commonly used in color TV receivers. It is designed so that blanking pulses may be added to the chroma signals for CRT blanking and bias level setting. It is possible that the MTOS approach may reduce component count by 50%. **R-E**

The NEW Heathkit® IG-28

Color Bar — Dot Generator...

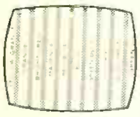
Advanced IC Design Gives 12 Patterns Plus Clear Raster Display & Eliminates Divider Chain Instability Forever!

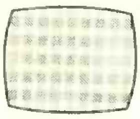
Stable Integrated Circuitry And Well-Engineered Layout

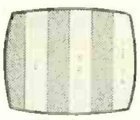


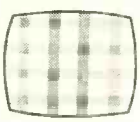
Circuit Board-Wiring Harness Construction. Note the extremely clean, open layout — another advantage of integrated circuitry. The Video board is upper left, the Divider board mounts on the chassis.

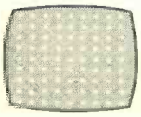
Fast Switch Selection Of Either Standard 9 x 9 Display OR Exclusive Heath "3 x 3" Display

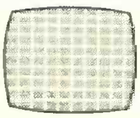

Color Bars

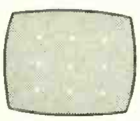

Shading Bars

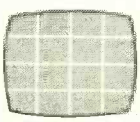

3x3 Color Bars


3x3 Shading

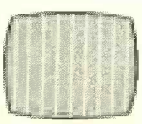

Dot Pattern

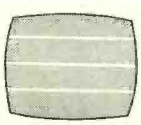

Cross Hatch


3x3 Dot


3x3 Cross Hatch


Horizontal Bars


Vertical Bars


3x3 Horizontal


3x3 Vertical

The Most Advanced Instrument In Color TV Service

• All solid-state construction using Integrated Circuitry • No divider chain adjustments • Stable pattern display — no flicker, bounce or jitter • Produces 12 patterns plus clear raster • Instant switch selection of all functions • Exclusive 3x3 display plus standard 9x9 display of all patterns • Horizontal lines only one raster thick for added accuracy • Variable front panel tuning for channels 2 through 6 • Variable front panel positive and negative video output • Front panel negative going sync output • Two handy AC outlets on front panel • Built-in gun shorting circuit with lead piercing connectors • Front panel switchable crystal controlled sound carrier • Copper-banded transformer to reduce stray fields • Safe three-wire line cord • Fast, easy construction with two circuit boards and two wiring harnesses

The new Heathkit IG-28 is the ultimate signal source for all Color and B&W TV servicing. No other instrument at any price will give you as much stable, versatile TV servicing capability. Here are the details:

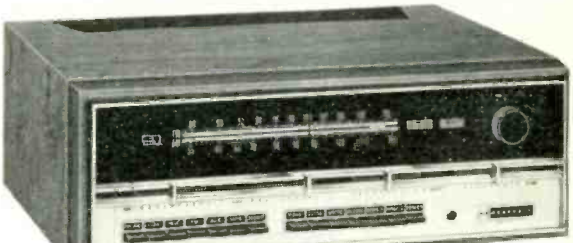
All Solid-State Circuitry produces dots, cross-hatch, vertical and horizontal lines, color bars and shading bars in the familiar 9x9 display . . . plus the exclusive Heath 3x3 display of all these patterns so necessary for static convergence, linearity and color demodulator phase adjustments . . . plus a clear raster that lets you adjust purity without upsetting AGC adjustments. Fifteen J-K Flip-Flops and associated gates count down from a crystal controlled oscillator, eliminating divider chain instability and adjustments.

Time-Saving Versatility. While many generators only give you one or two channel capability, the new IG-28 has variable front panel tuning for channels 2 through 6. The RF tank coil is actually etched into the circuit board for extra stability. Plus and minus going video signals are available at the turn of a front panel control. And for sync, in-circuit video or chroma problems, there's a front panel sync output. Convenient AC outlets are provided for degaussing coil, test instruments, TV set etc. Built-in gun shorting circuits and grid jacks are also included. Add any service type scope (with horizontal input) to the IG-28 and you have vectorscope display capability too. Other features include a crystal controlled sound carrier oscillator, a well regulated full wave power supply with dual primary copper-banded transformer, safe three-wire line cord, and rugged, compact Heath instrument styling. Two circuit boards and two wiring harnesses provide easy construction in about ten hours. Start enjoying the versatility you couldn't get before . . . put the remarkable new Heathkit IG-28 on your service bench now.

Kit IG-28, 8 lbs. **$79.95***

Exciting New Kit Ideas from Heath

New Heathkit 100-Watt AM/FM/FM-Stereo Receiver



Kit AR-29
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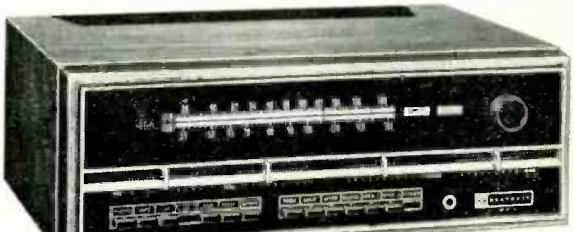
World's finest medium power stereo receiver . . . designed in the tradition of the famous Heathkit AR-15. All Solid-State . . . 65 transistors, 42 diodes plus 4 integrated circuits containing another 56 transistors and 24 diodes. 100 watts music power output at 8 ohms — 7 to 60,000 Hz response. Less than 0.25% distortion at full output. Direct coupled outputs protected by dissipation-limiting circuitry. Massive power supply. Four individually heat sinked output transistors. Linear motion bass, treble, balances and volume controls. Push-button selected inputs. Outputs for 2 separate stereo speaker systems. Center speaker capability. Stereo headphone jack. Assembled, aligned FET FM tuner has 1.8 uV sensitivity. Two tuning meters. Computer designed 9-pole L-C filter plus 3 IC's in IF gives ideally shaped bandpass with greater than 70 dB selectivity and eliminates alignment. IC multiplex section. Three FET's in AM tuner. AM rod antenna swivels for best pickup. Kit Exclusive: Modular Plug-In Circuit Boards . . . easy to build & service. Kit Exclusive: Built-In Test Circuitry lets you assemble, test and service your AR-29 without external test equipment. The AR-29 will please even the most discriminating stereo listener.

Kit AR-29, (less cabinet), 33 lbs.................................$285.00*
AE-19, Assembled oiled pecan cabinet, 10 lbs......................$19.95*

New Heathkit 60-Watt AM/FM/FM Stereo Receiver



Kit AR-19
$225.00*

The AR-19 circuitry reflects many of the advanced concepts of the AR-29. It uses 108 transistors and 45 diodes including those in 5 integrated circuits. It delivers 60 watts music power at 8 ohms. At any power level, Harmonic and IM Distortion is less than 0.25%. Frequency response ranges from 6 to 35,000 Hz. Direct coupled outputs are protected by dissipation-limiting circuitry. A massive power supply includes a section of electronically regulated power. The assembled, aligned FET FM tuner has 2.0 uV sensitivity.

A preassembled and factory aligned FM IF circuit board gives 35 dB selectivity. The multiplex IC circuit provides inherent SCA rejection. It features two switched noise muting circuits; linear motion controls for bass, treble, volume and balance; input level controls; outputs for 2 separate stereo speaker systems; center speaker capability; two tuning meters; stereo indicator light; front panel stereo headphone jack. The Modular Plug-in Circuit Board design speeds assembly. Built-in Test Circuitry aids assembly, simplifies servicing. "Black Magic" panel lighting, black lower panel, chrome accents. Compare it with any model in its price range . . . the AR-19 will prove itself the better buy.

Kit AR-19, (less cabinet), 29 lbs.................................$225.00*
Assembled AE-19, cabinet, 10 lbs.................................$19.95*

New Heathkit Deluxe 18-Watt Solid-State Stereo Phono

Kit GD-109
$74.95*

Looks and sounds like it should cost much more. Here's why: 16-transistor, 8-diode circuit delivers 9 watts music power per channel to each 4½" high-compliance speaker. Speaker cabinets swing out or lift off . . . can be placed up to 10' apart for better stereo. Has Maestro's best automatic, 4-speed changer — 16, 33-1/3, 45 & 78 rpm. It plays 6 records, shuts off automatically. Ceramic stereo cartridge with diamond/sapphire stylus. Has volume, balance & tone controls. Changer, cabinet & speaker enclosures come factory built . . . you build just one circuit board . . . one evening project. Wood cabinet has yellow-gold & brown durable plastic coated covering. This is a portable stereo you can take pride in.

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Kit SB-220
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Incomparable performance and value. The new SB-220 has 2000 watts PEP input on SSB & 1000 watts on CW and RTTY. Uses a pair of Eimac 3-500Z's. Pretuned broad band pi input coils. Requires only 100 watts PEP drive. Solid-state power supply operates from 120 or 240 VAC. Circuit breaker protected. Safety interlocked cover. Zener diode regulated operating bias. Double shielded for max. TVI protection. Quiet fan — fast, high volume air flow. Also includes ALC to prevent over-driving. Two meters: one monitors plate current; the other is switched for relative power, plate voltage and grid current. Styled to match Heath SB series. Assembles in about 15 hours.

Kit SB-220, 55 lbs...$349.95*

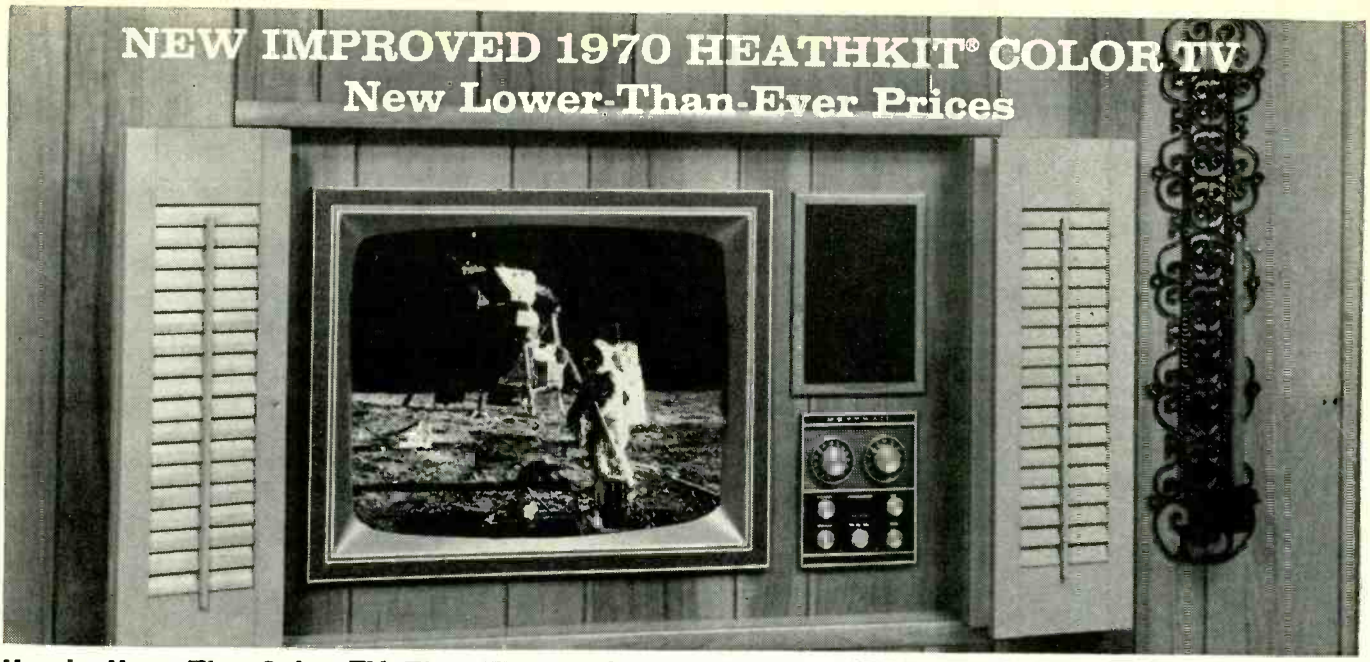
New Heathkit Portable Fish-Spotter

Kit MI-29
$84.95*

Costs half as much as comparable performers. Probes to 200 ft. Spots individual fish and schools . . . can also be used as depth sounder. Manual explains typical dial readings. Transducer mounts anywhere on suction cup bracket. Adjustable Sensitivity Control. Exclusive Heath Noise-Reject Control stops motor ignition noise. Runs for 80 hrs. on two 6 VDC lantern batteries (not included). Stop guessing — fish electronically.

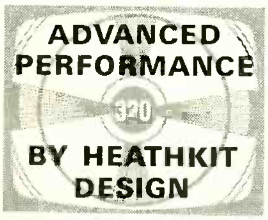
Kit MI-29, 9 lbs...$84.95*

NEW IMPROVED 1970 HEATHKIT® COLOR TV
New Lower-Than-Ever Prices



Here's How The Color TV That Thousands Call Best Became Even Better and Lower In Price

Since the very first model was introduced, thousands of owners, electronic experts, and testing labs have praised the superior color picture quality and extra features of Heathkit ColorTV. Now Heath has made improvements that make the 1970 models even better.



Sharper, More Detailed Pictures. Latest design improvement in the circuitry of Heathkit Color TV video amplifiers has increased their bandpass capabilities. The result is an increase in the number of lines of resolution . . . greater than in any other brand of color TV we have tested. This improvement means you get sharper, more detailed pictures as shown by test pattern measurements. You not only get the superior *color* pictures Heathkit Color TV has always been noted for, but you also get sharper pictures.

New Brighter Tube. Now all Heathkit Color TV models include the new brighter picture tube you've read so much about. These new tubes produce noticeably brighter pictures with more life-like, natural colors and better contrast. (We also offer the RCA Hi-Lite Matrix tube as an extra-cost option for the Heath GR-681 and GR-295 kits.)

New Safety Features. As an added safety precaution, AC interlocks have been added to all Heathkit Color TV cabinets.

Now The Best Costs Less. How can Heath make improvements in its Color TV Models and still reduce the prices? We have passed on to you the savings which have accrued due to reduced picture tube prices. The result is your 1970 Heathkit Color TV will cost you $20 to $55 less depending upon which model you choose . . . proof that Heathkit Color TV is a better buy than ever.

All Heathkit Color TV's Have These Superior Features

• New brighter American brand rectangular color tube with bonded-face, etched anti-glare safety glass • Exclusive built-in self-servicing aids so you can adjust and maintain the set for best performance always • Automatic degaussing plus mobile degaussing coil • New broader video bandwidth for better resolution • 3-stage video IF • Improved retrace blanking • Gated automatic gain control for steady pictures • Automatic color control • Exclusive Magna-Shield surrounds picture tube for better color purity • Deluxe VHF tuner with "memory" fine tuning and precious metal contacts (models with automatic fine tuning also are available in all 3 picture tube sizes) • 2-speed UHF solid-state tuner • Completely shielded hi-voltage supply • Extra B+ boost for better definition • 2 hi-fi sound outputs for built-in speaker or your hi-fi system • 300 ohm & 75 ohm antenna inputs • Circuit breaker protection • Optional wireless remote control can be added anytime • Factory assembled and adjusted tuners, IF section, and hi-voltage supply • Exclusive 3-way installation capability — in a wall, custom cabinet or Heath cabinets

Choose Your Heathkit Color TV Now . . .
It's Better Than Ever in Performance . . . and A Better Buy Than Ever

New Lower-Than-Ever Prices On All Models

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(295"-AFT)
save $30
Now only $469^{95}*

Heathkit GR-681MX
(with Matrix tube)
save $55
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Heathkit GR-295
(295")
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save $55
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cabinets from $65*

Heathkit GR-581
(227"-AFT)
save $20
Now only $399^{95}*

Heathkit GR-227
(227")
save $20
Now only $359^{95}*

cabinets from $39.95*

Heathkit GR-481
(180"-AFT)
save $30
Now only $329^{95}*

Heathkit GR-180
(180")
save $30
Now only $299^{50}*

cabinets from $27.50*

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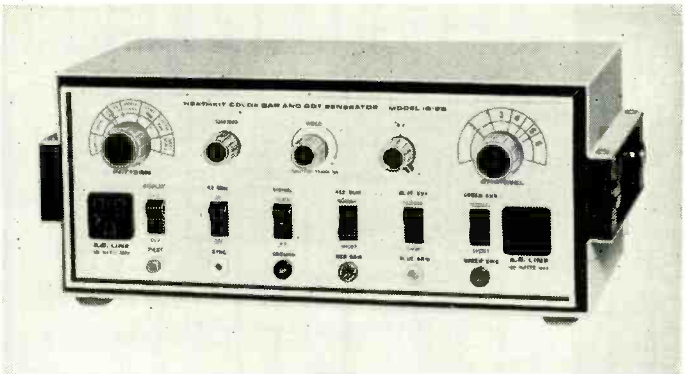
Circle 27 on reader service card

EQUIPMENT REPORT

Heath IG-28

For manufacturer's literature, circle No. 30 on Reader Service Card.



by JACK DARR
SERVICE EDITOR

EVERYTHING'S "COMPUTERS" TODAY. The integrated circuit, of course, is the parent of the computer. The last word in "IC-ization" (I can make up words, too!) is the Heathkit IG-28 color bar and dot generator. This versatile instrument uses computer circuits to generate the complex waveforms needed to form the standard color TV test patterns.

Transistors are ideal for this kind of work. They can make very sharp, very short pulses with almost ridiculous ease. The waveforms needed for dot and line patterns *are* very short, sharp pulses. The sharper the pulse, the cleaner the line on the screen. Heath's engineers have taken full advantage of this; this instrument makes some of the cleanest patterns I've ever seen.

You're going to have to "buy the book" to get the full description of the circuit. Even the block diagram is too big to reproduce here! As briefly as possible, it begins with a crystal-controlled 190.08-kHz master clock oscillator.

There are no less than 15 J-K flip-flops, plus AND gates, NAND gates, OR gates, NOR gates and a few odd things such as rf oscillators, clippers, shapers, blankers, etc. There are 12 "regular" transistors and 10 IC's, one type with 24 transistors in it. The whole thing is powered by a Zener-regulated 3.6-volt dc supply.

The IG-28 will make all of the standard TV convergence-test patterns—the "9x9" dot, vertical and horizontal line and crosshatch. Beside these, it will make a "3x3" line pattern for any of them. The color-bar pattern is the stock 10-bar keyed rainbow; switching to 3x3 gives you a three-bar color pattern: red, blue and green. A "clean raster" pattern for setting purity is provided; also, a "wide crosshatch" bar pattern in either 9 or 3-bar style. This is a very good simulation of a TV picture, and is used for making gray-scale tracking adjustments.

The output of the IG-28 can be either modulated rf, which is tunable from channel 2 to 6, with an adjustable signal level from a very low level to 50,000 μV, or composite video at a level of at least 1 volt p–p. The video output can be varied, or reversed in sync polarity, with the VIDEO OUT control on the panel. There is also a SYNC OUT jack on the panel, for those sets having separate sync and video demodulators; output is 3.5 volts p–p at least. A rocker-type switch can be used to get either rf or video output on the same output cable.

Also on the front panel are three jacks for the gun-killer circuit and the jack switches. Insulation-piercing clips are used for convenience. With these hooked up to the grid wires, test leads can be plugged into the red and blue grid jacks. Any service-type scope will then make a "vectorscope" pattern, if it has a separate horizontal input jack. You may think your scope is too old, but try it; you'll be surprised.

The CHROMA control on the panel varies the color level from "0 to 200%" as usual. The VIDEO LEVEL control works only on the video output. It does not affect the modulation of the rf output. As a final touch, two three-wire, safety-type ac outlets are provided, one on each end, for whatever you might want to plug into them. A 4.5-MHz signal is provided, for setting up fine tuning when using the color-bar patterns.

The heart of this instrument, as you might have guessed, is a PC board. This holds practically all the working parts—the transistors and the 10 IC's, which plug into sockets.

The wiring is already made up, laced and the ends stripped. All you do is tuck it in place and wire it in. Be sure to follow the book when installing components: solder (then pull carefully on the wire to make sure you *did* solder!), then trim off the excess lead under the board with a pair of wee dykes. Be sure you don't leave any wire protruding; it's easy to make a "wire bridge".

In this type of instrument, there are no adjustments at all in the counter chain. These were the big headaches in the early models, if you remember. as I do. You have a total of *three* controls to set—two trimmers and one pot. There is a trimmer on the rf oscillator, but you shouldn't need it, since the oscillator is continuously tunable.

The instruction book includes a very detailed set of troubleshooting instructions, plus a chart, voltages and waveforms, for making any tests needed for the instrument. There is also a complete set of basic instructions for converging color sets, and aligning color-sync circuits, demodulators, and all sorts of good stuff. Even included is a section on color TV basics, which is handy.

The assembly and testing of this instrument took me about half the time I thought it would. In fact, it surprised me greatly; it almost worked the first time I turned it on! It did make horizontal bars, and after I got a solder bridge out, it worked on all functions. A very useful instrument indeed, and a necessity in the modern TV service shop. **R-E**

"Boy is he mad! He just found out solid state doesn't mean Texas."

FIX CB FAST

Part II: Continued from Jan. 1970

Let's move to the next step which tells us to inject a signal at the volume control. This could be done by touching the top or center terminal of the control (Fig. 2, page 70, January) with your finger or by using a signal generator. No sound.

Now inject a signal at the grid of the 12AU7 af amplifier. No sound.

Next we inject a signal at the grid of the second af/squelch tube. Here we get a healthy tone from the speaker, proving that the trouble lies in the first audio stage. Now break out the voltmeter and check the voltages of the grid, plate and cathode of the first af amplifier tube. UnHuh! What do we find? The plate voltage at pin 6 is +5 volts instead of 45 volts.

Moving the probe down to the junction of R1, C1, we also read +5 volts. The other end of R2 reads 370 volts, and we see that R2 is discolored. What part could cause this?

Could it be C1? Let's get the ohmmeter.

Measure the resistance from the junction of R1–C1 to ground. The ohmmeter reads 50 ohms. Now, measuring the resistance from pin 6 to ground we find 22K. This indicates that C1 is shorted. Capacitor C1 is removed from the circuit and the ohmmeter reads infinity across it. When C1 is replaced with a new capacitor, the unit works normally. Although R2 appears to be OK, it should be replaced to avoid failure.

Troubleshooting the transmitter

The second case deals with the transmitter. Here we have a General Model VS-6 transceiver with no rf output (Fig. 3, Jan.). The receiver operates normally. Turn to the transmitter servicing chart and proceed.

Turn on the unit and connect it to a power-output and modulation meter. The first step is to see if all the tubes are lighted. If they are not, check the fuses, wiring, etc. If some of them light, check the tubes that don't light as well as the wiring to the tube sockets.

When all the tubes are lighted, press the mike button and observe the rf output on the output/modulation meter. When it's zero, the chart says to check the TR (transmit–receive) switch. But since this unit uses "electronic switching," we'll skip this step and go directly to the radio/bullhorn switch. This measures OK with the ohmmeter.

Now check the mike cord and switch. In this case, both are OK. Next measure the grid voltage of the PA (rf power amplifier) section.

NOTE: *It is recommended that you use a vtvm here with a 1-meg isolating resistor in the probe. This reduces the loading effect of the meter. See Fig. 4, page 71, January.*

This grid voltage should be at least −5 to −10 volts.

But the meter reads −0.5 volt!

Now move your vtvm probe to the control grid of the oscillator. We should read −5 volts or more. Our meter reads −10 volts, so we can conclude that the oscillator is working. Since the oscillator is working normally, the trouble lies between the plate of the oscillator and the grid of the PA tube.

The next test on the chart is to check the voltage and resistance to ground of the plate of the oscillator and grid circuit of the PA tube. These read normal except at the grid of the PA, which reads −0.5 volt. What part could cause this trouble between the oscillator and the PA section? Could it be C1? Let's substitute for it and see what happens. We do this and the unit transmits again. In this case, the coupling capacitor was open, so no rf signal was applied to the grid of the PA tube.

Summary

See how simple it is to troubleshoot your CB rig? With the help of the servicing chart, most common troubles can be easily solved. **R-E**

NEW PRODUCTS

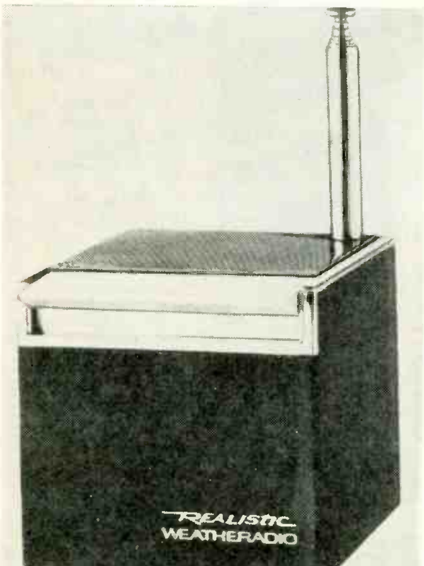
More information on new products is available from the manufacturers of items identified by a Reader Service number. Use the Reader Service Card at the left and circle the numbers of the new products on which you would like further information. Detach and mail the postage-paid card.

REVERBERATION AMPLIFIER, *Model SR-202.* Solid-state double-scatter unit provides additional depth and three-dimensional sound. Signal input 3

volts max at 1 kHz, harmonic distortion at 1 kHz less than 0.2%, output level 330 mV. Additional features: front-panel mode and reverberation mode controls. $95.—**Pioneer Electronics U.S.A. Corp.,** Farmingdale, N.Y.

Circle 46 on reader service card

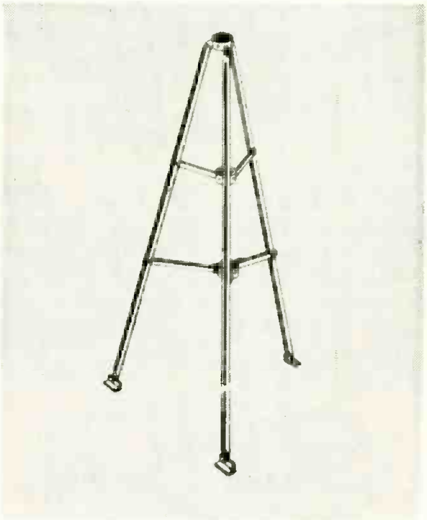
WEATHER RADIO, *"Talking Barometer"*, tunes you into continuous area weather forecasts over U.S. Government channel 162.55 MHz. Designed for maxi-



mum sensitivity; noise rejection. Controls are pre-set once. Comes in handsome rosewood and plastic cube cabinet, 3 inches on a side, with pull-out antenna. Battery operated. $14.95.—**Radio Shack Stores,** Boston, Mass.

Circle 47 on reader service card

ANTENNA MOUNT TRIPODS available in 2, 3 and 5-foot sizes. All have



gold baked enamel finish, plus six lag screws and three tar patches for sealing mounting holes. 3 and 5-foot towers have heavy duty 1¼" diameter legs, original tilt-up feature for easy antenna installation. 2-foot tripod carries *No. 9064*, 3-foot is *No. 9146*, 5-foot is *No. 9145.*—**GC Electronics,** Rockford, Illinois.

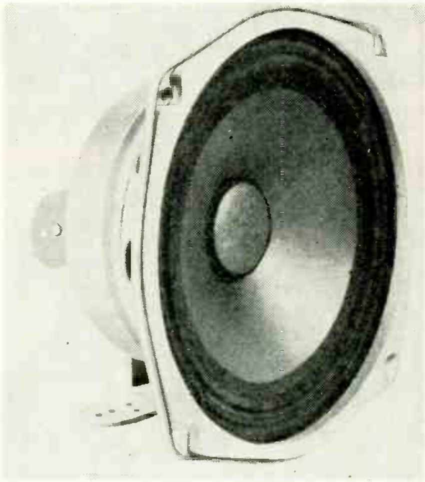
Circle 48 on reader service card

PSYCHEDELIC LIGHT CONTROL, *Model X-93,* 33/4" x 3 3/4" x 6¼". Operate on 110 to 120 volts 60 Hz. By connecting three lights or sets of lights

to the controller, the light intensity is changed in tempo with the music to produce psychedelic light patterns on walls and ceiling. $89.98.—**Olson Electronics Inc.,** Akron, Ohio

Circle 49 on reader service card

COMMERCIAL SOUND LOUDSPEAKER, *Model FX-52,* 5¼", 8-ohm voice coil. This speaker produces super-low resonance and can use grill screens as small as 6" diameter. Removable universal bracket permits end transformer mounting in shallow spaces or back transformer mounting for deep spaces with small diameters. The speaker, with plastic diaphragm and specially protected moving system, is completely weath-



erproof. $24.95.—**Jensen Mfg. Div., Muter Co.,** Chicago, Ill.

Circle 50 on reader service card

TRANSISTOR/FET TESTER, *Model TF17,* in-or-out-of-circuit tester. Checks regular transistors for ac beta; I_{CBO} leakage. Also checks all FETs-MOS, dual gate and new enhancement types, in or

out of circuit for gain; out of circuit for leakage. Provides increased current check for high power transistors; special test for critical rf transistors. With "Handicase" reference book.—**Sencore, Inc.,** Addison, Ill.

Circle 51 on reader service card

AMPLIFIER, *LA-750* 30-Watt solid-state stereo. 5 stereo inputs; aux. 250 mV,

tuner sensitivity 500 mV, mag phono sensitivity 2.3 mV, ceramic phono 30 mV, tape monitor 500 mV. Transistor-

Service Clinic

By JACK DARR
SERVICE EDITOR

Uhf tuner problem

I've got a uhf problem in a Zenith 25MC33 chassis. The picture and sound are separated. The vhf tuner works fine, and the uhf tuner works fine on another chassis! Another uhf tuner (working) shows the same result on the Zenith. What's going on here?—F. S., Philadelphia, Pa.

This Zenith chassis has the Gold Video Guard turret tuner. On uhf, a special strip converts the vhf tuner into a 40-MHz i.f. *amplifier*. Since your uhf tuner works on another set, and another uhf tuner shows the same symptoms on the Zenith, this uhf strip must be out of alignment.

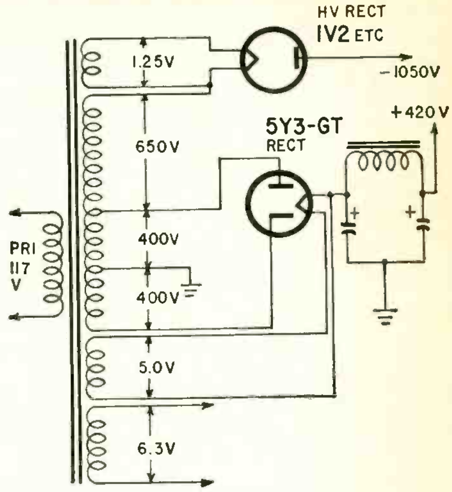
Remove enough strips from the turret so that you can see the uhf strip coils while it is switched in. Tune in a signal and check these coils. Better still, feed a 40-MHz swept i.f. signal into the uhf input jack, and adjust the uhf strip coils for the proper curve shape. Last resort is a new uhf strip.

Replacing scope transformer

The power transformer in my old Precise 300-C scope is burned out. Can you tell me where to get a replacement? Will a radio power transformer work?—W. R., Anniston, Ala.

A radio power transformer could be made to work, but it wouldn't be easy. Thordarson-Meissner lists several transformers in its catalogue, including one which is an exact replacement for the Heathkit O-12.

This has 400-volt center-tapped secondary and 650-volt high-voltage windings and enough filament windings to handle any typical scope circuits. The figure shows what this type of transformer looks like. This is the 24R178.



If you can't get one with the high-voltage rectifier filament winding, use a high-voltage silicon rectifier, such as a boosted-boost rectifier, etc. from a color TV.

Ten-channel remote control on tape

I need a unit that will put 10 inaudible signals on a tape, for controlling a multiple-function remote-control device. They'd have to go on the regular sound track, along with the sound signals. This should be "wireless," for maximum usefulness.—D. F., La Habra, Calif.

Your best bet, probably, would be to use one of the ultrasonic control circuits now found in many remote-control TV sets. These operate in the 38–40-kHz region. For example, you could use one of RCA's 8-channel remote-control receivers, of the type used with some color TV's. If you need the full 10 channels, a couple of extras shouldn't be hard to add.

You will get into one problem, though, if you plan to record or superimpose these signals on a standard tape recorder: You'll probably have to work the amplifier and heads over to get enough response up in the ultrasonic region around 40 kHz. The average home tape recorder gets up to around 20,000 Hz, and even that's doing pretty good for some of them! You might get better results by using the original transmitter, which has a set of tuned bars struck by spring-loaded hammers.

Suggestion: Replace the original two-track head on the recorder with one of the four-track types. Use two of the tracks for sound, and the other two for control signals. A separate high-frequency amplifier and speaker may be necessary.

You might be able to get a complete remote-control unit, microphone and all, from RCA as an alternative, look for a used TV set with one on it!

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

If you're really stuck, write us. We'll do our best to help you. Don't forget to enclose a stamped, self-addressed envelope. Write: Service Editor, Radio-Electronics, 200 Park Ave. South, New York 10003.

Sticking transformer cores

I've got an old Raytheon chassis in for repairs, and the core of the sound i.f. coil is stuck. I'm afraid to use force on it. Any ideas?—S. R. W., Scotland Neck, N. C.

Usual reason for core sticking is wax from the coil form or intentional sealing of the core with wax. Get an Allen wrench that fits snugly inside the core's hex socket. Hold the tip of a soldering iron against the wrench until it gets hot enough to melt the wax.

With long-nose pliers, carefully turn the wrench. If the core doesn't loosen the first time, continue heating the wrench.

Gate switches under ice

At a local hospital, they use electrically operated gates. A pair of treadles work them, when a car passes over. The problem is that they're clogging with snow and ice! What kind of sensing device would work here?—B. L., Denver, Colo.

Any one of several kinds. You might try the pressure-sensitive, sealed *Tape-switch* kind: these are used in supermarkets, etc, to open doors when you step on them. Being sealed, they should not be affected too much by ice.

Or, try a photo-electric cell device on the gateposts, set up about 4 feet off the ground. Because you need two sensors for each gate, *proximity* sensor *might* give trouble due to having the pickup plates so close together. This would have to be checked experimentally. The PE-cell devices can work on very narrow beams.

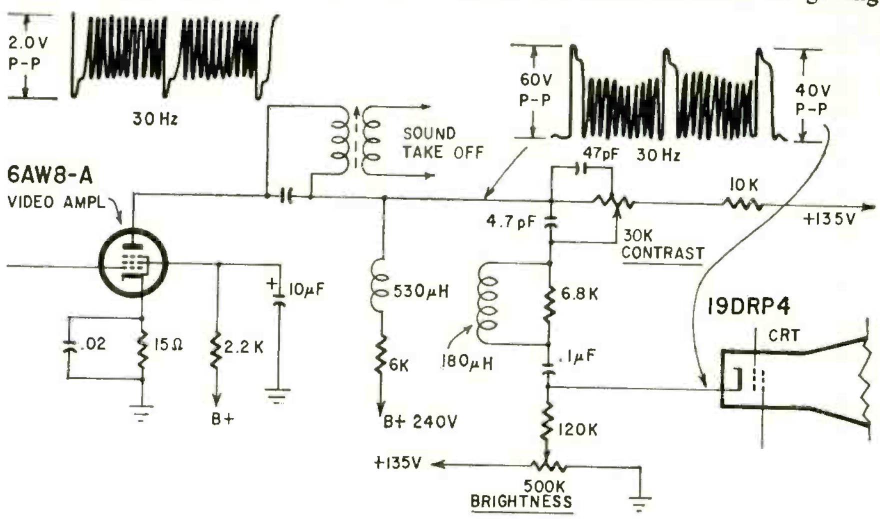
Horizontal shading in picture

I have a DuMont 758 chassis with picture shading across the screen. On a blank raster, it is not visible. I've seen the same thing in other chassis of this number. I've tried a lot of things, but they haven't helped. Recommendations?—C. T., Berlin, N. Y.

Analysis: This is the same thing as vertical "hum bars," except that it goes crosswise instead of up and down! In other words, you're getting some kind of "sawtooth" voltage, *at the horizontal sweep frequency*, into the *video* signal! This isn't in the sweep or B+ circuits, as it could be if you had hum bars from a leaky electrolytic filter capacitor. However, it is due to insufficient filtering *somewhere*.

The unshaded raster clears the sweeps from suspicion; so, check the video signal with a scope. Start at the 6AW8 control grid, and follow it to the CRT cathode. The normal wave forms and peak-to-peak voltages are shown on the diagram.

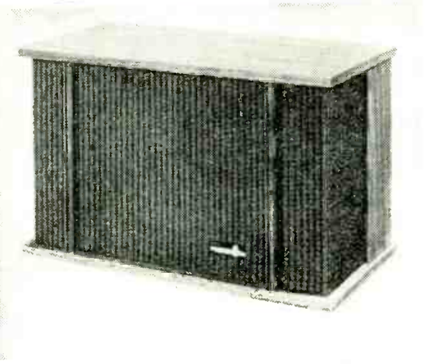
Note that the normal signal waveforms are flat; they show no slanting up or down in the video portions. If the video slants up from left to right, this will make the picture darker on the right side. Slanting down left to right would make it lighter at the right. (Black is "up" in waveforms with positive-going sync, as on the CRT cathode.)



Possibilities: something like a 15,-750-Hz sawtooth getting into the +135-volt line. In this chassis, this comes from the cathode of the 6CU5 audio output tube. Cause: lack of sufficient filtering, either at the 6CU5 cathode or in the boost circuit itself. (The boost feeds the plate of the 6DT6 audio detector, to eliminate warmup buzz. This is a possible path for the interfering sawtooth voltage. (It could "modulate" the audio signal on the 6CU5.)

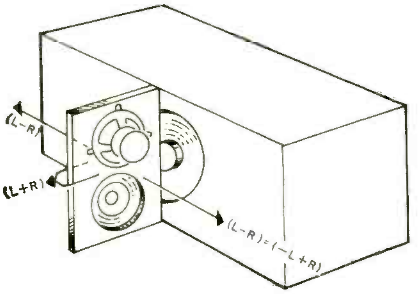
Also, and quite conceivably more likely (from the clean-raster symptom!) the sawtooth could be getting into the second video i.f. amplifier stage. This is also fed from that +135-volt line. It also feeds the sync separator, noise inverter and agc tubes. Since any of these might have this effect, I'd recommend this as the "most likely suspect." **R-E**

ONE SPEAKER



by FRED SHUNAMAN

STEREO FROM A SINGLE SPEAKER SYSTEM? Sounds impossible, but Jensen has done it with the Stereo-1. And believe it or not, the technique is based on the same L + R–L – R approach that separates the sounds in ordinary stereo. The new system will make stereo feasible in small rooms or apartments that lack the space needed for two-speaker stereo to be really effective.



1. (L+R) + (L–R) = L+R+L–R = 2L
2. L+R+ [–(L–R)] = L+R–L+R = 2R

Fig. 1—How the right and left signals are combined in the STEREO-1 system.

The new speaker is built as shown in Fig. 1. After separating the signals—we'll get to that later—the L + R signal is fed to the 8-inch speaker mounted in the main enclosure, and the L – R signal to the two speakers on the vertical vane mounted ahead of the main speaker and at right angles to it. Since the outputs from the front and rear of a speaker are not the same, it is necessary to have two speakers mounted in opposite directions to have identical output on each side.

How do we matrix the left and right signals back into L + R and L – R? There must be many ways—any right and left amplifier connected in parallel or in series will put out an L + R signal when connected in phase and an L – R signal if connected out of phase.

Possibly the simplest way would be with a matrix composed of the output transformer secondaries, the speaker voice coils and a tapped coil, connected as shown in Fig. 2. The main 8-inch speaker is across the whole circuit and—if the amplifier terminals are correctly phased—receives the R + L signal. The two 5-inch speakers are connected between the center tap of the coil and the common terminal of the two amplifiers. Thus the signal through them is L – R. If the instantaneous signal from the left amplifier is greater than that in the right, a current in phase with the left amplifier signal flows, and equally but oppositely if the right amplifier signal is greater. On a mono signal, the two amplifiers should be perfectly balanced with no current through the 5-inch speakers.

Now imagine the cone of the main speaker moving forward and at the same time the cones of the two smaller speakers moving left. The sound going forward is L + R and that going left is L – R. The two L's add and the two R's subtract (cancel each other) giving an L, or left, signal toward the left. On the right side of the speaker, the cones are moving away from the right side of the main speaker, producing the reverse of the signal on the left side, or – (L – R). This without the parentheses is – L + R, and the R's add while the L's subtract, producing an R or right signal toward the right of the speaker. Looks like pure mathematics, but it works!

Jensen's actual circuit, a little harder to understand at first glance, is roughly similar. The matrix is a bridgelike circuit, also using a tapped coil. As shown in Fig. 3 the amplifiers are in phase in *parallel* (L and R both "+" at the same time). The left and right hot leads are connected across the L – R speakers. When the L and R signals are identical, no current flows through these speakers—they receive only the *difference* signal.

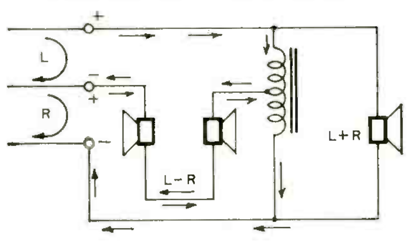


Fig. 2—A tapped coil helps matrix the signals into L plus R and L minus R.

The right signal flows through the L + R speaker, one side of the tapped coil and back through the common lead. The left signal flows through the other side of the coil and back through the common, setting up a current in the other half of the

STEREO SOUND

coil by transformer action. This current, of course, flows in the opposite direction to the one that set it up (Lenz's law) and aids the right signal. Thus the signal through the main speaker is L + R.

Furthermore, Jensen states that the L and R sources of varying magnitude and phase are matrixed in the air to create a series of virtual sound sources all across the stage, an effect harder to produce in a two-speaker

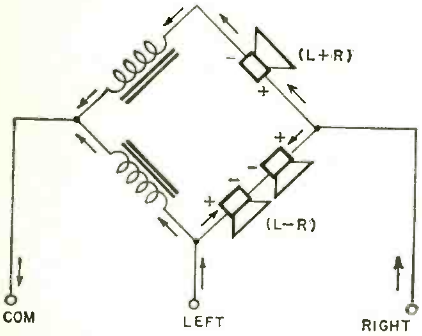


Fig. 3—Jensen uses this matrix system.

system. (We are all aware that stereo is more than right and left signal—stereo "sounds different" at the end of a long corridor connected to the listening room by a door on the side —and it may well be that mixing in space gives its own special effect.) It would seem that variations in magnitude and phase would be taken into account in the stereo multiplexer, in two-speaker systems, but of course the end product has to come from two points—the right and left speakers. **R-E**

SIMPLIFIED STEREO AMPLIFIERS?

JENSEN'S APPROACH TO stereo might possibly be applied to improve or simplify stereo amplifiers. Since the L + R and the L — R signals are used, why not use them direct and save some complexities? Just rectify the L — R signal and amplify it, also amplifying the L + R signal, and use them to operate speakers.

A single amplifier that separates the signals and gives L + R and L — R output was actually described in the December, 1958 issue of RADIO-ELECTRONICS (Benjamin Bauer **et al**, "2-Way Amplifier." It handled one channel through an all-pushpull amplifier, and amplified the other signal by applying it to the two input grids in **parallel.** There were two output transformers—one the regular pushpull transformer, the other in the common lead supplying both output tubes.

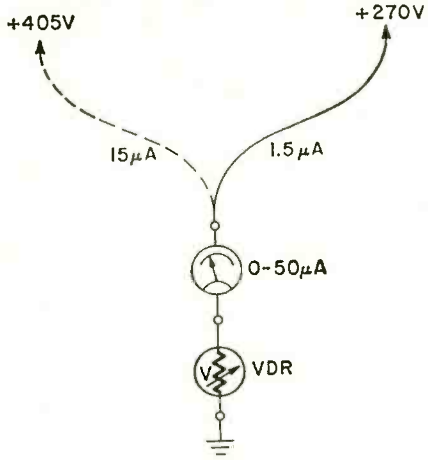
If a Left signal were applied to one input and a Right signal to the other, the output would be L + R across the pushpull transformer, and L — R across the one for parallel use. **R-E**

TECHNOTES

CHECK VDR IN RCA CTC 35 CHASSIS

The VDR (voltage-dependent resistor) in the vertical output circuit regulates the bias on the vertical output tube to hold the picture height constant with wide variations in line voltage. This element is generally trouble-free but there may be instances when you want to check its operation.

An open-circuited VDR will cause vertical over-scan and some loss of vertical hold due to excessive feedback pulses from the output section to the oscillator. A shorted VDR causes loss of vertical deflection due to the loss of feedback from the output to the oscillator section.



One quick check of a VDR is to substitute a new part. Another check is to temporarily replace the VDR with a 1-megohm resistor. If the VDR is defective, this resistor will permit the circuit to operate—but, with excessive size and without needed voltage regulation.

A simple out-of-circuit test method is shown in the diagram. It is based on the difference in current through the VDR when two different positive voltages are applied to it. A voltage difference of approximately 1.5 to 1 (405 and 270 volts) results in a 10 to 1 current change. The voltages for the test set-up are readily available from the TV chassis. This test illustrates the operating characteristics of a VDR.—*RCA Plain Talk and Technical Tips*

SCOPE FINDS SHORTED FLYBACKS AND YOKES

This test for shorted turns and partial shorts in flybacks, yokes and linearity and width coils is based on the ability of a tuned circuit to "ring" when a pulse is applied. The scope is used as the indicator and source of the applied pulse. The tests can be made without removing the component from the chassis. This item is based on material that appeared in *RCA Plain Talk and Technical Tips.*

The test pulse is tapped off the cathode of the scope's sweep oscillator through a 680-pF, 600-volt capacitor and then fed to an insulated binding post—marked SWEEP—on the front panel. The pulse from the SWEEP terminal is applied to the component under test. If the coil is good, the pattern is a damped wave-train as in Fig. 1. If the coil has one or more shorted turns, the pattern is a highly damped wave-train as in Fig. 2.

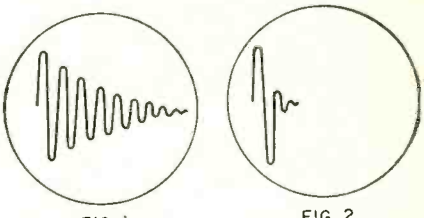


FIG. 1 NORMAL WAVEFORM FROM GOOD COIL

FIG. 2 HIGHLY DAMPED WAVEFORM FROM DEFECTIVE COIL

Adjust the scope sweep rate to display a single waveform as in Figs. 1 and 2. Use a sweep rate in the range of 2500-5000 Hz when testing width and linearity coils, the deflection yoke and the horizontal deflection circuit with yoke attached. Use a sweep range of 500-1000 Hz for flyback tests and for the horizontal deflection circuit with the set's yoke disconnected.

The complete horizontal output system, including flyback and yoke, can be checked by removing the plate cap from the horizontal output tube and connecting the SWEEP lead and the scope probe to the plate-cap lead on the transformer. Connect the scope ground lead to the TV chassis. A single shorted turn will produce the heavily damped wave in Fig. 2. The effect of a shorted turn can be seen when checking a good flyback by temporarily shorting the filament winding.

If a yoke checks bad, be sure to test internal capacitors and other auxiliary components before discarding it.

OLYMPIC CTC19, –20, –21 CHASSIS

Poor horizontal lock, particularly after replacing the 6JW8 horizontal oscillator tube, can be remedied by shunting a 680-pF capacitor across C267, a 0.003-μF unit. Do this on the underside of the board after checking to see if this 680-pF capacitor has been installed at the factory or during prior service.—*Olympic Service Bulletin*

R-E

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APRIL 1970

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Please clip out and mail to: Larry Steckler, Managing Editor, **Radio-Electronics,** 200 Park Avenue South, New York, N. Y. 10003

NOTEWORTHY CIRCUITS

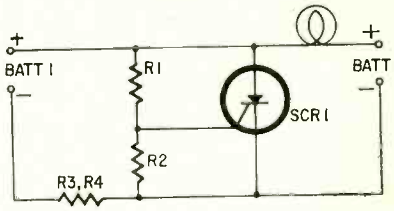
PORTABLE SCR TESTER

HERE IS A SIMPLE PORTABLE TESTER FOR silicon controlled rectifiers (SCR's) and silicon diode rectifiers. While not as sophisticated as may be necessary for precise laboratory work and semiconductor comparative evaluation, its straightforward go—no-go operation is ideal for general troubleshooting and service work. It detects opens and shorts in diode rectifiers and SCR's and checks forward blocking ability and triggering on SCR's. Convenient battery operation is particularly useful when you work with automotive, marine, and aircraft equipment. This tester is more objective than the often-used ohmmeter test because it applies at least 10 volts to the semiconductor under test. Distributor parts cost is less than $20.

Shown below is the circuit of the test set. A good rectifier lights the lamp at each of the first four positions of switch S1. No light at one or more positions means a defective semiconductor. SCR1, which has a sensitive gate-triggering characteristic and acts as a high-gain amplifier, compares the "signal" from the parameter being tested with its own critical gate-trigger-ing voltage, and lights the lamp if that parameter is OK.

Switch S1 has five positions: BATTERY CHECK, FORWARD VOLTAGE DROP AND TRIGGER (for SCR's), REVERSE LEAKAGE, FORWARD LEAKAGE (for SCR's only) and OFF.

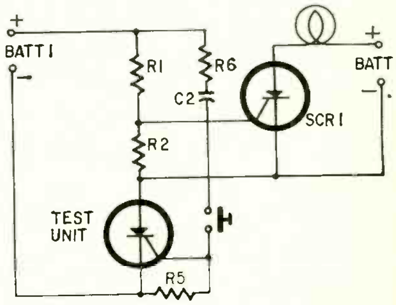
Figs. a-d show equivalent test circuits for each position of S1. In the BATTERY CHECK position (a, below), the



a

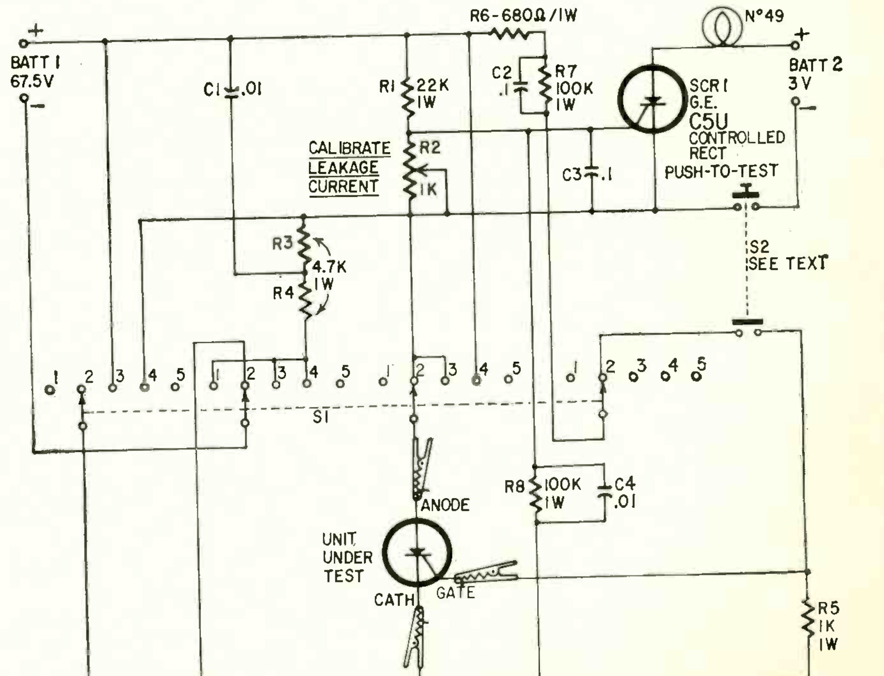
gate of SCR1 measures a portion of BATT1, the measuring battery. If the voltage is too low, the SCR will not fire and the lamp will not light. If the indicating battery (BATT2) is too weak, again the lamp will fail to light.

In the FORWARD VOLTAGE DROP test (b, below), the diode or SCR under



b

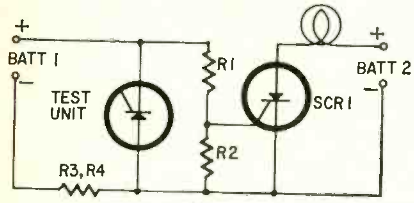
test is put in series with the measuring circuit, and a gate signal is applied if the unit under test is an SCR. If its for-



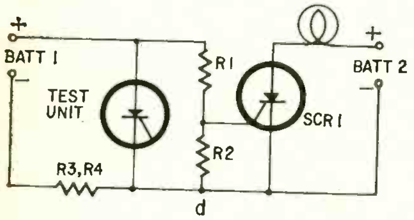
S1-
1-BATTERY CHECK; 2-FORWARD VOLTAGE DROP & GATE TRIGGER (FOR SCR'S); 3-REVERSE LEAKAGE CURRENT; 4-FORWARD LEAKAGE CURRENT (FOR SCR'S ONLY); 5-OFF

ward voltage drop is low enough, SCR1 is triggered and the lamp lights.

To measure leakage current, the rectifier or SCR is connected in parallel with the divider of the detecting circuit (circuits c, d below). Excessive leakage



c



d

current diverts current from "sensing" resistor R2, preventing SCR1 from being triggered and keeping the lamp dark. The OFF position doesn't need much explaining.

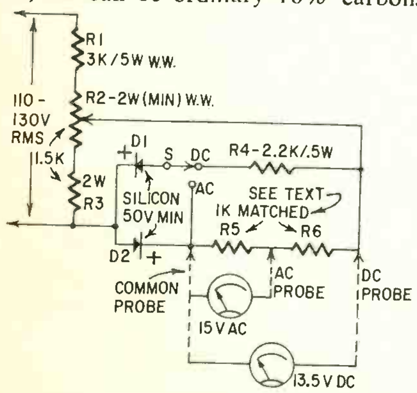
In the FORWARD VOLTAGE DROP position, pushbutton S2 triggers the gate of the SCR under test when it is depressed, and resets SCR1 when it is released between tests. Adjust the pushbutton contacts so that the indicating lamp circuit closes just before the gate circuit does.

CALIBRATE YOUR VTVM

A vtvm should be checked periodically. This is easy if you have the usual balanced-bridge type (Heathkit, RCA, Eico, etc.).

Check the dc calibration with your vom, or preferably a 1.35-volt mercury cell (Mallory RM-640RT2 or equivalent). This has two tabs for easy clip or solder connection. Shelf life is 2 years or more; but when voltage does decay, it goes down rapidly.

Now check the ac calibration with the circuit shown. Calibrating resistors R5, R6 can be ordinary 10% carbons,



matched on your ohmmeter. Select two of nominal 1,000-ohm value that match exactly—they can be high, low, or "on the nose." After soldering into the circuit, check that the ac voltage is equal across R5 and R6.

Calibration procedure is simple: Set the vtvm and calibrator to DC, and adjust R2 for 13.5 volts across R5 plus R6. Then switch the vtvm and calibrator to AC. The vtvm should indicate 15 volts across R5.

For these readings, explanation is brief: On dc, the vtvm indicates the arithmetic average of the sine half-wave. On ac, the vtvm is switched above to indicate the geometric average (root of the mean square) of half the sine full wave. The ratio of these average values is $2\sqrt{2}$ divided by π, which is .9002, or 13.5 to 15.

Because this ratio holds for sine waves only, the calibrator must be connected direct to the power line, not through an isolating transformer. A Variac (or other autotransformer), however, can be used, and can even replace the voltage divider. Accuracy of the ac calibration then depends on the dc calibration.

During calibration, note the line voltage, because dc (and hence ac) indications may vary with it. For an 8% drop in line voltage, from 120 to 110, my Heathkit drops 3% in dc indication, from 1.35 to 1.31 volts. Likewise, for an 8% rise in line voltage, the dc indication rises 1.5%.

This calibrator is an improvement over my previous device (RADIO-ELECTRONICS, May 1958, page 116) because the dc reading is brought near full scale by matched resistors R5, R6.

Your vom can now be checked for accuracy by comparison to the vtvm, using the calibrator as a power supply. Due to loading error, the calibrator can't check vom's directly.—*J. H. Sutton* **R-E**

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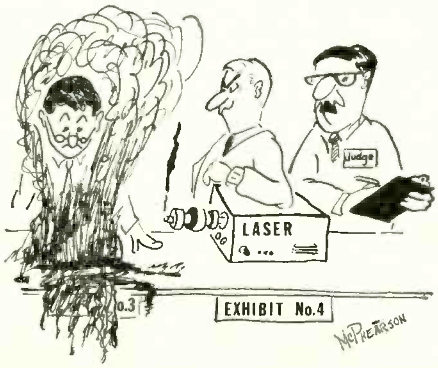

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Circle 136 on reader service card

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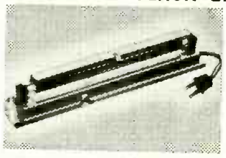

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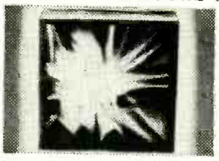

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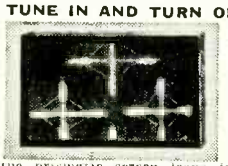

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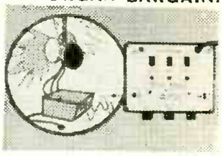

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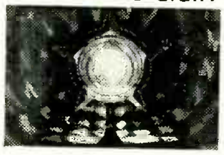

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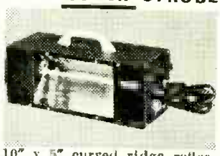

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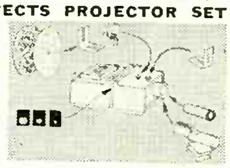

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EQUIPMENT REPORT

Hickok 860 Injecto-Tracer

For more information circle reader service No. 60

THE AVERAGE SHOP CAN SERVICE small radios profitably with the proper "instrumentation." The Hickok 860 Injecto-Tracer could be it. This is a combination signal generator, signal tracer and power supply, all in one compact package. The 860 and a vom or vtvm could be all you need, plus the service data to tell you where everything is in the radio.

The "son" of the famous Model 155 Traceometer, the 860 provides several features not in that instrument. A transistor-regulated dc power supply has two output ranges, 0–5 and 0–15 volts, adjustable to a desired voltage. A panel meter reads the actual voltage, and can be switched to read the current drawn by the radio. Two ranges are provided, 0–10 and 0–100 mA.

The signal generator provides all necessary frequencies for testing: audio at 1000 Hz, AM i.f. signals from 240 kHz up and rf signals from 50 to 1750 kHz. These can be modulated or unmodulated. A 10.7-MHz FM i.f. signal is also included.

The handiest thing in this instrument is the signal tracer. This covers audio and radio frequencies in the same range as the signal generator (same dial is used), and will detect and amplify any signal in this range.

With this, stage-by-stage gain tests can be made through any audio- or radio-frequency circuit, or the "place where the signal stops" can be very rapidly located. The high impedance signal-tracing probe causes little disturbance to tuned circuits.

The inputs of a stereo amplifier can be tied together, and a signal fed into them. Then, with the 860's probe, you can make A–B checks of signal levels to corresponding points in each channel. This will help to locate stages with lower-than-normal gain or distortion, or dead stages. It's also invaluable for following signals through multiple-stage, direct-coupled ("totem-pole") transistor output circuits.

Small transistor auto radios can be checked with the 860's built-in power supply. The variable-voltage feature of the power supply, along with the signal tracer, can be used to check for oscillator dropout, intermittents and such troubles.

Intermittent troubles can be monitored by using a load resistor in place of the set's speaker and connecting the signal-tracing probe to any point in the circuit. If the signal drops out there, the probe is moved to the next test point, and so on. The instruction book includes a good "short course" in radio testing techniques using this method.—*Jack Darr*

R-E

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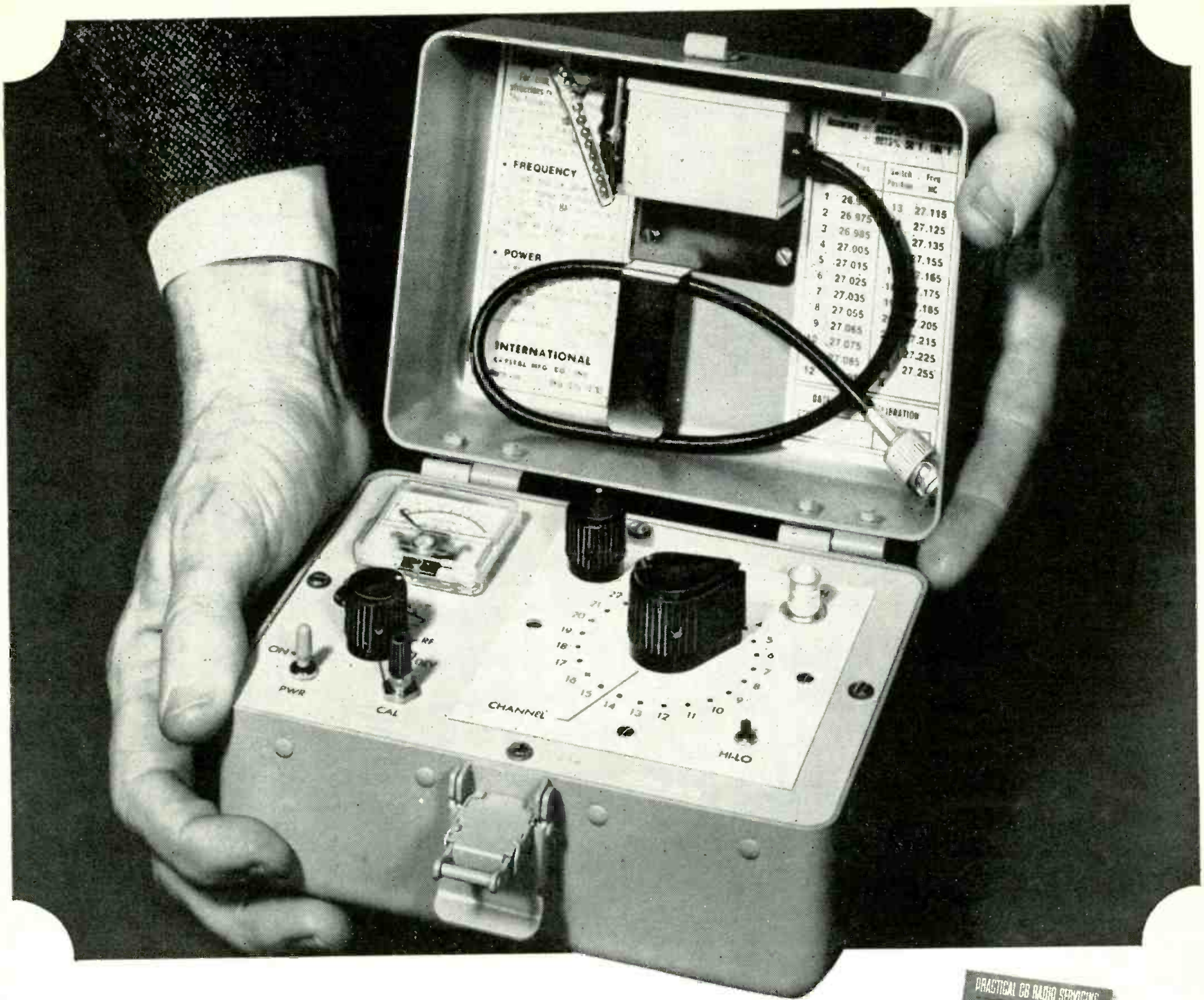

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The brilliance of our new color replacement tube is matched only by the sharpness of its pictures

RCA MATRIX

Now it's easier to sell up to the best. RCA has added brightness without sacrificing sharpness! Here's how and why:

To produce the brightest color picture tube in RCA's history, we developed a new phosphor-dot screening process that incorporates a jet-black matrix. But we didn't stop there. We wanted a tube that could deliver sharp, vivid pictures even in strong room light. So, we added the brilliance of new phosphors and deposited each red, green and blue phosphor-dot within the black matrix. Result: brighter pictures with no loss of contrast. Thanks to the matrix technique, combined with our new high resolution gun and greatly improved phosphors, the Matrix is also the *sharpest* color picture tube in RCA's history. Matrix owners can turn up brightness *without* "turning down" color!

Will your customers see the difference? You bet! What's more, they'll be pre-sold on the difference—every time they see the 1970 big-screen color sets people are talking about! So when they need a replacement tube, satisfy their appetite for brighter, sharper pictures. Don't replace their old tubes with another "old" tube. Give their sets new brilliance and more vividly detailed pictures with RCA Matrix. The Matrix Tube is 100% brighter than any previous color picture tube manufactured by RCA.

For complete details, call your RCA Distributor.

RCA Electronic Components,
Harrison, New Jersey

RCA

The RCA 25BCP22 Matrix Tube can directly replace 25XP22, 25EAP22 and also the following types: 25ABP22, 25AFP22, 25AMP22, 25AP22, 25AP22A, 25AQP22, 25BMP22, 25CP22, 25CP22A, 25GP22, 25GP22A, 25SP22, 25WP22, 25XP22/25AP22A and 25ZP22.