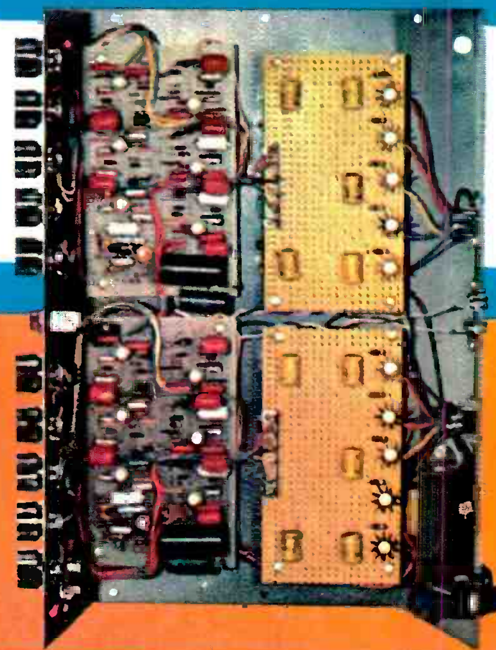
Radio-Electronics

60c ■ OCT. 1969

A GERNSBACK PUBLICATION

SPECIAL ISSUE

Stereo 1970

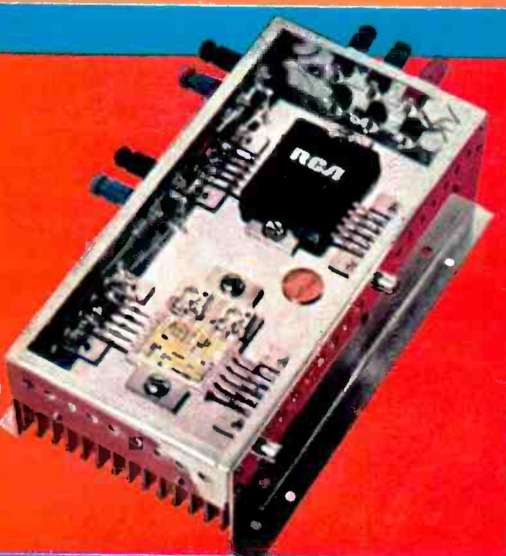


BUILD R-E's

Stereo Color organ

NEW! All IC

200-watt stereo ampl



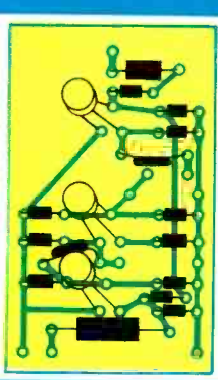
R-E's

STEREO RECEIVER ROUNDUP

STEREO HEADPHONE TEST REPORT

Electronic crossover

EASY-READ DIAGRAM



ALL ABOUT TOOLS

Tear-out book

"I REMEMBER RADIO...

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the breath-taking adventures, the nostalgic music of the old-time radio years...wrapped up for the first and only time in this historic Treasury.

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With all the magic of time turning back...this great Treasury brings you the Duke of Windsor renouncing his throne for the "woman I love"...the famous emotion-packed account of the Hindenburg disaster...Neville Chamberlain declaring war on Germany ...Arthur Godfrey's long-remembered account of FDR's funeral ...Harry Truman giving the first news of the atomic bomb on that fatal day in 1945.

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The Dempsey-Tunney Long Count, with announcer Graham McNamee • Whirlaway wins The Kentucky Derby, with announcer Clem McCarthy

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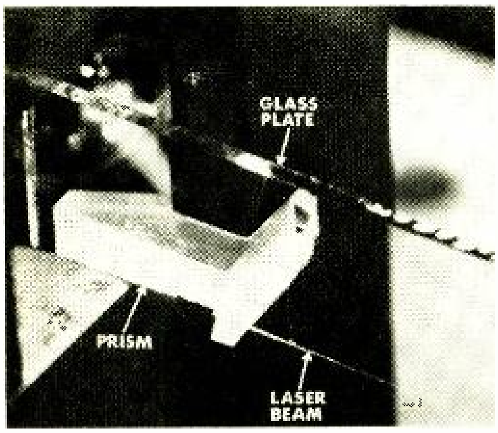
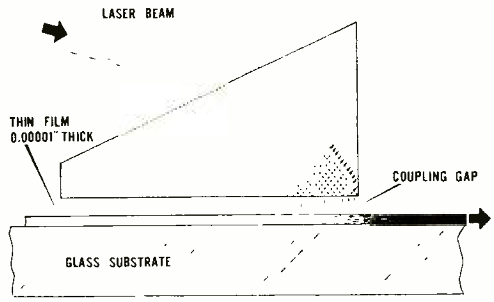
NEW & TIMELY

Volume 40 Number 10 RADIO-ELECTRONICS October 1969

PRISM PIPES LASER BEAM INTO CRYSTAL FILM





Laser beam-prism combination lets part of the light "tunnel" from the prism to the thin-film deposit in the form of electric and magnetic fields. In the film the polarized waves travel like electromagnetic waves in waveguides.

An efficient means of feeding laser beams into thin semiconducting film can lead to new laser amplifiers, light modulators, harmonic generators and parametric amplifiers according to Bell Labs, who developed the technique. The photo shows the streak of light from a laser beam traveling in a thin crystal film on a glass plate.

The drawing shows how the beam is fed into the thin film. (The beams flow in the crystal layers just as electrical current flows in copper wire.) A glass prism is used to reflect the laser beam into the film. Not all of the light beam is reflected from the base of the prism. Part of the light "tunnels" through the gap between prism and film, generating electric and magnetic fields.

Theoretically, an 80% energy transfer is possible. By changing the entry angle of the beam into the prism, the speed of the light waves travelling in the film can be varied.

IN THIS ISSUE

Another R-E "last-word" audio project starts on page 33. Build a 10-channel IC stereo color organ that outperforms any similar projects you've seen. A MOSFET agc circuit, IC op-amp filters and triacs mean spectacular color organ performance.

LOOKING AHEAD

by DAVID LACHENBRUCH
CONTRIBUTING EDITOR

Digital TV tuning

A unique electronic TV tuning system has been suggested by two engineers from Fairchild Semiconductor as one of several possible tuning methods of the future. Under the plan, each station would use a 7-bit identifying code during the vertical blanking interval between picture transmissions. A digital tuning control—possibly of the type used in touch-tone phone dialing systems—would be used at the set or as a wireless remote-control tuning device. Varactor diodes in the set's tuner would respond to the pushbutton command, immediately locating the proper channel by means of the transmitted tuning code. Both uhf and vhf stations could be tuned immediately by this method, without the necessity of tuning through other channels in sequence.

The engineers said this system, using the station-transmitted tuning code, would have an estimated receiver circuitry cost of about $20.

They also had an unusual proposal for a channel-number indicator. Since the picture tube itself is an indicator device, they reasoned, why not use it? A character generator could superimpose the channel identification on the screen for a period of five to 10 seconds after it's tuned in—then it would disappear, but would reappear on the screen for a short interval whenever a special 'display' button on the tuning device was activated, or when the channel was changed again.

Anything you can do . . .

Although originally devised for different purposes, endless-loop tape cartridges and tiny two-reel tape cassettes show signs of taking on each others' characteristics.

The cassette was supposed to be a portable voice-recording system. The 8-track endless-loop cartridge was supposed to be a music-playback substitute for the LP record. So what's happening? First, take the cassette. Evolutionary refinements have resulted in much higher fidelity—to the

continued on page 12

READINGS INDICATE GRAVITY PHENOMENA

Simultaneous readings on instruments 600 miles apart suggest a new phenomena—gravity waves—have been detected. Recordings were made near Chicago and College Park, Md. by Dr. Joseph Weber, a physicist, and his colleagues. The detectors for gravity waves are aluminum cylinders 5 feet long encircled with quartz piezoelectric crystals that generate electric pulses when the cylinders oscillate. The cylinders are cushioned against tremors originating in the earth.

According to relativity theory, the cylinders should oscillate as the gravity waves pass through the space-time continuum. The oscillation frequency is about 1660 Hz. in this experiment.

Further observations and confirmation of the discovery may help to resolve conflicting theories on the origin of the universe and the distribution of matter.

WILLIAM DUBILIER, 81, RADIO PIONEER

William Dubilier, a pioneer in electronics and radio and holder of 600 patents, died in West Palm Beach, Fla., July 25. He was 81.

Founder of the Cornell-Dubilier Electric Corp., Mr. Dubilier invented the mica capacitor, an electronic flash tube, several radio broadcast systems, and such diverse items as nylon window screens to one of his last developments, in 1966, a sinus-congestion mask.

NEXT MONTH

What's a MOSFET? How does it work? How can electronic experimenters and hobbyists put them to work in circuits? In November we'll start a two-part series that will answer these questions. Tom Haskett gives you the details.

Radio-Electronics

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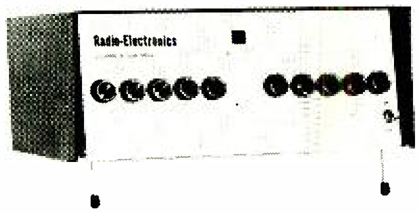
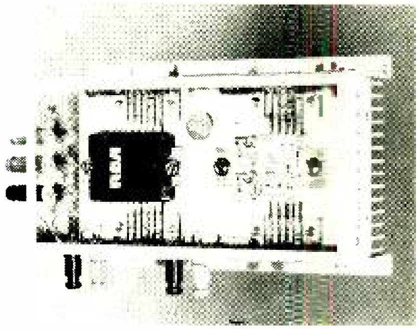
AUDIO—HI-FI—STEREO

GENERAL ELECTRONICS

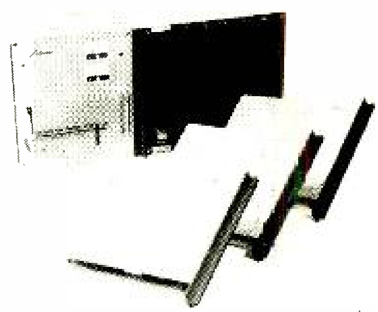
DEPARTMENTS



Build a 10-channel stereo color organ. Top performance with IC filters agc and high-power triacs. see page 33



New hybrid IC powerhouse is matchbox size, but can deliver up to 100 watts. Use two for stereo. see page 71



This electronic package spells trouble for tape hiss. Learn how the Dolby system is cleaning up recordings. see page 52

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DIODE TV TUNER

Digital logic circuits are being used in RCA's top-line 1970 TV sets for vhf channel selection. The electronic channel-switching system uses a wireless remote control unit with computer PIN diode switching techniques to eliminate the mechanical tuning motor. Channel selection is instantaneous.

IC FM TRANSCEIVERS TO GO UNDERGROUND

NEW YORK—According to G-E, this new hand-held FM two-way radio has more IC's than any previously available two-way gear.

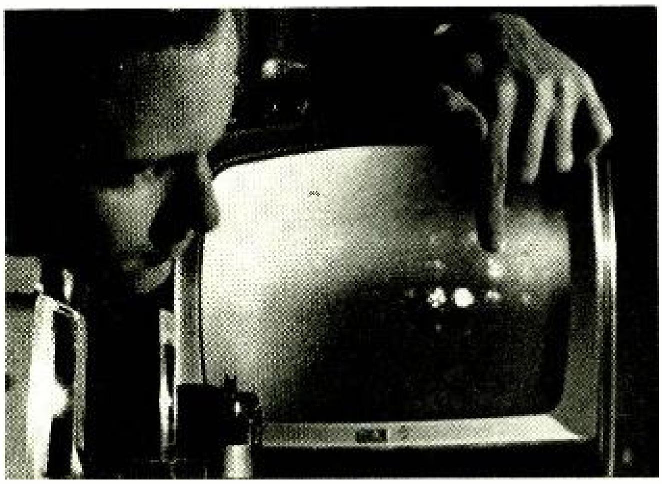
The company is supplying some 1100 specialized two-way radios to New York City to improve safety and efficiency in the subway system. About 980 radios will be installed in train cabs, while 100 hand-held units will be used by Transit police and other subway personnel. Communication is through wire-cable antennas being installed in all subways.

IN THIS ISSUE

Audio expert Norman Crowhurst shows you how to build a 3-way, 12-dB/octave electronic crossover network for loudspeakers on page 42.

Then try a 200-watt stereo amplifier to drive your speakers. All it takes is two of RCA's new power IC's and a good power supply. See page 71.

ERASABLE HOLOGRAMS DEVELOPED



PRINCETON, N.J.—A technique for magnetically erasing holograms may soon lead to an optical computer memory able to store 100 million bits in a one-inch square film. According to RCA, write time with the technique is 10 nsecs and erase time 20 μsecs.

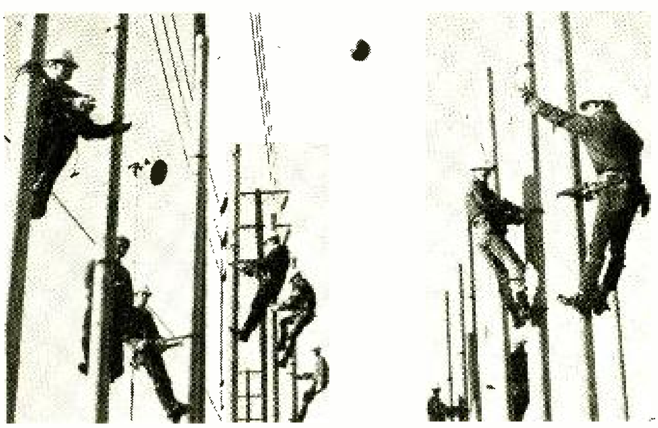
Manganese bismuth, a magnetic material, is deposited in a single-crystal layer on a mica base and magnetized to align its magnetic atoms. A pulsed laser beam is then split, one beam directed on the magnetic film, the other to the information bit pattern to be recorded and then to the film.

When the two beams interfere constructively, the magnetic material is warmed enough to realign the polarity of magnetic atoms. When the beams cancel each other, no magnetization takes place. Since the resulting magnetic pattern matches the interference pattern of the converging light beams, a magnetic hologram is generated.

The magnetic hologram is read out by transmitting a laser beam through it, or reflecting the beam from it. To erase the hologram film, a strong magnetic field is used to realign magnetic atoms.

The speed, erasing feature and 2000-line/mm resolution make the process very attractive for an optical computer memory according to RCA.

The photo shows a TV display of a bit array as a laser beam strikes a hologram and the "bits" are picked up by the TV camera (lower left).



Basketball in the sky is part of the "curriculum" for a five-day school run by General Telephone Co. of California. Anchored 25 feet in the air, students at a pole-climbing school gain confidence in working at heights and agility to "walk the stick" without getting hurt. Anyone passing poorly or missing climbs down to retrieve the basketball.

2-CHANNEL TV AUDIO IS TESTED IN JAPAN

OSAKA, JAPAN—Experimental broadcasts in English and Japanese over two TV sound channels with FM-FM modulation were studied for the Osaka 1970 World's Fair in July. Plans call for continued broadcasts over main network channels for stereo concerts, simultaneous dubbing of foreign films and commentaries on other broadcasts.

If tests show there is no interference with the main sound channel and crosstalk is not serious, regular transmissions will begin this winter. Uhf-type adapters costing $30 and up will be made by several major Japanese electronics companies.

'SORRY, 555-2368 DOES NOT ANSWER'

MURRAY HILL, N.J.—A new recorded "voice-with-a-smile" system is shown being checked at Bell Labs. The automatic intercept device tells callers what number they dialed and why a number cannot be completed. Prerecorded phrases, words, and digits on a 96-track magnetic drum are connected in

a programmed sequence when a telephone number is not working. Part of a message might be: "The number you have reached, 555-2368, is not in service in the 311 area."

Plans call for installing 40 systems in 25 major cities to free operators for other duties. Time, weather and even baseball scores can also be recorded.

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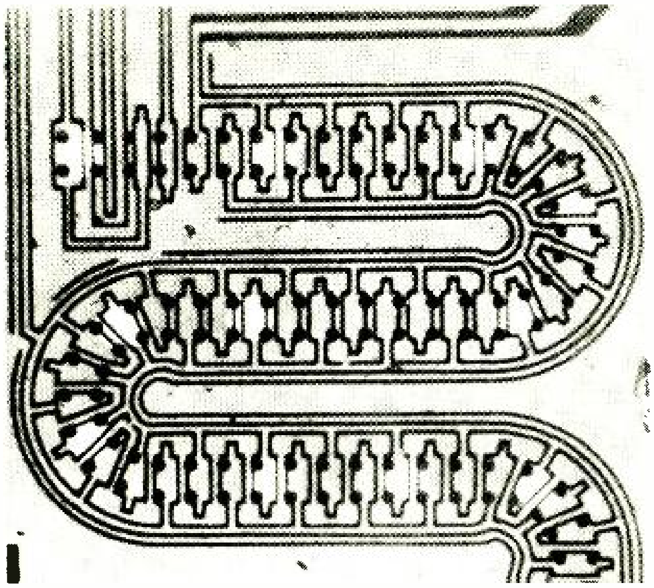
MAGNETIC 'BUBBLES' MOVE IN RARE EARTHS



MURRAY HILL, N.J.—A new technology involving magnetic "bubble" movement in crystalline materials is being studied at Bell Labs for use in logic, memory, switching and counting functions.

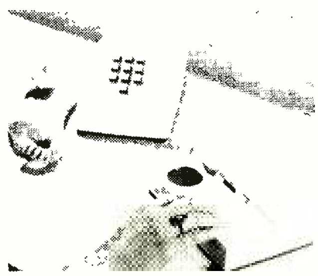
The magnetic bubbles, seen as light dots in the photo, are about 0.004 inch in diameter, and move through the magnetic material in which they are formed. The circuit pattern in the photo is etched on the surface of a thulium orthoferrite sheet, a rare-earth iron oxide, and signals applied to the circuit magnetically control the paths of the bubbles. The bubbles can also be directed with external magnetic fields.

Much smaller bubbles, the size of a few wavelengths of light, can also be manipulated, and may lead to memory densities of 1 million bits per square inch. In applications such as shift registers, data rates of 3 million bits per second have been demonstrated.

The presence or absence of the bubbles can be detected, they respond to each other's proximity (attracting or repelling) and can be combined or separated with no change in their size. Bell, who was granted a patent for the discovery, suggests "a computer on a slice" may become practical after more work is done with the technique.

PHONE FOR DEAF

MURRAY HILL, N.J.—A new telephone is under development by Bell Labs for deaf persons. Connected to a conventional phone, the Code-Com set allows a deaf person to "see" phone message in coded flashes of light or "feel" them in the vibration of a finger pad.



Light flashes come from a recess (black rectangle) in the center of the raised portion of the set. The circular vibrating pad is on the left. The sending key, used like a telegraph key, is on the right. The telephone "ring" may be indicated when the control unit switches on a light or other appliance.

ATS 5 SATELLITE MISSES ITS ORBIT

CAPE KENNEDY, FLA.—Applications Technology Satellite 5, shown here undergoing final tests at the Hughes Aircraft plant in California, went into a tumbling orbit on the wrong side of the earth after launch on August 12.

The satellite's main rocket was fired earlier than planned to save fuel in smaller control rockets. Officials hope to shift ATS 5, jammed with 13 experiments, from an orbit over India to a stationary orbit west of South America. **R-E**

Radio-Electronics

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Instruction is simple, very easy to grasp. Photos show you what a TV screen looks like when everything is normal, and what it looks like when trouble fouls it up. The texts tell you how to remedy the problem, and why that remedy is best.

Quizzes are spotted throughout the texts so you can check your progress. At the end of the course, you take a final examination. Then you get the coveted ICS® diploma, plus membership in the ICS TV Repairman Association.

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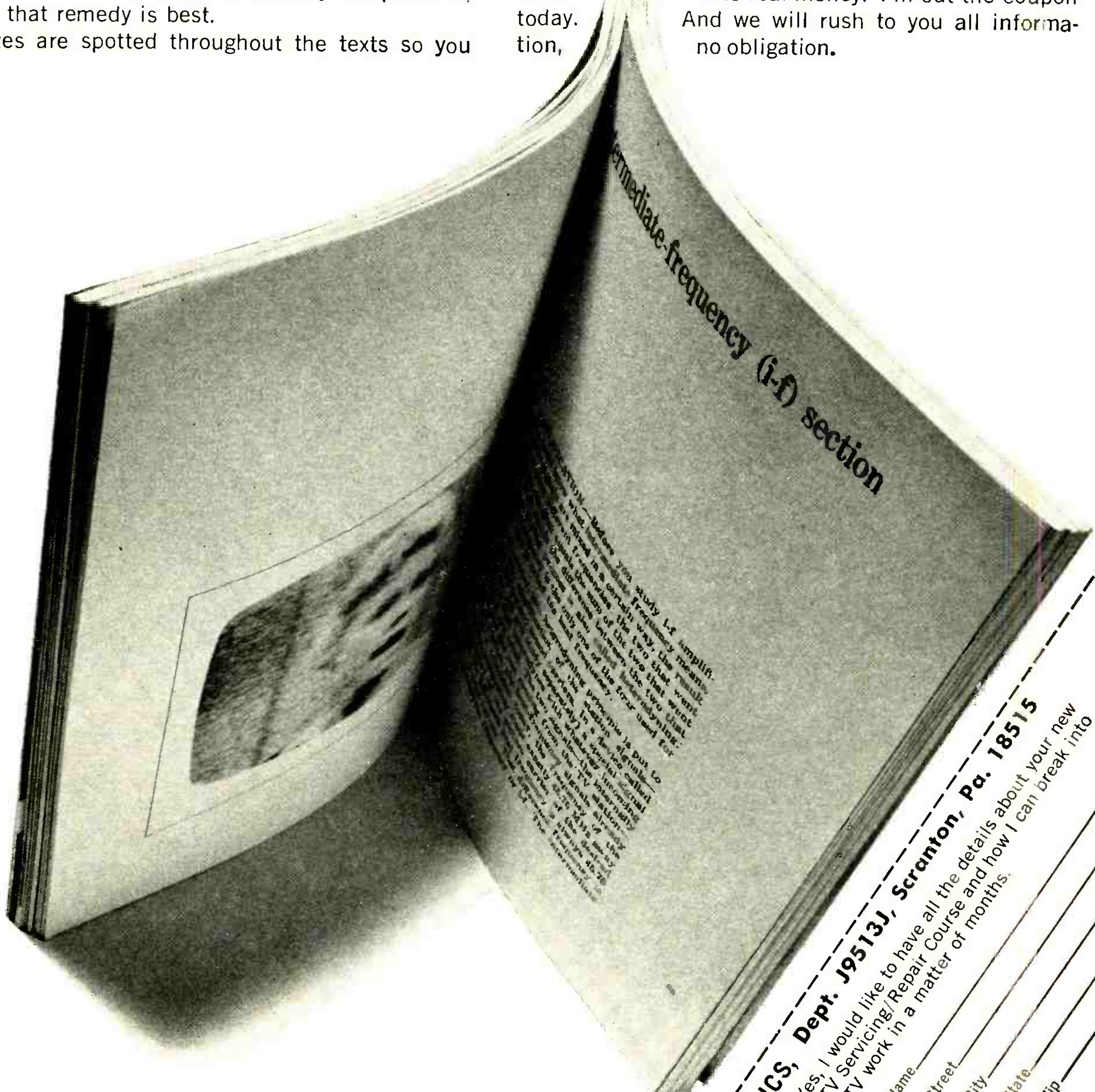
This new TV Servicing and Repair Course has been approved by National Electronic Associations for use in their Apprenticeship program. Because of its completeness, practicality and price, it is the talk of the industry. The cost is less than $100—just slightly over ½ the price of any comparable course on the market today. Remember, the sooner you get started on your course, the sooner you'll be turning your spare time into real money. Fill out the coupon today. And we will rush to you all information, no obligation.



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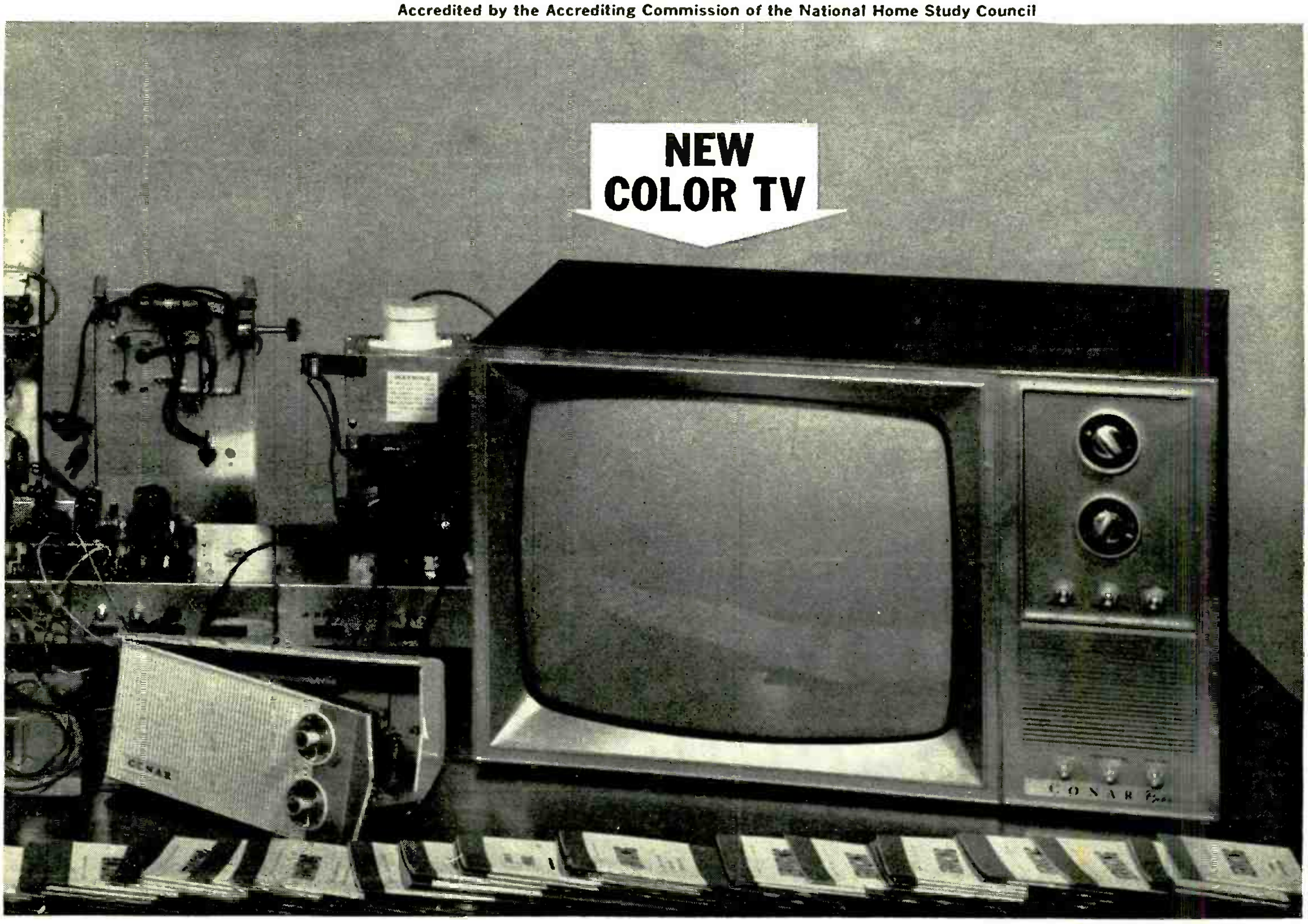


LOOKING AHEAD

((continued from page 2)

point where major hi-fi component manufacturers are offering combination cassette recorders and receivers.

Record companies, which ignored the cassette for some time, are now issuing music releases in cassette form—and that includes majors RCA and Columbia. Several equipment makers have introduced cassette recorder players which are slot-loaded, just like the cartridge players. Portable and automobile play-only cassette machines are now available. Automatic-reverse cassette recorders and players will be forthcoming soon. And Sony and TDK of Japan have both announced new endless-loop cassettes.

If cassettes are beginning to act like cartridges, cartridges are beginning to act like cassettes. First came rather expensive cartridge recorders from Roberts and others. Now, lower-priced cartridge machines with record capability are expected to be available soon in automobile versions from Motorola and Lear Jet, and in portable format from others.

To solve the problem of selection of a particular part of the tape, fast-forward cartridge players became available. The next step, due soon from Lear Jet, will be an 8-track cartridge with fast rewind. (Lear isn't saying just how this will be accomplished in an endless-loop cartridge.) But a cartridge still is bigger than a cassette—or is it? Lear now promises a cassette-sized mini-cartridge designed to play through any 8-track-cartridge player.

One less TV maker

A victim of the increasingly stiff competition from the giants—both domestic and foreign—is the Setchell Carlson brand name, which is disappearing from the consumer television market after 20 years, during which it pioneered the "Unitized" TV chassis. Setchell Carlson's assets have been sold by its parent company, Marquette Corp., to Audiotronics Corp., a specialist in educational audio-visual equipment.

The Setchell Carlson name will be kept alive by Audiotronics in the field of monitors and educational receivers, an area in which the TV manufacturer has increasingly specialized in recent years. Setchell Carlson is the second American firm to drop TV set manufacture within the last year, the other being Westinghouse.

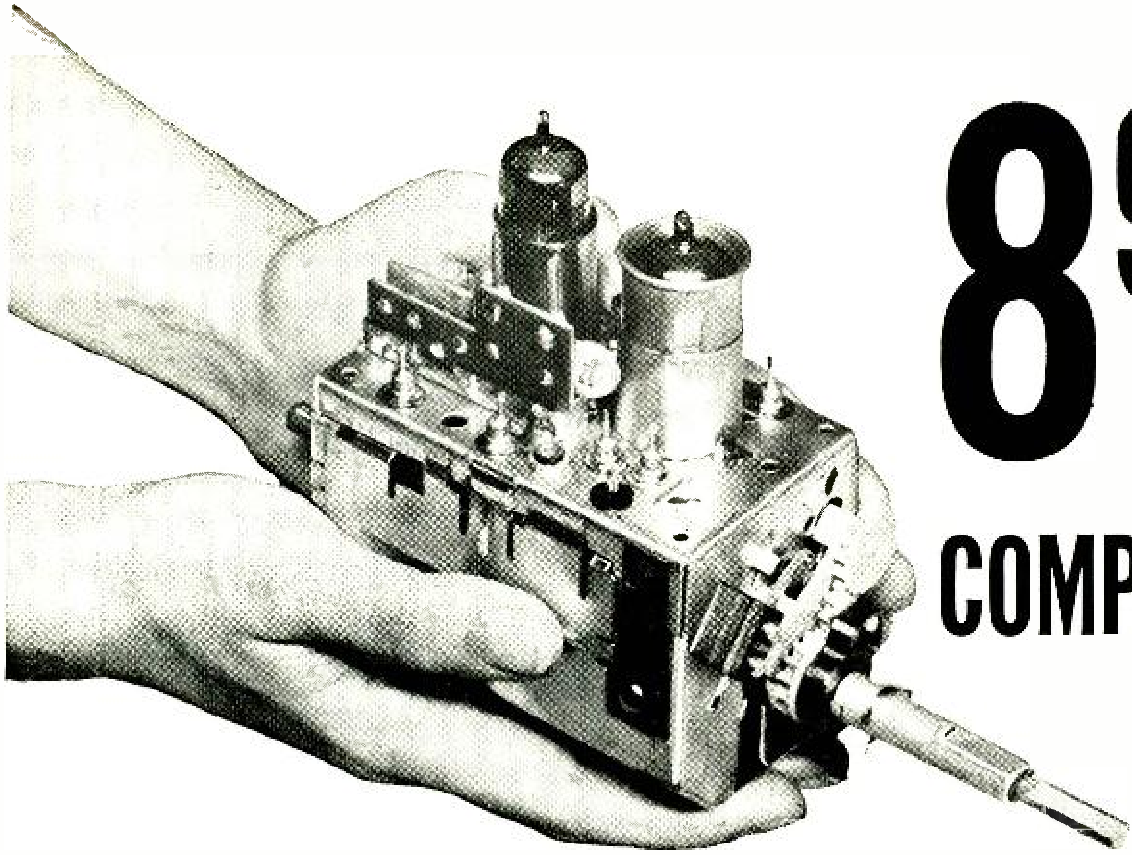
Renewal color tubes

The color TV tube replacement market is growing swiftly, a survey by Electronic Industries Association indicates. The poll of tube manufacturers found that approximately 1,130,000 color tubes will be replaced this year—renewals accounting for more than 16% of the total 1969 color tube market. In 1970, the figure should rise to 1,433,000, or 19% of the tube market. By 1972, the manufacturers believe, some 2,134,000 replacement tubes will be required, constituting 23.8% of all color tubes built that year. In 1974, the number may be 2,652,000, or 28.4% of color tube production.

How long a warranty?

Almost all renewal color tubes carry factory-guaranteed replacement policies running one year from date of installation, although occasionally some distributors add their own warranties to bring the term up to 18 months or two years. The Admiral Corporation recently conducted a market test of a 3-year warranty on its first-line all-new color renewal tubes, and currently is evaluating the results.

Admiral quite frankly is trying to get deeper penetration of the independent service technician market, and it is weighing whether a 3-year warranty will help significantly. Other tube manufacturers will be watching closely. **R-E**



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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

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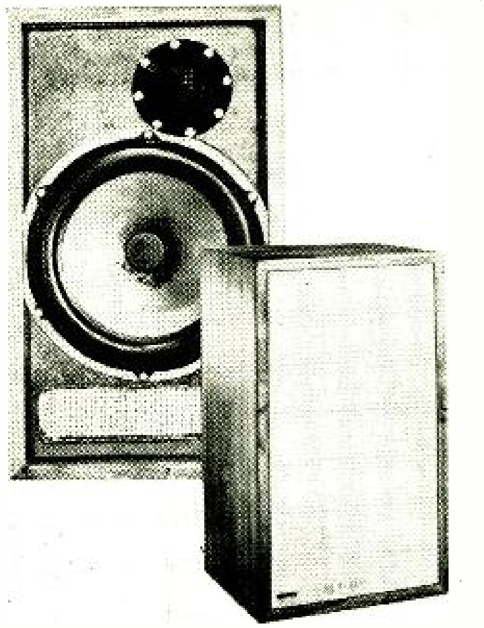


Dynaco A-25 Loudspeaker System

Dynaco's entry into the speaker market with their A-25 is an unusual approach to speaker system design. Manufactured in Holland, the A-25 is a two-way bookshelf speaker system utilizing a 10-inch extended excursion woofer. Crossover to a soft-dome hemispherical tweeter occurs at 1500 Hz through a noninductive dual-section filter. A five-position switch alters treble output 3 dB (at 10 kHz) in each position. Nominal impedance is 8 ohms. Dynaco recommends 15 to 60-watt (continuous) amplifiers.

Listening test with the A-25 revealed it has a very wide, smooth and clean response. According to Dynaco, this is due largely to the non-resonant or "aperiodic" design of the system. Although the cabinet is ported, there is virtually no acoustic output from the slot. Instead, it is heavily damped to adjust each A-25 for flattest impedance curve.

To compare the A-25 with an acoustic-suspension system with excellent response in the bass range, the two speakers were hooked to a 50-watt/channel amplifier, and an A-B comparison was made using sweep tones from an audio test record. Except for the lowest record range the two speakers "tracked" perfectly, presenting an equal audible output. For the 20–40 Hz sweep tone, it was necessary to slightly increase the output to the A-25 to maintain an equal audible output. (This could have been a phase characteristic of the listening situation.)

The smoothness and range of the A-25 in response to test tones was also evident in music passages. More important, there was no coloration to musical instruments—or voice. High frequencies were very clear, and widely dispersed on either side of the center axis.

An outstanding characteristic of the A-25 is its ability to reproduce low-frequency elements without the "heaviness" often introduced by speaker systems. During orchestral crescendos, for example, individual bass instruments can be clearly identified. The excellent damping of the woofer has obviously contributed to the system's definition.

According to the manufacturer, the A-25 has less than 1% total harmonic distortion throughout the music range of most instruments, and is below 3% above 50 Hz (considerably lower above 1000 Hz) with a constant 25-watt input signal. Also, says Dynaco, the A-25's 3rd order harmonic distortion is less than 0.1% above 1000 Hz.—*John R. Free*

Circle 16 on reader service card →

In the Shop . . . With Jack

By JACK DARR
SERVICE EDITOR

UP THE HI-FI TOTEM POLE

PRACTICALLY ALL HI-FI OR STEREO systems today are solid state. The most popular output circuit seems to be the output-transformerless type—either complementary-symmetry or "stacked" circuit. This is sometimes called a "totem pole" because the transistors are literally stacked on top of each other. Fig. 1 (one channel of the G-E T2N4 stereo phonograph) shows a simple type of stacked circuit. Both transistors are of the same polarity, npn.

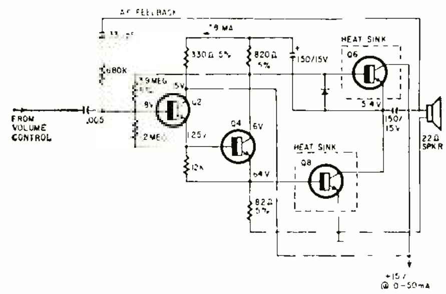


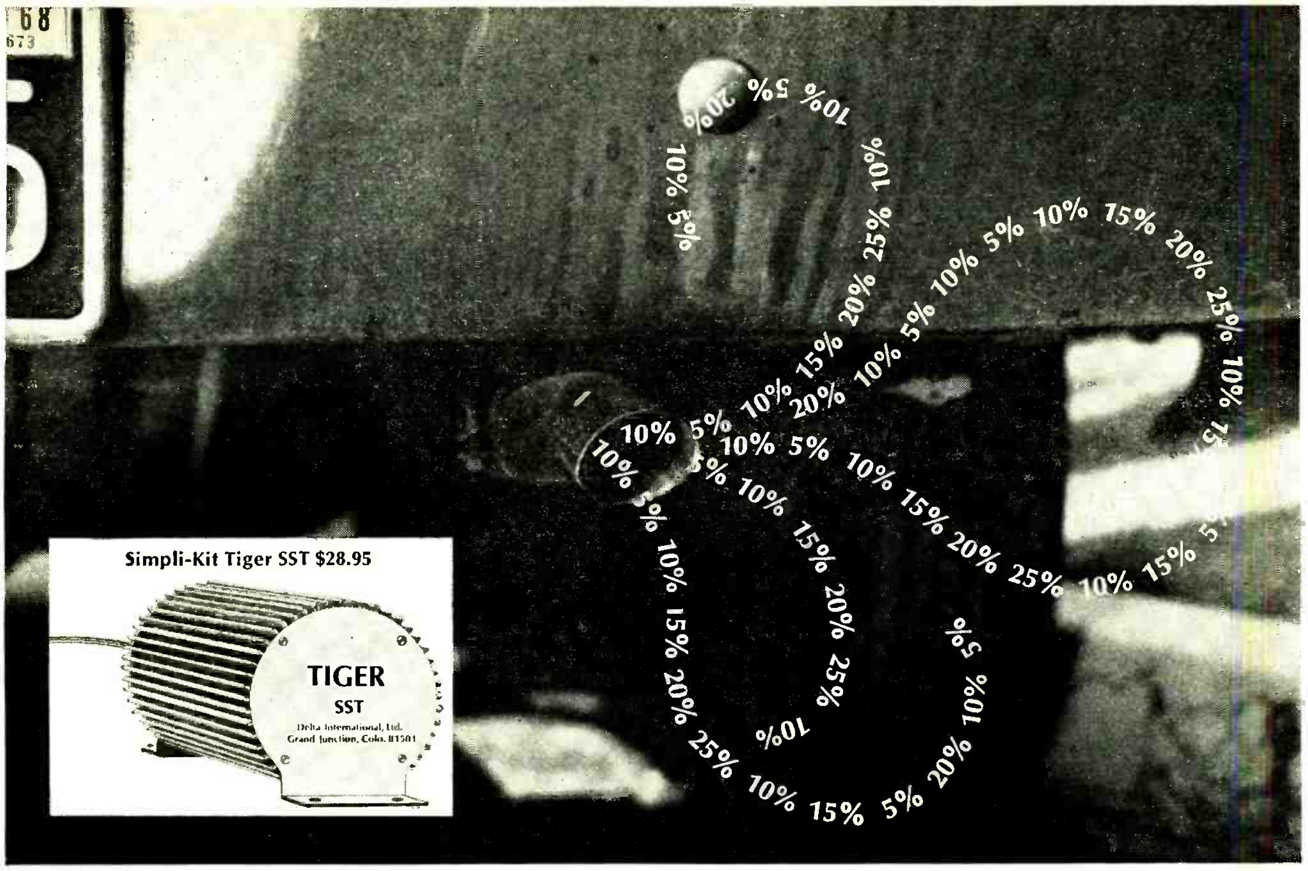
Fig. 1—G-E T2N4 stereo phono channel.

Because of the direct connections between transistors, they can be hard to check out unless you use the right methods. Note that Q4 is connected from base to base of Q6–Q8, the outputs. The emitter of Q2 is directly connected to the base of Q4. (And this is one of the *simple* ones!)

If the amplifier is completely dead on both channels, check the dc power supply voltages first. If these are OK, then read the dc voltages from top to bottom of the totem pole. The key voltage in this circuit is the dc voltage on the emitter-of-Q6/collector-of-Q8 point.

This is the no-signal voltage. Without an input signal, these dc voltages should divide up as they are shown here: +15 volts on the collector of Q6, and +5.4 volts on the emitter–collector junction. This voltage will tell you what's happening. If you get zero volts here, but the full +15 volts on Q6's collector (supply voltage), Q6 is either open or completely cut off. (The last can be quickly checked by reading Q6s' base voltage.) This is normally unlikely; it would take quite a bit of *negative*

(continued on page 22)



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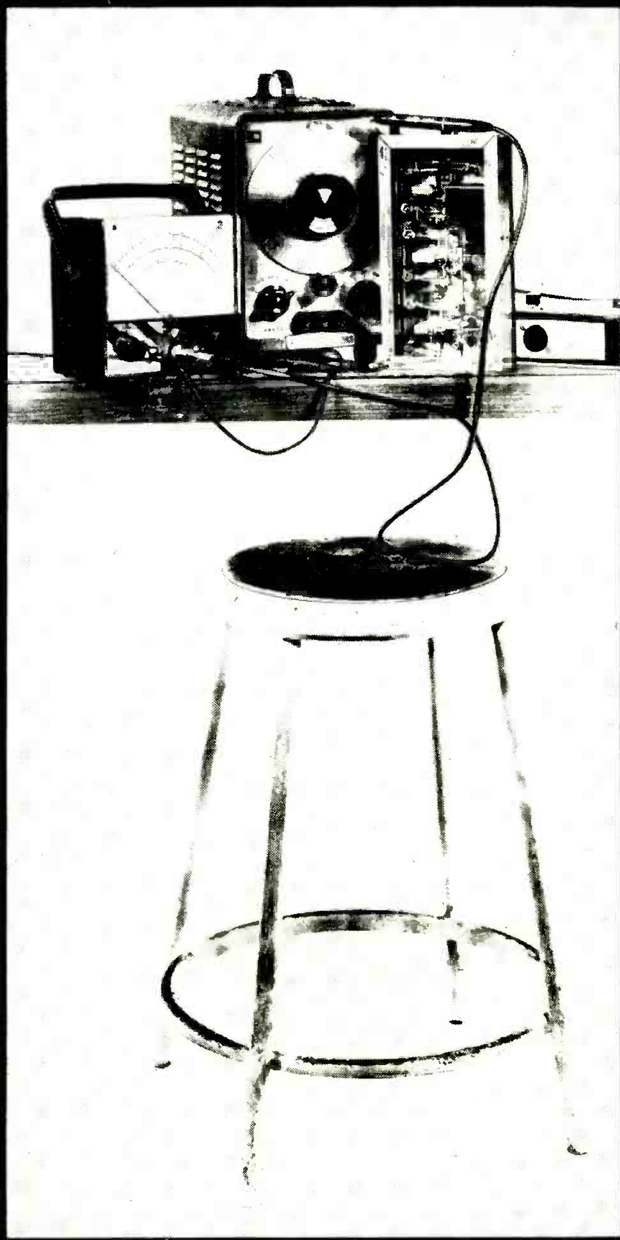

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Automatic Controls. Prepares you to be an Automatic Controls Electronics Technician; Industrial Laboratory Technician; Maintenance Technician; Field Engineer.

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IN THE SHOP
(continued from page 16)

voltage on the base to cut Q6 off, and there's no place for it to come from in this circuit! The chances are that Q6's collector–emitter junction is open.

The actual voltage ratio between top collector, center junction, etc. will vary with different makes. Some will split it evenly, others will have an unequal division, as here. In any case, it should be pretty close to the ratio given on the schematic.

The G-E model T20E (Fig 2.)

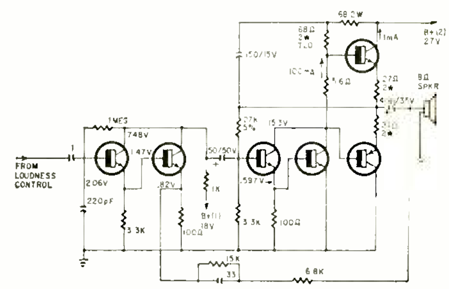

Fig. 2—G-E T20E phonograph channel.

has a more powerful amplifier circuit, with more elaborate interconnections. in these, or in any circuit where one transistor is connected "across" another, you'll have to *break the circuit* before you can get a reliable test. Even the best in-circuit transistor testers won't read a transistor correctly like this. To get a handle on this type of circuit, take out the *middle* transistor. This leaves both of the end ones ready for tests. (Then, you usually find that the one you just took out and laid on the bench was the bad one.)

If the complaint is distortion in one or both channels, there's only one really quick way to find the cause. Feed in a good clean audio signal, anywhere around 500–1000 Hz. Then follow this with a scope. You will be able to see any problems.

Be sure you aren't overloading the input. You can make up a homemade voltage divider with a couple of resistors to be sure that the input signal isn't too high. Rule of thumb: not more than 1 volt p–p.

Check the signal at the input, then at the output of the first stage. If you show peak clipping of the sine wave here, cut down the input signal.

Once you find the point where the signal either stops or distorts, you can take dc voltage readings, test transistors and check resistors.

Small leakages in transistors can cause large distortions. (They upset the bias.) **R-E**

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a Sony Sound Odyssey

If you are prepared to regard sound reproduction as an experience, and if this experience could possibly be worth $2000 plus to you, read on.

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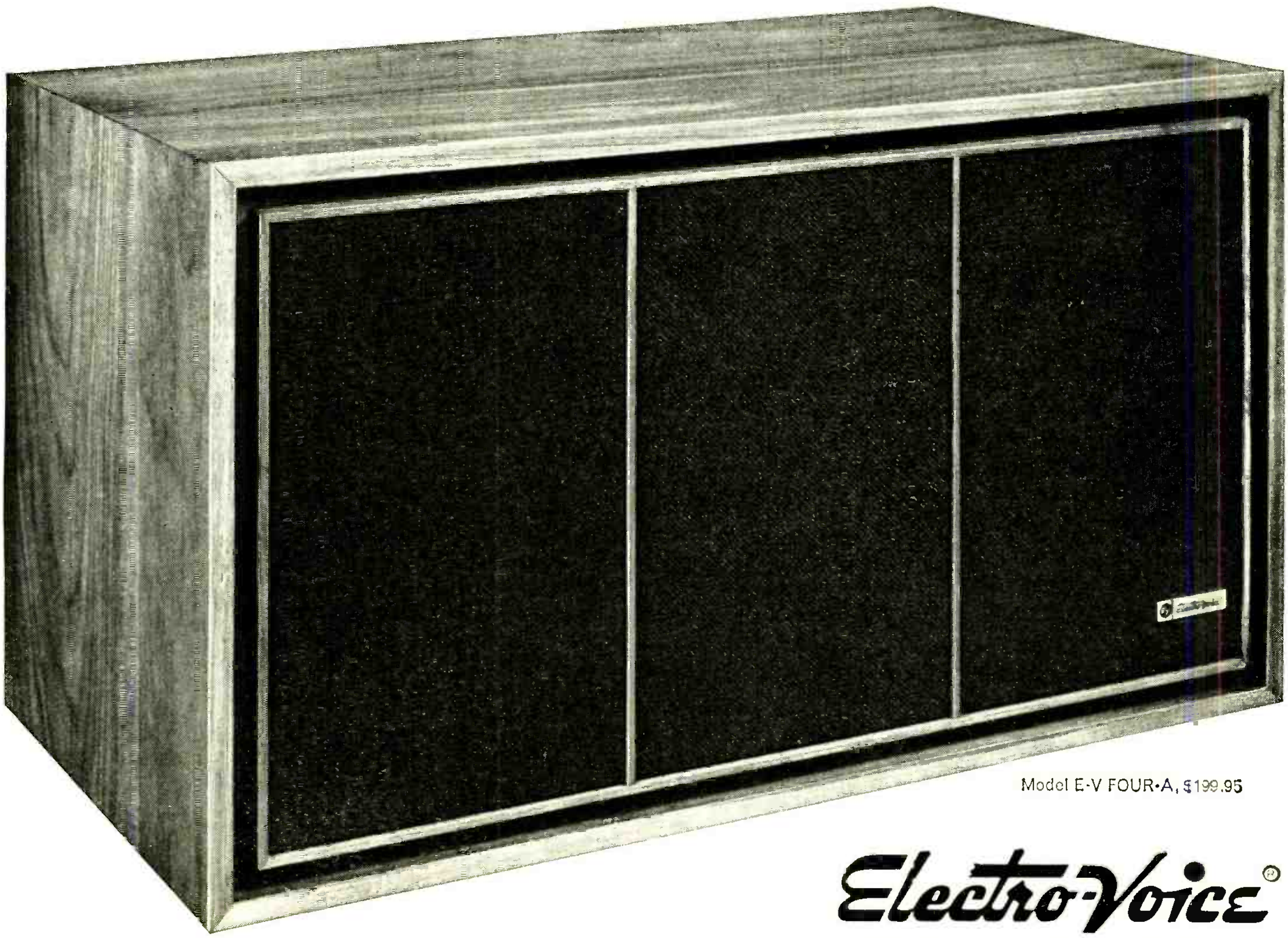

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Correspondence

DIFFICULT? IMPRACTICAL?

Mr. John A. Walker's negative attitude toward certification of all electronic technicians in the July 1969 Correspondence Column reveals a common weakness, so often expressed by the majority of humans when faced with a difficult task—"it is too difficult", "it is impractical", "it can't be done". With such an attitude, our forefathers would have been unable to invent the lightbulb, telephone, telegraph, radio, etc., neither would putting a man on the moon have been accomplished.

Quoting from Mr. Walker's letter—"It is impractical to cover all specialties". With such a hopeless attitude, the certification of electronic technicians is doomed before it starts.

I would like to bring to Mr. Walker's attention one such example where the profession is more specialized and diversified than the electronics technology, and where national certification has been established. All one has to look at is physicians and surgeons. One finds the following specialists:

Allergists, Anaesthetists, Dermatologists, Ear, Nose & Throat specialists, Internal Medicine Specialists, Neurologists, Neurosurgeons, Obstetricians & Gynaecologists, Ophthalmologists, Orthopaedic Surgeons, Osteopathic Surgeons, Paediatricians, Pathologists, Plastic Surgeons, Psychiatrists, Radiologists, Thoracic Surgeons and Urologists.

The only practical organization for the electronics technician is a mandatory union.

If a medical graduate wishes to practice medicine, he must join the College of Physicians and Surgeons; if a lawyer wants to practice law, he must become a Member of the Bar; if a teacher wants to teach, he must join the Teachers' Association. If an electrician or plumber wishes to work in his trade, he is forced to join the union, and similarly, if the technician wants to earn a livelihood in electronics, he should be forced to join The Electronics Technician Society, Association, Union, or what ever you wish to call it. R-E

ED KRENTZ
Edmonton, Alberta, Canada

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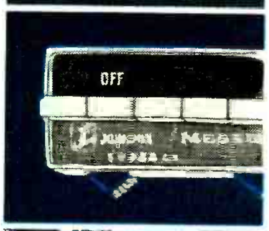

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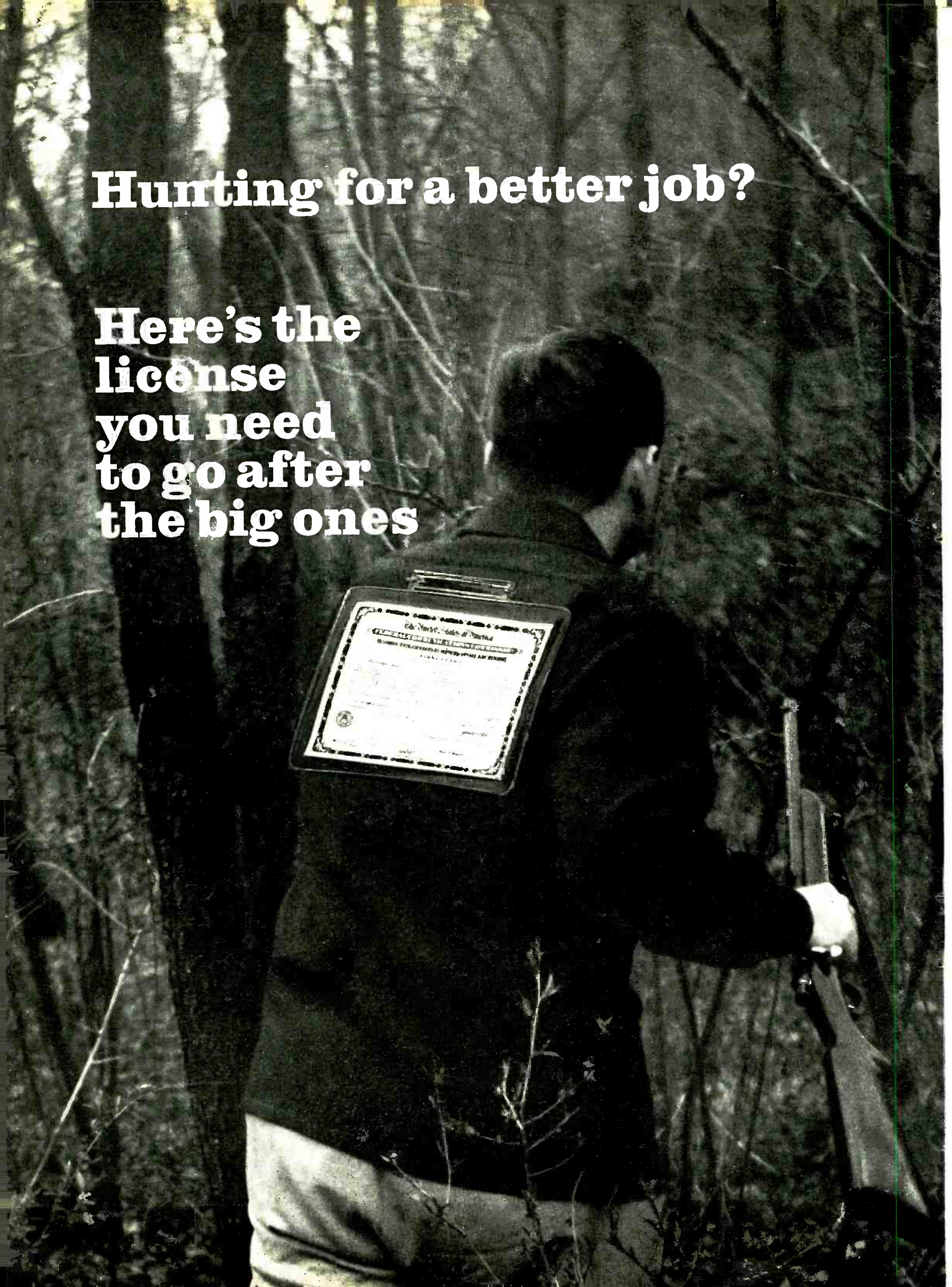
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BUILD R-E's Stereo Color organ

Spectacular performance with IC op-amp filters and MOSFET automatic gain control. Up to 300 watts/channel with triac-switched lamps

by BRIAN HOLLINS*

NATIONAL SEMICONDUCTOR

WANT TO SPICE UP YOUR BEATLES OR Bach? A color organ can add a spectacular visual dimension to your hi-fi system—even to an ordinary table-model radio. The colored lamps will blink and glow in response to music intensity and frequencies.

The 10-channel stereo color organ described can be built for about $160. If this figure tops your budget, a five-channel version can be assembled for about half that price. (Costs can easily be cut further by shopping for "bargain" packages of components.) The five-channel version will work with a stereo hi-fi or any audio system with 3–16-ohm speakers. If you decide to build the smaller color organ, five additional channels can easily be added to the same chassis later by originally planning chassis layout carefully.

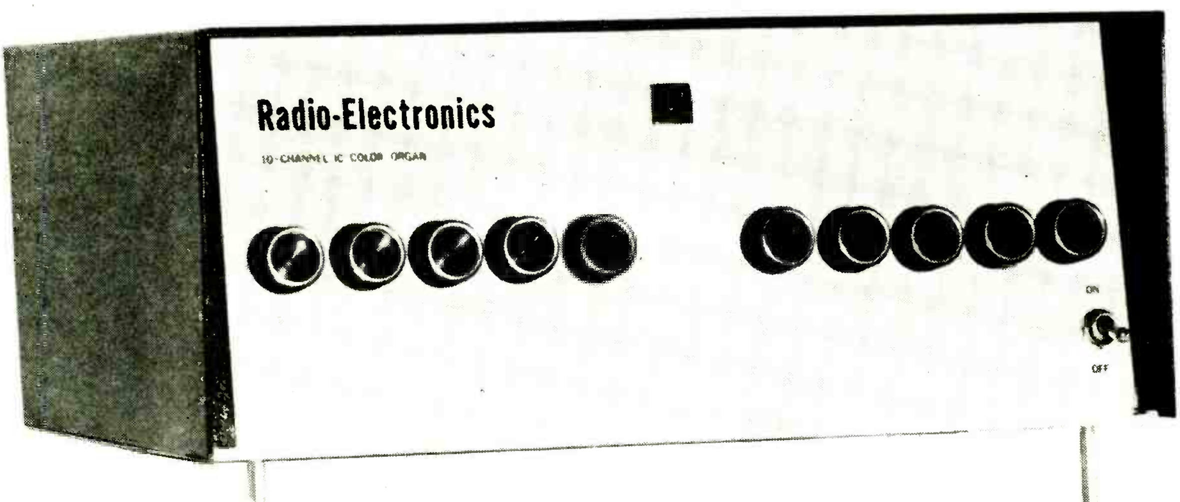
This color organ has two very important advantages over earlier circuit designs for color organs.

• First, its agc circuit accepts a wide input voltage range! This means the lights will respond evenly from the faintest violin whisper to the loudest drum roll. Without agc, any change in volume—even going from one record band to another—could cause the lights to saturate or go out entirely. Units with brightness controls for each channel must be "tweaked" constantly to maintain an even display. With this design, once you set the 10 (or 5) brightness controls to your preference, they rarely need touching again.

• Second, IC operational amplifiers are used in each channel as active filters. This design provides razor-sharp filter characteristics (Fig. 1) that insure good channel separation. Overlapping filter characteristics spoil the visual display of color organs since several channels often flash together.

What about lamp wattages? The triacs used to drive the lamps in the 10-channel version are limited to 150-watt loads. This light level is more than adequate for most listening rooms. But if you want higher wattages for auxiliary or commercial displays, 300-watt triacs can be sub-

*formerly with Fairchild Semiconductor



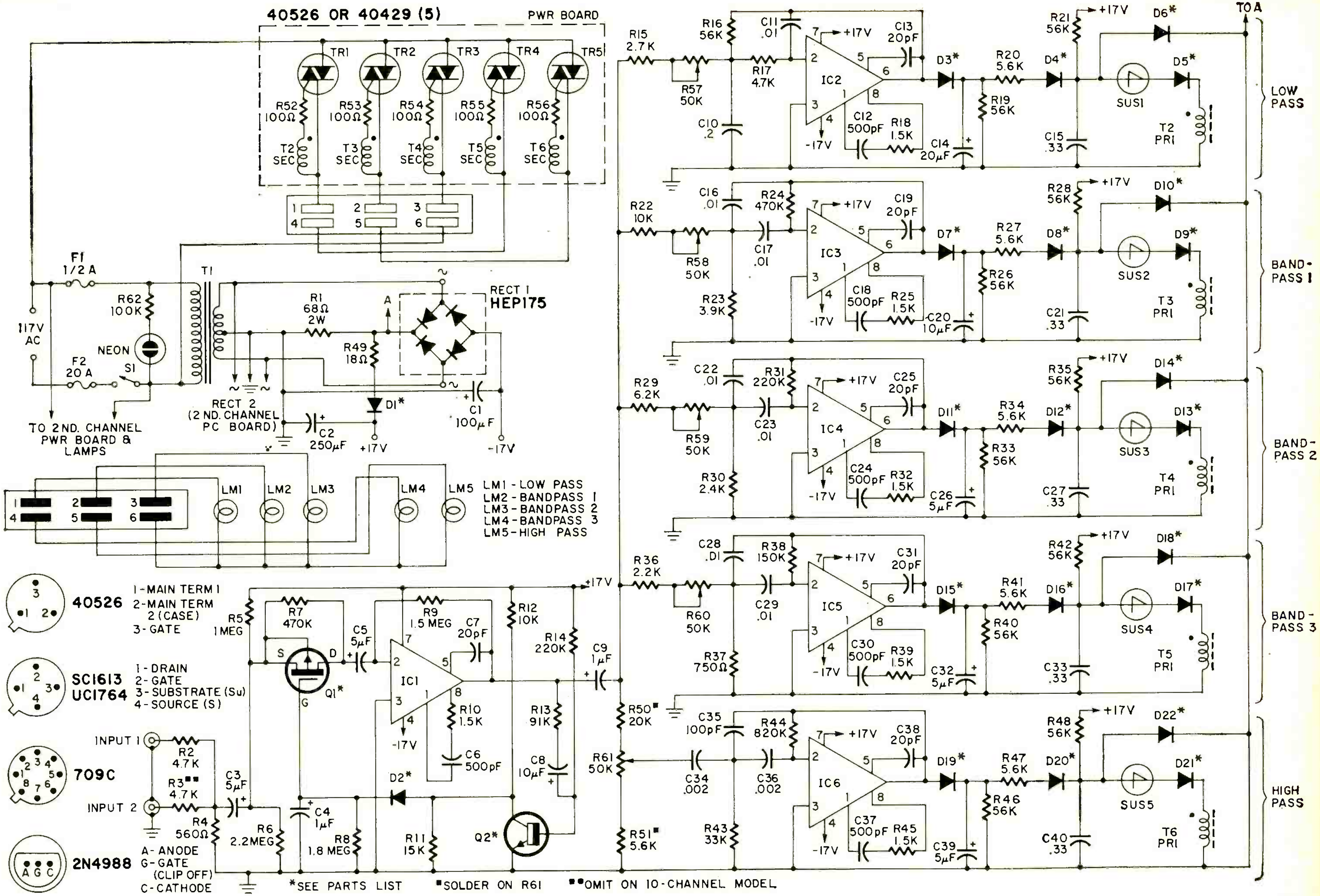


Fig. 2—Agc input stage (lower left) feeds the 5 IC band-pass filters (right) through C9. Pulse transformer primaries (far right) gate on the triacs through the secondary windings (upper left). PC board carries the power supply.

stituted for the lower-wattage devices.

Circuit operation in brief

Operation of the input agc stage can be seen in the color organ circuit (Fig. 2) and a simplied representation of the agc circuit in Fig. 3. The inverting amplifier in Fig. 3 has a voltage gain of $R_f R_s$ due to the very high gain of IC1, a 709 operational amplifier. The gain of this stage can be changed by varying R_s.

This is accomplished in the agc stage by using a metal oxide silicon (MOS) transistor in place of R_s. The drain-source resistance R_{ds} of transistor Q1 is changed by applying a gate-source bias dependent on the peak output voltage of the stage. With no input to the stage, Q2 is saturated; consequently maximum gate-source bias is applied to Q1. This sets the amplifier to its maximum gain state.

An input to the stage provides an output that pulses Q2's collector toward its off state. The peak detected bias applied to Q1's gate is then reduced and the R_{ds} of Q1 increases. This in turn reduces the overall gain and holds the output of the stage constant. The agc range of the stage is approximately 40 dB.

To provide the five frequencies for the colored lamps, commercial-grade 709 operational amplifiers employing multiple feedback are used. There are two advantages to this IC design: a useful voltage gain is possible and sharp amplitude attenuation beyond the cutoff frequency is obtained. The typical frequency response shown in Fig. 1 clearly demonstrates the desirable absence of overlapping adjacent characteristics. The dotted line shows the low-frequency attenuation introduced by coupling capacitor C9. This cutoff is needed to eliminate very-low-frequency components such as turntable rumble.

Frequency characteristics of the low-pass filter should be about 150 Hz (3 dB down), while the center frequencies of bandpasses 1, 2 and 3 should be 350 Hz, 650 Hz and 1300 Hz. The high-pass filter should be 2500 Hz (3 dB down). Minor variations in these figures due to component tolerances will not be detectable, but an optional calibration procedure is included if you wish to adjust your color organ exactly to these frequencies.

A simplified version of a driver stage is shown in Fig. 4. Capacitor C1 charges toward the supply voltage (V_{cc}) with timing constant R1C1. When the voltage across C1 exceeds about 7 volts, trigger diode SUS1, a silicon unilateral switch, switches on and discharges C1 through the pulse transformer primary. The pulse is coupled into the triac gate, which turns on and switches ac power to lamp LM.

This operation is phased to the line signal by D2, which discharges C1 to ground potential each time the line ac reverses polarity. Diode D2 then turns off and the cycle repeats. When a dc voltage E1 exists, C1 starts charging from E1 instead of ground and D1 switches on earlier in the cycle. This switches more power per cycle to the lamp. Voltage E1 is derived by peak detecting the filter stage output, so each lamp is illuminated when an output appears at its correspond-

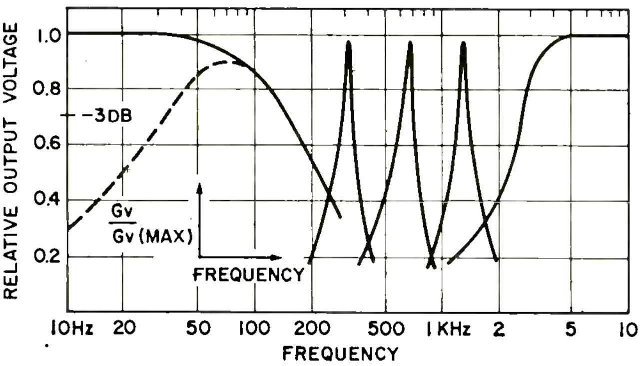


Fig. 1—**Sharp frequency** response of IC filters insures good channel separation. Dotted line is frequency cutoff to filter turntable rumble.

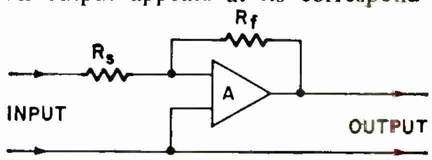


Fig. 3 — **Simplified** agc circuit. R_f/R_s voltage gain is varied by using a MOSFET for R_s and varying its drain-source resistance.

PARTS LIST

The following components are for a five-channel color organ. An identical set of parts is needed for the 10-channel version, except for fuses, T1, S1 and R62. Numbers in parenthesis are the stock and page numbers for most parts from the 1969 Allied Industrial Electronics Catalog (100 N. Western Ave., Chicago, Ill. 60680). If substitutions are used, consider space requirements on the PC board.

C1—100-μF electrolytic. Sprague TE1211 (43F6641, p180)
C2—250-μF electrolytic. Cornell-Dubilier 250-25 (43F9270, p191)
C3, C5, C26, C32, C39—5-μF electrolytic. Sprague TE1202 (43F6046, p180)
C4—1-μF electrolytic. Sprague TE1200 (43F1779, p180)
C6, C12, C18, C24, C30, C37—500-pF ceramic disc. Centralab CE501 (43F0877, p198)
C7, C13, C19, C25, C31, C38—20-pF. Mallory SX (43F0400C, p187)
C8, C20—10-μF electrolytic. Mallory MTA10D35 (43F0459, p188)
C9—1-μF electrolytic. Sprague TE1200 (43F1779, p180)
C10—0.22 μF. Sprague 2249R75 (43F3571, p183)
C11, C16, C17, C22, C23, C28, C29—0.01 μF. Sprague 96P-10391 (43F3582, p185)
C14—20-μF electrolytic. Mallory MTA20D30 (43F0456, p188)
C15, C21, C27, C33, C40—0.33 μF. Sprague 3349R75 (43F3572, p183)
C34—0.002μF. Centralab CF-202 (43F1459, p198)
C35—100 pF. Mallory SX (43F0400C, p187)
C36—0.002 μF. Mallory SX (43F0402C, p187)
All capacitors 25V or more

R1—68 ohms, 2W
R2, R3, R17—4700 ohms (omit R3 for 10-channel version)
R4—560 ohms
R5—1 megohm
R6—2.2 megohms
R7, R24—470,000 ohms
R8—1.8 megohm
R9—1.5 megohm
R10, R18, R25, R32, R39, R45—1500 ohms
R11—15,000 ohms
R12, R22—10,000 ohms
R13—91,000 ohms
R14, R31—220,000 ohms
R15—2700 ohms
R16, R19, R21, R26, R28, R33, R35, R40, R42, R46, R48—56,000 ohms
R20, R27, R34, R41, R47, R51—5600 ohms
R23—3900 ohms
R29—6200 ohms
R30—2400 ohms
R36—2200 ohms
R37—750 ohms
R38—150,000 ohms
R43—33,000 ohms
R44—820,000 ohms
R49—18 ohms
R50—20,000 ohms
R52–R56—100 ohms
R57–R61—50,000-ohm linear potentiometer
R62—100,000 ohms (optional)
Unless noted, resistors are ¼W, 10% or 5% (45F7150C, 45F7155C, p134)
IC1–IC6—709C operational amplifier. Fairchild μA7709C, National LM709C. (See advertisements in RADIO-ELECTRONICS)
Q1—p-channel MOSFET transistor.* Philco-Ford SC1613, Union Carbide UC1764, Motorola 2N4352 (Allied p71)
Q2—any npn transistor with h_{FE} over 40, BV_{CEO} over 15V. Motorola 2N708, 2N697, 2N718.

D1—any 1-amp, 25V or more diode. HEP 156
D2–D22—any 25V or more diode. IN34A, 1N98, Fairchild FD100
SUS1–SUS5—2N4988 silicon unilateral switch. G.E. (Allied p85)
TR1–TR5—40526 triac. RCA (Allied p99). 40429 for 300W/channel.
RECT1—bridge rectifier, HEP 175 (Motorola)
Other parts
T1—1-amp, 24V CT transformer. Triad F45X (54F3661, p361)
T2–T6—1:1 pulse transformer. Sprague 11Z12 (54F0300, p363) or equal
S1—spst switch, 20A for 10 channels (56F4714, p208). 10A for 5 channels
Plug & Socket—Cinch-Jones P-306-CCT, S-306-AB (47F0806, 47F0883, p297)
Fuses—F1, ½A. F2, 10A for 5 channels, 20A for 10 channels
MISC—Cabinet (Bud TV-2156), knobs, fuse holders, spacers, neon lamp, perforated board, 6-terminal strip(s), display sockets and lamps, input jacks (RCA type), Wakefield NF205 heat sinks (60F6529, p107), Grayhill 22-16-4 transistor sockets (47F-5289, p326), Cinch-Jones 8-ICS sockets (47F0155, p326)
Etched, drilled and pretinned epoxy PC board available for $8.50 each postpaid from Stafford Electronics, 427 Benhow Rd., Greensboro, N.C. 27401. Also, kit of semiconductors, T1 and PC board(s): $62 (five channels), $130 (10 channels).
*Philco-Ford SC1613 ($2.70 each) available from Milgray Electronics 160 Varick St., New York, N.Y. 10013 or write Philco-Ford Microelectronics Division, 609 Saw Mill River Road, Ardsley, N.Y. 10502 for other distributors. The Union Carbide UC1764 ($4.90 each) is available from Eastern Radio Corp., 312 Clifton Ave., Clifton, N.J. 07011.

ing filter. Potential E1, therefore, varies as the filter stage output, and controls lamp brightness.

Use of pulse transformers to drive the triacs isolates the control circuits from the ac line, easing testing of the control circuitry.

Assembly and calibration

All components fit on two PC boards except the power transformer, pulse transformers and triacs, resistors R52–R56, R50, R51 and the pots. You can prepare your own PC boards from the pattern provided, or order predrilled, solder-dipped boards.

Mount the triacs and pulse transformers on separate boards as shown in the photos. Wire and/or install the pulse transformers *identically* on both channels (use same wire for ground on each primary). If a band-pass lamp lights but does not respond to music, try reversing the wires on the primary. The triacs require clip-on heat sinks to prevent excess dissipation, and the cabinet should be drilled

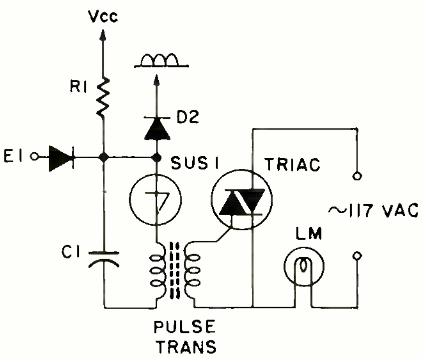


Fig. 4—**Simplified driver stage.**

Space pulse transformers 1 inch to prevent interaction. Extend R1 above other components (long leads). Mount PC boards with insulative-type washers.

or cut below and above the mounting boards for ventilation. If 300-watt triacs are used, mount them on an aluminum heat sink with at least 36 square inches surface area. Since the cases of the *larger* triacs carry the full 117-volt ac input, the triacs or the heat sink itself itself must be electrically isolated from all other parts of the circuit, including the chassis.

Commercial pulse transformers can be used, but a considerable saving is possible by winding your own. Cut ⅜-inch diameter ferrite rod (used for AM radio antennas) into 1-inch lengths. Each core is wound with 50 turns of No. 30 gauge insulated copper wire to form the primary. This layer is then insulated with a cover of electrical insulating tape and a second 50-turn winding (secondary) put on. The secondary should also be covered with a layer of insulating tape.

The color organ will work with the component values shown, but the following calibration procedure can be followed for optimum performance. A sine-wave audio generator and oscilloscope are needed.

Connect the signal generator between one of the inputs and ground. Set the generator output to 0.5 volt p–p at 1 kHz. An undistorted sine wave will be seen at pin 6 of IC1. Alter the value of R13 until this waveform measures 9 volts p–p. This setting optimizes the amplitude response of the color organ.

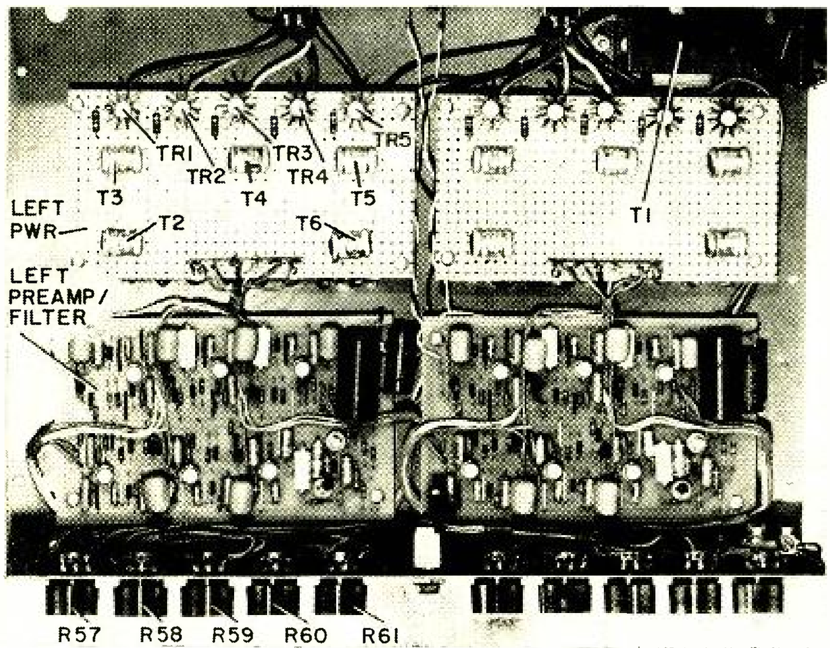
Check the agc action by increasing and lowering the input voltage; the output of IC1 should not change. Depending on the characteristics of Q1, this output should be constant over a 50-mV—5-volt input range. When the optimum value of R13 is known, install a fixed resistor.

To calibrate the frequency response of the bandpass stages, temporarily connect a 25K potentiometer across R13 and adjust its value for a 1-volt p–p output of IC1 (pin 6) with a 0.5-volt p–p, 1-kHz signal at one of the color organ inputs. Turn all channel intensity controls to minimum resistance. Connect the oscilloscope to IC3 (pin 6) and adjust the signal generator frequency until the sine wave peaks. Ideally this should occur at about 350 Hz. The peak frequency can be altered to the desired value by changing the value of R23. The maximum p–p output voltage of this stage at the bandpass frequency should be about 15 volts. If not, it can be adjusted by changing R22.

Now check the output of IC4 (pin 6) and adjust the frequency giving peak output to approximately 650 Hz by changing resistor R30. Adjust the p–p voltage to about 15 volts by changing R29.

Repeat the procedure with the output of IC5 (pin 6), altering R37 to obtain a peak at approximately 1300 Hz. Alter R36 to obtain about 15 volts p–p output at the center frequency.

The low-pass (IC2) and high-pass (IC6) stages do not require frequency optimization, but may need adjusting for 15 volts output. For IC2, use a 100-Hz signal for this and alter R15 if necessary. For IC6 use 5 kHz and alter R50 if required.



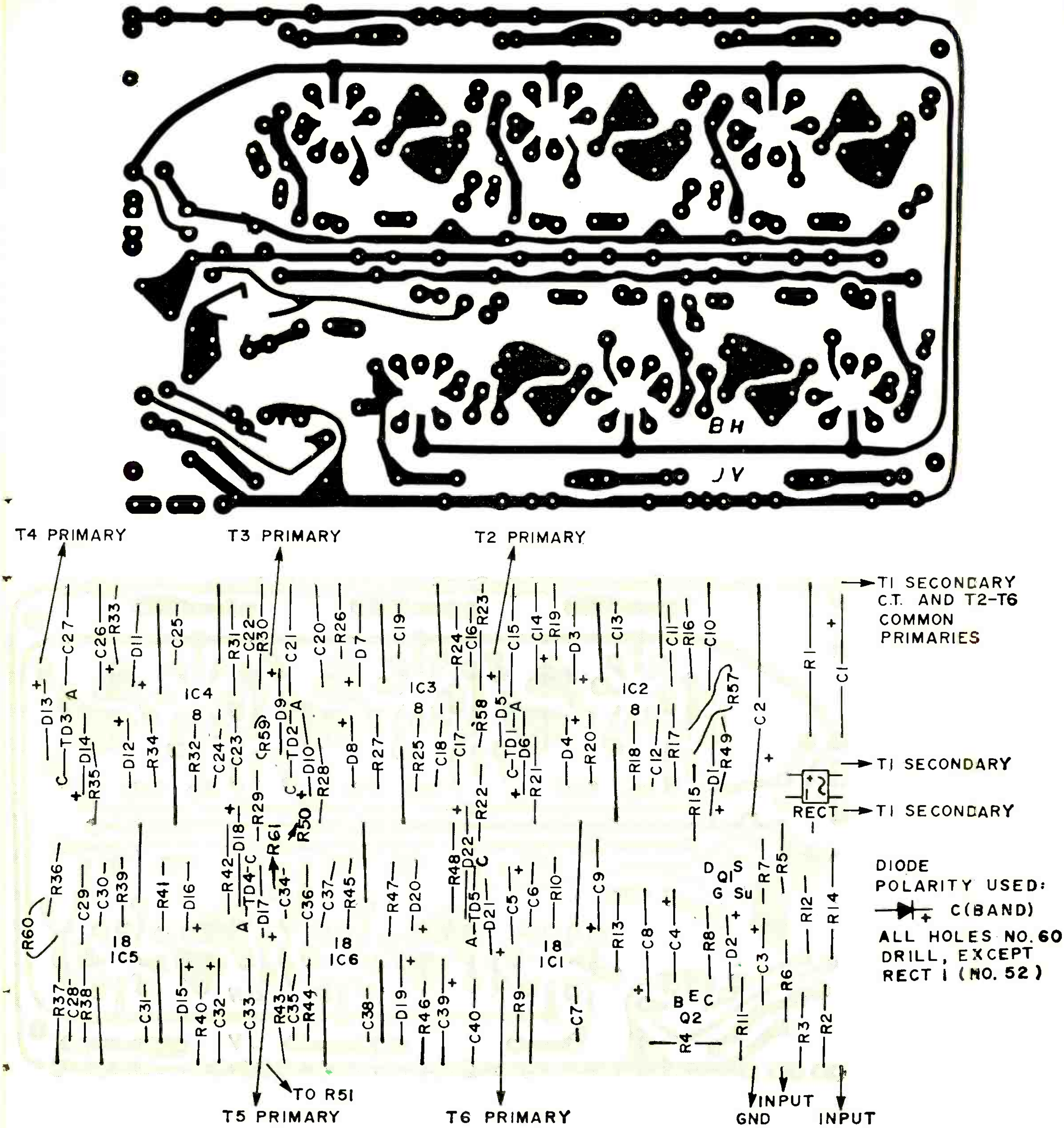
Hookup and displays

Inputs to the color organ are taken across the loudspeaker terminals. For the 10-channel color organ shown, the "live" terminal of each speaker is connected to each input and the ground terminal of each speaker to the ground input.

To connect a five-channel version to a stereo system, wire the live speaker terminals to the two inputs of the PC board (R2 *and* R3 must be installed) and the ground terminal of one speaker to the ground input. (*Make sure the stereo channels have a common ground in the hi-fi amplifier.*) The color organ sums the two inputs and sees them as a mono signal without affecting the stereo sound. For 8-ohm speakers, the crosstalk introduced is 78 dB down.

For any mono system with a 3–16-ohm speaker, connect the live loudspeaker terminal to one of the inputs and the ground terminal to the ground input.

Choice of a display arrangement is limited only by your imagination. One logical arrangement is to use flood or spot lamps of five different colors:



Actual-size copper-side PC pattern is on top with components side above. Board size can be 4 x 6 9/16". Codes TD1-TD5 above are SUS1-SUS5 on Fig. 2 and the parts list. For sockets, drill 9/32" holes for each IC and transistor and solder them in. Otherwise, drill No. 60 holes at the end of each connection "finger" and solder devices in directly. Note: wrap a bare fine wire around MOSFET leads until they are installed.

red for the low-pass (bass) channel, amber, yellow and green for the band-pass 1, 2 and 3 channels, and blue for the high-pass (treble) channel.

Although some may prefer the effect, higher-wattage lamps may produce a delay between the sound you hear and peak lamp illumination. The G.E. 150-watt PAR 38 Dichro-Color lamps provide "rich" colors due to built-in coatings.

The lamp-peaking delay can be shortened by biasing the lamps just below their illumination point. This can be done by lowering the values of resistors, R21, R28, R35, R42 and R48. (This might necessitate lowering IC1's output with R13.)

Lower wattage lamps such as Sylvania's stained-glass, 75-watt PAR reduce this delay between sound and light. Low-wattage lamps can be wired in parallel for direct-view displays. For their transparent colored sign lamps, G.E. recommends 40-watt blue, 25-watt red and green, 15-watt orange and 11 watt yellow. This combination prevents the "cool" colors from being overpowered by the yellows and oranges. R-E

R-E STAFF REPORT

Hi-Fi Stereo

STEREO HEADPHONES ARE IN! BECAUSE THEY REALLY do the job they have become one of the more desirable ways to listen to stereo sound.

Several things account for this change. First, and perhaps the most obvious, is that most of us like our music with oomph. To get it that way, we've got to turn up the watts and feed real power into our speaker systems. But while this is fine for us, the rest of the family, and our neighbors, might not like those hi-fi sounds.

Another solid reason for using phones is that they put you right in the middle of the music (and at the same time the middle of that stereo effect). When you get up to walk across the room, that perfect stereo position goes with you. And what the rest of the family is doing doesn't have any effect on your listening pleasure. With the phones on, level up, and thick padded ear seals you'll find yourself rather insulated from the rest of the world.

The great growing current interest in stereo phones led us to prepare this article. Because headphone users listen to them or at least through them, we decided to do an in-depth very subjective test of how they sound. The results of these tests appear on the next two pages of this article. But before you flip the page to those listings you might like to know how they were compiled.

First we decided that we would do a subjective report. Each of three editors on the staff of **Radio-Electronics** would use and listen to the phones and then report on their findings. Each of us used somewhat different testing techniques. Here's how it went.

Editor I—Music only!

Our first editor decided to just listen to his favorite music. He reported "I merely took each pair of phones, one by one, plugged it into my stereo system and listened to several selections from a few favorite records. I included a band of theatre organ to cover the low end and another band of lively percussion to check out the highs. The rest was widely assorted so I could observe the reproduction of transient sounds as well as overall quality.

"Comfort was also a simple test. If by the end of the listening period (about 45 minutes) the phones were not bothering me (too heavy, too tight) they were comfortable. If they did bother me, the degree of discomfort was subtracted from that perfect figure of ten.

"Ear seal effectiveness was also a practical text. The figure in that column merely depends on how much extraneous noise got through to my ears during the testing procedure."

Editor II—Test record results!

Our second reviewer did it up brown. Here's his report on how he conducted his tests. "To check out the low-frequency response of the phones I tested, I measured the ability of the left and right earpieces to reproduce the lower three sweep bands (80 to 115 Hz, 40 to 80 Hz, and 20 to 40 Hz) of the Stereo Review Test Record, model 211. In addition to listening for the audible level of these sweep tones, a comparison with the record's reference warble tones was made. The ability of the phones to reproduce the final organ note in Sinfonia to Bach's Cantata No. 29 (Music of Jubilee, Columbia MS6615) was tested.

"To test high-frequency response I judged the ability of the stereo headphones to reproduce the high-frequency sweep tones on the test record (up to 20 kHz), and a judgment of their response to high frequency passages in the Bach Cantata.

"When it came time to determine overall response I based my judgment on a combination of high and low-frequency response and clarity of sound. Also, a check for any obvious drop in response to middle frequencies on the test record and in the Bach Cantata.

"Clarity of sound was an easy one to check out. It is based on obvious distortion introduced into the musical selection used and the ability

1970 may be the year you buy your first set of stereo phones. This guide can make selecting a pair painless.

Headphones

of the stereo phones to handle moderately high levels without distorting sound.

"Effectiveness of the ear seal was determined by how snugly the phones fit over my ears to provide good low-frequency response.

"Comfort was determined by judging the pressure applied by the headband as well as pressure on and around the ears caused by wearing the headphones. This was judged after using each pair of phones over the entire test period."

Editor III—At home with phones!

Still another technique was used by this editor. He reports: "Testing all those headphones covered in this report in a house with four kids appeared, at first, to be an almost impossible task. With each child doing his or her own thing with a radio, record player, or TV; and my wife threatening to leave if I didn't get that pile of headphone cartons and boxes out of her livingroom. I was ready to quit before I even got started.

"Finally, to retain calm and keep everyone busy I enlisted the aid of my wife and nieces—13 and 19 years old. Test sessions were limited to one hour and not more than six headsets were tested in any one sitting. This was intended to prevent listening fatigue and also to allow enough listening time to evaluate such factors as comfort and effectiveness of the ear seal.

"All the phones were tested in pairs and were connected to a Bogen stereo receiver through a Lafayette stereo headphone adapter box. (We ran a quick test to select pairs with about equal efficiency first, so their audio output levels would be about equal.) Then we listened to the program material which consisted mainly of orchestral selections from the Audio-Fidelity FCS-50,000, Vanguard VSD-100 and High Fidelity Stereo Review 211 test records. Sweep and spot-frequency bands were used when we couldn't decide which of the two pairs of phones being used had the best high- or low-frequency response.

"Two listeners would make their tentative ratings and then turn the stereo phones over to the second pair of judges—usually my wife and I. The four of us would then decide which set of phones we liked best and then pair this one with a yet untested set.

"Throughout the tests, someone would ask for a previously tested set of phones to compare with another set he liked. It didn't take long to discover that the Koss ESP-6 had about the best and smoothest frequency response. So this set was then used as our standard for all tests that followed.

"Comfort was based on a combination of weight, balance, pressure on the ears, the tendency of the pads to cause perspiration and the length and flexibility of the cord. (My wife and my nieces were also influenced by how the headband fit without mussing their hair.)

"Effectiveness of the ear seal was easy to judge with eight- and nine-year old boys romping and blasting a TV and radio in adjoining rooms. If you couldn't hear them, the ear seal was rated tops."

Other important considerations

When purchasing phones you might keep in mind that you will have to hook them up to the amplifier. It's easy if you have a new unit, just plug in the jack. But if your amplifier is one of the older models without a jack, you'll have to get an adapter control box.

The cord that connects the phones to the amplifier is also important. Coil cords seem best, but watch out for stiff, uncomfortable ones. Most of all make sure the phone you buy has a cord that is long enough.

You may discover that some current headphones are not listed in the table. We tested all phones we could obtain. Some units did not arrive in time to be included and therefore, are not listed. For a complete listing of the stereo phones we did check, and their specifications turn the page. We hope you will find this listing a useful guide. —R-E

(TURN PAGE FOR CHART)

MANUFACTURER	MODEL	PRICE	EDITOR I: HIGH-FREQUENCY RESPONSE	EDITOR I: LOW-FREQUENCY RESPONSE	EDITOR I: OVERALL RESPONSE	EDITOR I: COMFORT	EDITOR I: CLARITY OF SOUND	EDITOR I: EAR SEAL EFFECTIVENESS	EDITOR II: HIGH-FREQUENCY RESPONSE	EDITOR II: LOW-FREQUENCY RESPONSE	EDITOR II: OVERALL RESPONSE	EDITOR II: COMFORT	EDITOR II: CLARITY OF SOUND	EDITOR II: EAR SEAL EFFECTIVENESS	EDITOR III: HIGH-FREQUENCY RESPONSE	EDITOR III: LOW-FREQUENCY RESPONSE	EDITOR III: OVERALL RESPONSE	EDITOR III: COMFORT	EDITOR III: CLARITY OF SOUND	EDITOR III: EAR SEAL EFFECTIVENESS
David Clark Co. Inc. 250 Park Ave. Worcester, Mass.	100	$45.00	4	6	**4**	5	6	6	3	4	**4**	5	5	6	4	6	**5**	7	5	5
	200	$26.95	6	9	**7**	6	8	7	7	9	**8**	5	9	6	3	7	**5**	5	5	3
	250	$32.00	6	5	**6**	6	7	5	5	6	**6**	5	4	6	7	5	**5**	6	8	4
	300	$19.00	7	6	**6**	6	7	6	6	6	**6**	5	5	6	7	7	**7**	6	8	7
Jensen Manufacturing Div. 5655 W. 73 Street Chicago, Ill.	HS-2	$24.95	8	7	**7**	6	8	4	9	7	**8**	7	7	3	7	7	**7**	6	7	4
Koss Electronics Inc. 2227 N. 31 Street Milwaukee, Wisc.	ESP-6	$95.00	10	10	**10**	6	10	10	10	10	**10**	10	10	10	10	10	**10**	6	10	8
	K-6	$26.50	6	5	**6**	7	7	7	6	6	**6**	7	8	8	5	4	**5**	5	5	7
	KO-727	$34.95	8	7	**7**	7	8	7	7	7	**7**	7	9	8	6	6	**7**	7	7	7
	PRO 4-A	$50.00	8	8	**8**	8	8	9	8	7	**7**	8	7	9	7	7	**7**	8	10	9
	SP-3XC	$24.95	6	6	**6**	7	7	7	6	7	**7**	7	7	7	5	6	**5**	7	6	7
Olsen Electronics 260 S. Forge Street Akron, Ohio	PH-113	$9.00	4	6	**5**	6	6	3	3	6	**5**	6	5	3	3	5	**4**	7	5	2
	PH-140	$11.98	7	7	**7**	5	5	7	8	7	**6**	5	5	6	5	6	**5**	7	4	8

PermaFlux Corp. 4111 San Fernando Rd. Glendale, Calif.	BHM-16	$35.00	4	5	**5**	7	6	6	3	4	**4**	5	5	6	4	5	**4**	7	5	6
	BDHS-28	$45.00	5	5	**6**	7	6	7	3	4	**4**	7	5	7	4	5	**4**	6	6	7
Pioneer Electronics Inc. 140 Smith Street Farmingdale, N.Y.	SE-20	$19.95	7	6	**6**	6	7	8	6	7	**7**	6	6	8	6	6	**5**	6	6	8
	SE-30	$29.95	6	7	**7**	7	8	8	7	7	**6**	7	7	8	6	7	**6**	7	7	8
	SE-50	$49.95	8	7	**8**	8	8	8	8	8	**8**	8	8	8	8	8	**7**	8	8	8
Sansui Electronic Corp. 34-43 56th Street Woodside, N.Y.	SS-2	$12.95	6	6	**6**	7	6	7	8	7	**7**	6	5	4	6	5	**5**	8	6	6
Sennheiser Electronic Corp. 500 Fifth Ave. New York, N.Y.	HD-110S	$72.00	4	5	**6**	7	6	6	4	6	**6**	6	6	6	4	3	**4**	6	5	6
	HD-414	$29.95	8	9	**9**	8	8	6	7	8	**8**	7	8	6	8	9	**9**	9	9	6
Superex Electronics 1 Radford Place Yonkers, N.Y.	ST-C	$19.95	7	6	**6**	7	7	6	7	6	**6**	7	7	7	5	5	**5**	6	7	8
	ST-M	$29.95	7	8	**7**	6	8	7	7	5	**5**	7	5	7	8	7	**7**	6	8	8
	ST-PRO	$50.00	8	7	**7**	7	7	7	7	8	**7**	6	7	6	7	8	**7**	5	7	8
E. J. Sharpe Instruments Inc. Amhurst Industrial Park Tonawanda, N.Y.	HA-9	$25.95	5	5	**5**	8	7	9	5	5	**5**	9	8	9	4	7	**5**	4	4	9
	HA-660 PRO	$60.00	6	7	**7**	9	8	8	5	6	**5**	10	9	9	7	7	**7**	8	9	9
	HA-10A	$43.50	7	7	**6**	9	9	10	6	6	**7**	10	10	10	6	6	**8**	9	9	10
	HA-10 MARK II	$45.00	6	7	**6**	9	9	9	6	6	**6**	10	9	9	5	8	**6**	9	9	10
Telex Acoustics 9600 Aldrich Ave. S. Minneapolis, Minn.	Combo	$19.95	5	5	**5**	7	5	6	3	7	**7**	5	7	5	4	4	**7**	9	8	9
	Adjustatone	$15.95	5	4	**5**	5	5	6	3	6	**3**	4	3	5	3	5	**5**	7	8	9
	Serenata 1	$59.95	4	5	**5**	8	6	6	2	6	**5**	9	6	9	3	6	**4**	7	4	6
Telefunken	TH-28	$24.95	6	7	**6**	8	7	8	NOT TESTED						NOT TESTED					

Build a 3-way electronic crossover

How to design a 12-dB/octave filter

by NORMAN H. CROWHURST

IN A PREVIOUS ARTICLE I PUT THE matter of electronic vs electrical cross-overs in some perspective, and commented that to date the only way to get a correctly designed 12-dB/octave (or sharper) electronic cross-over is to design and build one yourself (March 1969, R-E).

The basic amplifier circuit around which a 12-dB/octave filter can be built is in Fig. 1. It consists of a central voltage-gain stage and two emitter followers, to provide impedance isolation so performance is not affected by external circuits and their impedances.

The output emitter follower makes the output signal voltage developed by the voltage-gain stage available with a low source impedance, and the base circuit of the input emitter

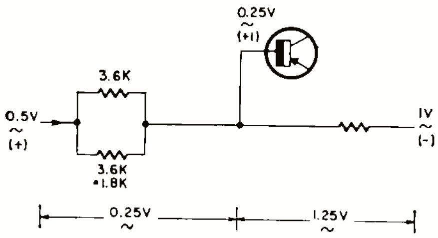
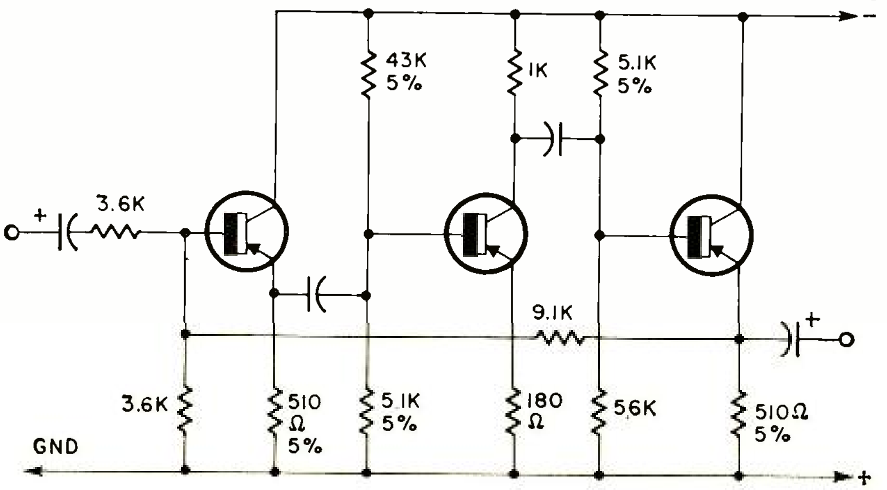


Fig. 1—Basic 12-dB/octave filter (below) uses two emitter followers. Fig. 2 (above)—Voltage relationships that determine feedback resistor value.



follower is fed by a 2:1 voltage divider. There is an additional 2:1 gain loss due to the 6 dB feedback used to sharpen the response to its correct shape.

So the voltage gain of the middle stage should be precisely 4 (12 dB). This will make the output signal voltage the same as the input, from each channel, within that channel's range.

Using a 12-volt supply and transistors with a current gain of about 100 (this is not critical in the circuit chosen) we calculate values. For the output emitter follower, we want the emitter dc voltage to be 6 volts. This allows maximum swing with the 12-volt supply.

Picking 510 ohms as the emitter resistor (assuming a 500-ohm load as minimum external output termination), the dc load at the base will be about 100 times this, or 51K. Using a bias potentiometer of 5.1K and 5.6K will bring the emitter voltage very close to 6-volts on a 12-volt supply.

Now to calculate the base input resistance of the output emitter follower: This consists of 5.1K and 5.6K, along with the reflected impedance of about 51K (with no external load connected) all in parallel. This combination figures to 2.5K. An external load of 500 ohms would reduce the reflected part to about 25K, reducing the combined input impedance to 2.25K, which is not a serious change.

To achieve an in-range gain of 4:1, we assume a collector resistor of 1K and calculate the collector load, which is this 1K paralleled for signal purposes with 2.5K, to make 720 ohms. With this collector load, an emitter resistor of 180 ohms will control the stage voltage gain to 4:1.

To get 6-volts on the collector of this stage, its current must be 6 mA, so the emitter voltage will be 1.08-volts. The 180 ohms will reflect to the base circuit as 18K.

The next step was based on using identical capacitors for controlling turnover in each stage of coupling. For the high-pass filter, the reactance of the coupling capacitor between collector and output emitter follower needs to be 3.5K (2.5K plus 1K) at root-2 times turnover frequency.

The input emitter follower will provide negligible source impedance, so the base input impedance of the voltage-gain stage should be 3.5K also. Trial and error led to the choice of 5.1K and 43K, along with the 18K reflected through the stage from the 180-ohm emitter resistor, which comes very close to the 3.5K desired.

This combination of resistors also controls the emitter voltage to 1.08 volts, and thus collector current to 6 mA and the collector voltage to 6 volts.

The input emitter follower also uses a 510-ohm emitter resistor. Its bias will normally be taken through the feedback resistor. Its input impedance, reflected from the emitter resistor, will be about 51K. Using two 3.6K resistors across the input signal voltage will divide the input voltage in half (before feedback is considered).

Feedback will reduce this signal voltage to one-fourth input and the 4:1 gain will bring the output voltage up to equal the original input signal voltage, as well as reversing its phase.

The source resistance for the input signal voltage of ½, at the base, is the parallel combination of two 3.6K resistors, or 1.8K. The signal voltage will be dropped, when feedback is applied, to ¼, while the feedback resistor will connect back to a signal voltage of 1, reversed phase. (Fig. 2).

So the feedback resistor will have 1.25 times the original input voltage across it, thus needing to be 5 times the impedance that "drops" the 0.25 part. Five times 1.8K is 9K, for which a 9.1K resistor will serve.

Using a blocking capacitor to keep dc out of the input circuit, the bias of the input emitter follower is taken from a 6-volt point (the output emitter) through 9.1K and 3.6K, yielding a working voltage of about 1.7 volts. As the signal level at this point is ¼ the input and output signal level, this voltage provides adequate margin for handling the signal.

The impedance reflected through the input emitter follower will be 1.8K divided by 100, or 18 ohms. And through the output emitter follower, 720 ohms divided by 100, or 7.2 ohms. Thus output loading can have little effect on operation.

Low-pass design

That about sets the picture for the high-pass configuration. For low-pass, we have the collector-circuit parallel impedance calculated at 720 ohms. This is the impedance the shunt capacitor works with. If we use a series resistor in the base circuit to make that also 720 ohms, the same value of shunt capacitor will serve. With the 3.5K in the base circuit, a 910-ohm resistor will bring the shunt combination at the base to 720 ohms. This resistor needs dc blocking, unless the section is bandpass, so the capacitor is needed for the high-pass function.

Thus the completed two-way crossover looks like Fig. 3. To make calculating the capacitors for turnover easier, we will figure them at whatever crossover frequency is chosen.

For high pass, they should be figured at root-2 times crossover, so their reactance will be root-2 times the series-circuit impedance at crossover, or 5K.

For low pass, they should be figured at crossover divided by root-2, so their reactance will be the parallel circuit impedance divided by root-2 at crossover, or 500 ohms,

This makes the figuring very convenient. We have tabulated some values of capacitors for selected crossover frequencies. If you want to make your crossover three-way or more, it is simple to combine the two functions into one circuit for any bandpass channels you use (Fig. 4).

If you plan on making several of these, in varying combinations, it may be worth planning an etched circuit (Fig. 5) that can be wired for low pass, high pass or bandpass. Fig. 6 shows a completed circuit for a three-way crossover, using these circuit boards.

Finally, you may need to know how to check the performance. The first step is to open the feedback loop. This can most simply be done by lifting the 9.1K resistor from the output emitter and connecting a 12K resistor in series with it to the negative supply. Now the unit should show precisely 2:1 gain, and 90° phase shift with zero gain at frequencies that are root-2 times crossover for high pass, and crossover divided by root-2 for low pass.

This 90° phase shift pattern should look like a circle on the scope when horizontal is connected to input and vertical to output with both inputs set to the same sensitivity. This can be set by paralleling them on the input and adjusting to give a 45° straight line. Check this at the appropriate root-2 frequencies. If the result is incorrect, find out where it goes wrong.

To find an error in a high-pass filter, or the high-pass function of a bandpass, use an electrolytic capacitor to bypass one of the turnover capacitors in turn; first one, then the other. Each of these should yield the 45° trace at root-2 times crossover frequency (Fig. 7).

If one of them doesn't, the capacitor has the wrong value and should be corrected. Finally, reconnecting the feedback should give the elliptical

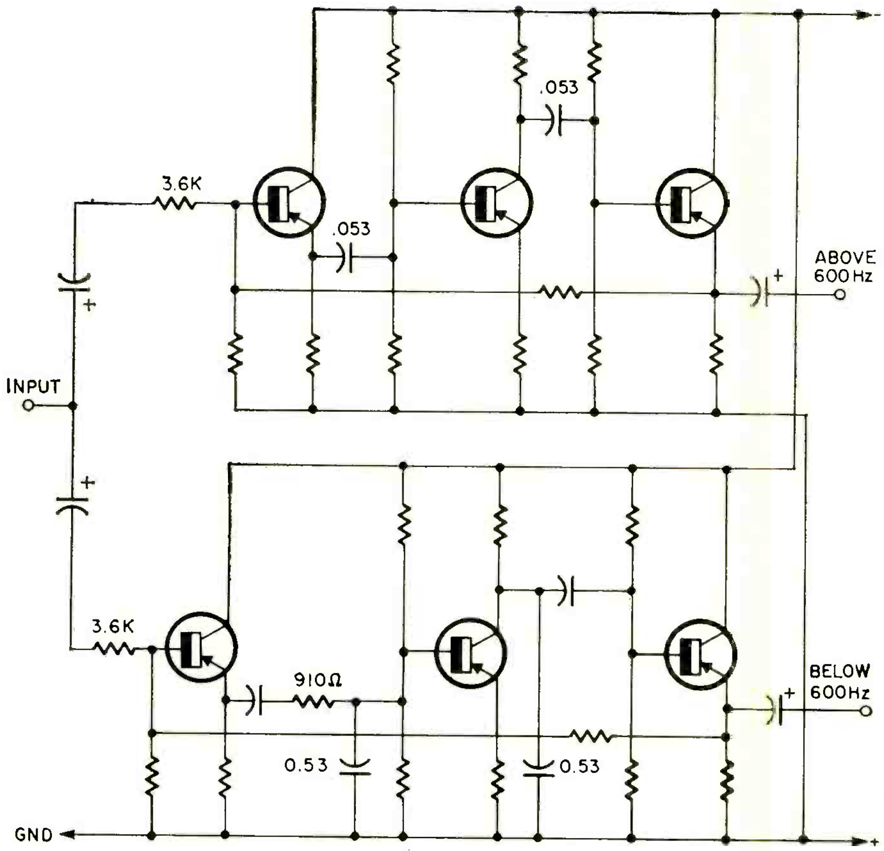
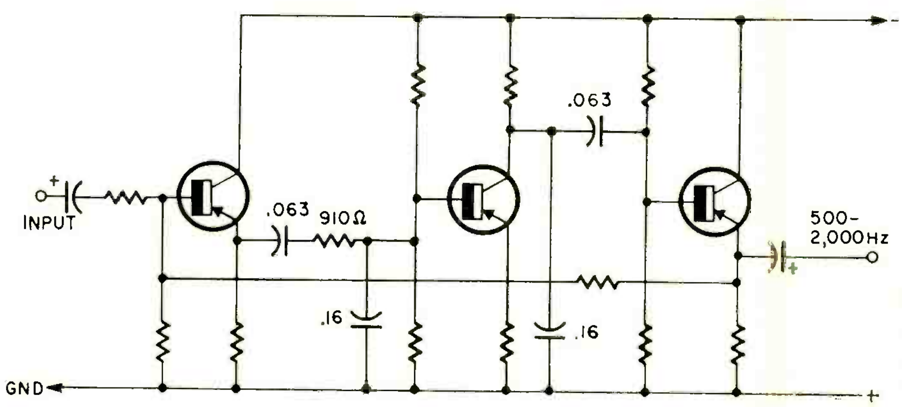


Fig. 3—High- and low-pass circuits alone make a useful 2-way crossover. Fig. 4—Band pass circuit added for a 3-way crossover. See table for values.



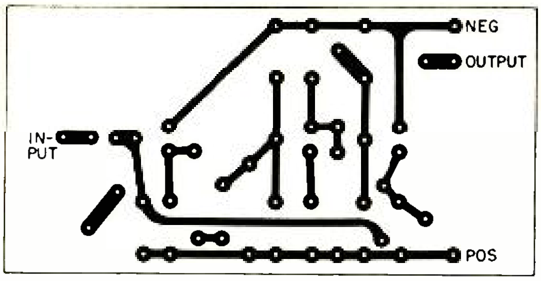
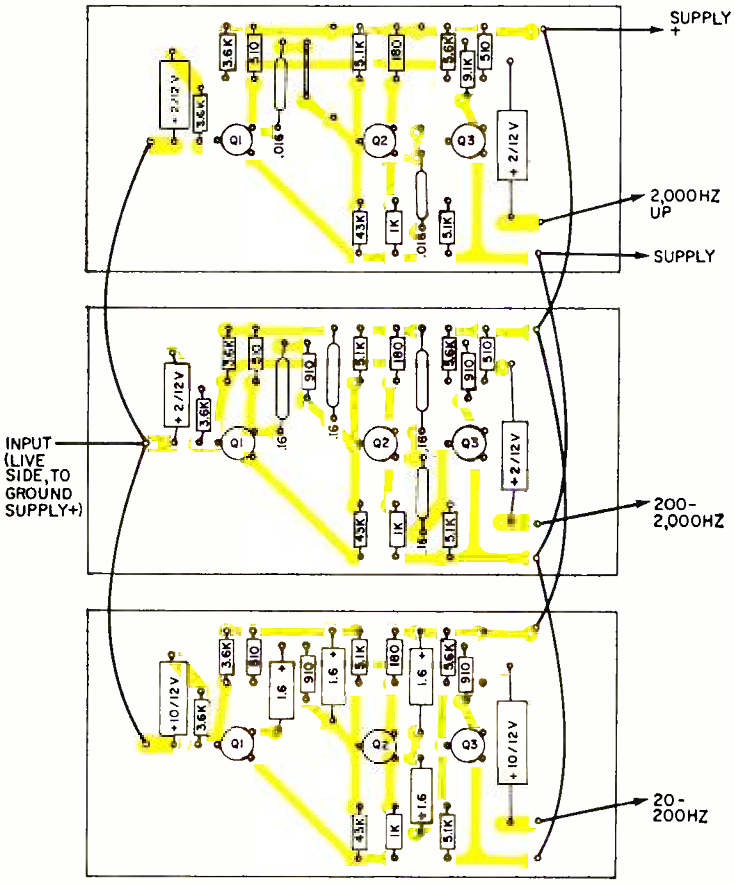


Fig. 5—Copper side of circuit pattern used for crossovers. Actual size of the PC board used is 3 x 6 inches. Draw or enlarge optically. Fig. 6 below shows the completed and wired 3-way crossover. Use table below for crossover values.



trace at crossover, instead of the circle at root-2 times frequency.

To find an error in a low-pass filter, or the low-pass function of a bandpass, merely disconnect one end of the turnover capacitors, each of them in turn. Each of these conditions should yield the 45° trace at crossover divided by root-2. Again, if one of them doesn't, the capacitor remaining in circuit is off value and should be corrected.

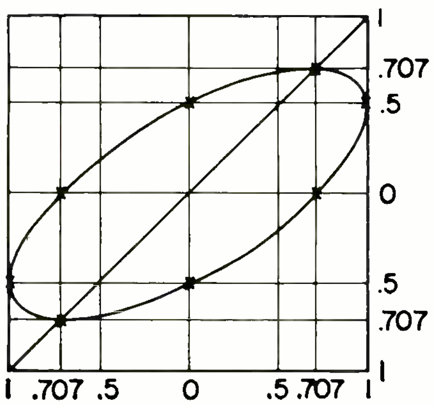
A little practice with this will find it quite simple to do, and the circuits obey the rules nicely.

Almost any pnp transistors will serve in this circuit. If you want to use npn transistors, merely reverse the supply polarity and the polarity of any electrolytics. With pnp, positive supply is also signal ground for input and output. With npn, negative supply is also signal ground.

The lowest low pass can incorporate a rumble filter, if desired, "at no extra cost," by using identical electrolytics with a value to give a 12-dB/octave rolloff at the desired frequency, say 20 Hz (as shown in Fig. 6).

The supply requirement for each unit of the crossover is about 21.5 mA. Thus a two-way crossover requires 43 mA; a three-way, 65 mA. This can easily be obtained from a filament transformer with small diode rectifier(s) and really large electrolytics for final smoothing (Fig. 8). The configuration used depends on the filament supply. You can probably use something from the shelf for this, because nothing is at all critical, except that it needs adequate filtering to avoid hum. **R-E**

Fig. 7—Scope pattern of the 45° phase-shift frequency, identifying 8 points on the ellipse. Here the 45° line is set at a mid-band frequency, and the ellipse should appear at the root-2 frequency. If the 45° line is set by paralleling vertical and horizontal, the ellipse will be twice as high for the same width. Fig. 8—Various power supply circuits: a is a 12V winding, one side grounded, b is 12V winding with center tap grounded (or 6V, one side grounded) and c is 6V with the center tap grounded.



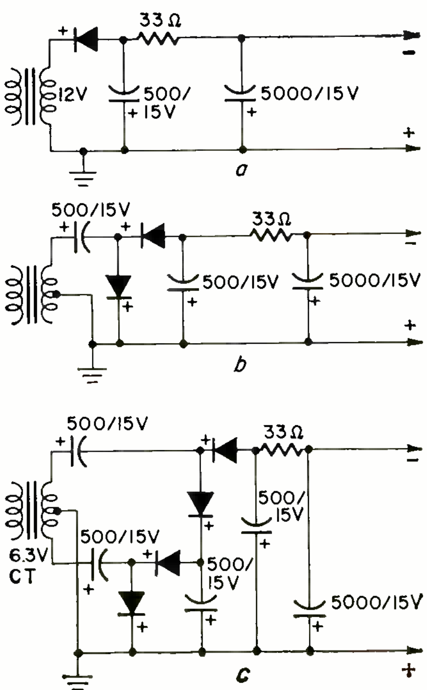


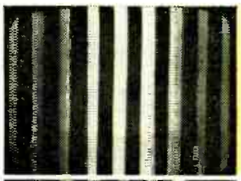
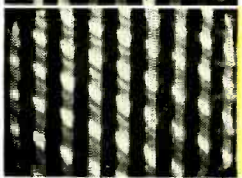
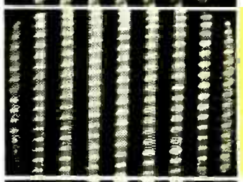
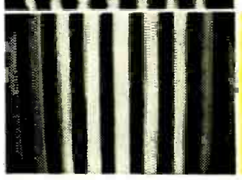
Table of Capacitor Values

Crossover Frequency Hz	Capacitor Values (μF) Low Pass	High Pass
20	16	1.6
25	13	1.3
30	10.5	1.05
40	8	0.8
50	6.3	0.63
60	5.3	0.53
80	4	0.4
100	3.2	0.32
120	2.7	0.27
150	2.1	0.21
200	1.6	0.16
250	1.3	0.13
300	1.05	0.105
400	0.8	0.08
500	0.63	0.063
600	0.53	0.053
800	0.4	0.04
1,000	0.32	0.032
1,200	0.27	0.027
1,500	0.21	0.021
2,000	0.16	0.016
2,500	0.13	0.013
3,000	0.105	0.0105
4,000	0.08	0.008
5,000	0.063	0.0063
6,000	0.053	0.0053
8,000	0.04	0.004
10,000	0.032	0.0032
12,000	0.027	0.0027
15,000	0.021	0.0021
20,000	0.016	0.0016

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
	NORMAL. Color bars show up as different shades of gray in these black-and-white photographs. Red is to the left, blue is in the middle, and green is at the right. As you can see in the photos that follow, color-sync symptoms can be shown this way just as successfully as with color photographs. Just read the descriptions of the symptoms that accompany the screen photographs.			
	Color slightly off sync; bars of color may float.	Screen-pin-6	not much help	C3 leaky
	Color out of sync; tint control narrow in range.	Cathode-pin-2	WF2 WF4	R3 open C2 open
	Color out of sync; tint control has no effect.	not much help	WF3 WF4	C8 open C6 short
	Color far out of sync.	Key-point-A	WF5	T1 faulty
	No color at all, just gray bars.	Grid-pin-1	WF4	R2 low/short C1 leaky/short
	Colors float lazily sideways.	not much help	WF2	C1 open
	Color weak and out of sync.	Grid-pin-1	WF3	C1 slt leaky
	Colors in sync, but wrong colors; tint control has no effect.	not much help	not much help	R6 open/short C6 open

*an Easy-Read™ feature by FOREST H. BELT & Associates © 1969

Use this guide to help you find which key voltage or waveform to check first.

Study the screen and the action of the Tint control. Most-helpful clues to the fault are found at the key test points indicated.

Make voltage or waveform checks as indicated for screen symptoms.

Use the Voltage Guide *and* Waveform Guide *to analyze results.*

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

The Circuit

THIS BURST AMPLIFIER IS DECEPTIVELY SIMPLE. IT'S MERELY a keyed amplifier. The tube is biased past cutoff and blocks video. But keying lets the burst of color-sync signal be amplified. The keying pulse comes from the same flyback winding that keys the agc stage. The input connection is preceded in most receivers by one stage of bandpass amplification. Other versions can be reduced to this basic stage.

Signal Behavior

A complete chroma signal (part of WF2), including color-sync burst, is fed from the first bandpass amplifier to the grid of the burst-amp stage by C1. The signal develops across grid load R1. Positive-going keying pulse WF1 is also fed to the grid of the burst amp. High-value cathode resistor R3 keeps the tube cut off most of the time, so no video or chroma information is amplified. The keying pulse lets the tube amplify, and the color-sync burst appears in the output (WF3).

Transformer T1 is called the *burst transformer*. It's tuned to 3.58 MHz to pass the color-sync burst efficiently. Its tapped secondary couples the burst signal through capacitors C7 and C8 to the phase detector that controls the 3.58-MHz Cw oscillator. Similar capacitors (not shown) couple the same signals to a phase detector for the automatic color control (acc) and color killer stages.

Exact phase of the sync signal applied to the phase detector is controlled by a capacitor-resistor shift network (C6 and R6) across half the secondary winding. The resistor is a potentiometer—the Tint control which lets a viewer adjust hue of the color picture for best flesh tones.

Bypass capacitors in the stage are C2 for the cathode resistor, C5 to bypass R5 and decouple the lower end of the transformer primary, and C3 and C4 for decoupling the screen supply circuit.

DC Distribution

Cutoff bias for the tube is developed by comparatively large-value resistor R3 in the cathode circuit. Plate-supply path is through R5 and T1 from the 375-volt supply line. The screen, fed by well-decoupled R4, is supplied from 260 volts dc.

Dc drops across R4 and R5 are slight, indicating there's not much average current flow. However, there's enough to develop bias across R3 to keep the tube in cutoff except during the keying pulse. Grid return is through R1 to ground.

Signal and Control Effects

With or without station signal, there is little change in dc voltages in the stage. The waveforms change, though. Without a signal, WF2 lacks the chroma and video information that is mixed with the keying pulse there. More noticeable is the missing color sync in all the other waveforms (waveforms without signal are included in the Waveform Guide).

Changing the Tint control position produces amplitude changes that are particularly noticeable in WF4 and WF5, and to a lesser degree in WF3. The Tint control has no effect on dc voltages.

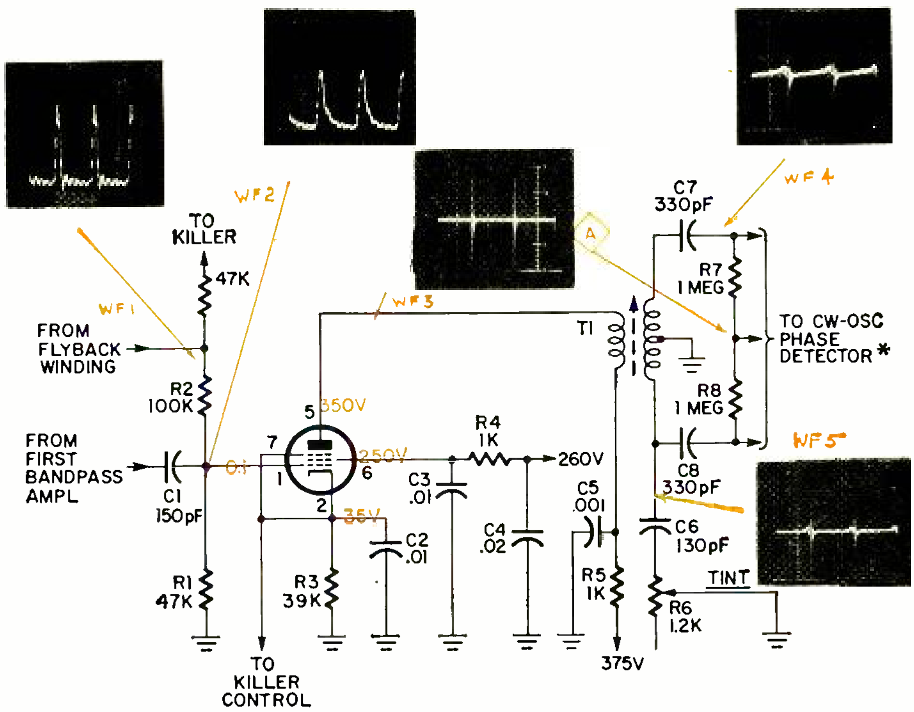
Quick Troubleshooting

The stage must receive both chroma and keying signals. Scoping WF2 (see Waveform Guide) shows if both are there. If so, your best bet is to try adjusting T1, with a low-capacitance scope probe at WF5. The transformer slug should make a noticeable difference in waveform amplitude (you can't see phase change on the scope). If T1 tunes okay, but color sync is still poor, check cathode dc voltage; it's the most revealing.

Hardest trouble to spot here is an open bypass capacitor. They show very nebulous symptoms. Best test is jumpering a good .01-μF capacitor across each one. An open C5 keeps T1 from tuning properly.

An open R3 may confuse you. It doesn't cut the tube off as you might think. The killer control (not shown) completes the cathode return circuit. However, the change in cathode voltage is significant (see Voltage Guide).

Some parts are critical. Replace C1 only with that exact value; otherwise there'll be a drastic change in WF2. C6 must be a silvered mica or other NPO type (not temperature-sensitive). The 330-pF capacitors and the 1-meg resistors should be carefully matched, or they'll unbalance the output circuit. **R-E**



VOLTAGES AND WAVEFORMS TAKEN WITH KEYED-RAINBOW INPUT TO SET.

*SIMILAR CONNECTIONS (CAPACITORS AND RESISTORS) GO FROM OUTPUT OF BURST TRANSFORMER TO ACC/KILLER PHASE DETECTOR

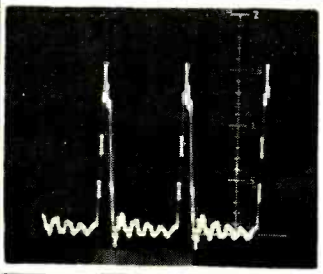
DC VOLTAGES AS GUIDES

Voltage change	to zero	very low	low	slightly low	slightly high	high
Grid-pin-1 Normal 0.2 V	R1 short C1 open R4 open* R5 open* T1 pri open* *or negative	R1 low	R1 low			C1 lky, short
	*Varies slightly with Color control					
Cathode-pin-2 Normal 35 V	C2 short	R1 short/lo C2 open R4 open	R1 slt low	C2 leaky R3 low R4 v high R5 v high T1 pri open	R3 open	R1 open
Plate-pin-5 Normal 350 V	R5 open T1 pri open		R5 high	R4 open C5 leaky		
Screen-pin-6 Normal 250 V			C3 leaky	C4 leaky		

	Slightly negative	Far Negative	Slightly positive	Far positive
Key-point-A Normal Zero to 0.3V	R7 low	T1 sec bot open	R7 open C6 open T1 sec top open	R8 open

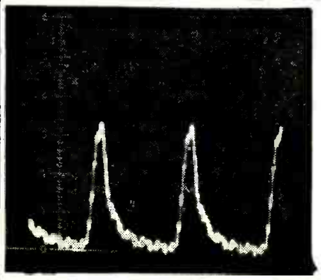
Use this guide to help you pinpoint the faulty part. Measure each of the five key voltages with a vtvm.
For each, move across to the column that describes the change you find.
Notice which parts might cause that change.
Finally, notice which parts are repeated in the combination of changes you find.
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



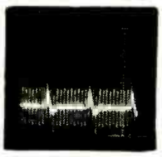
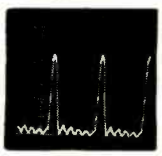
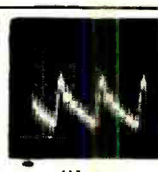
WF1 Normal 160V p-p

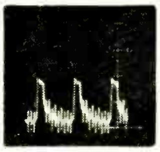
Keying pulses from the flyback transformer. Nothing *within* the burst-amp stage affects the shape or amplitude of this waveform. If the pulse is missing, of course you can tell by scoping this input point. However, you can also tell quite easily from WF2, below. Waveform WF1 is included merely for reference. If it is low in amplitude, the trouble is outside the burst amplifier stage—probably in the flyback transformer.

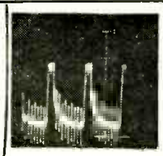


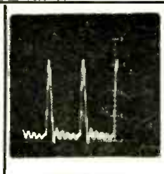
WF2 Normal 30V p-p

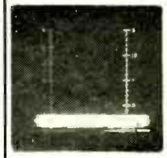
Taken at grid-pin-1 of the burst amplifier tube. The shape comes from mixing the keying signal (WF1) with the video and chroma signals coupled into the stage by C1. If the video/chroma signals are missing, the trouble might be in the stage that precedes C1—usually the first bandpass amplifier. The amplitude of the video (color bars) along the lower part of the waveform varies in height with the strength of the chroma signal, and with the setting of the Color (Color Intensity) control.

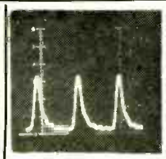
V p-p low	V p-p high	V p-p zero					
R1 low R4 open C1 leaky C2 v leaky			 11V p-p R2 open	 100V p-p R2 low	 45V p-p C1 open	 13V p-p C1 leaky	 4V p-p C1 short

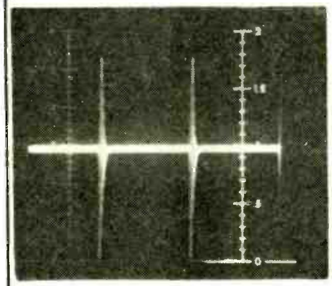

10V p-p
C2 short


15V p-p
R4 open


160V p-p
R2 short


3V p-p
Flyback pulse missing


30V p-p
Station signal missing



WF3 Normal 180V p-p

Output signal from keyed burst amplifier, taken at plate-pin-5. Video has been removed from between pulses. Each pulse contains several cycles of 3.58-MHz color-sync signal, extracted from station (or generator) color signal. The only way to "see" the burst signal spread out is with a triggered-sweep oscilloscope, which few shops own. Amplitude of this signal is affected to some degree by the Tint control setting, due to the loading effect reflected back through the windings of T1.

V p-p low	V p-p high	V p-p zero
R1 high R1 slt low R5 high R6 short C3 leaky C5 open	R6 open	R1 low/short R3 open R4 open R5 open C2 open C6 short


20V p-p
R2 open


70V p-p
R2 low

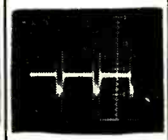

35V p-p
R2 short

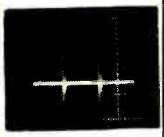

25V p-p
C1 open

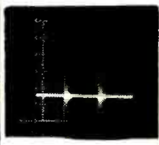

30V p-p
C1 leaky

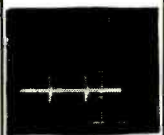

15V p-p
C1 short

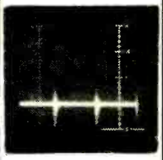

45V p-p
R3 open

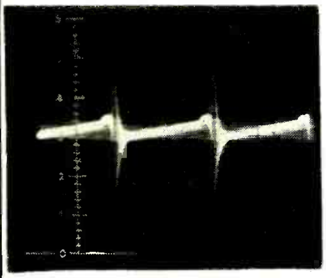

150V p-p
C2 short


90V p-p
C5 open


300V p-p
T1 sec top open


150V p-p
C6 short
C7 open

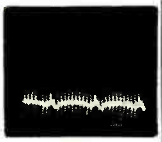

70V p-p
Station signal missing

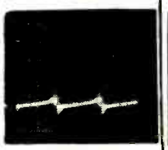


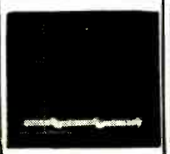
WF4 Normal 55V p-p

Taken past the output of burst transformer T1, after the coupling capacitor that feeds that portion of the signal to the phase detector (which controls the 3.58-MHz cw oscillator). Notice the upward slope of the baseline in the waveform. At the opposite end of the balanced resistor pair, the waveform is a flipped-over duplicate of this one, with downward-slanting baseline. The grounded transformer center-tap makes a phantom ground for the junction between the two balanced resistors. The values of C7 and C8 are critical here, and they must be matched.

V p-p low	V p-p high	V p-p zero
R5 high R7 low		R4 open R5 open C6 short C7 open T1 sec top open T1 pri open

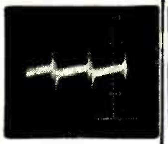

7V p-p
R2 open


30V p-p
R2 low


15V p-p
R2 short

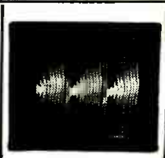

3V p-p
C1 open

WAVEFORMS AS GUIDES



18V p-p
C1 leaky

18V p-p
C1 short



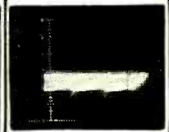
20V p-p
C1 v leaky

15V p-p
R3 open

50V p-p
C2 short

6V p-p
C2 open

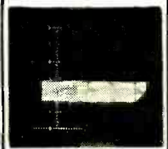
70V p-p
T1 sec
gnd open



25V p-p
T1 sec
bot open

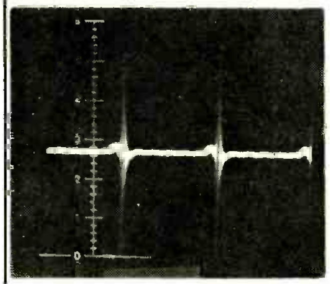
12V p-p
T1 sec
top open

45V p-p
C6 short



30V p-p
C8 open
R8 open
R7 open

30V p-p
Station
signal
missing



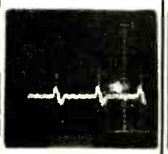
WF5 Normal 55V p-p

Taken directly from the bottom end of the burst-transformer secondary. The baseline is straight, not slanted as in WF4. Capacitor C7 is shaping the baseline of WF4; C8 has no effect on WF5. Tint control R6 affects the amplitude of WF5, the same as it does WF4 (and, to a small degree, WF3). Actually, most of the symptoms that show up in WF5 also show up in WF4. The chief departures from that rule concern faulty parts right around the secondary of burst transformer T1.

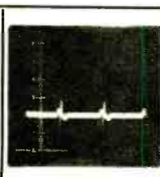
V p-p low	V p-p high	V p-p zero
R5 high R7 low		R4 open R5 open C6 short T1 pri open T1 sec bot open

15V p-p
R2 open

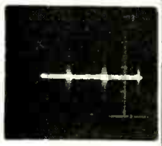
45V p-p
R2 low



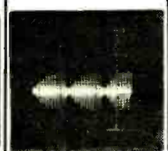
13V p-p
R2 short



3V p-p
C1 open



17V p-p
C1 leaky



18V p-p
C1 v leaky

15V p-p
R3 open

60V p-p
C2 short

25V p-p
T1 sec
gnd open

60V p-p
T1 sec to
open
C8 open
R8 open
R7 open

17V p-p
C1 short

30V p-p
Station
signal
missing

Use this guide and the Voltages Guide *to help you pin down fault possibilities.*
With the low-capacitance *probe of the scope, check the five key waveforms. The scope should be set at H or about 5 kHz, to show three cycles of waveform.*
Note amplitude. If it's low or high, check parts under those descriptions.
Note waveshape. If there's a change, check the parts indicated.
NOTE: Only waveforms that help most with diagnosis are included in this guide (with the exception of WF1).
NOTE: All waveforms in this guide are taken with a keyed-rainbow color-generator signal fed into the receiver at the front end.

. . . . 1970 STEREO

AMPLIFIER SECTION

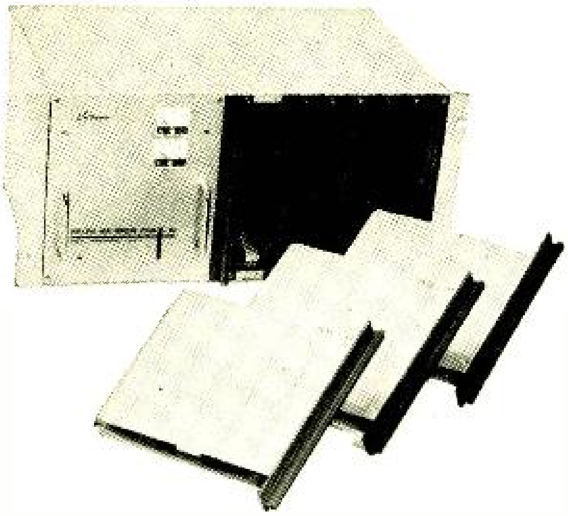
MANUFACTURER	MODEL	OUTPUT PER CHANNEL IHF WATTS @ 8Ω	DISTORTION HARMONIC (IHF) %	DISTORTION INTER-MODULATION (IHF) %	SIGNAL-TO-NOISE LOW-LEVEL INPUT (dB down)	SENSITIVITY MAG. PHONO (mv in)
AUDIO DYNAMICS CORP.	ADC-1000	50	*	0.8	75	2
ALLIED RADIO CORP.	Allied 339	16	1	0.22	65	4
	Allied 369	30	1	2	70	3
	Allied 395	80	1	0.07	79	2.5
	Knight-Kit KG-988	40	1	0.28	40	2.5
BENJAMIN ELECTRONIC SOUND CORP.	1025A	16	0.8	*	80	(internally connected)
	1035	22.5	0.8	*	80	(internally connected)
	1045	30	0.8	*	80	(internally connected)
	1050A	50	0.8	*	85	(internally connected)
BOGEN COMMUNICATIONS DIV. LEAR SIEGLER, INC.	BR 320	25**	0.5	0.7	80	2.5
	BR 340	40**	0.5	0.7	83	3
	BR 360	50**	0.5	0.7	83	3
	DB 240	22.5**	0.5	0.8	80	2.5; 7
EICO	Cortina 3570	35**	0.8	2†	60	4.2
ELECTRO-VOICE, INC. DIV. GULTON INDUSTRIES	EV 1182	42	0.8†	*	−70; −65††	3
	EV 1282	92	0.8†	*	−70; −65††	3
	EV 1382	70	0.3†	*	−80; −65††	2
FISHER	250-T	40	0.5	1†	90	2.5, 7.5
HARMON-KARDON, INC. SUB. JERVIS CORP.	Nocturne 330	70	0.8	0.8	90	*
	Nocturne 820	110	0.5	0.5	90	*
HEATH CO.	AR-14	15	1	1 (60-6000 hz)	60 (phono)	4.5
	AR-15	75	0.5 at 50W	0.5 at 50W	60 (phono)	2.2
	AR-17	7	1	2 (60-6000 hz	(45 phono)	5
	AR-27	7	1	2	(45 phono)	4
JVC NIVICO	5003 M	70		1†	70	1.5
KENWOOD	KR-77	28	<0.5	<0.5†	60	2
KLH RESEARCH & DEVELOPMENT	27	45	0.5	0.5	3μV	3.5 hi; 1.2 low
LAFAYETTE	LR-1000T	43	<1†	0.4†	*	2.2
McINTOSH	MAC-1700	40	<0.25†	<0.2†	75	2.4
MARANTZ CO., INC.	18	60	0.2 max.†	0.2 max.	74	1
	22	60	0.3†	0.3†	65	2
	25	45	0.3†	0.3†	52	2
	26	21	1†	1†	50	2
OLSON ELECTRONICS	RA 22	55	0.8†	*	57	3
	RA 90	15	<2	*	50	3
	RA 999	75	<1	1	55	3
PIONEER	SX-1500T	85	<1	0.5	65	2.5
RADIO SHACK DIV. TANDY CORP.	STA-35B	18	1	1	60	3
	STA-65B	36	1	1	60	4
	STA-120	70	0.5	0.5	65	2; 5 at 65 s/n
SANSUI ELECTRONICS CORP.	350	23	1	1	*	2.2
	2000	48	0.8	0.8	*	2.2
	4000	60	0.8	0.8	*	2.5
	5000	70	0.8	0.8	80	2.5
SCOTT, H. H.	342C	45**	<0.8	<0.3	65	3, 6
	386	67.5**	<0.8	<0.3	65	3, 6
	LR-88	40	<0.6	<0.3	65	4, 7
SHERWOOD ELECTRONIC LABORATORIES, INC.	SEL 200	140	0.2	0.3	90	1.5
	S7600a & S8600a	80	0.15	0.2	80	1.4
	S7800a & S8800a	120	0.35	0.6	65	1.6
SONY CORP. OF AMERICA	STR-6060	55	—	0.2†	100	2.3

* = Not specified by mfr.; or not available. ** = At 4Ω. † = At or below rated power. †† = Auxiliary input. ‡ = Steep quiting slope.

RECEIVER ROUNDUP

CHANNEL SEPARATION (dB)	BASS & TREBLE CONTROLS	LOUDNESS CONTROL	PAIRS OF INPUTS	FM TUNER SECTION					
				SENSI-TIVITY (IHF) (μV)	SELEC-TIVITY (IHF) (dB)	SEPARATION (dB)	CAPTURE RATIO (dB)	SIGNAL-TO-NOISE RATIO (dB)	PRICE
35	ganged	*	*	2.0	*	35	3	*	$289.50
25	ganged	control	4	2.5	20	25	7	56	149.95
35 at 10 Khz	separate	switch	5	2	35	25 at 1 Khz	2	56	189.95
45	separate	switch	7	1.6	*	38	2	69	299.95
45	separate	switch	5	3	28	30	3.5	45	179.95
*	separate	separate switch	1	3	*	27	*	65	299.50
*	separate	separate switch	*	3	*	28	*	65	349.50
*	separate	separate switch	1	3	*	28	*	65	449.50
*	separate	separate switch	2	2.7	*	30	*	70	599.50
40	ganged	switch	3	2.7	60	35	1.9	70 at 30 μV	249.95
40	ganged	switch	3	2.7	60	35	1.9	70 at 30 μV	279.95
40	ganged	switch	3	2.7	60	35	1.9	70 at 30 μV	339.95
40	ganged	switch	1	2.5	55	35	2.5	65	*
50	ganged	switch	4	2.4	45	40	4.5	60	259.95
40	ganged	"built in"	3	2.5	*	35	2	*	222
40	ganged	switch	3	2	*	35	2	*	266
60	separate	switch	5	2.5	*	30	*	*	*
*	ganged	switch	*	2	45	38	2.8	65	299.95
*	ganged	switch	6	2.7	*	30	2	*	199.95
*	ganged	switch	8	1.8	*	32	1.5	*	299.95
45	ganged	(none)	2	5	*	30	3	50	114.95K
45	ganged	switch	5	1.8	70	40 at mid freq.	1.5	65	339.95K
40	ganged	(none)	2	5	*	30 at 1 Khz	3	50	69.95K
*	*	(none)	2	5	*	*	3	50	39.95K
*	ganged(a)	switch	4	1.8	*	35 at 1 Khz	2	60	349.95
	separate	switch	4	1.9	45	35 at 1 Khz	2.5	60	239.95
*	ganged	switch	3 (+ tape)	1.9	3.5	35 at 1 Khz	3	55	319.95
*	separate	switch	8	1.6	*	45 at mid. freq.	1.5	71	239.95
*	separate	switch	5	<2.5(b)		>30	>2	>65	599
50	separate	(none)	6	‡	50	45 at 1 Khz	2.5	70 at 50 μV	695.00
47	separate	switch	7	2.4‡	80	40	2.5	65	425.00
42	ganged	switch	4	2.8	40	35	3	52	329.00
35	ganged	switch	4	3	*	30	3	57	199.00
50	ganged	switch	6	1.5	*	>30	2.8	55	200.00
42	ganged	"compensated"	2	3	*	>28	4.5	48	100.00
50	ganged	switch	4	1.5	*	>30	2	65	*
*	ganged	separate	*	1.7	*	37	1	65	360
*	ganged	(none)	2	3	35	25 at 1 Khz	8.5	45	119.95
*	ganged	switch	3	2.5	35	30	4	65	189.95
*	ganged	switch	3	2	50	35	1.5	65	269.95
40	ganged	switch	6	3	45	30	3	50	199.95
<50	separate	switch	10	1.8	50	35	2.5	65	299.95
<50	ganged	switch	12	1.8	40	35	1	60	379.95
<50	ganged	switch	11	1.8	50	35	1.5	65	449.95
50	ganged	switch	4	1.9	40	40	2.5	65	269.95
50	ganged	switch	4	1.9	40	40	2.5	65	349.95
50	ganged	switch	4	1.9	46	40	2.2	65	299.95
55	ganged	control	4	1.5	70	45	1.7	70	599
40	ganged	switch	2	1.8	55	40 at 1 Khz	2	70	359,319
55	ganged	switch	3	1.8	55	40	2	70	439,399
*	ganged	—	—	1.8	—	40	1.5	—	399.50

a = 5-band freq. control. b = 100% mod.



Rack-mounted A301 uses 4 plug-in PC cards for bands in identical stereo channels.

THE DOLBY

Taking the hiss from

Rapidly gaining acceptance by major recording companies, through 10 dB. Although you need a 'black box' to hear a

by WALTER G. SALM

THERE'S AN EVER-PRESENT ANNOYANCE with tape recordings. It's called tape noise. It takes various forms, with hiss being the most readily apparent to the listener. The other noises are tape recorder rumble and scrape, and that ever-present gremlin, print-through.

These noises occur at the tape recorder as the recording is being made—or in the case of print-through, after the tape is made. The noise isn't present in the signal coming to the tape equipment from the mixing console; up to that point, the signal's nice and clean.

Various methods have been tried to eliminate noise, hiss in particular —exotic filtering systems, compression or expansion amplifiers, and a variety of related devices. Manufacturers frequently announce a "totally new" noise-reduction system. Most of these systems work up to a point, but many inject "swishing" noises into the recording because of the compressor amplifier's relatively slow attack time. It can't react fast enough to the rapidly changing audio dynamics of the input.

Low-passage noise

Where are these tape noises most noticeable? You don't need a cram course in audio to know—it's always in the low-level music passages. In the loud sections of a recording, there are plenty of desirable decibels to mask any intruding noise, but hit that *pianissimo* section and suddenly the hiss comes storming through, along with print, scrape and rumble. If the intrusive noise could be drastically reduced in these low passages, so the reasoning goes, then the overall noise level would be reduced.

Working on this premise, Dr. Ray Dolby developed his A301 noise-reduction system, and started manufacturing it in England a couple of years ago. This system is inserted in the signal path between the console and the tape equipment during the taping session. During playback, the tape's signal must pass through the A301 again on its way to the amplifier. A Dolbyized tape cannot be played back without the benefit of reprocessing by the A301.

The A301 itself is actually a dual unit—two systems for two-channel stereo. The same stereo unit that's used for recording can be used for playback, simply by changing the connectors and flipping switches. The basic A301 is tagged at $1495, so it's not a toy that the casual home recording enthusiast can buy for his amusement. Tape-to-tape dubs do not require further Dolbyized (as long as tape-to-tape equalization remains the same).

The overall effect is to reduce hiss and other noise factors by 10 to 15 dB! A listening test demonstrates its effectiveness graphically. A–B comparison with and without the A301 in the system makes one thing immediately apparent—with the Dolby, there's absolutely no discernible hiss, not one little bit of it.

As a starting point, the Dolby system divides the audio spectrum into four frequency bands: 0—80 Hz, 80–3000 Hz, 3–9 kHz and 9 kHz to the upper limit of the audio spectrum. Crossover transitions between these bands are exceptionally smooth, with no measurable discontinuities or attenuation.

In the process of making a recording, low-level signals are boosted before reaching the tape recorder and compressed by an identical amount in playback. The expansion/compression moves the low-level signal up at least 10 dB. This 10-dB edge over intrusive noise is maintained during expansion. The net result is that noise level is at least 10 dB lower than without the Dolby process.

In his description to the Audio Engineering Society in 1967, Dolby characterized the basic elements of his black box as shown in Fig. 1. G_1 and G_2 are identical signal multipliers controlled by the signal's amplitude, frequency and dynamic properties. During recording, network G_1 passes low-level signals to the adder, which adds a component (signal expansion) to the signal on its way to the recorder. During playback, G_2 passes low-level components to the subtractor, which partially cancels these noise elements in the signal. G_2 also partially cancels low-level (desirable) signal components, thus offsetting (compressing) the signal that had been partially expanded through G_1's action.

Mathematically, Dolby explains that if the input to the recording processor is x (some function of time), the signal in the channel is y, and

SYSTEM–
How It Works

A tape deck using one Dolby frequency band to cut tape hiss is manufactured by KLH.

hi-fi tape recording

the Dolby system cuts tape hiss 10–15 dB and reduces print- Dolbyized tape, prerecorded tapes are sounding better than ever.

the output signal from the reproducing processor is z, the condition is described as:

$$y = [1 + G_1(x)]\,x \qquad (1)$$

and

$$z = y - zG_2(z) \text{ or}$$

$$z = \left\{ 1/[1 + G_2(z)] \right\} y \qquad (2)$$

Combining equations (1) and (2):

$$z = \left\{ [1 + G_1(x)]/[1 + G_2(z)] \right\} x. \quad (3)$$

Solving these equations, $G_1 = G_2$ and $z = x$. These solutions show that the output signal will equal the input signal if G_1 and G_2 are the same, provided G(z) does not become −1 (no oscillation) and the functions in (1) and (2) are continuous and single-valued—in other words, no tracking ambiguity.

It looks fine on paper, and the proof of the math is in the listening: it works. In fact, it works so well that, in A–B tests, the listener can't help but wonder if someone hasn't jacked up the hiss level in the unprocessed tape—the difference is that marked and apparent. But no, there's been no monkeying with the tape—just the normal amount of dubbing and processing.

Recording companies Dolbyize

First to recognize the value of this new system have been the major recording companies. Since every recording—tape and disc—must first go through several generations of tape dubs, eliminating the noise that creeps into these transfers and mixes makes the final, non-Dolbyized product that much cleaner.

True, the prerecorded tape purchased by the consumer has its own hiss and other noises, but *all the preceding noise* in the production chain has been eliminated. Thus, instead of a noise level as high as 10 to 14 dB, the finished product may have a noise level of only 3 dB—a more-than-tolerable level. Tapes commercially produced this way sound so good, in fact, that duplicators such as Ampex have started touting their remarkably noise-free quality. Although discs have had very low noise levels for some years, those pressed from Dolbyized master tapes sound notably quieter and cleaner.

But it's no simple matter for a recording company to Dolbyize. First, there's the very limited production of A301's. Ray Dolby has a baker's dozen technicians in his London shop lovingly hand-crafting his A301's with a Rolls-Royce kind of zeal and perfectionism. Total production capacity now is about 25 units per month, and a large recording company may require at least that many units to handle its manifold operations.

Dolby won't be hurried. He's a perfectionist, and he sees this perfectionism as part of his stock in trade. A brilliant designer, he was largely responsible for the development of the electronic circuitry for the original Ampex video tape recorders while he was still a teenage undergraduate at Stanford University. He received a PhD in physics from Cambridge in 1961.

Dolby at popular prices

The price picture isn't all that gloomy. There's one way the home recording enthusiast can get his feet wet with the Dolby system. It's called the KLH recorder. This is KLH's first entry in the tape field, and it's a lulu. In addition to a host of professional-caliber specs, the deck has a built-in Dolby system—and all for \$600. [A recently introduced KLH Dolby tape deck sells for less than half this price.]

Actually, it's not a full-blown Dolby. The machine just uses the third frequency band since this is where most hiss occurs. The KLH Dolby produces tapes recorded at 3¾ ips with no higher noise level than

(*continued on page 58*)

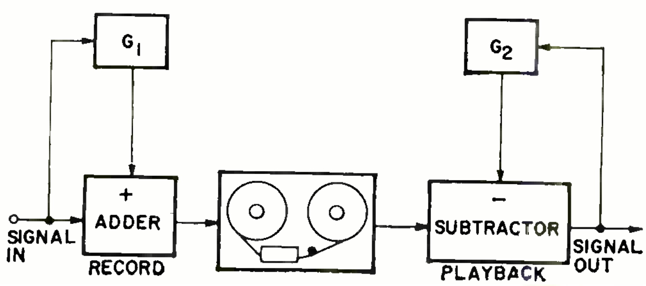
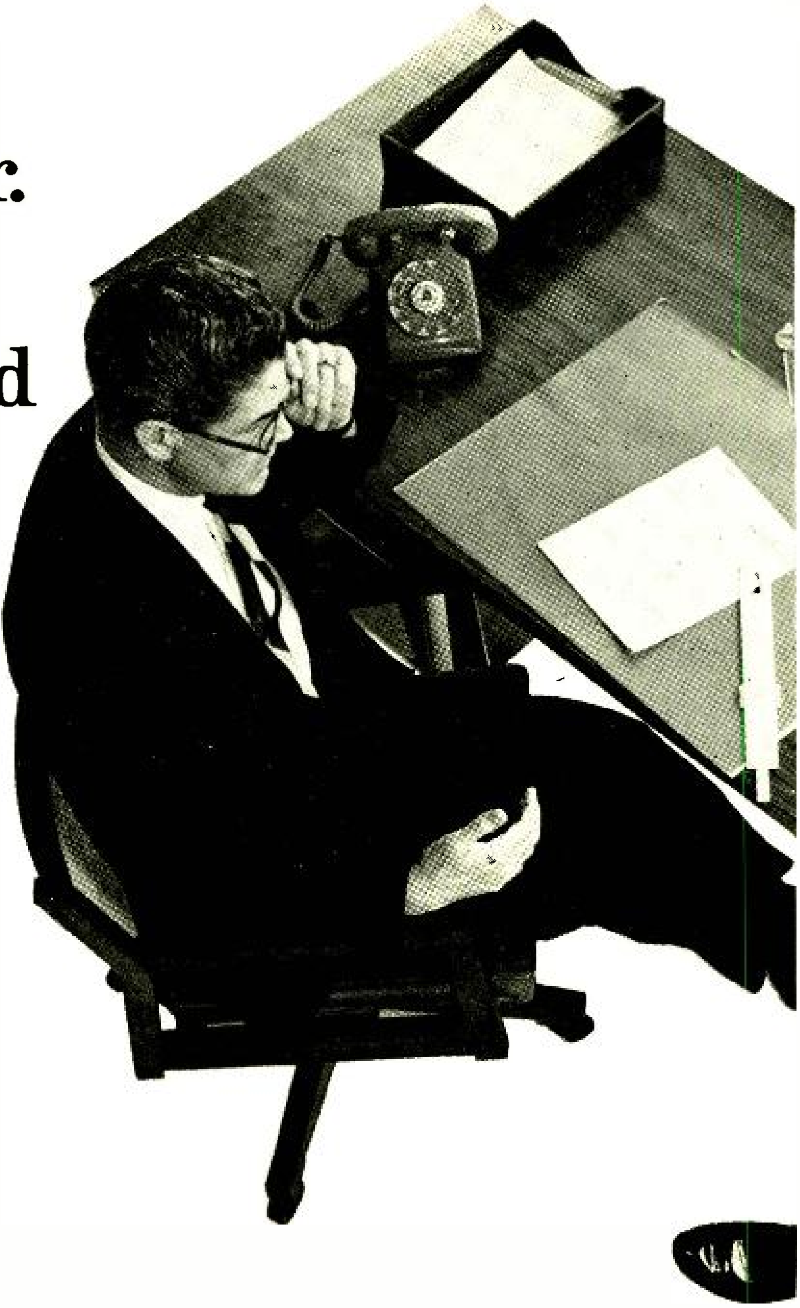


Fig. 1—System's feed-back loops provide necessary expansion and compression to override background noise.

"He's a good worker. I'd promote him right now if he had more education in electronics."



Could they be talking about you?

You'll miss a lot of opportunities if you try to get along in the electronics industry without an advanced education. Many doors will be closed to you, and no amount of hard work will open them.

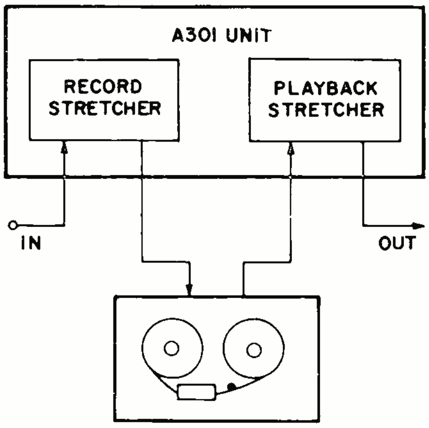
But you can build a rewarding career if you supplement your experience with specialized knowledge of one of the key areas of electronics. As a specialist, you will enjoy security, excellent pay, and the kind of future you want for yourself and your family.

Going back to school isn't easy for a man with a full-time job and family obligations. But CREI Home Study Programs make it possible for you to get the additional education you need without attending classes. You study at home, at your own pace, on your own schedule. You study with the assurance that what you learn can be applied to the job immediately.

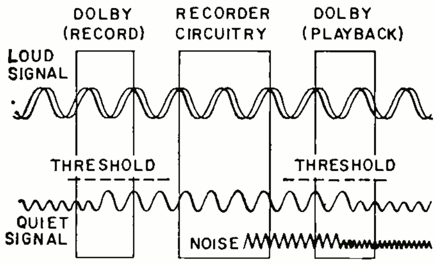
CREI Programs cover all important areas of electronics including communications, radar and sonar, even missile and spacecraft guidance. You're sure to find a program that fits your career objectives.

tapes recorded at 15 ips without Dolby treatment.

The KLH Dolby does a dandy job of killing hiss, and could be a very worthwhile investment for the serious recording hobbyist who wants to maintain the best possible quality in his home recordings. But what happens when he wants to dub and maintain noise free tapes? Buy two KLH recorders? This might be what the Cambridge whiz-kids had in mind, especially since they have an exclusive license to use the Dolby circuit for manufacturing in the US.



Identical A301 halves can serve for stereo or a record-playback monitor.



A301 boosts low-level audio before recording, compressing it in playback.

The system's noncompatibility

The Dolby system isn't a panacea. It can't clean up already recorded tapes. Its function is to process the sound going onto the tape. and then to reprocess it as it leaves the tape. It just won't clean up noise already indelibly etched in those oxide particles.

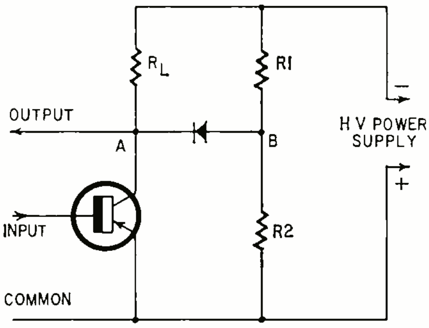
Another problem: in today's ever-expanding tape channel capabilities, the A301's price and relative unavailability makes it impossible to use with the 8- and 16-channel audio mastering that is becoming more and more popular. This might involve having as many as 16 units in a single recording studio control room for making just one master tape. Fortunately, such multitrack originals are mostly used for "Acid" rock and other popular sounds which don't make very critical demands so far as recorded noise levels are concerned. It's in the realm of the serious recording—which is usually taped in old-fashioned, two-channel stereo—that the Dolby system can really come into its own.

Another problematical restriction: Dolbyized tapes simply can't be played back on an ordinary tape system. The A301 must be in there to expand in the right places. Without it, the dynamics and recorded sound in general will come out sounding pretty weird. But in this era of electronic music and all of its strangeness to our more conventional ears, this may well open the door to a new avenue of experimentation with electronically generated musical effects. The engineer (or musician?) may play with a console that controls the amount of Dolby expansion to be imposed on a Dolbyized tape master.

And what about that A301? It's just a black box with some connectors on it. No knobs to twiddle; no meters to watch; no circuit failures to keep the service techs out of mischief. It's downright maddening! No knobs; really, Dr. Dolby! **R-E**

HIGH-VOLTAGE PROTECTION FOR TRANSISTORS

When operating a transistor with a high-value collector load resistor, a power supply of 100 volts or more may be needed. This is OK as long as sufficient collector current flows to keep the collector-to-emitter voltage below the maximum rating.



The schematic shows a method of preventing this catastrophe. The bleeder current through R1 and R2 should be about ten times the normal collector current through the load resistor, R_L. The voltage between point "B" and the positive terminal of the power supply must be below the transistor's maximum collector-voltage rating. The transistor's base bias may then be set to make the collector-to-emitter voltage about one-half this value. Under this condition, the diode is back-biased, and its resistance is so high as to have little effect on circuit operation. Should the transistor's base current go too far positive, the collector voltage rises until voltage at point "A" is equal to the voltage at point "B" (plus the diode's forward voltage drop). The diode conducts, the voltage at point "A" goes no higher. The transistor is protected. Reverse diode and power supply polarities for rpn transistors.—*Frank H. Tooker* **R-E**

TOOLS FOR ELECTRONICS

This issue, starting on the facing page, is the second part of our new series of articles on tools for electronics. It winds up our description of pliers and cutters. Next month we will continue the series with the first part of an article on screwdrivers and how to use them. 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, South Hauppauge, N. Y.

Specialized pliers

Surgeons use **hemostats** to clamp veins and arteries during an operation. Someone recognized the usefulness of such a tool, and developed the electronic version called **clamping pliers,** shown in Fig. 15.

Fig. 15—Hemostats can and are used outside of the operating room. Try these clamping pliers as a handy third hand. The Jonard model M-100-S is shown.

They have finger loops at the handle ends and very small, thin, serrated, needle-nose jaws. Their chief feature is a locking ratchet between the handles, which locks the jaws closed. To operate them, you simply grasp the work in the jaws, squeeze the handles until they lock, and let go. The jaws are then locked on the work. To unlock them, you squeeze and pull the handles slightly sideways. One of the most useful tasks for clamping pliers is as a heat sink when soldering semiconductor diodes, transistors, and small resistors. You can lock the pliers in place on the component lead, freeing both hands for the soldering gun (or iron) and solder. Clamping pliers are usually made in 5″ or 6″ sizes. Some models are available with bent jaws, for angle work. These pliers have almost no compressive or bending strength, and should be used only for picking up, holding, or clamping the work.

A somewhat similar device is shown in Fig. 16. This unit is actually an aluminum clamping pliers with a coiled spring between the handles

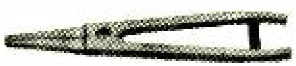


Fig. 16—Channellock's Heatsorb Clamp is another approach. This aluminum unit is ideal for heat-sinking transistor leads while soldering them into a circuit.

which provides the clamping action.

There are a number of very specialized pliers which are nearly unique, having been developed for specific jobs. One is shown here; a

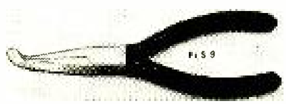


Fig. 17—Bent-nose duckbill pliers is especially suited for relay adjustments. It can also be used on other industrial and communications gear. Jonard PLS-9 is shown.

Another specialized plier is illustrated in Fig. 20. it is very

Fig. 20—The Lock-Griplier by X-Acto is very useful for picking up and holding small parts. As it can be locked to clamp a part in place it too acts as that extra "third hand" when you need one most.

useful for picking up and positioning small parts, and it can be locked to clamp the work and free both hands. Notches in the jaws permit wire stripping.

Of course, there are still other specialized plier features. You can get extra-long handles, tapered jaws, and various combinations of features. What we've covered here are the most common features used in servicing and hobby electronics.

Cutting pliers

Much like ordinary pliers, **cutting pliers** have handles, a joint, and jaws. They differ in that the jaws are shaped to sharp edges, and are used solely for cutting. The most common type is called **diagonal cutters,** or **dikes,** as the cutting edges form a diagonal from the plane of the handles (Fig. 21). As mentioned before, side cutters are straight

Fig. 21—Diagonal cutters are probably the most common type of cutting pliers and should be used only as cutters. At the left is the Vigor PL-506. At the right is the Allied Radio 26F2906, which has insulated handles.

with respect to the handles, and are an accessory to standard pliers. Both types are different from scissors or shears, as the cutting edges meet and stop, instead of passing one another. Also, it is not necessary for the edges to be as sharp as those of scissors, as the cutting is accomplished more by sheer pressure than by fine edges.

Job application has a great deal to do with cutter size. Three general sizes are available to cope with various jobs: A small pair (4″ long) bent-nose duckbill plier, which is useful when adjusting relays, stepping switches, and other industrial and communications equipment (Fig. 17).

Installing and replacing flat-pack IC's can be troublesome—unless you have the right tool. Special pliers for pulling IC's are the only right tool (Fig. 18). Teeth extend from its blunt-nose jaws, slip in between the

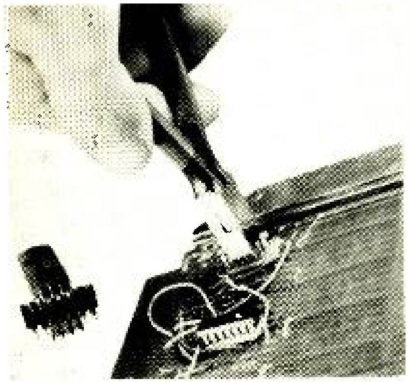


Fig. 18—Getting IC's in and out of sockets can be difficult. But if you use the right tool it's no trouble at all. Techni-Tool's IC Flat-Pack Plier is specially designed to pull IC's without damaging their sensitive pins or placing undue strain on the IC itself.

leads of the IC and grasp the body securely.

A useful, multipurpose tool is the unusual wrench in Fig. **19.**

Fig. 19—Plierench is a combination of a pliers and wrench in a convenient hand-held unit. A group of interchangeable jaws complete this Vaco tool.

The jaws remain parallel in all positions, so you can use the tool on nuts and bolt heads. There's a half-round indent in each jaw, enabling you to grip round or hex objects. The jaws are smooth and won't mark the work. Compression is multiplied at the fulcrum and the jaws have great gripping power. Accessory jaws are available which extend this tool's usefulness—a medium-sized pipe-wrench jaw, a large pipe-wrench jaw, and an internal-external jaw which can grip the inside or outside of a pipe or metal tube.

is useful for printed-circuit and transistor work, where you find fine wire and tight quarters. Most technicians have medium-sized dikes (5" or 6" long); these are general-purpose types, and obviously the most useful for most standard-size chassis work. Large cutters (7" or 8" long) are also made; they can handle heavy bus bar, or even be used to cut a piece of a thin metal chassis. Of course, the smaller models are most useful in small work, and their strength is limited; the larger tools have strength for large jobs, but can't be used in restricted spaces. It's poor workmanship to cut work too large for the cutters, as you'll nick or dull the cutter edges. You cannot file or dress the cutting edges very much, as they'll be worn to the point of handle contact, which is the limiting factor.

Small and medium cutters should only be used for snipping soft copper wire, up to and including about No. 18. For heavier wire, such as No. 14 and No. 12 power lines and antenna wire, use large cutters or side-cutting lineman's pliers. For hard steel or nickel wire, use **high-hardness cutters** (Fig. 22). These types have carbide cutting edges.

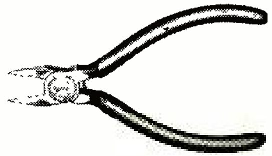


Fig. 22—High-hardness cutters are a must for trimming wire made of hard steel or nickel. Standard cutter edges cannot handle these materials. The Klein model 230D shown here has special carbide cutting edges to take care of this job.

There are several variations on the cutters described so far. Dikes and side cutters are parallel cutters—the edges cut all the way up and down the jaw at the same time. A variation is called **tip** or **nose cutters,**

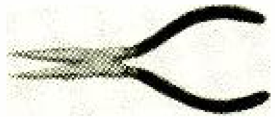


Fig. 23—Tip or nose cutters have cutting edges only at the top end of the tip. You'll find them most useful where you want to clip a wire located deep down in a cluttered chassis. The unit shown is a Boker Model 539-6. The insulation on the handles gives the user a firmer as well as a safer grip.

which bite only near the jaw tips (Fig. 23). These pliers are useful for snipping wire in crowded spaces.

Cutter edges are made in many styles. Regular edges are bevelled, and are used for most jobs, including hard wire. They leave a point on the wire end. **Semi-flush edges** leave a small point. **Full-flush edges** may be used only on soft wire; they leave no points on the wire, clipping instead straight across.

There are also variations in the shape of cutter jaws. Standard diagonals have rounded jaws, as you've seen so far. For fine work in confined spaces, the shape shown in Fig. 24 is used; it's called variously

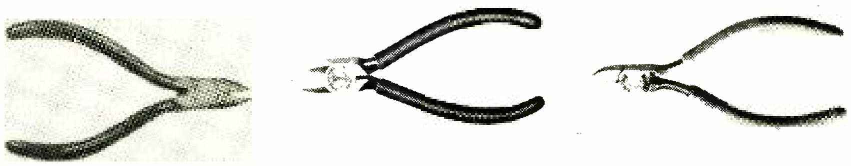


Fig. 24—Diagonal cutters come with a variety of jaw shapes. Standard units have rounded jaws, but needlepoint, thin-nose and tapered-nose tips for special applications are also available. Three kinds of pliers with various jaw types are available. At the left is the Xcelite 74CG a needle nose type. The Klein D257-4 in the middle has semi-flush cutter jaws as does the Hunter 97-B at the right.

needle point, pointed nose, thin nose, and **tapered nose.**

If you use a conventional pair of dikes to snip off a wire end, it can flip into your eye or face, or fall into a chassis. To overcome this disadvantage, two methods of wire retention have been developed.

Some cutting pliers have **plastic inserts** in the jaws (Fig. 25).

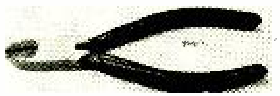


Fig. 25—Plastic inserts for the plier jaws grip the end of the wire you just cut, preventing the loose ends from shooting off and possibly injuring some other persons nearby. The inserts release the wire when the jaws are opened.

When you clip off the end of a wire, the plastic grips the end. Other cutters have steel springs between the jaws, which do the same job

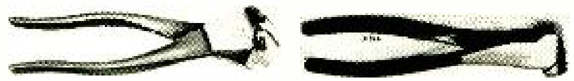


Fig. 29—Heavy-duty end nippers have wide blunt jaws and are set up so the cutting edges are near the joint to provide great cutting power. At the left is the Klein model 232-8. The Jonard 992-8 is on the right.

are near the joint, which provides for great cutting strength. Some of these cutters have angled cutting edges.

Another useful variation found on some cutters is the wire-stripping

Fig. 30—Wire-stripping cutters can be identified by the notch in their cutting blades. Two units are shown here. The Klein D240-6 (left) and Crescent 932-6 (right).

hole (or notch) shown in Fig. 30. With the hole, you can strip insulation; with the rest of the jaw edges, you can cut wire.

General notes on pliers

Plastic handle grips (Fig. 31) are available on nearly all pliers and cutters; some manufacturers furnish the grips installed, while others have them available as accessories. Grips are advantageous for two reasons: First, they make the tool more comfortable and easier to use, which reduces fatigue and increases efficiency. It is possible to get a more secure grip on plastic than on steel, thus minimizing the danger

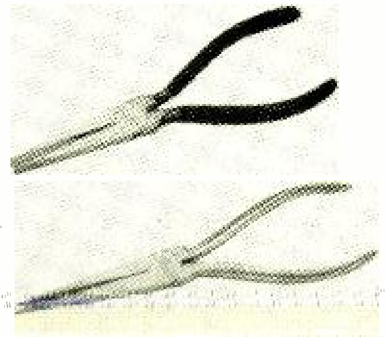


Fig. 31—Plastic grips are a plus in almost all cases. However, don't assume that the handles are insulated merely because you see plastic grips. Not all grips provide the same level of electrical protection. Most reliable manufacturers use grips that are excellent electrical insulators. But check to make sure before you poke around in voltage carrying circuits.

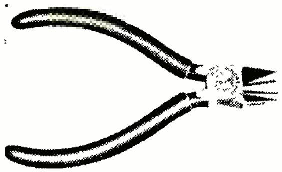


Fig. 26—Steel springs between the jaws of the cutting pliers can also hold the loose end of a wire being cut. When you release the handle the springs let the wire go. Tool shown is the Klein model D229.

(Fig. 26). In each case, when you open the handles, the wire end is released.

Ordinary cutting pliers produce a slight shock when the cutting edges meet. This shock can damage certain miniature diodes, transistors, and IC's. To prevent such shock, **shear-type cutters** have been developed. As shown in Fig. 27, the cutting edges pass one another, like scissors.

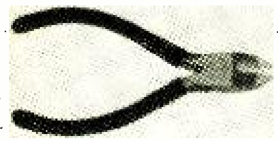


Fig. 27—Shear type cutters, like the Klein model D-207-SC shown here, are specially built to reduce the cutting shock that can damage supersensitive miniature diodes, transistor and integrated circuits.

The cutters you've seen so far work in the plane of the handles, or slightly offset from it. **Transverse cutters** work at right angles to the handle plane. There are two types: **Long-nose end nippers** are simply long-nose pliers with transverse cutter edges at the tips (Fig. 28). Such a tool is practically indispensable for printed-circuit work, as it can be maneuvered down into a cluster of parts to nip a component lead coming straight out of the board. These nippers don't have much cutting strength since the cutting edges are at the jaw ends.

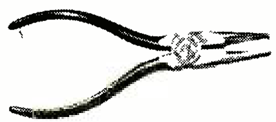


Fig. 28—Transverse cutters have their cutting edges at the tips of the tool. While excellent for getting into tight corners such cutters have little cutting strength. The unit shown here is a Utica model 15165. Its handles are not insulated.

Where more cutting strength is required, **heavy-duty end nippers** are used (Fig. 29). The jaws are wide and blunt, and the cutting edges of slipping and injuring your hand. Second, the grips are insulators, and this lets you work on hot circuits. It's usually better to purchase pliers with the grips factory installed, since the accessory types never seem to stay on the handles as securely. One point to watch out for. Plastic-covered handles don't automatically mean electrical insulation. Check first, and make sure they are really insulated before you use them in hot circuits.

Before you buy pliers, try to get your hands on them. Pick up the pliers by one handle; the other should fall freely. If it doesn't, the bolt may be binding. Work the handles back and forth a few times and see if the joint loosens up. If the joint binds, you'll waste time and effort using the pliers, since you'll have to force the handles open.

Good pliers and cutters are made of high-quality tool steel (or similar alloys) and they are usually drop forged. Since they are used to contact metal, they must maintain their shape and edges, not to mention temper. Steel tools rust, of course, and to prevent this you should go over your pliers with an oily rag now and then. If you find any rust, work it off with sandpaper, emery cloth, or a wire brush. Keep any serrations or milled surfaces free of debris by wire brushing them.

You can buy many pliers with chrome or nickel plating, which does not rust.

A few other tips

Don't destroy jaw alignment or ruin cutting edges by hammering with a plier. It is safer and cheaper to use a hammer. Never use a plier to cut a hot wire; the resultant hole in the cutting edge can't be removed. Use the right size gripping plier; if you can't grip the material and keep the plier jaws parallel, then the plier is too small for the job.

Don't use a needle-nose plier to grip objects of larger diameter than the point of one of the jaws. Don't use pliers to do a pipe-wrench job. And don't rock a diagonal cutter sideways to do a tough job; you may break the jaws. Use a large cutter. (to be continued)

TECH TOPICS

by **ROBERT F. SCOTT**
SENIOR TECHNICAL EDITOR

An active filter, transistor Vackar, unusual detector and a different wind direction indicator

It looks like *Technical Topics* got off to a good start in June. We told you that your comments and criticism would be welcome. Well, we got some feedback from John M. Mealing, Jr. on the heterodyne filter (Fig. 3, page 47). He writes, "I fear there was a slight drafting error. The output shown will not produce a bandpass characteristic. A corrected copy of the drawing is included. Also included are several Twin-T bandpass filters and their characteristics."

Mr. Mealing's "corrected" diagram showed the output taken from the plate (left) end of the Twin-T. A check of the original reference material showed the circuit in Fig. 3 to be correct so photocopies of the original report were forwarded to Mr. Mealing.

Being rushed to get out material for this issue, I didn't attempt a circuit analysis. However, at a glance, I see the right-hand half of the 12AU7, not as a feedback amplifier, but as a Q multiplier to increase the Q of the Twin-T to sharpen its response curve so there is a minimum attenuation of frequencies closely adjacent to the whistle frequency.

Note that Mr. Mealing says that the output connection shown will not produce a *bandpass* characteristic. Well, the circuit is not supposed to have a bandpass characteristic. I probably misled him with the statement "An audio filter can be used . . . if it is tunable with a very narrow *passband* and high attenuation at the interference frequency."

In casual conversation, I, and many others, often use *bandpass* and *passband* synonymously. However, when I write *passband*, I am referring to the response of a circuit to a band of frequencies in which the attenuation (or gain) is less than (or greater than) a specified value. On the other hand, a *bandpass* circuit or filter is one that passes a single band of frequencies. The lowest frequency is above zero and the highest is below infinity.

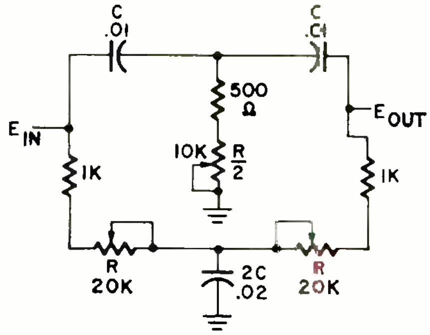


Fig. 1—Twin-T notch filter connected into a feedback loop becomes a passband. Filter reduces amount of feedback.

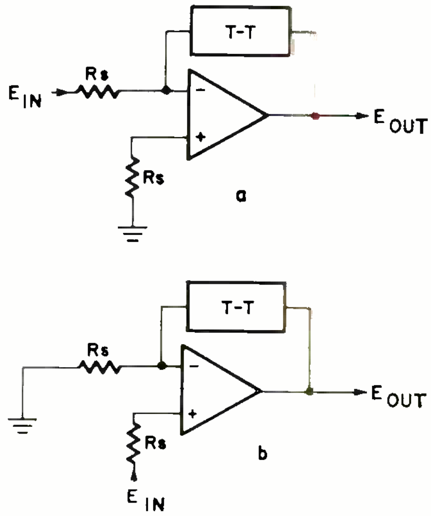


Fig. 2—Operational amplifier configurations with a bandwidth of about 100 Hz. CW transmissions require 400 Hz.

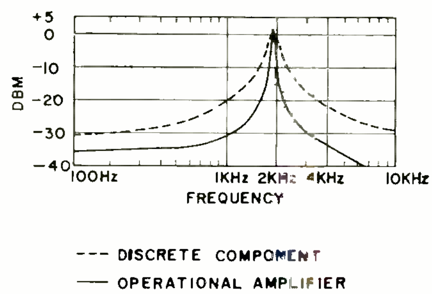


Fig. 4—Comparison of filter responses for discrete and operational amplifier circuits. Note sharp op-amp falloff.

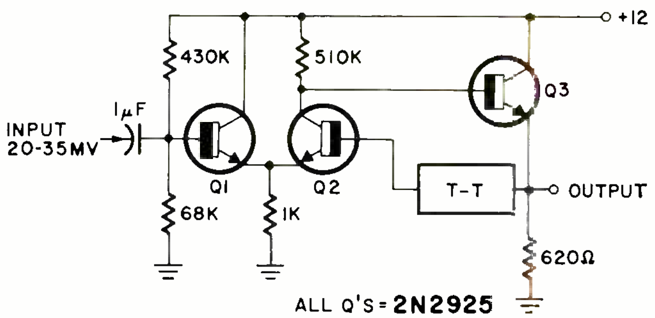


Fig. 3—Active filter with 30 dB power gain. Q3 serves as an impedance-matching emitter follower on the coupled pair.

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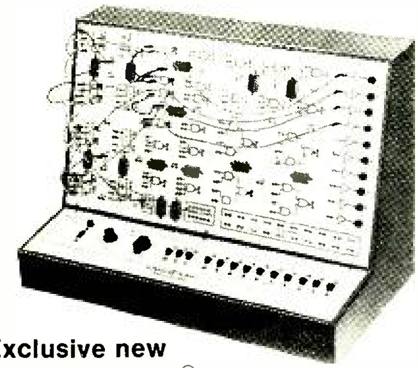

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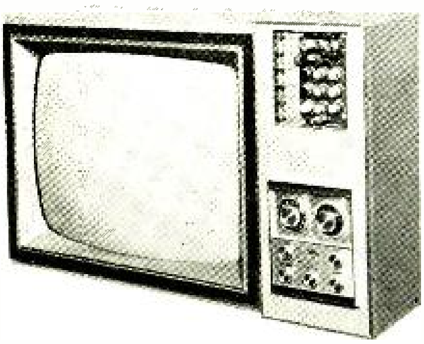

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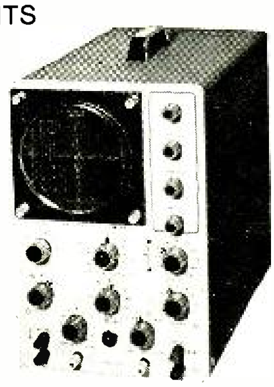

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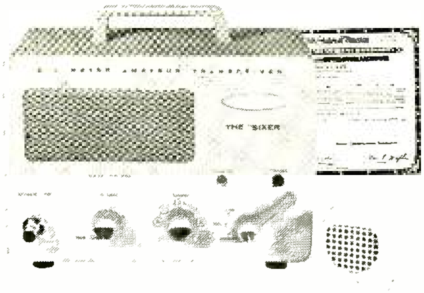

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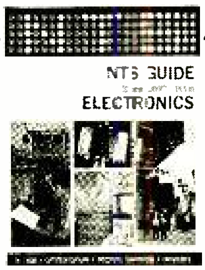

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With this question squared away (I hope), let's take a look at Mr. Mealing's contribution to *Technical Topics*.

An active bandpass filter

The filter shown in Fig. 1 is a Twin-T notch filter. However, when it is connected into a feedback loop, the notch becomes the passband. This happens because the filter reduces the amount of feedback as resonance is approached. Thus, the output has a bandpass characteristic. The width of the passband divided by the center frequency is the Q of the circuit. Ideally, this is equal to ¼ of the gain of the amplifier. Practically, this value is seldom achieved.

Two configurations using an operational amplifier are in Fig. 2. These filters have a bandwidth of approximately 100 Hz. This is fine if you want to listen to a whistle; but even CW transmissions require a 400-Hz bandwidth.

A discrete-component filter using three transistors is in Fig. 3. Q1 and Q2 form an emitter-coupled pair. Q2 has a high-value collector resistor for high gain. Unfortunately, this also yields a high output impedance. Therefore, Q3 has been added as an impedance-matching emitter follower. It is also a low-impedance source for the filter. Fig. 4 compares the responses of the circuits in Figs. 2 and 3.

The values in Fig. 1 will tune the filter over a range of approximately 800-20,000 Hz. The center frequency f_0 equals 1/6.28RC, and Q is nearly constant over the entire frequency range.

Note: The active filter in Fig. 3 has about 30 dB of power gain. An input signal much more than 30 millivolts with drive Q2 to saturation. This will degrade the filter characteristics.

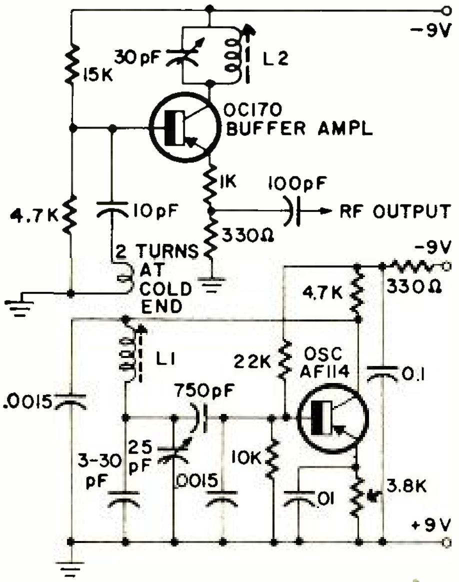


Fig. 5—Vackar oscillator operates at 21 MHz and shifts frequency from human body heat when person stands 2 feet away.

A transistor Vackar

In June, we discussed a vacuum-tube Vackar oscillator used by a number of British hams. Figure 5 is a transistor Vackar oscillator used by G5BB for 21-MHz described in *RSGB Journal* (Now *Radio Communications*). Oscillator tank coil L1 and the buffer tank coil L2 consist of 19 and 23 turns, respectively, of No. 22 enameled wire on ¼-inch slug-tuned forms. The oscillator is coupled to an OC170 buffer amplifier by a 2-turn coil wound around the cold end of L1. The OC170 and AF114 are pnp junction germanium transistors similar to the 2N1177.

G5BB reported that the oscillator tank is extremely temperature sensitive. Heat from a human body 2 feet away causes a gradual frequency shift. Interesting design factors developed in the article are:

Enclose the oscillator and tank circuit in a heavy metal box to protect it against drafts and sudden changes in ambient temperature.

For maximum stability, select a transistor with a cutoff frequency at least ten times the operating frequency and operate it in Class A.

Use inductive coupling to the following circuit. Capacitive coupling appears to have an adverse effect on frequency stability.

Unusual superregenerative detector

The superregenerative detector is characterised by high sensitivity and poor selectivity. Once the heart of the basic vhf/uhf communications receiver, its use is now confined almost entirely to model-control receivers where simplicity, light weight, small size and low power drain outweigh the disadvantages of broad tuning and reradiation. (If you don't know what a superregenerative detector is or how it works, a brief rundown follows this item.) The superregenerator in Fig. 6 features ultra-sharp tuning and very low power consumption. It was developed by Ted Hart, of Collins Radio and described in *Electronic Design* and *American Modeler* magazines. Disregarding the crystal between Q2's collector and emitter and the tuned circuit in the collector lead, we have a conventional multivibrator operating at 20-30 kHz. Now, look at the circuit as though Q1, C1, C2 and R1 were omitted. We have Q2 connected as a vhf crystal-controlled oscillator. Replace the crystal with a 5-10-pF capacitor and we have a tuned-collector oscillator. Combing the multivibrator and crystal-controlled oscillator functions, Ted Hart has come up with a crystal-controlled superregenerator using a multivibrator-type quench circuit. Detected audio is developed across R4. A Twin-T or similar filter removes the quench frequency before amplification.

Multivibrator frequency adjustment

The crystal and tuned circuit are selected for the desired receive frequency. The multi-vibrator frequency may be left as is or adjusted to a frequency no higher than one hundreth of the operating frequency.

[Superregenerative detector: Imagine an ordinary diode detector using the grid and cathode of a vacuum tube or the base-emitter junction of a transistor. The signal in the plate or collector circuit is an amplified replica of the signal on the grid or base. Take some of the detector's rf output voltage and feed it back to the input in proper phase so it adds to the input voltage and thus increases circuit amplification. This process is *regeneration*. If we feed back enough signal to overcome the losses in the input circuit, oscillation occurs.

A superregenerative detector is a regenerative detector designed so it quenches (goes in and out of oscillation) at a low rf rate—usually 20-100

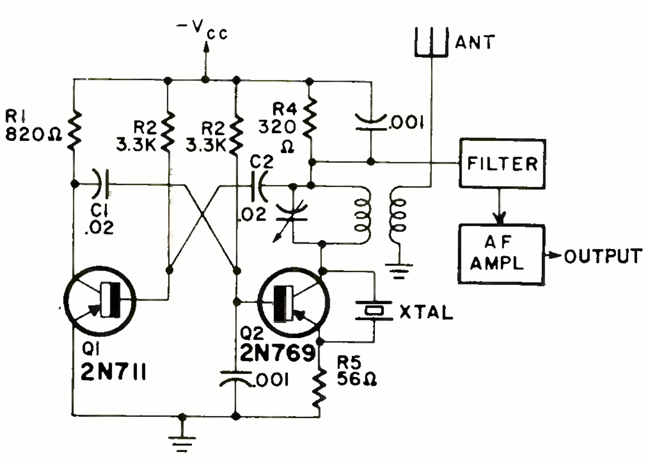


Fig. 6—Ultra-sharp tuning superregenerative detector uses Q2 as a vhf crystal-controlled oscillator for precision.

Khz). This additional regeneration makes the circuit extremely sensitive. Some superregenerators use a separate oscillator to supply the quench frequency but the simplest types produce the interruption frequency so a separate oscillator is not needed.]

Wind-direction indicator

A number of methods have been developed for remote-indicating wind vanes. Among them are selsyns with the repeater driving a pointer around a compass rose; bridge circuits in which the resistance of one leg varies with vane position so wind direction is shown on a meter which indicates bridge unbalance; and vane-driven rotary switches with one position for each desired indication. The switch contacts are connecetd to lamps marked N, E, S, W, etc. In many instances, it is difficult to protect the switch, pot or other pickup against ravages of the weather so these systems required frequent maintenance.

This solid-state wind indicator, described in *Le Haut-Parleur,* uses a small vane-driven bar magnet and reed switches as pickups (Fig. 7). The switches are normally open types connected between V_{cc} and the base of a 2N525 transistor (Fig. 8). The indicator is a 2-volt lamp in the collector circuit. The diagram of a 4-point indicator is shown in Fig. 9. The reed switches are hermetically sealed and are not affected by weather or corrosive elements in the air. Leads from the switches are run through a cable to the transistors and lamps at the remote point. **R-E**

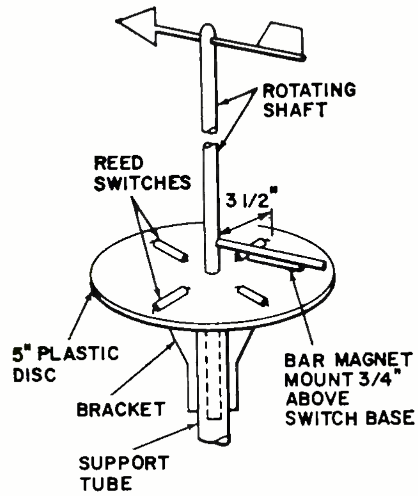


Fig. 7—Solid-state wind indicator uses reed switches as pickups and a vane-driven bar magnet. Reeds are open normally.

CORRECTION

There is an error in the circuit of the Turn and Backup Indicator on page 95 of the April issue. Mr. J. M. Borde of Bombay, India noticed that the right-turn lamps are in series with the buzzer and will not function if both are rated at 12 volts. Actually Mr. Ives, the designer, connected the right-turn lamps between the flasher and ground as in the left-turn circuit. Our thanks to M. Borde for calling the drafting error to our attention.

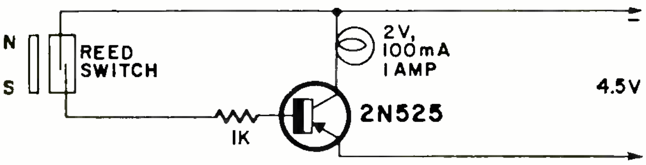


Fig. 8—Reed switches are connected between base and V_{cc} of 2N525's.

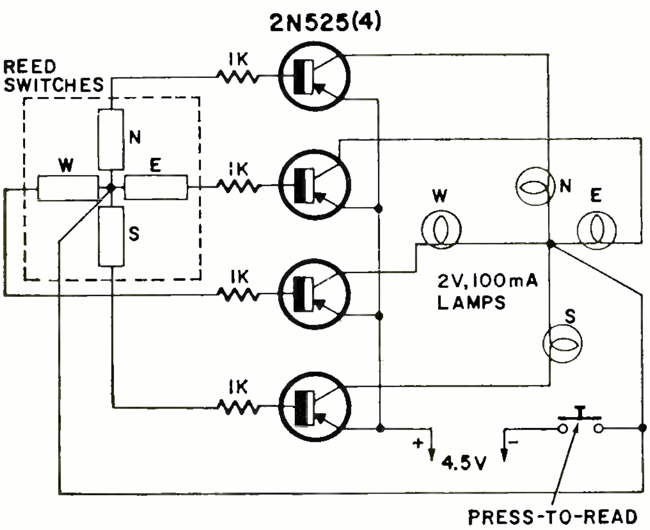


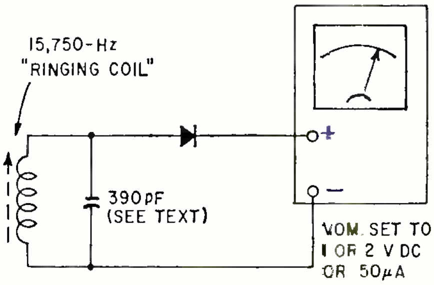
Fig. 9—Overall diagram of wind indicator. Indicator lamps indicate what position the vane is in.

QUICK TEST HORIZONTAL OSCILLATORS

For those odd occasions when you want to know if the horizontal oscillator is on-frequency, but don't have a scope with you, try this. You'll need a standard "ringing-coil" of the type used in horizontal multivibrators, the correct size capacitor to make it resonate at 15,750 Hz, and a diode.

Connect the diode in series with one of the VOM leads and then connect the meter across the coil terminals (see diagram). Now, if you hold the coil near the set's horizontal oscillator coil, the horizontal output tube plate lead, the flyback, or any other point where there is a high 15.750-Hz energy field you'll get a good-sized reading on the meter.

This can be read on the 0-1 or 0-2.5 dc volts scale, if the meter is at least a 20,000 ohms per volt type. A more sensitive range is the 0-50 microampere scale.

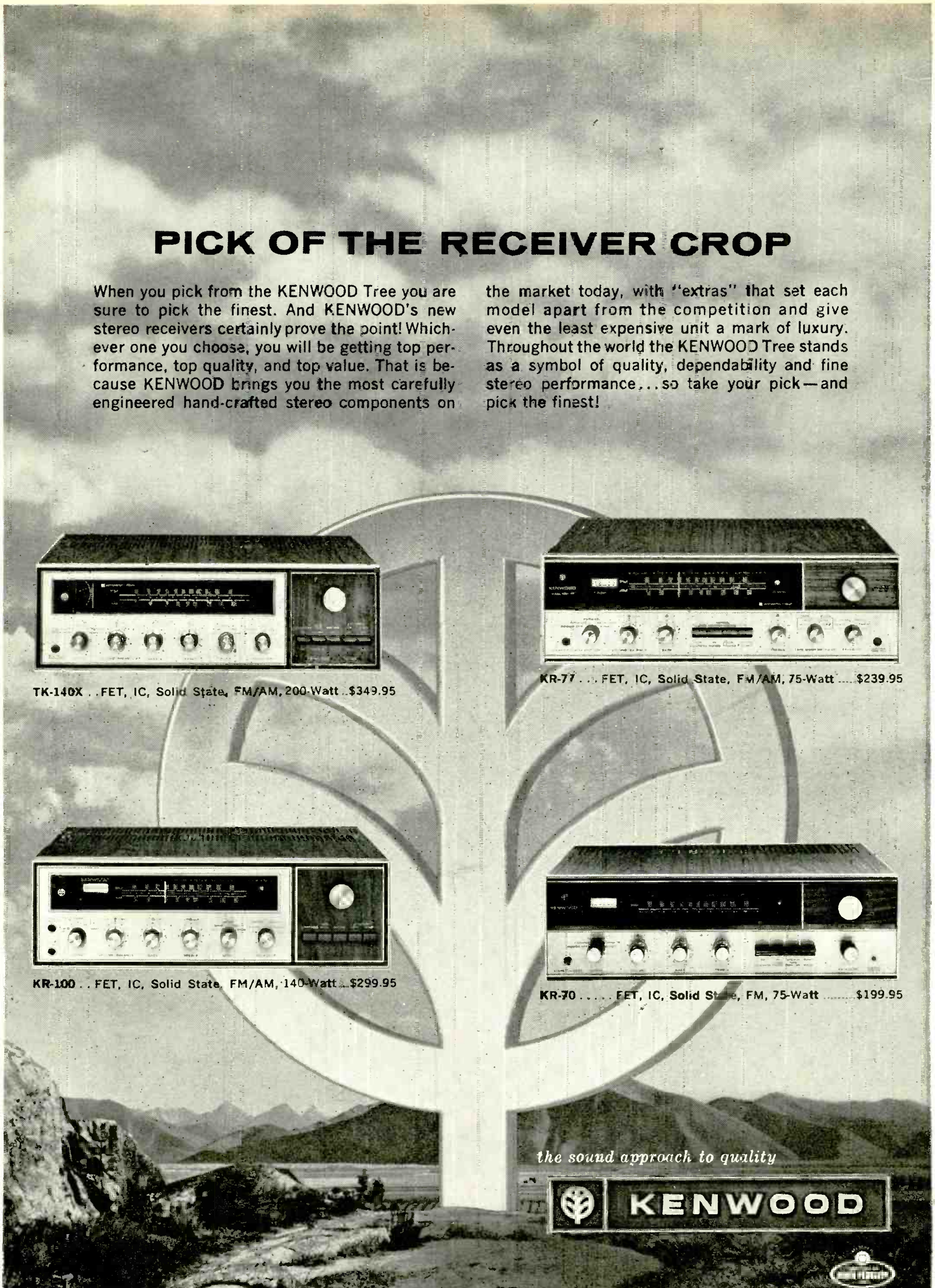


If you want to do a bit of gadgeteering, mount the coil on the end of a small metal or plastic box. Inside the box, mount a small variable capacitor, say about 0-100 pF., and then add enough fixed capacitance to bring the coil back to resonance with the variable capacitor set at about half-range or 50 pF. for the standard horizontal oscillator coil, this would be about another 220 pF for a total around 390 pF. (This varies with different coils; check the one you use to make sure.)

You can make a small dial-scale on the box, and use a pointer knob. This should be set at zero when the frequency is exactly 15.750 Hz, and then go + or − in either direction.

You can use this as a sort of rough 'output indicator', since it will indicate the presence or absence of a strong energy field on the plate cap of the horizontal output tube, the plate lead to the high-voltage rectifier, the damper tube or the flyback.

The 'frequency' calibration may be a bit wide, if you get a low-Q coil, but the output indication will be OK. You'll get readings like 1-1.5 volts dc with the pickup coil held against the set's oscillator coil.—*Jack Darr*



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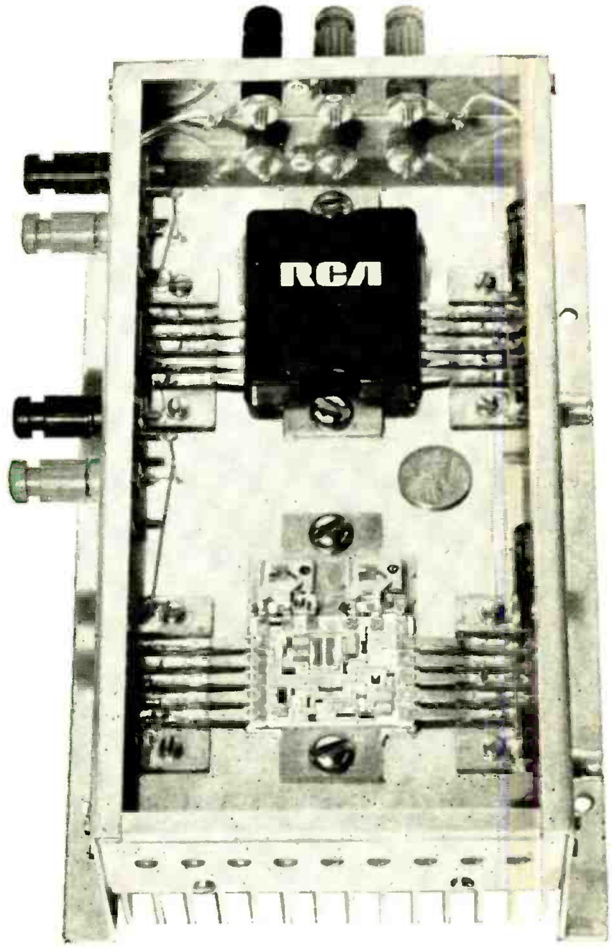


by F.S. KAMP and
J.C. SONDERMEYER*

ADVANCES IN HIGH-POWER THICK-film technology combined with a unique circuit have resulted in a hybrid IC power amplifier with universal applicability. The amplifier was designed for the industrial and commercial market where a high-power, audio-range, reliable and compact linear amplifier was needed.

Although not fabricated specifically for high-fidelity applications, the performance characteristics of the TA7625 hybrid power module (see Table I and Graphs I–III) suggest it is quite adequate for this purpose. The photo above showing an encapsulated and unencapsulated module mounted on a heat-sink type chassis indicates the extreme compactness possible for a 200-watt stereo amplifier. The power supply for the modules is mounted on a separate chassis, although single-chassis construction is possible if preferred. The power modules are available for $80 each.

The protective circuitry of the modules insures they cannot be internally damaged by a sustained short at the output or faulty power-supply voltages. The design permits use of the module with capacitive loads (electrostatic speakers).

TABLE I

Data taken with split supply at ±37.5 volts, 4-ohm load, 1-kHz signal frequency and feedback resistor = 820 ohms.

- Zero signal dissipation = 1.725 watts*
- Input voltage = 1.00 @ 100watts output
- THD = 0.38% @ 100 watts output
- Input voltage = 0.62 @ 35 watts output
- THD = 0.14% @ 35 watts output

* Of this, 585 mW is dissipation in resistors R_2, R_3 and R_7, leaving a device dissipation of 1.14 watts.

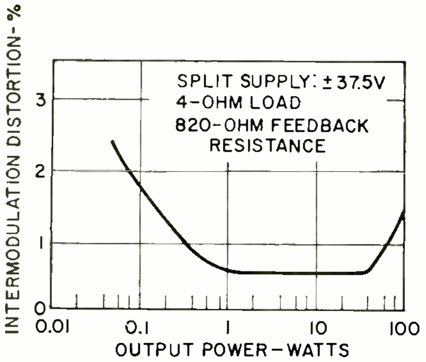
*RCA Electronic Components, Somerville, N. J.

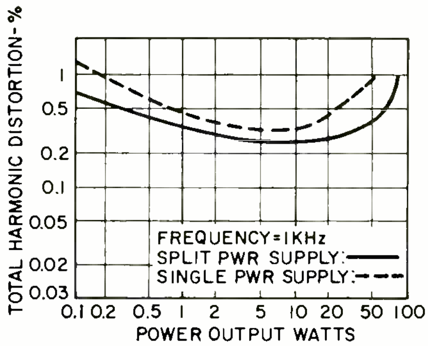
Structure & circuits

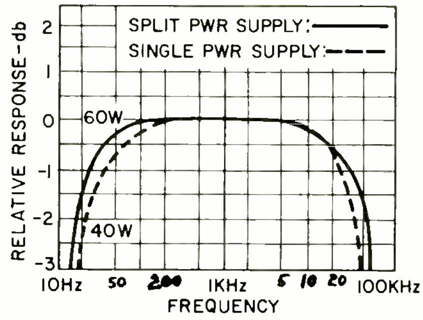
The internal structure of the hybrid amplifier is shown in Fig. 1. It has a rugged steel base plate on which both the thick-film circuit and the output assembly are mounted. This output-transistor assembly is an all lead-solder mount system with a lead frame for easy fabrication. A ceramic substrate is used under each pellet to isolate it from the base plate. The pellet is mounted on a heat spreader which reduces the heat flux density by the time it gets to the ceramic.

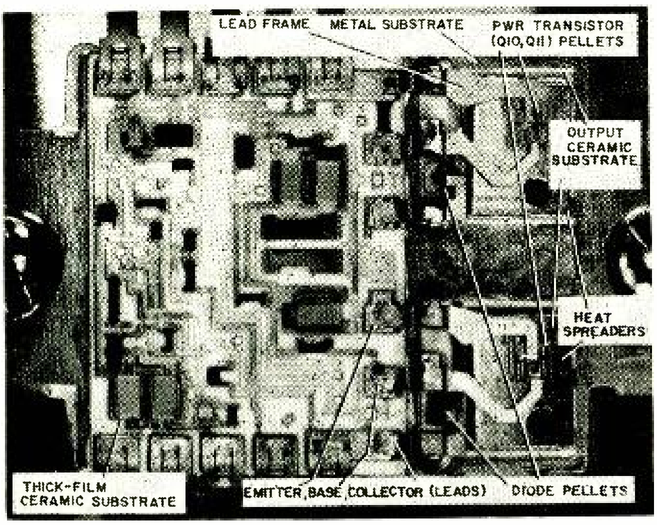
The schematic for the circuit of the hybrid power amplifier is shown in Fig. 2. A differential bridge (Q1–Q2) is employed at the input of the amplifier to provide good control on the quiescent operating point zero-output voltage. Imbalances of the bridge circuit with supply variations are solved by using constant-current source Q3 in the emitter circuit. This approach is almost universally used in integrated circuits to function over a wide range of supply voltages.

The voltage at pin 8 dictates the output voltage at pin 3. A pair of matched resistors (R2 and R3) control the output voltage to half the supply voltage. Pin 8 is grounded directly for the split supply case (Fig. 3-a) and ac-grounded with a 100-μF







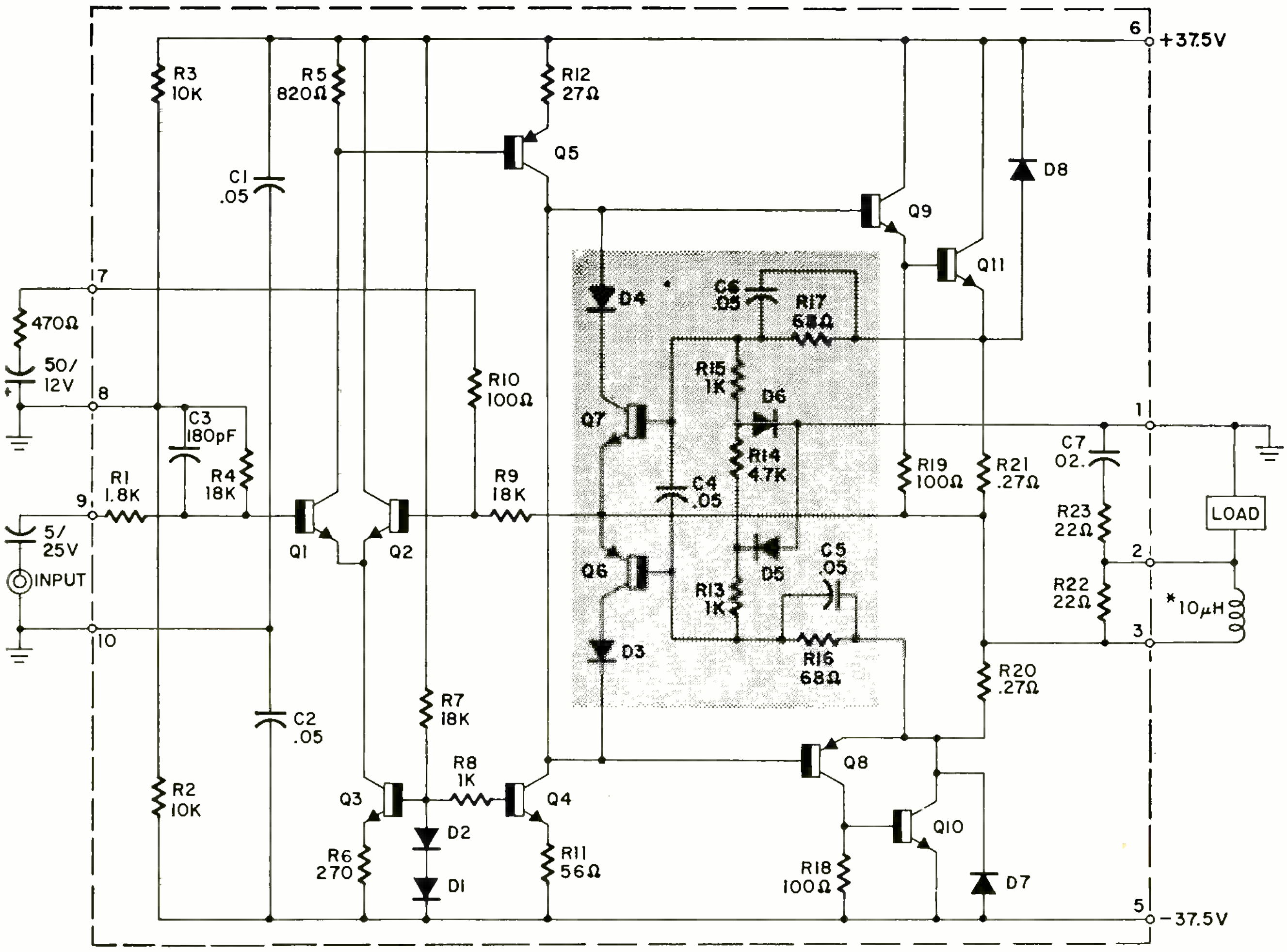


Graphs I–III above show performance curves for the IC. The Fig. 1 photo (left) shows the interior of the hybrid module and Fig. 2 below is the TA7625 schematic.

capacitor for the single supply case (Fig. 3-b) The constant-current sources (Q3 and Q4) allow the amplifier to be biased properly from a total supply voltage of much less than 30 volts to the 75-volt maximum.

The true class-B quasi-complementary output/driver stage is driven by the bidirectional current source. The output devices (Q10 and Q11) are chips from the 2N3055 family and the pnp/npn drivers are from the 2N5322/2N5320 families. The bidirectional current source npn/pnp's are from the 2N2101/2N4036 families.

A technique for eliminating crossover distortion in class-B output stages is to operate them from a high-imped-



*Miller No. 5220 or 40 turns of No. 20 copper wire (3 layers) over a 2W carbon resistor (100K+)

ance source (a current source). The current transfer characteristics of a typical output stage do not exhibit the offset steps as do the transconductance characteristics. The high-impedance source consists of a second current source. Q4, direct-coupled to the class-A predriver, Q5. In this case, the class-A stage is a pnp device since the bridge devices are now npn type. This arrangement also allows the current source to be an npn type as well and can share the same reference diodes, D1 and D2.

This approach is a simple collector-to-collector connection of complementary devices providing an inherently high collector impedance source: together with the differential bridge, the system performs as a "con-

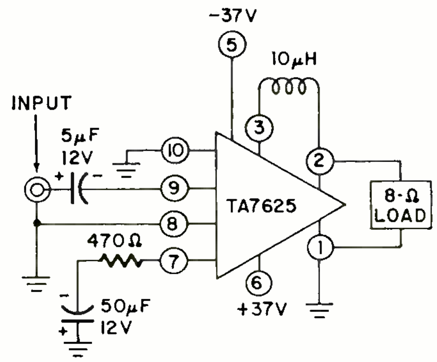


Fig. 3-a—This power supply configuration is a split supply (pin 8 grounded).

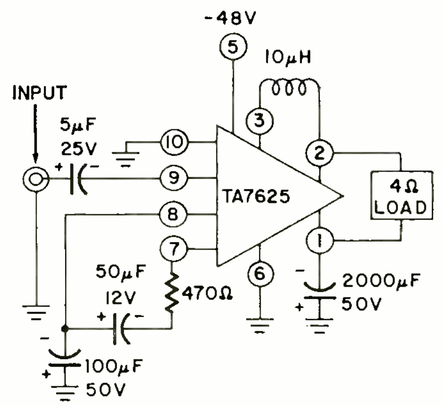
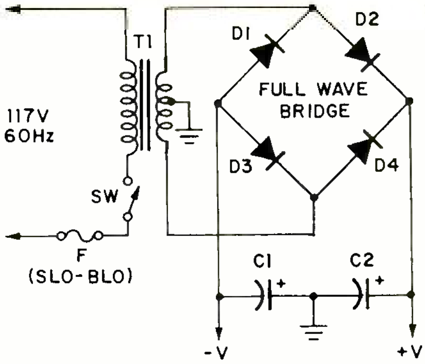


Fig. 3-b—The single supply arrangement with pin 8 ac grounded through 100 µF.

trolled bidirectional current source." Its operation is completely independent of supply voltage variations.

Versatility was achieved by bringing the feedback terminal out (pin 7). Maximum gain is limited by the 100-ohm internal resistor, R10.

The load-line limiting circuit (shaded area) protects the amplifier from a sustained short at the output. This unique limiting circuit places restrictions on the allowable operating area of the drivers and outputs. It functions as a voltage and current sampling circuit to provide operating



Power supply circuit for stereo ampl.

TA-7625 Power Supplies

P_{out}	C1-C2	D1-D4	F
120 watts (60W/chan.)	5000 µF 50V	1N1202A	7A
40 watts (20W/chan.)	3500 µF 50V	1N1614	2A

limitations on the output devices. The limits chosen do not inhibit normal operation, but any overload condition including a short circuit will remain within the safe area of operation of the device. Diodes D7 and D8 and the load-line limiting circuit protect against a faulty output transformer secondary that may reflect voltages to the amplifier output termination, exceeding the power supply voltages. The diodes clamp this reflected voltage to the power supply, while the load-line limiting circuit limits the drive.

Controlling the gain bandwidth product of the output stage in relation to the preceding stages and adding the 10-µH inductor and R23–C7 for capacitive loads are other design factors for added versatility. **R-E**

RCA KCS144-E TV CHASSIS

There is a common defect in this set's tuner that is likely to cause trouble as the set ages. The symptoms usually show up first as flashing in the picture accompanied by a loss of vertical sync. Later, the circuit breaker will open intermittently. When the circuit breaker is reset, the set plays normally for quite a while.

If the trouble is not corrected at this point, the 4700-ohm, 1-watt and 470-ohm, ½-watt resistors (R13 and R91, respectively) in the tuner will burn up. If the tuner is run through the uhf channels, R55 and R56 (2200 and 1500 ohms, respectively) will also burn up.

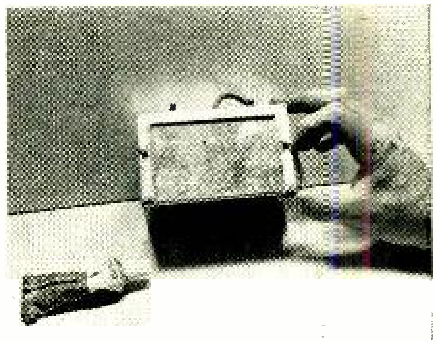
This trouble has been traced to a terminal lug that carries B-plus voltage to C26. This lug is so close to ground that if a small particle of dust or other foreign matter lodges at this point, it will develop a carbon path to ground. Then the fun begins.—*Sid Elliot*

TRY THIS ONE

HOMEMADE RUBBER FEET

You can make feet or pads for your home-brew gear out of a silicone rubber caulking compound such as G-E's Bathtub Seal. You can get it at most hardware stores.

Squirt the rubber cement at the de-



sired spot and smooth the edges with a knife. Level the feet as well as possible. Let the cement set over night. The next day grind off the rough edges so the feet are even and the case is level. (Be sure the surface is clean before applying the rubber cement).—*Homer L. Davidson*

CLOCK SHAFT REPAIR

A clock radio in our shop had a knob that turned the hands and also set the alarm, but the knob was slipping on its shaft. The threads on the small shaft from the clock body were stripped, and the aluminum extension shaft would turn around it. Since aluminum is not easily soldered, we made a replacement from a brass ballpoint-pen cartridge.

Cut off the ballpoint and solder that end of the tube to the threaded brass shaft on the clock. Measure the length of the original shaft and at that point solder a large washer with a small hole, as a knob. Snip off the remaining brass. Enlarge the hole in the Masonite back to pass the large washer.—*H. L. Davidson*

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If you are continuously fighting "tough-dog" service jobs, keep your eyes on *Technotes*. The chances are good that a fellow technician has passed on the dope that will help you tame the next "dog" that lands on your bench.

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Service Clinic

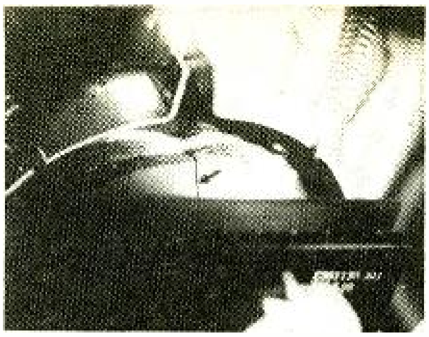
By JACK DARR
SERVICE EDITOR

Yoke cracked

In a Magnavox U90413-15, with the 23" rectangular color tube, I have poor convergence, bad pincushioning (mainly at the top) and poor horizontal linearity. The horizontal efficiency coil affects the edges of the raster, but doesn't help the center.

The two halves of the yoke's ferrite core seem to be split. The crack is about 2 mm wide. I checked others, and they do not show this wide a crack. Could this have any effect?—J. E., San Francisco, Calif.

Very likely! The two halves of this core should be cemented together, with about 0.001" "gap". This



(*continued on page 78*)

(continued from page 74)

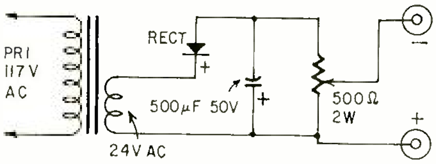
problem occurs in other makes, and causes, at the very least, bad convergence. In this case, with a 2-mm gap, it could be causing all your troubles. Tighten it up until you can't see the crack.

Needs a bias box

How about a diagram for a TV bias supply, ac-powered?—I. W., Middleboro, Mass.

Here it is. It's just a small filament transformer, silicon rectifier, filter capacitor and a variable resistor.

The transformer determines the voltage. To be safe, get a 24-volt one if you can. The silicon rectifier can be any kind. The filter capacitor should be about 500 μF at 50 volts, and the variable resistor something like a 2-



watt wirewound at about 500 ohms.

This will give you a peak dc of about 30 volts. You can calibrate the variable-resistor knob, or measure it with a dc voltmeter.

Testing 1500 speakers

I take care of a 1500-unit drive-in theater. This requires a lot of speaker testing. How about some kind of test unit that would let me check individual speakers without having to go to the booth to turn on the amplifier?—P. R., South Plainfield, N. J.

Easy. All you'll need is a small audio signal generator with about 4–6 volts output. Each of your speakers will have a matching transformer. Lift one side of the primary and couple the test signal to the transformer. If anything is wrong, you won't hear the sound.

Several small noise- or buzzer-type signal generators are available. With one of these and a good vom, you should be able to make any necessary tests. **R-E**

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.

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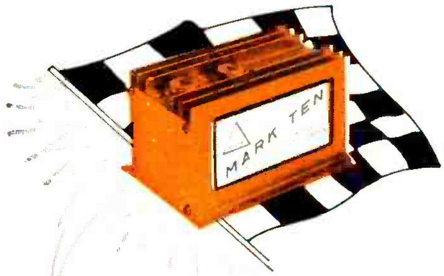

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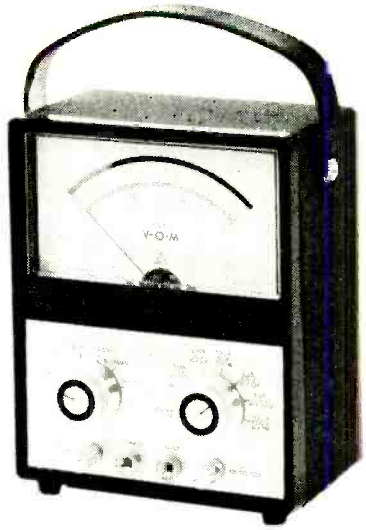

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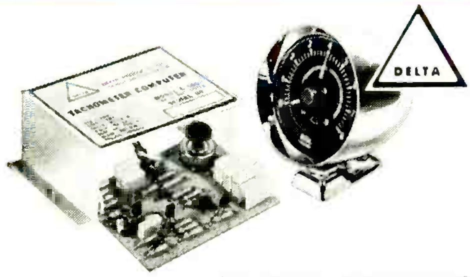

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Delta, pioneers in CD ignition who produced the fabulous MARK TEN®, now offer a precise computer-tachometer which obsoletes any type tachometer on the market today! You achieve unbelievable accuracy in RPM readings due to the advanced, solid-state electronic matched components used in the computer, coupled with the finest precision meter in the world. Works on all 2, 3, 4, and 6 cylinder 2 cycle and with 4-6-8 cylinder—4 cycle 12 volt engines.

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- ▲ Use it with ANY ignition system
- ▲ Meter: 3⅛" dia. X 3⅜" deep
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EP 9-9

DELTA PRODUCTS, INC.

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Circle 36 on reader service card

Don't sell a color picture tube unless its been on a test ride.

Down at the bottom of the page, you have a major advance in space-age homeliness.

And a major advance in color tube testing as well.

That machine squatting down there is our beloved Iron Horse, the fully-automated, revolving carousel we use to test our color bright 85® tubes for emission, gas leakage, shorts, arcing and screen uniformity prior to shipment.

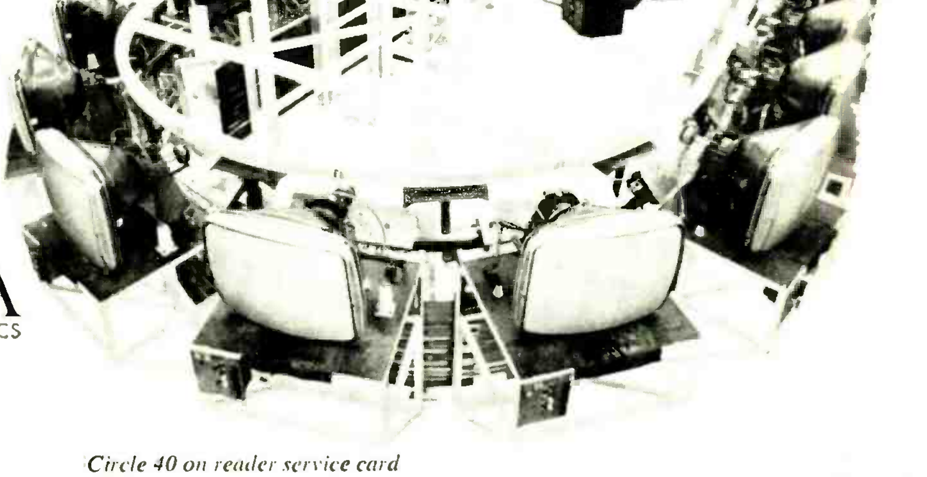
Now we don't intend to go into a song and dance on how total automation reduces testing error.

But we will tell you one thing.

Our Iron Horse test ride, combined with our life testing and 100% set testing, makes it almost impossible for you to get a defective color tube from us.

Which in turn makes it almost impossible for you to get chewed out by a customer.

Next time you need a color replacement tube, remember the great thing about the color bright 85. We don't send it to you till it's been around.



SYLVANIA
GENERAL TELEPHONE & ELECTRONICS

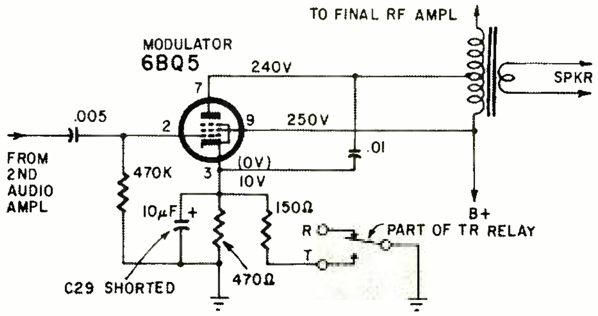
Circle 40 on reader service card

CB Troubleshooter's Casebook

Compiled by
Andrew J. Mueller*

Case 1: Distorted modulation and frequent modulator tube replacement.

Common to: ECI Fleet Courier.



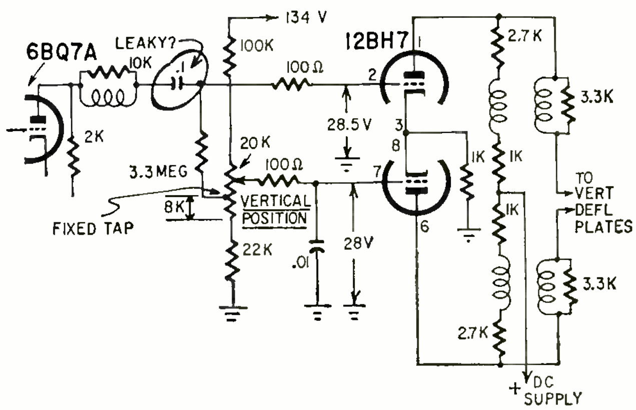
Remedy: Replace C29.

Reasoning: When C29 shorts, it removes bias from the 6BQ5. The tube now draws excessive plate current, causing premature tube failure. Modulation is distorted since the operating point shifts when bias is removed. The effect of this no-bias condition is that the output signal is not symmetrical with the input signal, hence the distortion. **R-E**

VERTICAL POSITIONING TROUBLE IN SCOPE

I just built a kit scope. Now, I can't position the trace vertically, more than about 1½ inches from the top or the bottom of the CRT. All of the voltages in the circuit check, except for the pin-2 grid of the 12BH7. Book says 8.5 volts to ground, and I've got 28 volts. The company service department gave me no encouragement, but they insist that I should have 8.5 volts at this point, as the book says. What's going on?—A. W., Albany, Ga.

Believe them. After all, they *made* the thing! Seriously, you can see that this much difference in voltage between these two tubes would cause a 'difference' in the steady-state dc plate voltages, and a shift of the spot position. Looking at this circuit, I'd say that by taking out all tubes, you could measure voltages across that voltage divider (which is all that resistor string is) and tell where your trouble is really located. I'd tend to suspect a slight leakage (say about 20 volts worth) through that 0.1-μf coupling capacitor from the 6BQ7 plate. **R-E**



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SA-500 INTEGRATED STEREO AMPLIFIER — The perfect starter unit for a stereo system, the all solid state SA-500 produces 44 watts of music power. Even at the highest crescendo, distortion is less than 0.5%. Two sets of inputs plus outputs for speakers, tape recording, loudness contour and a headset jack make it tops in versatility. $99.95

TX-500 AM-FM TUNER — All solid state, its multiplex circuitry provides wide channel separation with excellent frequency response. An FET front end, combined with years-ahead design, assures high sensitivity and superb image rejection. Containing advanced features that place it on a par with more expensive units, it is priced at $99.95.

SR-202 REVERBERATION AMPLIFIER — The most dramatic new component in years! No matter what your system is, the SR-202 adds dimension and greater realism to your stereo sound than you can realize. The SR-202 increases the natural quality of your recordings and tapes. Reverberation can be added to an audio amplifier using one or two tape recorders, a record player, or a tuner. In fact, a total of 15 equipment combinations are possible. $95.00

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Circle 44 on reader service card

TECHNOTES

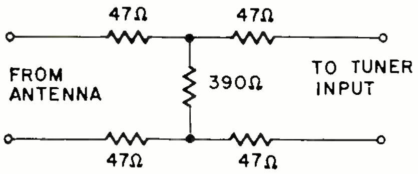
INTERFERENCE IN CHANNEL-8 PIX

In moderate to weak signal areas, Emerson color sets may exhibit interference in a channel-8 picture. It is due to the radiation of the 4th harmonic of the video i.f. from the leads connecting the aft IC on the PC board to the aft circuits in the tuner.

Take the following steps, in order, to eliminate or minimize the interference:

1. Check to see that the set is operating from a properly installed balanced 300-ohm antenna. If you are not certain as to whether or not the antenna system is properly balanced, use the resistive pad shown in the diagram between antenna lead-in and tuner input. It will show an improvement on an unbalanced antenna system.

2. Reduce the signal into the tuner using additional resistor pads. Dress the four leads connected between the aft IC and the tuner down and away from the 300-ohm shielded lead (going to the tuner input terminals) to reduce picture interference.



3. Disconnect the lead between pin 9 of the IC and the aft switch on the front panel.

4. Connect a fixed rf choke (Emerson part No. 705049 in series with each of the three remaining aft leads between the IC and the tuner. These chokes (3) should be connected in series with the leads at the PC board.

5. When interference persists, connect a small tunable trap (Emerson part No. 708542) between pin 2 of the IC and the PC board. Keep the leads as short as possible.

In most cases, it is only necessary to redress the aft leads between the IC and tuner. Signal strength is an important factor and picture interference can be eliminated or minimized by improving the pickup efficiency of the outdoor antenna. If the signal is too weak, the pad cannot be used to improve antenna balance, because it further attenuates the incoming signal.

If interference remains after the above steps have been taken, retune the secondary of the aft transformer very slightly (about ⅓ turn or less) to shift the tuning point away from the point of picture interference to an interference-free point.—*Emerson Field Service Bulletin*

DISTORTION IN G-E TV PORTABLE

If the audio is initially good and becomes distorted in a few hours or if it is poor when the set is first turned on and gradually gets better, the trouble may be traced to the quadrature-coil tuning capacitor. This capacitor (C308 in S-2, P-2 and V-2 chassis and C307 in H-2 and G-1 chassis) has a negative temperature coefficient to compensate for temperature-produced drift in associated components. Distortion occurs when this capacitor does not track properly with temperature changes.

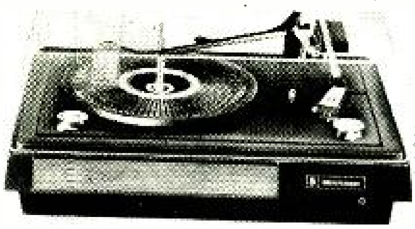
Replacement capacitors must have the proper temperature coefficient for distortion-free performance. In the chassis lister above, the capacitor should be 18 pF, 10% *N470* (G-E catalog No. ET18X399).

After replacing the capacitor, realign the quad coil and then check the audio quality at two temperature extremes; when the set is cold and when it has reached normal operating temperature.—*G-E Portafax* **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.

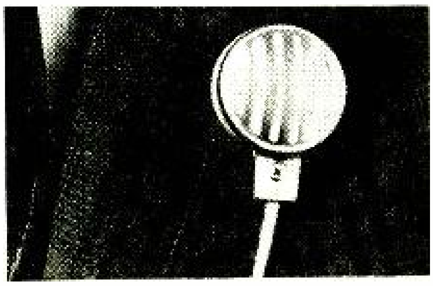
AUTOMATIC TURNTABLES Three models. *Model Minichanger* is designed for compact equipment installations, especially for shelf component systems. *Model 5500T* comes complete with base,



cartridge and diamond stylus. *Model 4700*, $29.95, is ideal for replacement purposes.—**BSR (USA) Ltd.**, Blauvelt, N. Y.

Circle 46 on reader service card

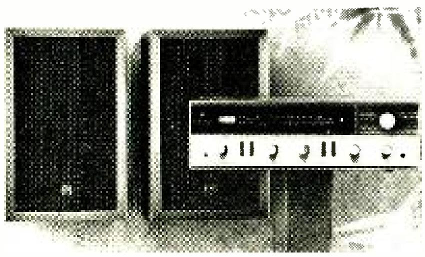
LAPEL MICROPHONE, small and easily handheld, this crystal unit is ideal to be worn readily on a lapel or pocket. It



has an impedance rating of 85 K ohms and a sensitivity of −65 dB. $1.25.—**Calectro, GC Electronics,** Rockford, Ill.

Circle 47 on reader service card

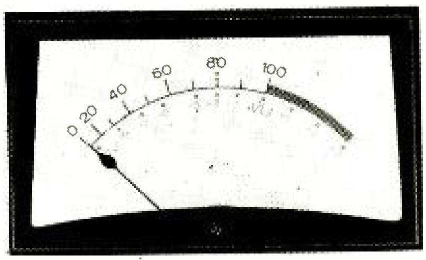
STEREO RECEIVER SYSTEM, *Model KRS-44,* solid state includes *Model KR-44,* receiver and two speakers. Receiver delivers 48 watts music power at 8 ohms. FM/AM tuner section features 2 FET's,



3-gang tuning capacitor and 2 IC i.f. circuits and offers either 75 or 300 ohms antenna input. The 6½" woofers and 3" cone-type tweeters provide a frequency response of 30–20,000 Hz, with an impedance of 8 ohms. $239.95.—**Kenwood Electronics Inc.,** Los Angeles, Calif.

Circle 48 on reader service card

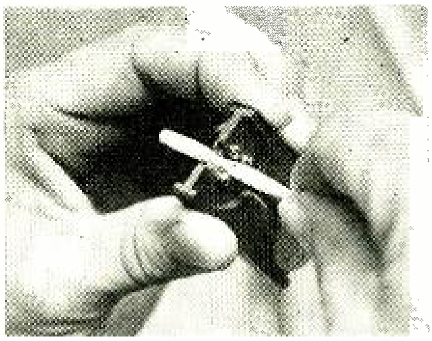
VU METER LINE consisting of 9 models measures amplitude of studio signals in broadcast and recording applications. Units conform to all specs of ASA Stan-



dard C16.5-1954. Attractive recessed-mounting meters available. Price range $29.50–$33.00.—**API Instruments Co.,** Chesterland, Ohio

Circle 49 on reader service card

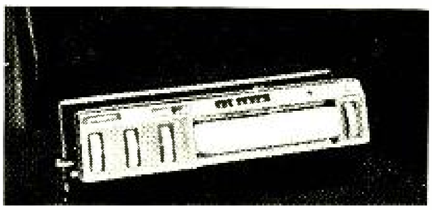
INSULATION STRIPPER, *Model 40,* removes outer insulation of multiconductor cable within 0.060" to 0.250" without damaging inner shielding or conduc-



tor. Ideal for MIL 80144, Kynar, Tedlar and other high-temperature insulation except Teflon. $19.80.—**MacDonald & Co.,** Glendale, Calif. 91204

Circle 50 on reader service card

AUTO STEREO TAPE PLAYERS, the *Untouchables* series, include a built-in



alarm system which triggers a loud alarm to frighten off would-be thieves in case of an attempted burglary. Come in 12 models; 4- and 8-track tape players with/without FM radio, 8-track tape cartridge with FM radio, 4- and 8-track stereo players and compact 8-track players. Price range **$59.95-$179.95.—Tenna Corp.,** 19201 Cranwood Parkway, Cleveland, Ohio 44128

Circle 51 on reader service card

RADIO CONTROL, *Model Genie AC-24,* solid-state, 24-volt, can be used as garage-door opener system. Signals from palm-sized transmitter are picked up by

receiver which activates door opener. Pushbutton on the transmitter controls garage door and light within a range of 100'.—**Alliance Mfg. Co.,** Dept MI, Alliance, Ohio

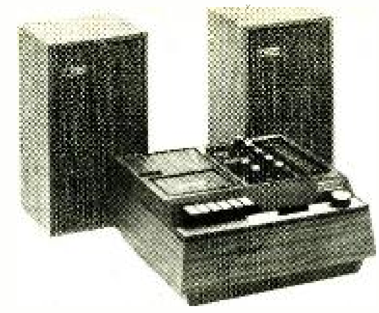
Circle 52 on reader service card

SOLDERING-IRON STAND designed to hold instrument irons safely. Its sturdy spiral rack holds the iron at the proper grasping angle. Replaceable sponge with a cavity for holding excess dross, is kept

moist by a simple water-injection system. Translucent plastic water reservoir permits users to see when refilling is needed. Extra cavity opposite the reservoir holds spare tips.—**Hexacon Electric Co.,** Roselle Park, N.J.

Circle 53 on reader service card

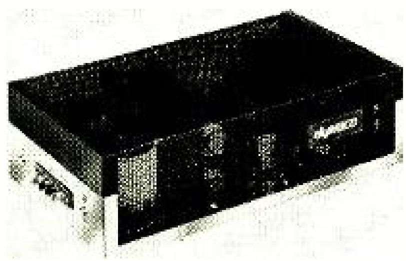
AM/FM CASSEIVER SYSTEM, *Model 2560,* combines an AM/FM stereo receiver, cassette recorder and pair of speakers. Receiver section features FET circuitry, minimizing cross-modulation and drift. IC's are utilized both in the i.f. section and in the preamplifier. Cassette is powered by a precision synchronous ac motor, which cuts out annoying



flutter and wow. $399.95—**H. H. Scott Inc.**, Maynard, Mass. 01754
Circle 54 on reader service card

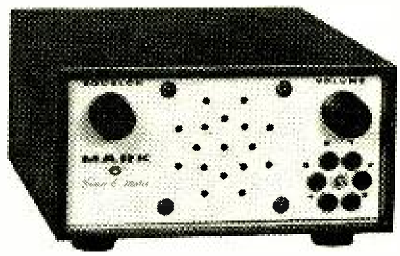
Write direct to the manufacturers for information on items listed below:

POWER AMPLIFIER, *Model Stereo 80,* is rated at 40 watts continuous rms power



per channel across the entire audio spectrum with both channels driven simultaneously into 8 ohms. Harmonic distortion 0.5% and IM under 0.1% at rated output. $159.95 factory-assembled. $119.95 kit form.—**Dynaco Div.**, Philadelphia, Pa.

COMMUNICATIONS RECEIVERS, *The Mark 6,* solid state, and crystal controlled are available in one-, two- and six-frequency models. Model *Scan-O-Matic,* six-channelled, automatically scans frequencies installed every half



second and locks on to the active frequency until carrier is released. Sensitivity, 0.8 μV for 20 dB quieting. Selectivity, 6 dB ±12 kHz. Power requirements, 117 Vac or 12 Vdc.—**Sonic Industries Inc.**, Indianapolis, Ind.

HI-FI CABINET *Model 303,* crafted from genuine hardwood and finished in oiled walnut, features two adjustable component shelves (17¾" x 15"), a changer/turntable shelf (17¾" x 15") that glides out on ball-bearing slides and a speaker compartment (23¾" x 16¼" x 14"). Overall dimension, 32⅝" x

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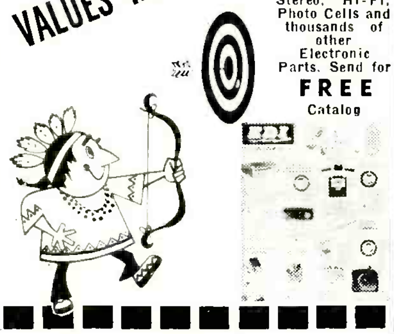

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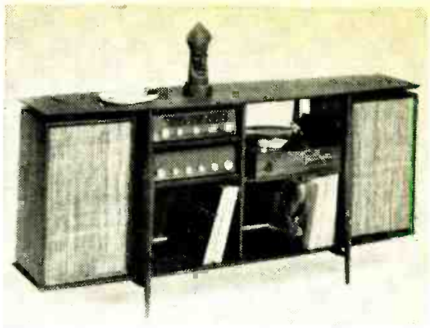
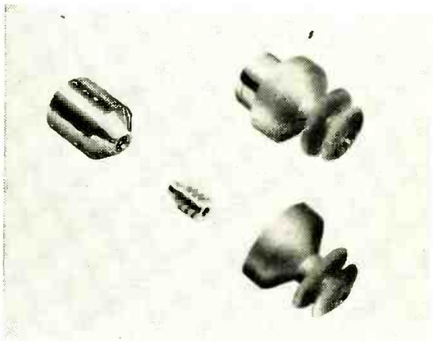


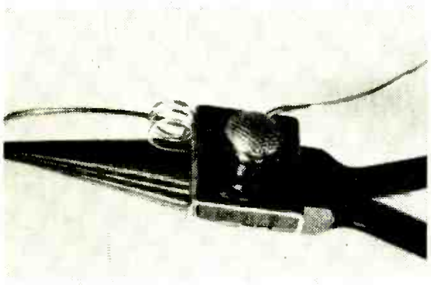
72½" x 16". Also provides plenty of space for records. $142.50.—Audio Originals, Indianapolis, Ind.

HEARING PROTECTOR, *Ear-Valv*, has a sound-actuated mechanism which acts as an auxiliary to the human ear's own



protective mechanism. Damaging noises are filtered out while harmless level sounds are permitted to pass through unaltered. Replaceable insert cushion is made of formula silicone rubber. Device consists of 18 precision watchlike parts. $3.95 a pair—**Sigma Engineering Co.**, North Hollywood, Calif. 91601

THIRD HAND, *Solder Jockey*, firmly secures a supply of solder to the pliers or other tool to which it is attached due to its magnetic base. Both objects to be soldered can then be held at the same



time. Unit is useful while soldering connections together. $1.00.—**Solder Jockey**, P.O. Box 1427, Long Island City, NY. 11101 R-E

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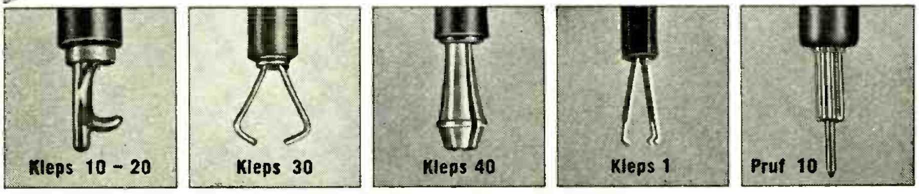

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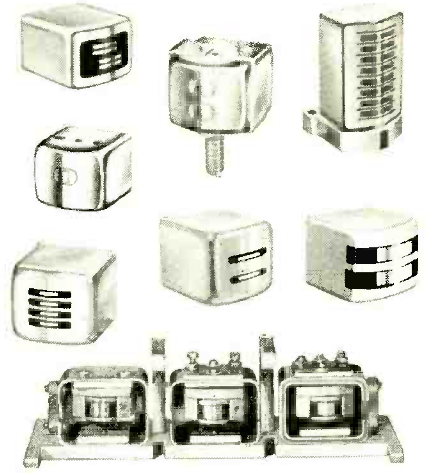

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NEW LITERATURE

All booklets, catalogs, charts, data sheets and other literature listed here with a Reader's Service number are free for the asking. Turn to the Reader's Service Card facing page 87 and circle the numbers of the items you want. Then detach and mail the card. No postage required!

TEST EQUIPMENT, solid-state, including vectorscopes, color-bar generators capable of producing 10 color bars with each bar spaced 30 electrical degrees apart, picture-tube analyzer, transistor analyzer, sweep-circuit analyzer and Citizen's-band analyzer plus power supplies are detailed with specs and prices in an 8-page catalog.—**Lectrotech Inc.**, Chicago, Ill. 60625

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CABINETS consisting of six panels and twelve vise-grip slides as well as some typical applications to which they are put are illustrated in a 4-page bulletin. *"New do-it-yourself FLEXI-CAB"*. Sizes, descriptions and prices also given. —**Bell Educational Lab, Div. Beltronix Systems, Inc.** Hauppauge, N.Y.

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AEROSOL PRODUCTS for cleaning and lubricating transistor circuitry, TV tuners and all electronic, electrical and mechanical relays and contacts are described in a 4-color aerosol chemical brochure. **GC Electronics**, Rockford, Ill.

Circle 63 on reader service card

TV & RADIO TUBES is the title of a 32-page catalog covering over 100 different types of tubes plus many hand tools, electronic lubricants and electrical equipments. Photos and illustrations are also included. Item prices are listed.—**Cornell Electronics Co.**, San Diego, Calif. **R-E**

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Circle 117 on reader service card

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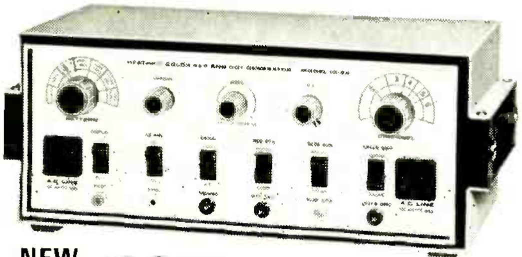
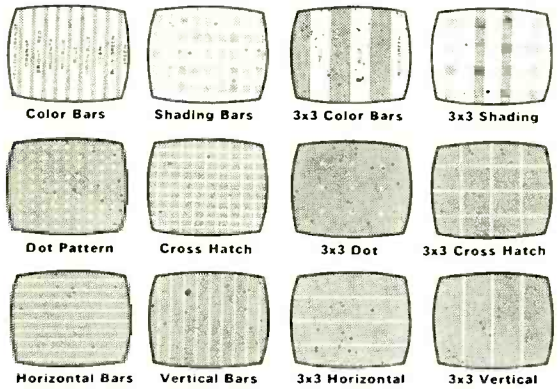
8 Exciting New Kits



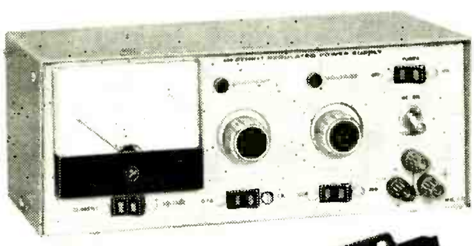
NEW
Kit IG-28 $79.95*

Standard 9 x 9 Display OR Exclusive Heath "3 x 3" Display



NEW Heathkit Color Bar-Dot Generator... Advanced Integrated Circuitry Produces 12 Patterns Plus Clear Raster, Eliminates Divider Chain Instability Forever

The new IG-28 is the signal source for all color and B&W TV servicing. No other instrument at any price will give as much stable, versatile TV servicing capability. Its solid-state circuitry produces dots, cross hatch, vertical and horizontal bars, color bars, and shading bars in the familiar 9x9 display . . . plus exclusive Heath 3x3 display of all these patterns . . . plus a clear raster that lets you adjust purity without upsetting AGC adjustment. Fifteen J-K Flip-Flops and associated gates count down from a crystal controlled oscillator, eliminating divider chain instability and adjustments. And for time-saving convenience the IG-28 has variable front panel tuning for channels 2 through 6. Plus & minus going video signals at the turn of a front panel control . . . for sync, in-circuit video or chroma problems, use the front panel sync output. Two front panel AC outlets for test gear, TV set, etc. Built-in gun shorting circuits and grid jacks too. Add any service-type scope with horizontal input and you have vectorscope display capability as well. Fast, enjoyable circuit board-wiring harness construction. You can't beat the Heathkit IG-28 for versatility or value . . . put it on your bench now. 8 lbs.



NEW
Kit IP-28
$47.50*

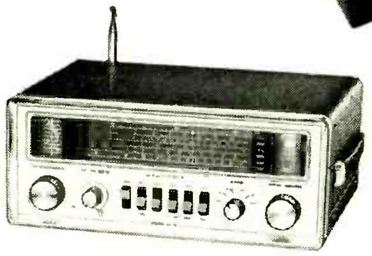
NEW Heathkit 1-30 VDC Solid-State Regulated Power Supply

The new modestly priced IP-28 is an excellent power supply for anyone working with transistors. Compact Heathkit instrument styling with large, easy-to-read meter . . . two voltage ranges — 10 V., 30 V. . . . two current ranges — 100 mA, 1 A. External sensing permits regulation of load voltage rather than terminal voltage. Adjustable current limiting prevents supply overloads and excessive load current. Convenient standby switch. Fast, easy assembly with one circuit board and wiring harness. Order yours today! 9 lbs.

NEW
Kit ID-29
$29.95*

NEW Heathkit Solid-State Auto Tune-Up Meter ... Measures Dwell, RPM And DC Voltage

The new Heathkit ID-29 is most versatile . . . really three automotive test instruments in one. Measures Dwell on all 4-cycle, 3, 4, 6, or 8 cylinder engines . . . measures RPM in two ranges, 0-1500 and 0-4500 . . . measures DC voltage from 0 to 15 volts. And no batteries are needed . . . running engine provides both signal and power. Easy to use . . . on both 6 and 12 volt system without changing leads. Lightweight and easy to carry . . . its black polypropylene case has a built-in lead storage compartment and is resistant to virtually everything. Fast, simple assembly . . . only about 5 hours. The perfect accessory for the handyman, emergency road service personnel or shop mechanics . . . order your ID-29 now. 4 lbs.



NEW
Kit GR-78
$129.95*

NEW Heathkit GR-78 Solid-State General Coverage Receiver... Tunes 190 kHz To 30 MHz In Six Bands

The new GR-78 combines wide coverage, superior performance and portability with sharp styling to provide a remarkable value in general coverage receivers. Tunes AM, CW & SSB signals from 190 kHz to 30 MHz in six switch-selected bands. The all solid-state circuit employs modern FET's in the RF section and 4 ceramic filters in the IF to deliver maximum sensitivity and sharp selectivity. Bandspread Tuning is built-in, and can be calibrated for either Shortwave Broadcast or Amateur Bands. Completely portable . . . comes with a nickel-cadmium rechargeable battery pack and built-in charger that operates from 120 or 240 VAC and 12 VDC. Many built-in features . . . 500 kHz crystal calibrator . . . switchable Automatic Noise Limiter . . . switchable Automatic Volume Control . . . Receiver Muting . . . Headphone Jack and many more. Order yours today. 14 lbs.

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Adapter arm for jamb & pivot doors, Model GDA-209-2, $7.95*

From The Leader HEATHKIT®

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The new Heathkit GR-681 is the world's most advanced Color TV with more built-in features than any other set on the market. Automatic Fine Tuning on all 83 channels . . . power push button VHF channel selection, built-in cable-type remote control . . . or you can add the optional GRA-681-6 Wireless Remote Control any time . . . plus the built-in self-servicing aids that are standard on all Heathkit color TV's. Other features include high & low AC taps to insure that the picture transmitted exactly fits the "681" screen, automatic degaussing, 2-speed transistor UHF tuner, hi-fi sound output, two VHF antenna inputs, top quality American brand color tube with 2-year warranty. With optional new RCA Matrix picture tube that doubles the brightness, **Model GR-681MX only $535.00.**

GRA-295-4, Mediterranean Cabinet shown **$124.95***

Heathkit "295" Color TV

With Optional RCA Matrix Tube . . . with the same high performance features and built-in servicing facilities as GR-681 above . . . less AFT, VHF power tuning and built-in cable-type remote control. You can add the optional GRA-295-6 Wireless Remote Control at any time. New optional RCA Matrix tube doubles the brightness, **Model GR-295MX, $485.00.**

GRA-295-1, Contemporary Walnut Cabinet shown **$64.95***

Both the GR-681 and GR-295 fit into the same Heath factory assembled cabinets; not shown Early American style at $109.95*

NEW Deluxe Heathkit "581" Color TV With AFT

The new Heathkit GR-581 will add a new dimension to your TV viewing. Brings you color pictures so beautiful, so natural, so real . . . puts professional motion picture quality right into your living room. Has the same high performance features and exclusive self-servicing facilities as the GR-681, except with 227 sq. inch viewing area, and without power VHF tuning or built-in cable-type remote control. The optional GRA-227-6 Wireless Remote Control can be added any time you wish. And like all Heathkit Color TV's you have a choice of different installations . . . mount it in a wall, your own custom cabinet, your favorite B&W TV cabinet, or any one of the Heath factory assembled cabinets.

GRA-227-2, Mediterranean Oak Cabinet shown **$109.95***

Heathkit "227" Color TV

Same as the GR-581 above, but without Automatic Fine Tuning . . . same superlative performance, same remarkable color picture quality, same built-in servicing aids. Like all Heathkit Color TV's you can add optional Wireless Remote Control at any time (GRA-227-6). And the new Table Model TV Cabinet and roll around Cart is an economical way to house your "227" . . . just roll it anywhere, its rich appearance will enhance any room decor.

GRS-227-5, New Cart and Cabinet combo shown **$54.95***

Both the GR-581 and GR-227 fit into the same Heath factory assembled cabinets: not shown, Contemporary cabinet $64.95*

NEW Heathkit Deluxe "481" Color TV With AFT

The new Heathkit GR-481 has all the same high performance features and exclusive self-servicing aids as the new GR-581, but with a smaller tube size . . . 180 sq. inches. And like all Heathkit Color TV's it's easy to assemble . . . no experience needed. The famous Heathkit Color TV Manual guides you every step of the way with simple to understand instructions, giant fold-out pictorials . . . even lets you do your own servicing for savings of over $200 throughout the life of your set. If you want a deluxe color TV at a budget price the new Heathkit GR-481 is for you.

GRA-180-1, Contemporary Walnut Cabinet shown **$49.95***

Heathkit "180" Color TV

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GRS-180-5, Table Model Cabinet & Cart combo **$42.50***

Both the GR-481 and GR-180 fit the same Heath factory assembled cabinets; GRA-180-2, Early American Cabinet $94.95*.

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Kit GR-227 NOW ONLY **$379.95*** (less cabinet & cart)

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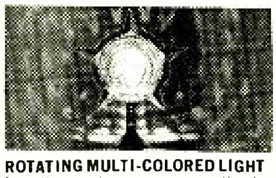

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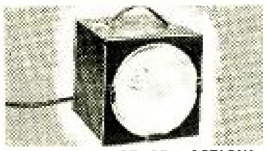

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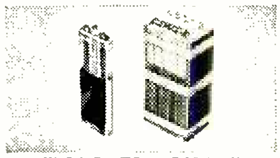

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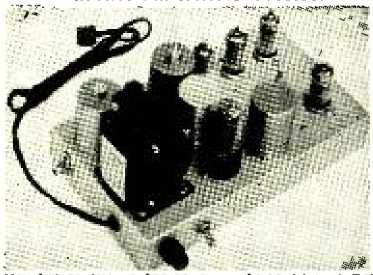

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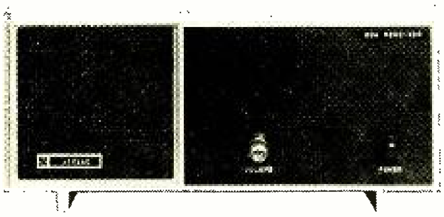

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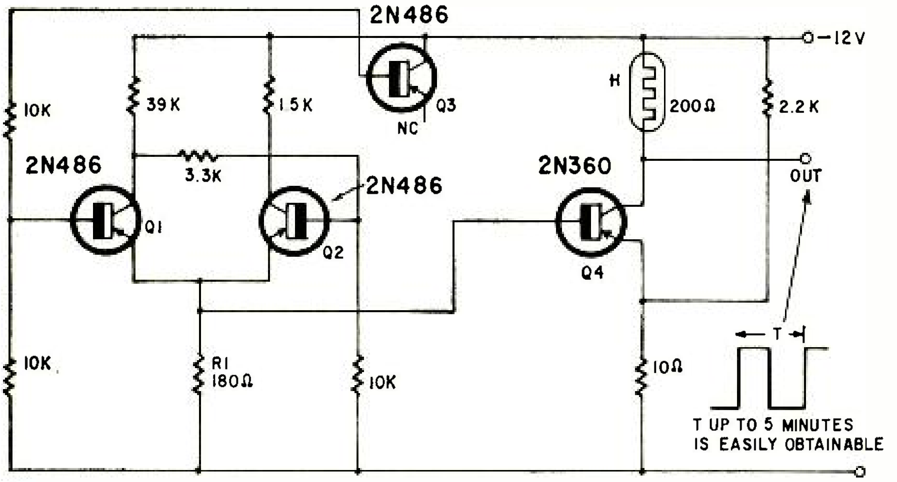
Here is a circuit that uses a Schmitt trigger to drive a heating element (H) wound over the case of transistor Q3. The leakage current through Q3's base-collector junction increases with temperature until it is high enough to trip the Schmitt trigger and turn off the heater. When the junction cools down, the Schmitt trigger flops back and the heating cycle begins its cycle all over again.

Note that one of the collector load resistors for the Schmitt trigger (Q1-Q2) is very much larger than the other. This is done so that when Q2 conducts, the voltage across the common emitter resistor (R1) is large enough to keep Q4 in conduction. However, when Q1 is conducting and Q2 is off, the voltage across R1 is much smaller and Q4 is cut off completely. Using a 200-ohm heater and the circuit constants shown in the diagram, the timer takes about 5 minutes to recycle.—*G. Varadarajan*

(The author did not include details on the heater. However, you can probably use resistance wire salvaged from a wire-wound resistor or potentiometer.—*Editor*) **R-E**



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