60c ■ MAR. 1971

Radio-Electronics

FOR MEN WITH IDEAS IN ELECTRONICS

EXPERIMENTS WITH 4-CHANNEL STEREO
Tape—Disc—FM

BUILD AN FM STEREO ADAPTER
No Coils—No Alignment

CASSETTE RECORDER ELECTRONICS
Step-by-step-servicing

BOB SCOTT'S TECHNICAL TOPICS
Receiver Selectivity

NEW FEATURE
...ce Electronics Repair

... The Right
...ement Transistor

4-Channel Disc
(see page 3)

A GERNSBACK PUBLICATION

Be creative and thrifty too!

SAVE WITH EICO KITS AND WIRED EQUIPMENT.

NEW "TREASURE HUNTER" KIT

Finds metals, pipes several inches underground. EICO TH-30 Solid State Treasure Hunter locates iron, steel, tin, gold, silver, copper etc. Beep pitch increases as you near object.

Battery operated. **$29.95.**

NEW "BULLHORN" KIT

Carries your voice up to 400 feet. **EICO BH-16** Solid State Bullhorn. 2½ lbs. light, is perfect for all outdoors, camping, sports. Battery-operated. **$15.95.**

NEW EICOCRAFT

The electronic science project kits for beginners, sophisticates, educators. 42 kits to date.

FM Wireless Mike $9.95.

8 NEW EICOCRAFT KITS

Automotive "LIGHTGUARD" • "VARIVOLT" DC Power Supply • "MOODLITE" Light Dimmer Control • "VARASPEED" Motor Speed Control • "LIGHTSHOW" Sound/Lite Translator • "ELECTRIC FIESTA" Audio Color Organ • "SUPER MOODLITE" Remote Control Light Dimmer • "ELECTROPLATER" From $2.50 to $14.95.

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Classic white 18" Cube features a fantastic audio-responsive light display.

"CELESTIAL LITES"
Constantly flowing color images move in rhythm to music. 24" x 24" x 6".

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Translucent dome provides 3-dimensional world of ever changing light patterns in response to music. 38" high.

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The lowest-priced component quality high fidelity!

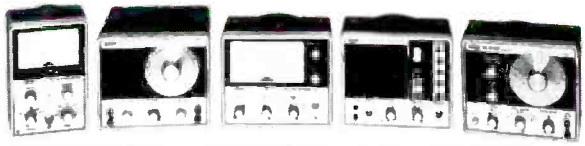
EICO 3780 50-Watt Silicon Solid State FET AM-FM Stereo Receiver. Kit $109.95, Wired $169.95

EICO 3080 50-Watt Silicon Solid State Stereo Amplifier. Kit $69.95, Wired $109.95

EICO 3300 Silicon Solid State FET AM-FM Stereo Tuner. Kit $69.95, Wired $109.95

NEW SOLID STATE TEST INSTRUMENTS

The first and only solid state test equipment guaranteed for 5 years!



EICO 240 Solid State FET-TVM. Kit $59.95, Wired $79.95.
EICO 379 Solid State Sine/Square Wave Generator. Kit $69.95, Wired $99.95.
EICO 242 Solid State FET-TVOM. Kit $69.95, Wired $94.50.
EICO 150 Solid State Signal Tracer. Kit $49.95, Wired $69.95.
EICO 330 Solid State RF Signal Generator. Kit $59.95, Wired $89.95.

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The now dimension to music pleasure. EICO all electronic solid-state Audio-Color Organs transform sound waves into moving synchronized color images.

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MODEL 3440 (10" x 15" x 16") 3-Channels. Kit $49.95. Wired $79.95. Other models to choose, from $19.95 and up.

TRANSLATORS

The electronics you need to create audio-stimulated light displays.

MODEL 3460 1 Channel. Kit $24.95, Wired $39.95.

MODEL 3465 3 Channel. Kit $49.95, Wired $69.95.

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Burst of white light flash in cadence of each beat of audio.

Model 3470 Adjustable Rate. Kit $29.95, Wired $44.95
Model 3475 Audio Actuated. Kit $39.95, Wired $59.95.

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EICO 889 Solid State Capacitive Ignition System. Boost gas mileage up to 25%, life of points, plugs to 100,000 miles; Kit $29.95, Wired, $39.95.

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Performance

*Audio magazine says:

"It is extremely attractive with its base and dust cover, both of which are optional accessories, and it performs superbly. In over twenty hours of use, the unit performed flawlessly, with never a fault in its changing operations during that time. Naturally, we cannot test any equipment to destruction and still produce a number of profiles each month. However, Garrard's reputation practically guarantees continued high-quality performance for years, and any user should be completely satisfied with this model, which represents the culmination of many years of turntable manufacture."

Price

**Stereo Review says:

"At a time when most automatic turntable prices are soaring, it is encouraging to note that the price of the SL95B is unchanged from that of the SL95 ($129.50). A number of different bases are available ranging in price from $6.50 to $19.95. A dust cover that fits all bases is $6.50."

Unbeatable combination

Garrard's SL95B

Garrard's SL95B Automatic Turntable $129.50.

For literature, write Garrard, Dept. AC 141, Westbury, N.Y. 11590

British Industries Co., a division of Avnet, Inc.

Circle 2 on reader service card

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← *Circle 1 on reader service card*

NEW & TIMELY

Volume 42 Number 3 RADIO-ELECTRONICS . . . FOR MEN WITH IDEAS IN ELECTRONICS MARCH 1971

SERVICE SEMINARS ON USING TEST GEAR

LONG ISLAND CITY, N.Y.—A series of more than thirty seminars exploring the proper use of TV, FM, AM and audio test instruments has been launched by Leader Instruments Corporation. Taking place in various regions throughout the nation, the newly developed program is geared for service technicians. ★

Service Techs Blow Off Steam

NEW YORK, N.Y.—Appliance and TV service technicians vented their frustrations at a recent meeting between the Service Managers Association, Inc., and State Attorney General Louis J. Lefkowitz, according to an article in Home Furnishings Daily.

"To put it in simple terms," said Elliot S. Scheff, national service manager for Capehart Corporation and president of the Association, "we wanted the Attorney General to know that we are willing to work with any Government agency to clear up some of the problems that have plagued this industry."

Grievances of service technicians aired at the meeting included the constant visits to Small Claims Court necessary to settle consumer complaints; bad checks issued by consumers; licensing by Government; and parking tickets handed out by police while technicians are making service calls.

Lefkowitz reminded the audience, "Today, anyone can put out a sign and become a TV service technician. You're all affected by it. Police your own field."

The Association asked Lefkowitz, who has criticized service technicians for many years, why isn't the Small Claims Court available to them as it is to the consumer, and how can an independent technician stop a consumer from giving his company a bad name when the firm is not in the wrong? ★

Cassette Tape Demonstrated

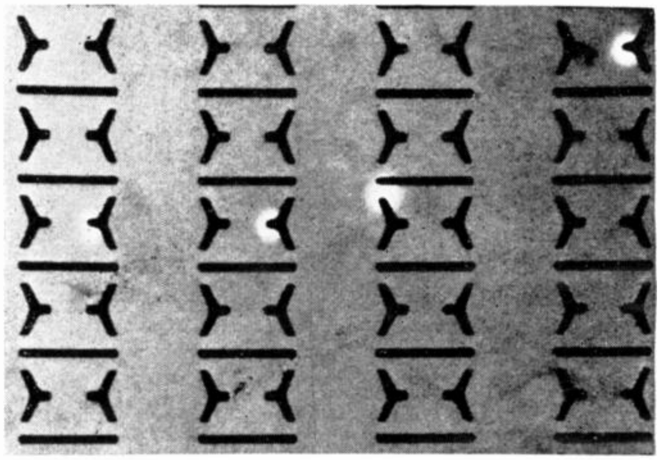
NEWTON, MASS.—The claimed first demonstration of a Dolbyized tape on a Dolby-equipped home cassette player was given recently. Vox made the tape, Advent the player.

Vox reports that each tape, which offers the equivalent of two records in playing span, is now ready for national distribution. Advent president Henry E. Kloss states: "We are perhaps the only makers of equipment that can make optimum use of Dolby-ized tape."

The signal is Dolby-processed both before and after recording to keep tape hiss to a minimum. ★

Advances In Magnetic Bubbles

MIAMI, FLA.—At the Conference on Magnetism and Magnetic materials, Bell Labs scientists, working toward cheaper and more easily manufacturable magnetic bubble devices, reported that they have for the first time grown homogeneous uniaxial magnetic garnet films using liquid phase epitaxial techniques. These permit making devices with more than 1,000,000 bubbles per square inch for use in future computer and digital communications applications.



Magnetic films have already been used in shift registers with over 100 working steps. A shift register is a component widely used in transmission equipment and computers for the temporary storage of binary digits.

Predictions have it that, as small scattered imperfections are eliminated, much larger shift registers will be produced.

Bubble materials that are homogeneous and crack-free can be grown by a method called liquid-phase epitaxy, which utilizes a hot solution to cover a substrate. During a cooling period a thin film forms on the substrate. It is then covered with a thin silicon oxide layer upon which is directly fabricated a nickel-cobalt-phosphorous propagation circuit.

Magnetic bubbles technology was initiated and first reported by Bell Labs in October 1967, and a research and fundamental development effort has been carried on at Bell Telephone Labs since that time to expand basic technology. ★

MUSICIAN EXPERIMENTS WITH BRAIN WAVES

NEW YORK, N.Y.—David Rosenboom, a twenty-three year old composer, hit on a plan for investigating the relationship of musical waves to encephalographic waves.

As a faculty member of York University Rosenboom has been working with students in groups of three at a time, testing his theory that people can control the type of brain-waves they emit, and hence their psychophysical states, or moods.

He connects electrodes to the skin of their heads and feeds the impulses that they emit into a computer he designed and made. It analyses the waves digitally.

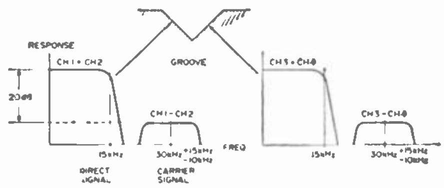
(continued on page 6)

Radio-Electronics

FOR MEN WITH IDEAS IN ELECTRONICS

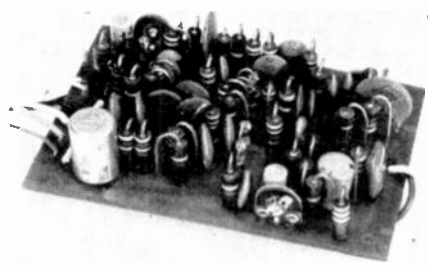
March 1971 • Over 60 Years of Electronics Publishing

ON THE COVER . . .
A four-channel stereo disc made by JVC is being played on Dual record changer. Across the lower right hand corner of the cover is a microphotograph of the 4-channel grooves. For more information on the cover and how the photographs were taken see page 38.



4-Channel Stereo is as new as today. Here's the lowdown on tape-disc-FM.
... see page 33

Use Your Wattmeter when servicing appliances. It will save you a lot of time and effort. See how it can be done.
... see page 26



Build A Stereo Adapter without using coils or transformers. Tricky new way to make this FM unit. ... see page 68

DEPARTMENTS

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LOOKING AHEAD

Volume 42 Number 3 RADIO-ELECTRONICS . . . FOR MEN WITH IDEAS IN ELECTRONICS March 1971

by DAVID LACHENBRUCH
CONTRIBUTING EDITOR

Tuner-less television

If cable television is indeed the wave of the future, then why not eliminate the front end—the tuner—completely? Its purpose is to fish signals out of the air, and if the signals come in via cable, who needs it?

This is the theory of a CATV system now operating in Dennisport, Mass., on Cape Cod. It's called "Dial-A-Program" and uses equipment developed by Rediffusion, Inc. of Great Britain, which provides wired television programming to many homes there. In Britain, only three programs are available at any one time, so a simple three-position switch serves as a channel selector. However, the Dial-A-Program system is designed to provide 36 or more channels to the home—without a tuner.

"Dial-A-Program" means just that. Each subscriber's home is connected to a central exchange by four wires—one pair capable of carrying a video program each way, the other pair a "control" system which permits the subscriber to select any program available at the exchange. In the Dennisport system, there is currently one central exchange. Larger systems would have about 10 exchanges per square mile. At the exchange, there is a 36-position electromechanical switcher for each subscriber. To choose his program, the subscriber merely dials the appopriate number. To determine just what he wants to watch, the subscriber dials to a special "guide" channel which tells him what's on each of the other channels.

The switching system adds extreme flexibility to CATV. For example, the exchange can indicate just how many subscribers are watching each channel. Homes can be selectively blacked-out from specific channels to permit, for example, beaming special programs to physicians only. At present, the two-way capability of the system isn't being used, but tests have been made of its burglar and fire-alarm capability. Remote meter-reading is also a possibility.

Special CATV receivers?

The existence of the Dial-A-Program system and other similar techniques raises the question of whether simplified and specialized receivers might be developed especially for such closed-loop systems. Although TV sets used with Dial-A-Program currently are conventional types, the tuner is strictly vestigial. Receivers used with the Rediffusion system in Britain and elsewhere have no tuners at all. Such centrally-switched systems could give birth to a new and simplified "gutless wonder" television set, costing perhaps 20% less than current comparable receivers and less prone to failure. Incorporating the switching or dialing system in the receiver could also eliminate the clutter of black boxes (special tuning systems) in CATV homes.

DIAL-A-PROGRAM being installed at Cape Cod, Mass. uses special color TV or conventional sets with converters. A multi-pair cable carries a 5-MHz to 10-MHz "super video" band of vhf/uhf signals.

Currently, of course, almost all CATV systems feed rf into subscribers' homes and therefore use the complete receiver, tuner, front end and all. But if CATV becomes sufficiently widespread—and if a standard tunerless system is developed and accepted—there certainly will be room for receiver simplification. But, of course, there are many roadblocks to be faced. A subscriber to one of these special systems (with his special receiver) couldn't move to an area with off-the-air reception and expect to use his television set. And there's the little matter of the federal All-Channel Law which requires that all television receivers be capable of receiving all 82 channels.

Black-and-white color camera

CBS Laboratories has received a patent for a home camera which can make color movies or still slides using black-and-white film. The non-electric camera, claimed to be as compact and low-priced as existing home movie cameras, would make films which could be shown on a home TV screen through the CBS-developed EVR Teleplayer.

The EVR player uses a cartridge containing black-and-white film with electronically coded color information and optical monochrome image side-by-side on film about 8.3-mm wide. Currently, EVR film cartridges are made from either color film or video tapes—the master film being recorded electronically, duplicates printed optically. The newly patented camera would use optical filters to encode the color information on either standard super-8 black-and-white film or a special EVR film. The film would then be sent out for processing, and returned in an EVR cartridge playable through a standard EVR teleplayer. If the camera's user decided to make still pictures, he could pack 1800 individual slides in a single EVR cartridge.

CBS Laboratories says that the system is in very early stages of development. Nevertheless, it gives CBS a new weapon in the battle of the videoplayers.

Super-8 TV

As videoplayer fever mounts, Eastman Kodak has launched a campaign to make super-8 color film the standard home TV playback medium. In its advertising and in engineering seminars, the film company continually drives home three points: (1) Color film scanning is a known technology. (2) A large library is already available on super-8 film. (3) Anyone with a home movie camera can produce his own TV shows via super-8. The arguments certainly are enticing. Anyone who regularly goes through the trouble of setting up projector and screen and darkening the room would appreciate the advantages of being able to show his home movies through a color TV set.

American equipment manufacturers so far have shunned the super-8 TV system, although it has gained adherents in Europe. NordMende, a large German TV maker, has introduced a super-8 color TV system there, and Vidicord Holdings Ltd. is pushing the system in the United Kingdom. Sylvania was on the verge of introducing such a system here a year or so ago, but backed off after meeting cool market response to its Color Slide Theater, a combination color TV set and slide scanner.

Eastman Kodak says it has no plans to introduce hardware for the system, but it's known to have developed prototype equipment. Behind the scenes, however, Kodak is believed to be talking with TV manufacturers in an attempt to get them to enter the field. If no major American TV maker is interested in a super-8 scanner, there's the possibility Eastman Kodak could enter the field itself in 1972 or 1973. **R-E**

THE WORKHORSE

The industry's top replacement tube, 6GH8A, is used in so many makes of TV and in so many different applications that it will be a high volume replacement type for years to come.

RCA's versatile 6GH8A is designed to satisfy the demands of all these applications:
Multi-vibrator type horizontal-deflection-oscillator circuits, sound if-amplifier, agc-amplifier, burst-amplifier, chroma-amplifier, 3.58 MHz-oscillator demodulator circuits, video-amplifier, sync-separator, noise inverter, color killer control, matrix-amplifier and blanker applications.

Three good reasons to replace with the RCA-6GH8A:

1. Stringent performance tests eliminate shorts. Special processes and tests minimize inter-element leakage.
2. Low heater-cathode leakage.
3. Optimum gm for efficient operation in all applications.

Stock up on the industry's workhorse 6GH8A and specify RCA! See your RCA tube distributor for all your tube requirements.

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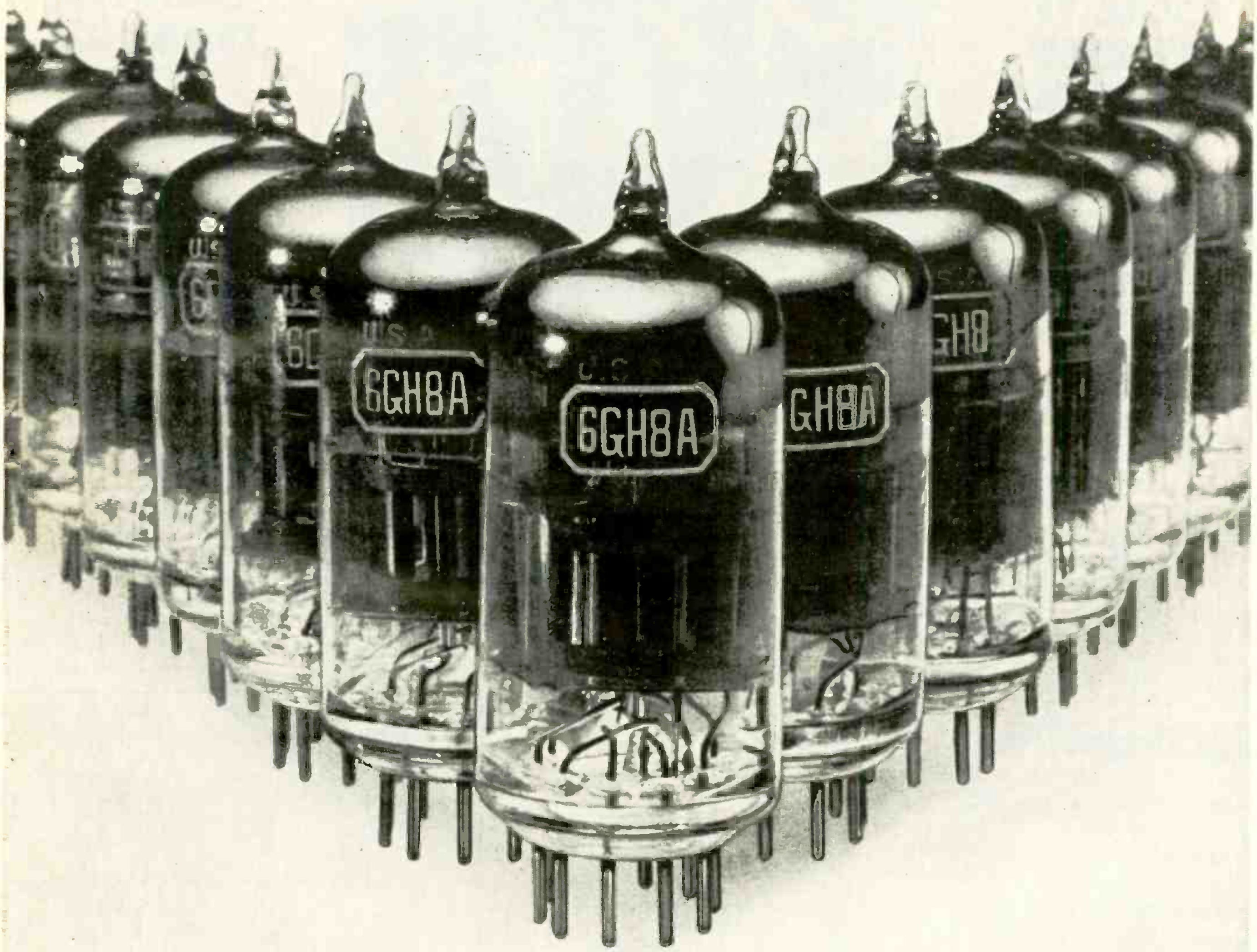

RCA

(continued from page 2)

Charles Ives proposed the concept of using brain-waves to make music early in this century, and a number of contemporary American and European composers have played with the idea.

Mr. Rosenboom is trying to discover how to control the emission of brain-waves and make them into music, an attempt to unearth "a mediational language" by which brain-wave music might work. ★

CABLE TV VS VIDEO CARTRIDGES

NEW YORK, N.Y.—Debate still rages over the numerous entries into the viewer-controlled video market. Home video cartridges, disk systems, cable TV, all claim to be bonanzas to the consumer, but the combination of high price, operating difficulties, technical bugs and maintenance are still problems.

Paul Klein, president of Computer TV, Inc., and a former NBC vice president, believes cable will outmode any single cassette system, according to the New York Times. He says a variety of programs would be stored in a computer bank. From a weekly list of possible offerings, the viewer, for a price, could see what he wanted. ★

Police Car Hard Copy Via Keyboard & Radio

MOUNTAIN VIEW, CALIF.—An electronic system that enables a patrol officer to transmit and receive descriptive and numerical data on crimes, accidents, and other incidents has been introduced by Sylvania Electric Products Inc.

The Sylvania/digicom 300 system consists of mobile and base station terminals, each of which includes a keyboard for typing messages and a cathode ray tube (CRT) display for presentation of transmitted and received communications. Names, addresses, license numbers, and other information are entered on the keyboard and displayed on the CRT.

After typing the message, which can contain up to 64 characters, the dispatcher or patrol officer presses a button to transmit the entire communication in seconds. The unit also enables the officer to transmit by push-button status codes, pre-selected messages, and an emergency alert that he requires assistance.

Designed to reduce channel crowding on existing police networks, the system complements voice communications without relying upon, excluding, or interfering with verbal message exchange. ★

COMPUTER TRANSLATES SOUND

NEW YORK, N.Y.—A new process that can identify any recorded sound by computer was revealed by Sound Signatures, Inc., Los Angeles, Calif. and Tracor, Inc., Austin, Tex. recently.

Sound Signatures, a company founded by thirty-four year old Ronald Katz, invented the unique electronic device that translates sound into computer-readable language. In conjunction with Tracor, a company that designs and manufactures computer systems, a process was developed that can start with any recorded sound and result in a computer-printed list that identifies the sound.

"The system accepts raw

(continued on page 12)

Radio-Electronics

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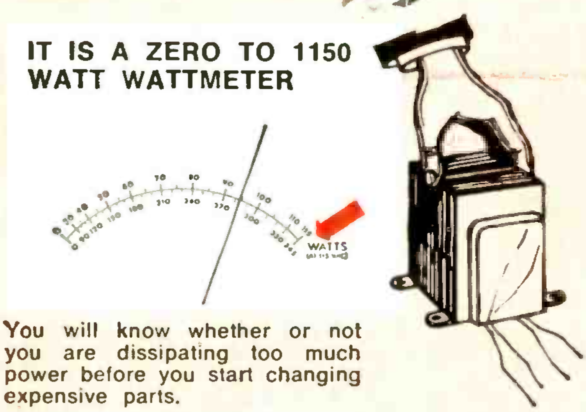
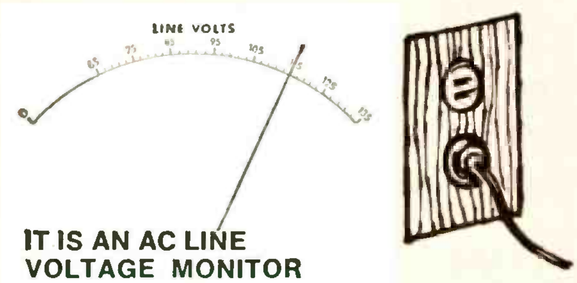


You will know whether or not you are dissipating too much power before you start changing expensive parts.

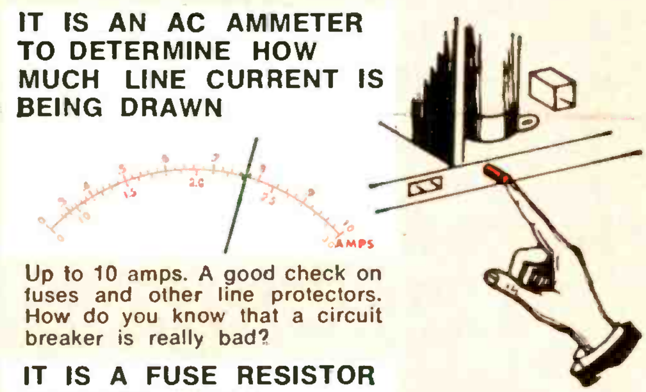
B.



IT IS AN AC LINE VOLTAGE MONITOR

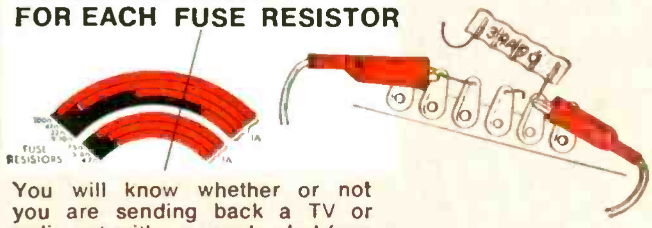
Calibrated right on the nose at 115 volts. How many times has your trouble simply been line voltage and you could have saved so much time?

C **IT IS AN AC AMMETER TO DETERMINE HOW MUCH LINE CURRENT IS BEING DRAWN**



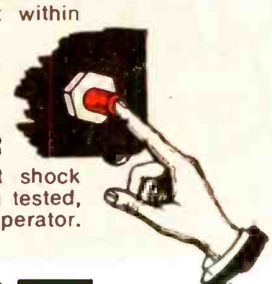
Up to 10 amps. A good check on fuses and other line protectors. How do you know that a circuit breaker is really bad?

D **IT IS A FUSE RESISTOR CHECKER WITH SPECIAL SCALES FOR EACH FUSE RESISTOR**



You will know whether or not you are sending back a TV or radio set with an overloaded fuse resistor that will go out within hours.

E **IT IS PROTECTED BY A 10 AMPERE CIRCUIT BREAKER**



Fully protected against shock hazard to appliance being tested, and is also safe for the operator. 8" x 6" x 5" 5 lbs.

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America's oldest and largest Electronic, Radio-TV home-study school

Compare if you like. You'll find—as have so many thousands of others—that NRI training can't be beat. From the delivery of your first lessons in the remarkable, new Achievement Kit we send you, to "bite size," easily-read texts and carefully designed training equipment . . . NRI gives you more value.

Shown below is a dramatic, pictorial example of all of the training materials included in just one NRI Course. *Everything* you see pictured below is included in low-cost NRI training. Other major NRI courses are equally complete. Text for text, kit for kit, dollar for dollar—your best home-study buy is NRI.

All this is yours—from Achievement Kit to the only Color TV specifically designed for training—when you enroll for NRI's TV-Radio Servicing course. Other courses are equally complete. But NRI training is more than kits and "bite-size" texts. It's also personal services which have made NRI a 50-year leader in the home-study field. Mail the postage-free card today.

Approved under GI BILL
If you served since January 31, 1955, or are in service, check GI line in postage-free card.

(Continued from page 6)

sound as input. No coding or control signal is necessary or utilized," states Louis Sackin, president of Sound Signatures.

The first application developed and discussed in detail concerns radio monitoring and the performing rights industry, which is responsible for determining and paying the royalties to music composers and publishers each time one of their recordings is played on the air.

Plans are in the works to monitor recorded radio and television commercials, so program sponsors and ad agencies can be provided with proof of performance. ★

LASER AIDS ATTACK ON POLLUTION

Menlo Park, Calif.—Scientists have found a way to detect pollutants in seemingly clean air with laser beams.

Ronald Collis, chief meteorologist at Stanford Research Institute, helped develop the technique for locating invisible pollutants, such as carbon monoxide and sulphur dioxide.

Lidar, the device used, is so named for its function, (*LIght Detection And Ranging*). Lidar uses shorter wavelengths in the visible light portion of the frequency spectrum. These wavelengths measure only 0.6943 micron (about 27 millionths of an inch).

"This makes a raindrop show up like the side of a house on our screen," Mr. Collis remarked. Lidar picks up extremely tiny particles, too small to be seen with the naked eye. It is even possible to track some gases in the atmosphere.

The device typically consists of a ruby laser that produces one pulse every one or two seconds. The pulses are 30 billionths of a second in duration and are directed into the atmosphere in a scanning beam that automatically sweeps out a sector in a horizontal or vertical plane.

Lidar helps pollution researchers observe the structure and height of mixing layers. It is also used to measure the movement and diffusion of smoke plumes or clouds of particles and to determine smoke plume opacity. ★

4-Channel Stereo
If you're interested in this new kind of listening, don't miss the article on page 33, "Experiments With 4-Channel Sound". It's a complete description of what's happening today.

Satellite Earth Station

Juneau, Alaska—RCA Alaska Communications Inc. has filed a request with the FCC for authority to establish and operate a ground station that would make Alaska the first state to utilize satellites for intrastate communications.

Howard R. Hawkins, President of RCA Alascom, said the satellite earth station would be located at Lena Point, Alaska, near Juneau. He indicated that the station would provide additional circuits for telephone service, two-way television transmission and expanded voice/record services.

The station would make possible the first live television between the Juneau/Sitka area and other parts of Alaska and the south 48 states, Mr. Hawkins said.

Equipped with a 32-foot antenna, the Lena Point station would be connected to the Juneau telephone toll center by an existing microwave route which has a present capacity of 300 voice circuits. This link is being upgraded and expanded by RCA Alascom to provide two-way television transmission capability.

Also connecting at Lena

(continued on page 14)

New & Timely

(continued from page 12)

Point would be an existing microwave system to Hoonah and a new microwave system to Angoon and Sitka, each with a capacity of 600 voice circuits and two-way television transmission capability.

The earth station is designed to supplement the backbone network between the major urban centers in Alaska. It also would provide additional direct paths to the south 48 states and alternate routing with terrestrial facilities. The Lena Point station would operate with the stations at Talkeetna, Alaska and Jamesburg, California or Brewster Flat, Wash. and with other Alaska stations as they are installed. ★

TAPE PIRATES ATTACKED

NEW YORK, N.Y.—A program calling for Federal legislation to eliminate bootlegging and pirating of prerecorded tapes is underway through the efforts of the National Association of Record Merchants. At an emergency meeting, representative record and tape manufacturers agreed to form a legislative committee to combat such piracy. According to the Association, there are an increasing number of companies which duplicate prerecorded tapes, either directly off one tape or from several sources, and then retail it to dealers for a great deal less than the original manufacturer charges. ★

Appliance Shock Safety

NEW YORK, N.Y.—Householders throughout the nation using electrical appliances will be protected against possible hazards posed by leakage current with the application of a new American National Standard.

American National Standard C101.1, Leakage Current for Appliances, sets a maximum leakage current of 0.5mA for household appliances having two-wire or three-wire flexible cord connection and rated for use on 120-volt circuits. Research on which the standard is based showed that the 0.5 limit will not directly endanger the user or startle him into a hazardous reflex. ★

STEREO YOUR BAG? There are several articles in this issue. Try Cassette Recorder Electronics on page 39; or Solid-State Amplifier Design on page 45; or 6-Ways To Improve Your Stereo System on page 54; or you could just read this issue from cover to cover. . . . It's worth your time.

B & W Cameras Take Color Pix

WASHINGTON, D.C.—A patent has been issued for a new lightweight portable camera that can take up to 12,000 still pictures in full color or make a half-hour motion picture with one loading. Inventors Dr. Peter C. Goldmark, president of Columbia Broadcasting System Laboratories, and his associate, William E. Glenn, Jr., of Stamford, Connecticut, have assigned the patent to C.B.S.

The C.B.S. camera, which can be operated without any electric power, does not use color film. Ordinary black-and-white film is employed. A section of the film carries the basic image and the color values are optically registered by a coding process on the remaining portion.

If sound is desired, magnetic recording strips can be added to the edges of the film.

An Electronic Video Recording attachment electronically retrieves the optical coding of colors and restores the original image in natural hues on the home color TV screen.

Dr. Goldmark said it was too early to predict when the C.B.S. camera might be marketed but that in price, weight and size it would be competitive with cameras now available. R-E

Have you tried our canned tuner?

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Circle 7 on reader service card

Correspondence

CET TEST NEWS

I want to thank you for the very informative article on our NEA Certified Electronic Technician Program (RADIO ELECTRONICS, December, 1970). You have explained what the program is very thoroughly and have put the program in its proper perspective.

There are a few corrections that I would like to make to the article. The fee for this exam is now $10.00. Also, we now have a new exam that consists of 120 questions. We will also be coming out with a newer exam in about a month.

Last of all, inquiries should be sent to Mrs. Judy Lucid, NEA Director of Certification, 1309 W. Market Street, Indianapolis, Ind. 46222. Phone 317-632-2469.

MRS. JUDY LUCID
Director of Certification
National Electronics Associations Inc.
Indianapolis, Ind.

Thanks for the information. We already presented some of it in our January issue. This reminder will back it up. And a note to all you readers: take the CET test, pass it, and add that CET after your name. It's worth the effort.

NEED OLD TUBES?

I find I have a large quantity of hard-to-get obsolete radio tubes. Drop me a line and tell me what you need and I'll quote you a price by return mail.

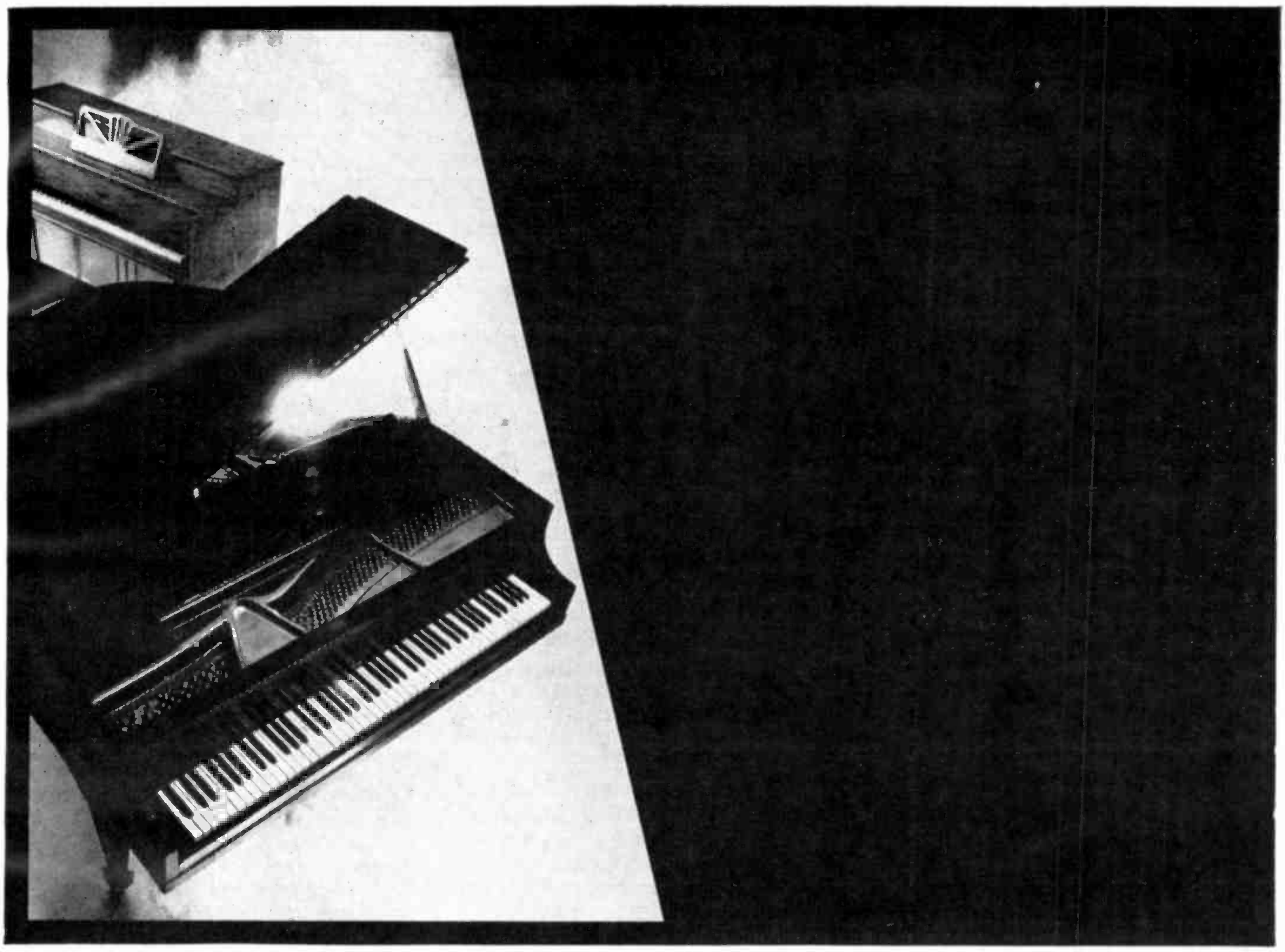
GOODWIN RADIO SHOP
Rankin, Ill.

ELECTRONIC UMPIRE RE-DESIGNED

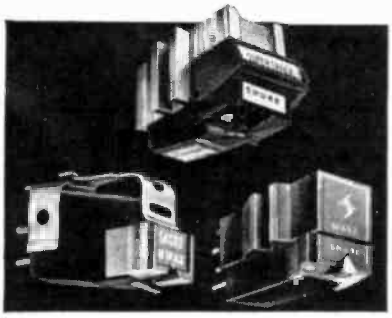
Sometimes a problem can be solved better by avoiding the newest technology, as you can see by re-designing the Electronic Umpire, December, 1970 issue of RADIO-ELECTRONICS. A two-man umpire can be built as shown (see diagram on p. 18).

The bulb controlled by the first switch to be thrown is the only one which will light—since the maintaining voltage is lower than the breakdown (firing) voltage. (An occasional bulb may have an abnormally

(continued on page 18)



To each his own.



Not *everybody* needs a concert grand piano, nor does everybody *need* the best cartridge Shure makes to enjoy his kind of music on his kind of hi-fi system. Eventually, you'll want the renowned *V-15 Type II Improved,* the peerless cartridge for advanced systems and ample budgets. But, if your exchequer is a little tight, consider the *M91E*, widely acclaimed as the *second best* cartridge in the world. With a sharply circumscribed budget, all is *far* from lost. Choose any of the four models in the *M44 Series*, built for optimum performance in the easy-to-take $18-25 price range. Write for a complete catalog: Shure Brothers Inc., 222 Hartrey Avenue, Evanston, Illinois 60204.

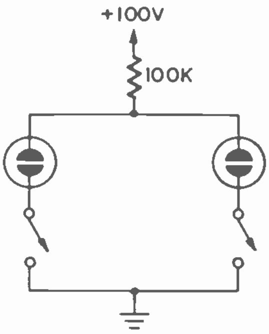
SHURE

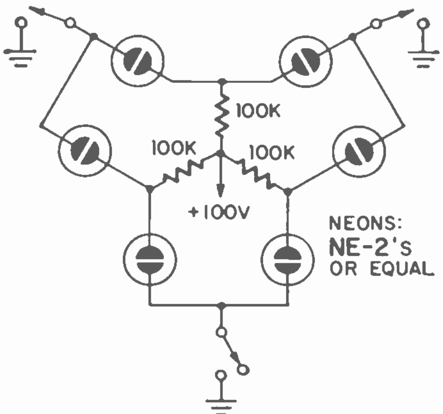
Circle 9 on reader service card

CORRESPONDENCE
(continued from page 16)

high maintaining voltage and may be discarded.)

By supplying a two-man umpire





to each *pair* of contestants, we produce the complete design. Only one switch is needed for each contestant. An example for three contestants, using the same parts values, is shown.

The number of lights you turn on is equal to the number of players you have beaten.

This design can be extended to any number of stations. For six stations the parts count would be: 6 spst switches, 30 NE-2 lamps, 15 resistors and a power supply. This is inexpensive, easy to construct and displays all six places in the order in which the switches were thrown. Who needs IC's?

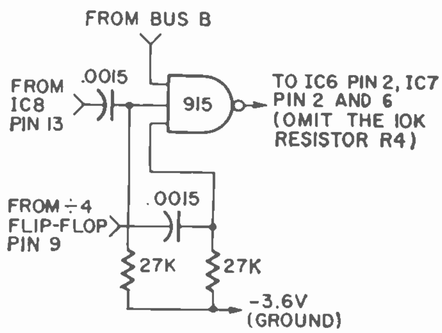
Henry E. Schaffer,
Assoc. Prof. of Genetics
Raleigh, N.C.

IMPROVING DIGISYNTONE OPERATION

Congratulations on the excellent construction article "Digisyntone Music Synthesizer" in the September 1970 issue. I have just completed a synthesizer from this article and I am very pleased with its operation and performance.

I did find it necessary to make a few changes in the unit to achieve proper operation, and I thought you might be interested to know about these if other readers encounter the same difficulties with the unit as I did.

First, the Motorola Integrated Circuit Handbook specifies that the output loading factor of the MC790P flip-flop is 10, and that the input loading factor of the MC724P quad 2-input gates is 3. This means that no more than three gate inputs should be driven by a single flip-flop output. In the decoder section of the Digisyntone, the flip-flops are driving from four to twelve gates each. Fortunately, the Motorola recommendations appear to be rather conservative, as the flip-flops in my unit managed to drive the gates, but with one exception. The outputs of IC2 through the first half of IC5 are driving from four to seven gates each. The last half of IC5 drives all twelve gates, and in my unit, the flip-flop couldn't quite hack it. I was able to get proper operation by decreasing the load resistance of IC5, by connecting an 820-ohm resistor from pin 8 of IC5 to plus 3.6 volts at pin 11.



The second problem I had was in the summing of the outputs from IC8 pin 13, the divide-by-four flip-flop pin 9, and the highest octave of the keyboard from bus B. These outputs drive IC6 and IC7. I was unable to achieve proper operation with the circuit as shown, using the two .0015-μF capacitors. In my unit, I had to add an extra three input gate for this purpose. I used one-half of a Fairchild 915 dual three-input gate, as I happened to have this on hand. Any other rtl gate with three or more inputs should work. The revised circuit is shown here.

At this time, I am running my unit with an adjustable power supply that I have. It appears to function better at 3.6 volts (which Motorola specifies) rather than lower voltages. With this input, the voltage at the gates is 2.3 volts (as shown on the schematic). Readers who use the power supply shown in the article might want to make changes to increase the output to 3.6 volts. At this voltage, my unit draws about 450 ma.

I hope this information will help, and thank you once again for this article.

Gregory Moline
No. Hollywood, Calif. R-E

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-CONTENTS-

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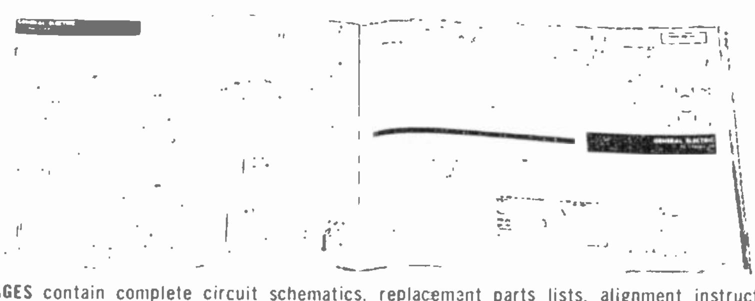

LARGE PAGES contain complete circuit schematics, replacement parts lists, alignment instructions, critical part locations, important waveforms and voltage readings.

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RE-31

Circle 11 on reader service card

EQUIPMENT REPORT

Lectrotech TO-50 Triggered-Sweep Scope

For manufacturer's literature, circle No. 20 on Reader Service Card.

I'VE PLAYED WITH THE MORE EXPENSIVE triggered-sweep scopes in the past. Mostly, I use service-type scopes. But now, I've finally had a chance to give a good triggered-sweep scope a real workout, and I've enjoyed it!

This is the Lectrotech TO-50. Frankly, I was always a bit confused with triggered-sweep scopes. However, this one is easy to use. Even I found out how to run it in only about 5 minutes fiddling. Beside having a *slightly* wider bandwidth (dc up to 10 MHz!) than my own antiques, I was able to get rock-steady patterns on all kinds of TV signals. For the first time, I counted the cycles in a *burst* waveform! (There *are* 8.) I've always wondered.

Seriously speaking, while the vertical and horizontal controls of this scope are calibrated in "Volts per Division" (V) and "Microseconds per Division" (H), you'll be able to run it in short order. There are three marked preset ranges on the horizontal sweep: "V" for VERTICAL, "H" for HORIZONTAL, and "C" for COLOR. Setting to these points shows you the waveform you want right away and locks it in.

Each control has an outer knob calibrated in steps and an inner knob, continuously variable, for fine sweep selection (or gain, in the vertical amplifier.) To get an exact calibration, all you have to do is turn each of the variable controls full clockwise and that's it.

For instance, to look at a horizontal-sweep waveform, or one line of video signal with the horizontal sync pulse, you set the horizontal sweep speed to 10-μsec/div. The graticule of the scope is calibrated in 10 major divisions; so, if each of these is 10 μsec, the beam will cover the distance between the outer limit markings in 100 μsec. Since one line of TV horizontal sweep is 64 μsec with the sync-pulse, you'll see one full line and almost all of the following one. (A horizontal sync pulse is 10 μsec wide, roughly)

The TO-50 has a novel circuit in this department. If you want to expand the displayed waveform, to count the cycles in the burst, you pull out the HORIZONTAL POSITION knob. This "magnifies" the sweep horizontally 5 times. This makes the 10-μsec/div speed go to 2.0-μsec/div, and the image expands. Minor adjustments are made with the variable inner knob. This works exactly the same on all horizontal-sweep ranges.

The vertical amplifier is calibrated in "VOLTS/DIVISION". It has a range from 0.02 volt/div up to 50 volts/div. The inner knob again can be used for minor variations and is calibrated exactly when turned full cw. Calibration can be checked instantly from the front. A "CAL OUT" 1.0 volt p-p jack is provided on the panel. Just touch the probe-tip to this jack, set the selector to 0.2 volt per div, and see if the screen shows 5 divisions on the flat-top square wave. That's all. A recessed screwdriver adjustment is provided, if gain calibration adjustment is needed.

A dual-purpose direct-low-capacitance probe comes with the TO-50. I like the selector switch used! Unlike some, this one is a locking type switch. It can't be accidentally changed.

The triggering part of the sweep isn't hard to learn. You must have the sweeps set somewhere *near* the frequency of the signal you want. Actual triggering is determined by the position of the TRIGGER LEVEL control, and the 3-position SELECTOR switch. This has V (vertical) and H (horizontal) and "NORMAL" positions. The V and H positions will preset the trigger circuits so that a waveform near these frequencies will lock in.

If you wish, you can disable the trigger by pulling out on the TRIGGER LEVEL knob. This puts the sweep into AUTOMATIC triggering and you get a waveform on the screen regardless of the trigger-level setting. Once the sweeps are adjusted somewhere close to frequency, the trigger-level can be pushed back in and set for most stable triggering. The trigger sync must be set at the right polarity. For example, in a video output waveform where the sync is positive-going, set the SLOPE selector to "+". Then, the waveform will trigger and lock in. Another SYNC SELECTOR switch allows the choice of external sync, internal sync, or line sync (60 Hz).

The TO-50 can be converted for use as a Vectorscope by operating two switches on the back panel. Connecting jacks are also located there.

This is an ac or dc scope. Mode selection is made with a slide switch on the front panel. By setting the vertical gain knob to the proper range, you can read any dc voltage, or combination of ac and dc voltages, such as video waveforms, etc.

An "EXTERNAL HORIZONTAL AMPLIFIER" is provided for use in sweep alignment. External horizontal sweep from the sweep generator can be used, or the LEVEL knob can be pulled out to connect an internal LINE-SWEEP. There is a PHASING control on this amplifier panel for making the curve look right!

All of the CRT controls are grouped closely on the front panel. Even the FOCUS and ASTIGMATISM controls are out front.

All solid-state circuitry is used in the TO-50. A very complete instruction manual not only gives you very detailed instructions on how to run this instrument, but a service checklist and troubleshooting instructions.

All in all, this is quite an instrument, and one that could be a lot of help to you in your daily work, no matter what it is.—*John Fitzgibbon* **R-E**

SONY® achieves true integration

In all too many transistor integrated amplifiers, the preamp stage does not quite live up to the performance of the amplifier section.

Not in Sony's new TA-1130. Thanks to an FET front end, this integrated package has a preamp stage that really does full justice to its output section.

Why FET's

For the same reason that we use them in our tuners and receivers, and in our studio professional condenser microphones; because FET's have a far wider dynamic range than ordinary transistor types.

And the preamplifier needs that range. Because it has to be sensitive enough to handle the lowest-output, moving-coil cartridges, yet still accept the highest output cartridges without overloading. (The power amp has it easier: you keep its input level fairly constant with your volume control.)

Power to Spare

But if the power amplifier doesn't need that range, it does need power. The output section of TA-1130 has it: 230 IHF watts (into 4 ohms), with continuous power rated at 65+65 watts into 8 ohms. (With all that power, we made sure that both transistor and speaker protection circuits were included.)

SONY F.E.T. Amplifier

Nothing Stands Between You and the Sound

Both sections are powered by balanced positive *and* negative supply voltages (not just positive and ground), so there need be no coupling capacitors or interstage transformers between you and the sound.

Without them, the TA-1130 can extend its power band width down to 7 Hertz, and actually *exceed* its rated damping factor of 100 all the way down to 5 Hz.

An Abundance of Audiophile Conveniences

Of course, the TA-1130 has all the control facilities that you could ask for: low and high filters, tape monitor, a speaker selector, and even an Auxiliary input jack on the front panel. The selector switch is Sony's instant-access knob-and-lever system.

There's even provision to use the TA-1130's power amp and preamp sections separately, to add equalizers, electronic cross-overs, or 4-channel adapters to your system.

In fact, you can even get the power output section separately, as the model TA-3130 basic amp. It makes a great match for our TA-2000 preamp, too.

Your Sony dealer has both models available, and at prices—$359.50 for the TA-1130; $239.50 for the TA-3130. Sony Corporation of America, 47-47 Van Dam Street, Long Island City, New York 11101.

Circle 13 on reader service card

...the new Heathkit® 25″ ultra-rectangular TV color picture is that perfect.

"Picture postcard perfect"...an apt description for the quality of color reproduction in the new Heathkit GR-371MX 25″ ultra-rectangular solid-state color TV. And the reasons are as clear as the expanded 315 sq. in. view:

New Heath MTX-5 ultra-rectangular matrix picture tube. Developed in conjunction with leading domestic tube manufacturers to produce a sharper picture, purer colors, more natural flesh tones. Specially formulated etched face plate cuts out unwanted glare, increases contrast without sacrificing brightness. Matrix screen around phosphor dots eliminates reflected light, allows use of higher transmission glass for greater light output. New square-corner rectangular design opens up the largest picture in the industry...25″ diagonal measurement, a full 315 sq. in. of viewing enjoyment. New shape allows complete transmitted image to be seen for the first time. Pictures don't wrap around sides of tube as before. And 25,000 volt high voltage assembly assures optimum picture quality.

Unique solid-state design: 45 transistors, 55 diodes, 2 silicon controlled rectifiers; 4 advanced ICs containing another 46 transistors and 21 diodes; and just 2 tubes (picture and high voltage rectifier) combine to deliver performance and reliability unobtainable in conventional tube sets.

Other plus-performance features include: High resolution circuitry for improved picture clarity, plus new adjustable video peaking that lets you select the degree of sharpness and resolution you desire; an exclusive solid-state VHF tuner with MOS Field Effect Transistor for superior reception even under marginal conditions; Memory Fine Tuning; 3-stage solid-state IF, factory-assembled and aligned; Automatic Fine Tuning; VHF power tuning; "Instant-On"; Automatic Chroma Control; adjustable noise limiting and gated AGC; adjustable tone control; hi-fi sound output to your stereo or hi-fi system.

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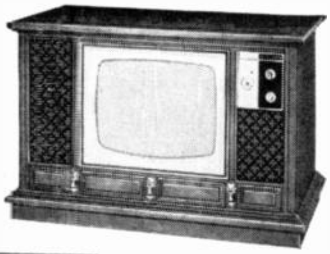
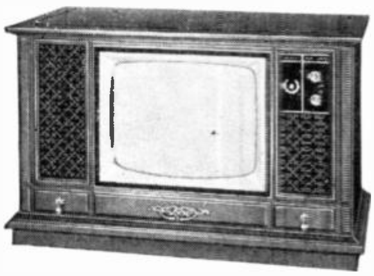


20″ solid-state color TV

Kit GR-270, 109 lbs., less cabinet **489.95***



23″ solid-state color TV

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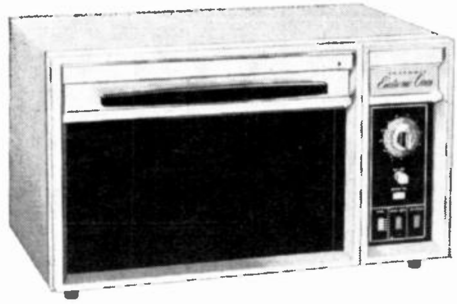

Ⓑ

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And while you're at it, picture these Heathkit newsmakers in your den, kitchen, ham shack or shop.

Ⓐ New Heathkit solid-state "Legato" 25-pedal Theater Organ

One of the world's most versatile musical instruments...now in money-saving kit form. Designed exclusively for Heath by Thomas Organ craftsmen. All solid-state. Features 15 manual voices, 4 pedal voices...any or all at the flip of a tab. 25-note heel & toe pedal board, range 16' & 8' C0 to C3. Color-Glo® key lights and comprehensive organ course supplied have you playing like a pro in minutes. Two 44-note keyboards; accompaniment range 8'...F1 to C5. Solo manual 16', 8', 4', 2'...F1 to C7. 200 watts peak power from two solid-state amplifiers...one for the 2-speed rotating Leslie speaker and one for the two 12" speakers. Tape record/playback jack on amplifier. Band Box & Playmate accessories available.

Kit TO-101, 299 lbs. **1,495***

Ⓑ New Heathkit microwave oven

The cooking revolution of tomorrow, here today in easy-to-build kit form...saving you hundreds of dollars over comparable electronic ovens. Exclusive patent-pending Heath double door interlock system provides absolute safety...oven cannot be turned on if door is open. Prepares meals in minutes, not hours. Cooks on china, glass, even paper plates in spacious, roast-size oven cavity. Low-profile, countertop design fits unobtrusively into kitchen decor. Portable convenience, too...can be used on patio, at poolside, etc...wherever a 120 VAC grounded outlet is provided. Give your wife a break from kitchen drudgery...with this new miracle of microwave cooking.

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Circle 14 on reader service card

HOME APPLIANCE ELECTRONICS

by **JACK DARR**
SERVICE EDITOR

USING THE WATTMETER

THE WATTMETER IS ABOUT AS HANDY A test instrument as you can find! It is useful in any kind of work involving ac-powered equipment; radio, TV, hi-fi, and in all types of appliance work. It's especially useful with modern multiple-speed, multi-purpose electrical appliances. By reading the power-drain of the unit, you can tell very quickly whether it is working normally or not.

Multiple-heat units, especially, can be checked with the wattmeter. It will tell you which heating element is open. Such complaints as "It doesn't get hot enough" are easy to pin down. It will also tell you whether there is any real trouble in the thing. For instance, if a gal complains that her hair drier "just won't get hot enough," check the rating plate. If it says that the normal drain of the unit is 300 watts, and it shows 300 watts, that's it. It's doing the best it can! Sell her a new hair-drier with a bigger element.

Other tests, which previously took a lot of time, are easy. For example, let's look at any motor-driven fan/heater type of appliance—a class which includes hair-driers and many more. You can check them for correct wattages. This will tell you if the heating element is still ok. If so, check the total drain very closely. Alternately, disconnect the heating element and check the wattage drawn by the motor alone. If this increases as the motor warms up, there is very apt to be a dry bearing in the motor, which causes more and more drag as the motor runs. This draws more current, but more important, it *slows down the motor*.

The result is that less air is forced over the heating element due to reduced fan speed and the drier doesn't work as well as it should. In severe cases, the reduced air-flow may let the plastic case get too hot and even melt it, causing irreparable damage. Slow fans can lengthen a drying cycle in clothes driers, etc., upsetting the timer.

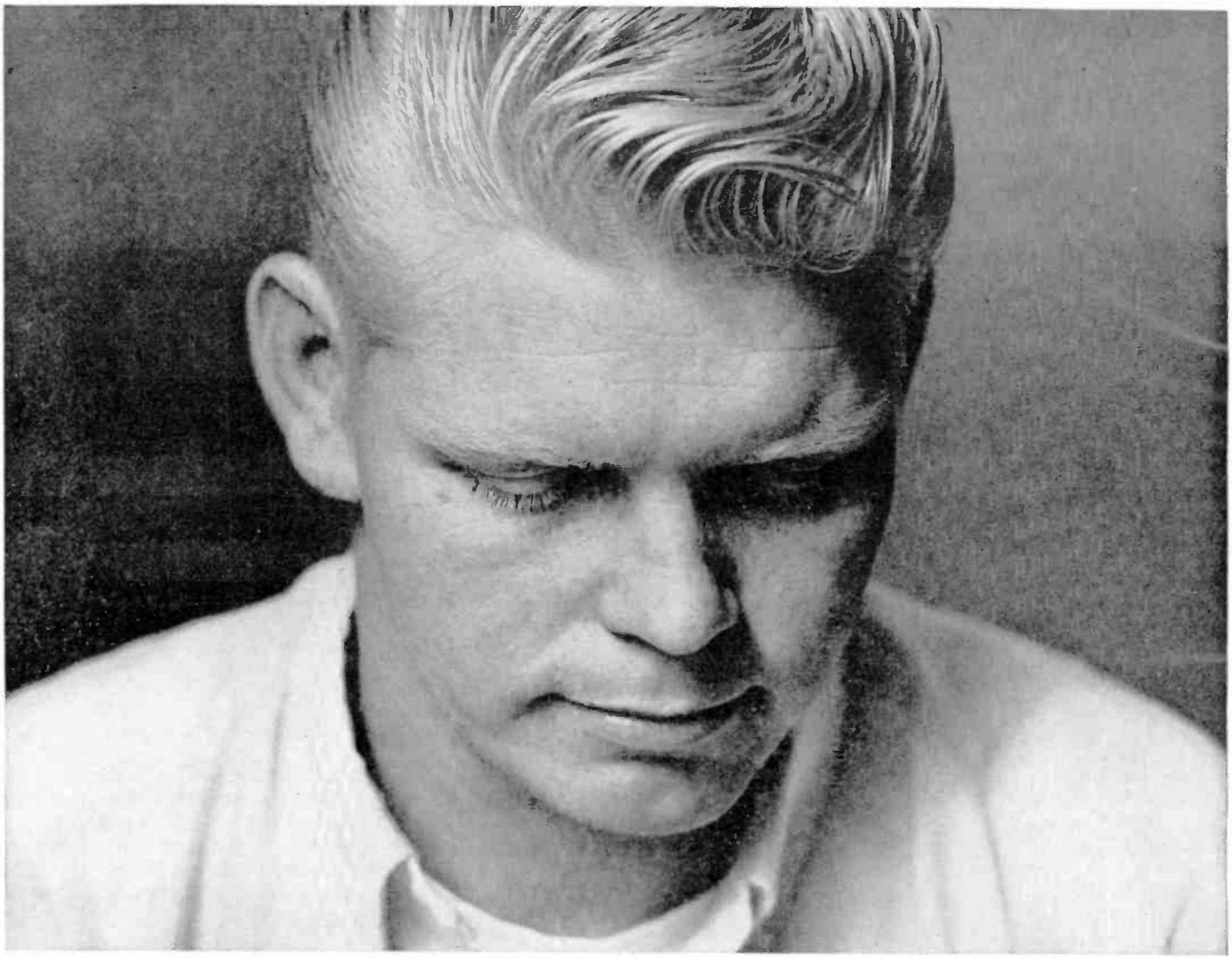
In multiple-function units, you can make a careful check of just *what* is in-circuit and check at that point with the wattmeter. In timer-controlled devices, where several things may be switched on at the same time, watching the wattmeter reading can tell you which one is not working. For an example, at a certain point in the cycle, you have a large motor drawing 250 watts, a heating element at 1,000 watts, a relay at 50 watts and a sensor circuit at 20 watts. This gives us a total of 1,320 watts.

Set the timer to a point just before it gets to the one giving the trouble. (Like all electrical things, the trouble can be intermittent!) If the wattage drain suddenly drops to 270 watts, what has happened? The relay or heating element has opened. (We have 250 + 20 watts left; the motor and the sensor.) With this reading, it would be more apt to be the relay + the heating element—we've lost 1,000 + 50 watts. This is in cases where the relay controls the heating element, which is common. So, since we've lost the relay's 50 watts too, look for an intermittent coil on the relay or a dirty plug-in contact, etc. If our reading dropped to 320 watts, we'd have 250 + 20 + 50; the relay would be closing (coil still drawing normal current), and the trouble would be pinned down to a dirty relay contact or an open heating element. As in all electrical work, "process of elimination." If we lost everything but the motor's 250 watts, then we could suspect the sensor or electronic control circuitry. It often controls the relay; so it would be checked first.

The normal current drain of all appliances should be given on the "rating plate." This is sometimes a small metal plate riveted to the case. It will be found stamped into the metal case of others, but it is supposed to be there before the appliance will be accepted by the Underwriter's Lab. This rating should also be given in the service data. As a last resort, if you can find a duplicate unit that is working, you can take a set of readings and make your own list for future use!

The photo shows a modern wattmeter. Operation is simple; just plug the unit under test into the panel outlet and plug the wattmeter into the wall. It has three ranges, 0–1, 0–3 and 0-10 am-

(continued on page 83)



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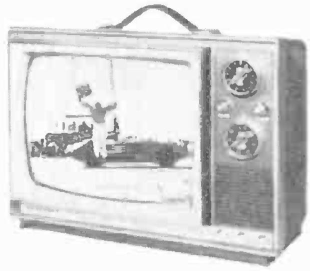

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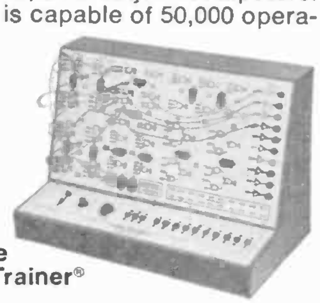

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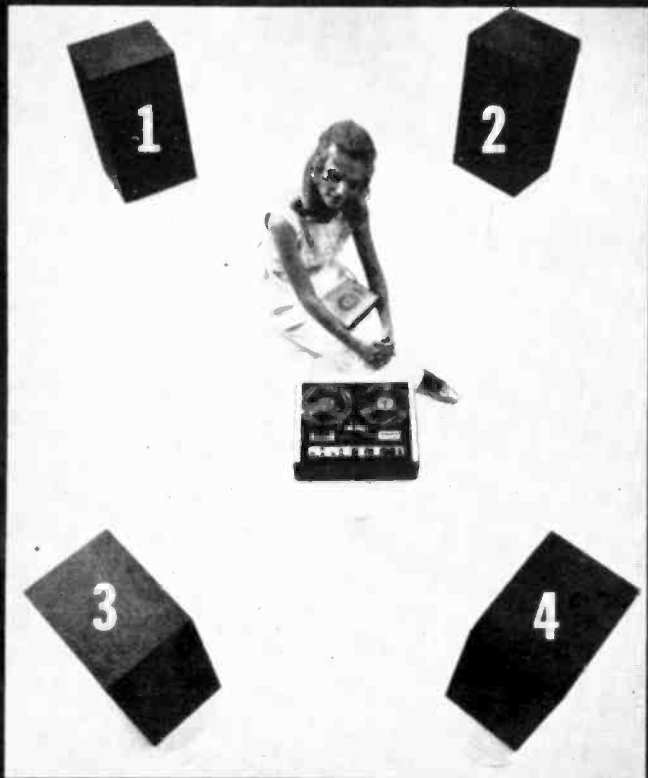


PHOTO BY 3M

The first steps forward are happening now. Here's the inside story by an insider about today's exciting changes and the startling 4-channel sound of tomorrow

by HARRY E. MAYNARD

"Will we need four ears to appreciate four-channel sound?" a facetious question asked by an engineer who has made a considerable contribution to FM broadcasting, but with an undertone of seriousness. Further conversation with this engineer revealed that he was "down" on four-channel stereo because he was not "up" on it. Two-channel stereo was good enough for him. His question would indicate that he doesn't know much about psycho-acoustics.

This attitude is not new. Perhaps you will remember the resistance of many people, including me, to two-channel stereo. It took years of exposure before we became conditioned to two-channel stereo. Today the record business can hardly give away a monophonic record.

History is repeating itself. As in the early days of two-channel stereo, there is talk of four-channel stereo being a trumped-up device to sell more hi-fi equipment. Some dealers oppose it because they fear the consumer will postpone buying currently produced hi-fi equipment. Many dealers don't understand that most proposals for producing four-channel sound are largely compatible with existing equipment, and will be essentially add-on devices.

I know of no reputable manufacturer planning to produce four-channel stereo equipment that obsoletes equipment currently in consumers' hands or on dealers' shelves. The transition from two-channel stereo to four-channel stereo can be more orderly, relatively cheaper and can occur more gradually than the transition from monophonic to two-channel sound did. Available right now are various kinds of "halfway houses" to "pure" four-channel sound. One is the Dynaco proposal which is really, enhanced two-channel stereo sound. Others are more complex matrixing systems such as the Scheiber, Electro-Voice, Sansui, JVC, "Stereo Quad," (CBS Labs) etc.

A semantic fog has enveloped four-channel sound with a plethora of descriptive terms such as "Surround Sound", "Quadraphonic" and "Quadrasonic", confusing (temporarily) both consumer and dealer. But the fog will blow over.

A growing number of hi-fi companies, recording executives and the sonically literate (i.e. the appreciation of better sound is a learned response) are developing an enthusiasm for various forms of multi-channel sound. Most hi-fi editors and writers have embraced some form of four-channel sound even if they are often critical of the way it has been recorded. One editor commented recently, "I'm for four-channel sound if it's done right, but most of what I've heard I haven't liked".

Recording executives such as Seymour Solomon, President and co-owner of Vanguard Records, whose company produced the first commercially available four-channel tapes, and Enoch Light, President of Project Three Records, who later followed in producing commercially available four-track tapes, are adamant that "surround sound" is the wave of the future. RCA which mass markets tape cartridges has announced the availability of quadraphonic sound on 8-track cartridges. Numerous titles along with two playback units are available now. RCA is aiming at the mass market, both in the home and the automobile, utilizing the many tracks of the 8 track cartridge. Motorola is producing playback equipment for the car. Fisher will also have 8-track playback units for the component market.

Why four-channel sound anyway?

Before answering this question, let's look at the history of the recording business since World War II. Every ten to fifteen years, technological factors converge to give the consumer a major leap forward in commercially available sound reproduction hardware. First there was the LP record which packed more high quality sound in an extraordinarily convenient package with considerable playing time. The LP record was not new then—nor is four-channel stereo now. The LP record format survived two-channel stereo with its requirements of more information and the record will survive the extra information requirements of four-channel sound. JVC (Victor Company of Japan) has demonstrated a four-channel record that compares favorably with the original multi-channel tapes from which it was produced.

But why four-channel stereo? The fundamental reason lies with the listener himself. The ability of his two ears to locate sounds at any point around him means that he normally hears this way. Not just from in front of him, but all around him. Even in a concert hall. Psycho-acoustically he hears binaurally (i.e. 360° around him).

There seems to be general agreement in the industry that the ideal four-channel sound system should:

1. Reproduce any sound from any direction around the full 360° of our normal sound field as intended by the composer and producer making the original recording.
2. The signal quality should meet current standards.
3. In monophonic sound reproduction, all the sounds in the four-channel program should be heard without changes in level or program balance.
4. In two-channel stereo compatibility should be preserved, so when the recording is played on a two-channel system all sounds should be heard in proper left to right order with no changes in level from the original.
5. There should be no serious reduction in playing time and cost as compared to two-channel stereo.
6. The system should have media compatibility (i.e. usable on disc, tape and FM broadcasting).
7. The system should allow direct control by the record producer, giving an integration during recording of the final result heard by the listener.

Is four-channel sound as big an improvement over two-channel stereo as two-channel stereo was over monophonic sound? In answering this question we must understand how human beings perceive sound. It is surprising how few people, including engineers in the sound business, understand psycho-acoustics; a subject that Ben Bauer, vice president of CBS Laboratories, says "lies at the heart of any discussion of high fidelity".

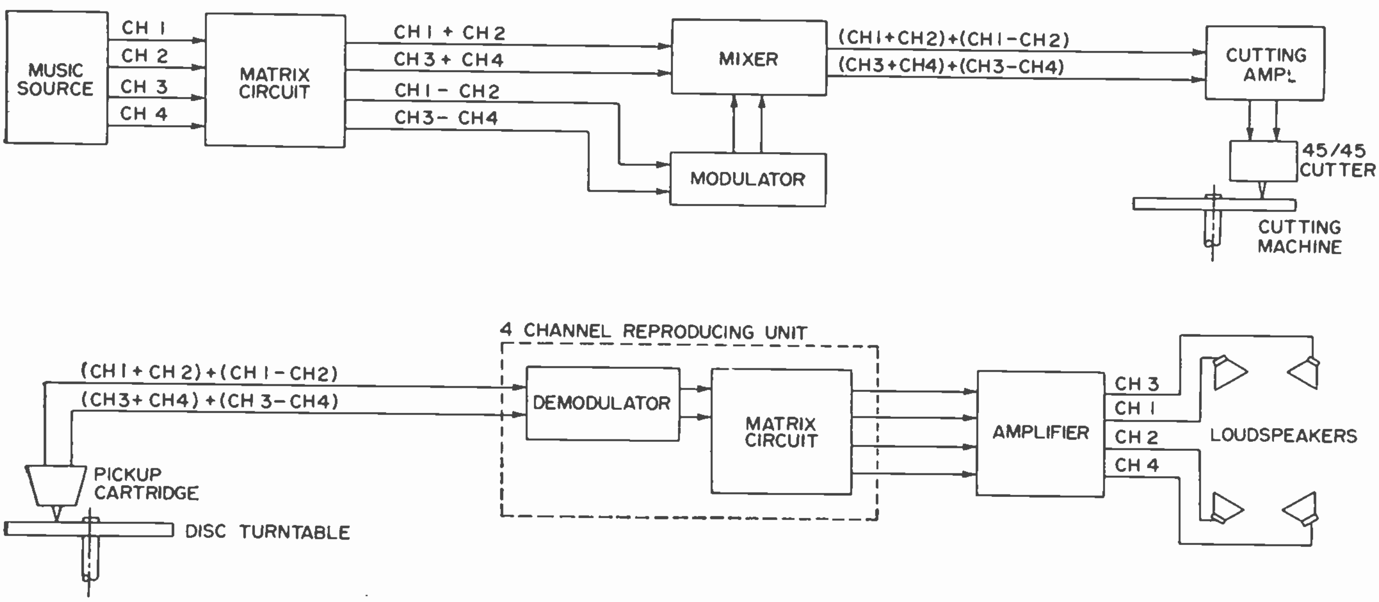
Psycho-acoustics, simply defined, is the science and study of how we human beings interact with auditory information. Experts agree that we listen binaurally (i.e. from all around us; up, down, a full 360°). Human beings don't have to learn to appreciate 360° sound aesthetically—it's simply the way we normally hear. Four-channel sound reproduction is the least expensive way we've come up with to duplicate "normal hearing" until the millenium comes when we have sonic wall paper, or its equivalent.

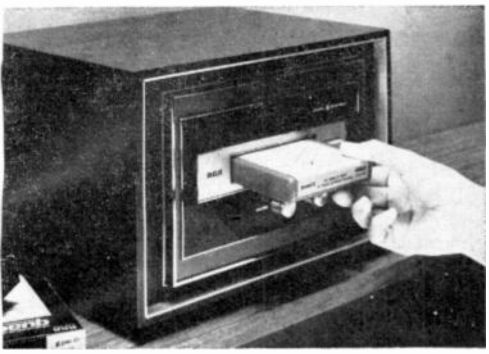
Because of its acuity the human ear has been one of our most important organs for survival. Most humans can hear ten octaves and spot differences in certain sonic cues up to a millionth of a second. The crucial point is that our binaural listening capability preserves the difference information arriving at our two ears. This marvelous computer, the human nervous system, combines the virtues of both an analogue and a digital computer. It can compare the different sounds arriving at each ear and tell us how far the sound is from us, where the sound is coming from and help us locate ourselves in space.

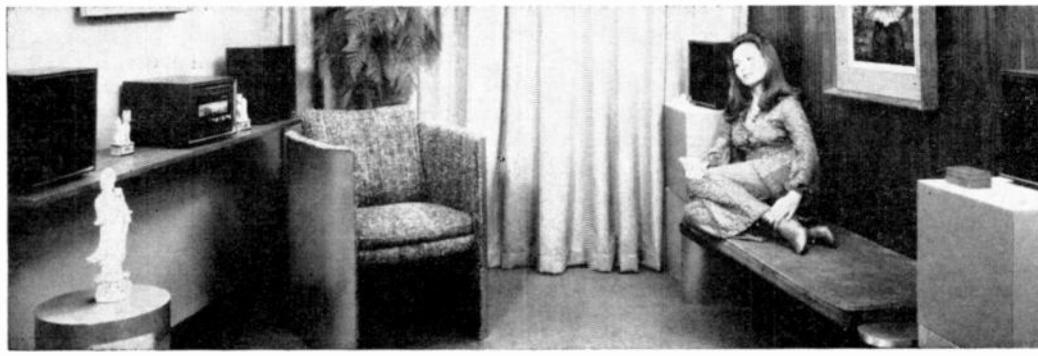
Stereo sound of all kinds, two-channel, three-channel, four-channel and beyond, gives us not just point source information (directionality) but random, ambient information which recreates our normal sonic experience.

The challenge to our recording experts is to replicate the multi-dimensional field of everyday listening. Multi-channel hardware such as the multi-channel tape recorder, gives the recording director the "sonic palette" and the control to record with more realistic effect. It also gives the recording director, artist and composer the new opportunity of creating sounds not heard before. The new electronic

MATRIXING ARRANGEMENT FOR JVC 4-CHANNEL RECORD. Top diagrams show how the four channels are separated, remixed and encoded for recording on the two channels of the conventional record stereo. The bottom diagram shows how the record is played in a 4-channel system.







4-CHANNELS ON CARTRIDGE TAPE is RCA's entry in the quadraphonic sound race. They use an automotive-type 8-track tape cartridge and simply record in four-tracks. Playback unit is made for home.

sound has invaded all fields of composition from rock and pop to "classical".

Basically, multi-channel sound will succeed and evolve into greater complexity in both recordings and hardware because the human nervous system craves more information. More than novelty alone, we seek to explore our sensory universe microcosmically as well as macrocosmically. In nature there are no two things exactly alike. No two human beings hear the same things. Einstein's famous statement that "the light that enters your eye can never be the light that enters mine" can be applied to sound too. The sound that enters your ear can never be the sound that enters mine. It is clear that modern recording and hi-fi technology have reached the point where by enlarging the difference information that reaches our two ears, we can continue to evolve in the development of multi-channel sound.

Approaches to multi-channel sound

The easiest and least costly step to multi-channel sound is the Hafler-Dynaco approach. David Hafler, President of Dynaco, has pointed out that many of today's stereo records already have considerable ambient sound and difference information encoded into them. This ambient sound (L—R, out of phase information) can be extracted from many of our existing two-channel records utilizing a regular two-channel amplifier.

Most record companies have been recording with multi-mike setups with considerable difference information. These records have been mixed down to two channels from as many as sixteen and more channels.

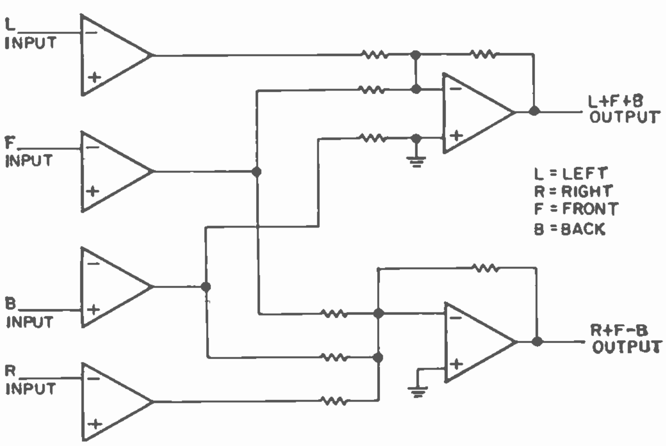
If you have a two-channel stereo amplifier and it permits connecting the two ground leads (one from each speaker output) together without damaging the amplifier), it is quite easy to connect the third speaker (usually placed in the rear of the room) across the two hot output terminals of your amplifier. Ideally a constant-impedance pad should be added to the rear-speaker connection so the speaker's volume can be controlled, otherwise it may be obtrusive.

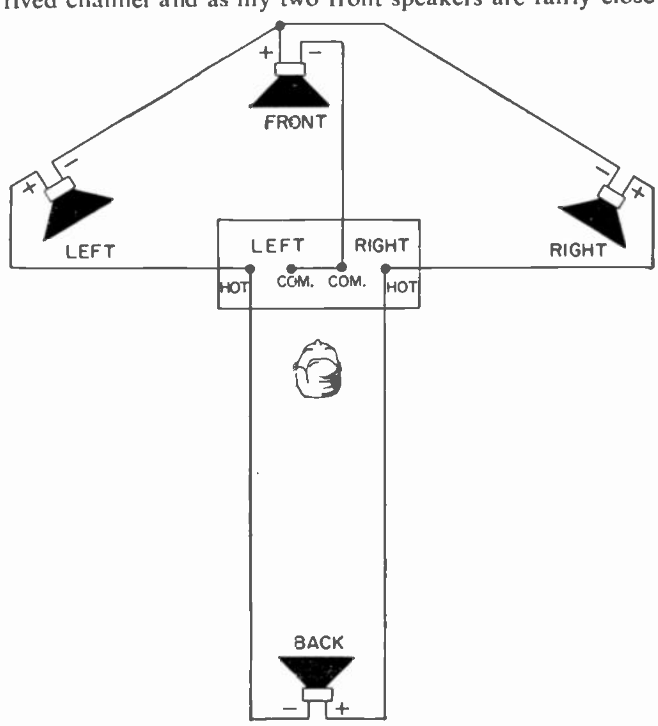
Hundreds of letters from excited listeners to my radio program have told to me that this hookup gives them dramatic improvement over two-channel stereo. Here are some typical responses:

"I finally purchased an inexpensive third speaker and hooked up the Dynaco system. The result is that a new world of stereo-phonic enjoyment has opened up for me. The results are nothing less than astounding. Listening to old records is a new experience, as if they were being played for the first time. The third speaker has increased my enjoyment of my present system by 100%."

Dynaco also suggests another hookup along with a rear speaker, putting one up front between the front left and right front, to give L plus R information (sum information) (below). Here is part of my letter to Washington's "FM Forecast" magazine: "My receiver has no center derived channel and as my two front speakers are fairly close

SYSTEM USED BY DYNACO to add front (F) and back (B) information to left and right channels. SPEAKER ARRANGEMENT for turning existing 2-channel system into pseudo 4-channel. All you must add are two additional speakers and a special matrix network (shown below). When using this arrangement adjust the amplifier balance control for minimum sound in the back speaker when monophonic material is being played.





together, I decided to forego that speaker. Another difference is that I was unable, due to the peculiarities of my room to locate a speaker directly behind me. Instead I put a speaker to each side of me and connected them in series and added to the 'third channel.' This I found works very well and has the additional advantage of giving me four speakers properly situated when I go "full quadrasonic." The only level control that I am using is a pot in the line to the rear speakers.

"As to the effect of the sound, I am unable to compare it with true quadrasonic as I have not had the chance to hear it yet. This hookup does add a definite sense of presence. It is variable, however, depending on the recording. I have tried it with both classical and pop and found that it improves the classical more. But there are exceptions. I have a Ray Coniff album that is simply astounding with this setup. Summing up, I would like to say that there is to me, a definite improvement and well worth the cost and effort required to set it up."

Some of my listeners who have heard simulated four-channel stereo have said that it is such an enormous improvement over conventional stereo that they expect "true" four-channel stereo to be even better. Here is a reaction to a "true" four-channel demonstration:

"Well, I heard it demonstrated. And it was ping-pong all over again. Except now it's two games going at the same time, or, perhaps I should say, one game—four players and light spitballs. You never know where, next, or when. The effect was disconcerting. There seems to be some opinion that different instruments coming from different speakers is a perfectly valid approach for pop music. But I would point out that even at a Rock Festival all of the noise comes from one general area (in front)—unless one includes the audience.

"The only really true and, therefore, valid listening experience must be one where each and every instrument can be heard at each of the four speakers, be it at different levels, time and phase relationships. But you do this by simply recreating what already can be done most effectively and most satisfactorily with simulated four-channel stereo, which incidently I find makes for a far more impressive listening experience than four-channel ping-pong. So why go through all the extra complexity, inconvenience and expense of four-channel stereo???"

I have quoted from these letters, not because I agree with them in all details, but because they do indicate fundamental attitudes and typical experiences upon first exposures to multi-channel sound.

Other "halfway houses" to true four-channel sound are the matrixing systems—still not "pure" in the sense of being four separate and equal channels of sound. The first of these systems to be announced and demonstrated was the Scheiber system. Its virtue is that it is now compatible with most current equipment, including mono (which it was not originally) and meets many criteria of an ideal four-channel system. It is more sophisticated than the Dynaco and has the virtue of giving the effect of four discrete channels of information. It can be broadcast over existing FM bandwidths, but the listener must buy a decoder to pick it up. It also requires two added stages of amplification and two rear speakers.

Another matrix system that has been announced and demonstrated is the Electro-Voice system (right). By the time you read this article, Electro-Voice hopes to have a low-cost decoder on the market, selling for about $50. Its technical details have not been announced pending patents. As a system it too gives far more localization of point source information than the Dynaco system, but requires an extra stage of amplification and of course two rear speakers. It does have the virtue of enhancing regular two-channel stereo records.

I have heard all these systems and feel they have considerable merit in enhancing two-channel stereo and giving quadraphonic effect. They also have another merit. FM stations with specially encoded records, or with existing records can broadcast them immediately. They should not require FCC broadcast approval. They require no significant investment by FM stations. However, the consumer will need the decoder along with another stereo amplifier and extra speakers. But the consumer will need these anyway if he ever goes for "true quadrasonic sound."

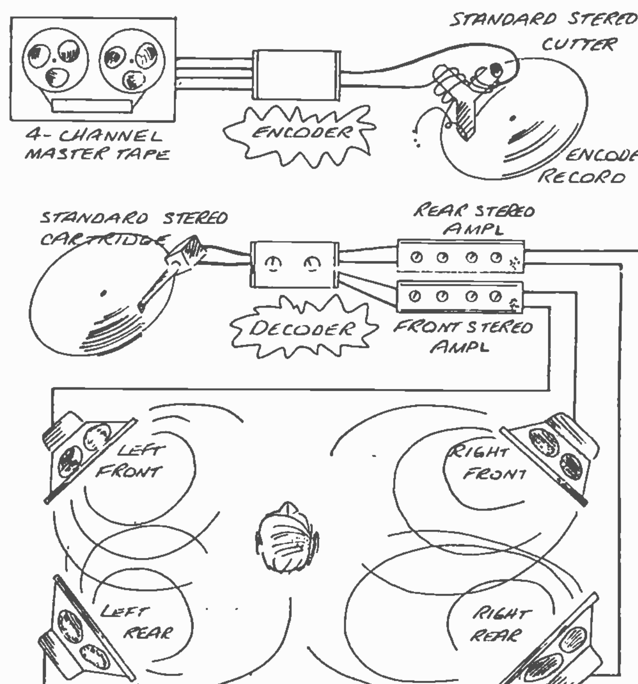
Most FM broadcast pros agree that the FCC will never approve a system of four-channel broadcasting unless it allows for four separate and equal channels, with the two rear channels being of equal quality to the two front channels. FM broadcasting experts such as William Halstead and Leonard Feldman suggest that it will take the FCC at least as long a period to approve four-channel stereo broadcasting system as it did to approve a two-channel stereo broadcasting system.

If your memory goes back that far (1950), you'll remember that it took the FCC five years to approve the currently used GE-Zenith system. Over 50 systems were proposed, 17 were extensively field tested. The field was narrowed down to six and a latecomer, the GE-Zenith system, was picked because it met the many complex political, economic, as well as technical requirements. For example, it preserved the SCA income channel as it was, still an important source of revenue for some stations in some markets.

The most promising system yet proposed and which is about to be demonstrated experimentally by KIOI in San Francisco, is called the Dorren system. This system, invented by a young West Coast engineer, Louis Dorren, uses a standard FM exciter and stereo generator. It does not involve a big investment by the FM station. However, the Dorren system will require some small changes in the current FCC regulations. It works well in the laboratory. The Dorren system requires a decoder but will require no significant change in currently produced stereo FM tuners or receivers.

As this issue went to press, James Gabbert, KIOI-FM, San Francisco, announced that the FCC had approved late

ELECTRO-VOICE MATRIX SYSTEM uses special encoder when recording. Playback decoder turns two channels from record into the four channels originally recorded.



night experimental broadcasts of the Dorren system, starting December 25. The first broadcast demonstration material was the JVC four-channel disc in conjunction with a local auto show. Gabbert, who has run other experimental four-channel stereo broadcasts utilizing two stations, says, "I'm not wedded to any particular system".

The broadcasts will be available from midnight to 6 AM and will include everything available in four channel. Mikado built decoders will be available on a sample basis in the San Francisco area to evaluate reception. (*Readers: drop us a line and let us know if you've listened to KIOI four-channel and what you think of this new sound.*)

The JVC disc used in these broadcasts, is literally two stereo-FM stations in one record groove; taking advantage of FM versatility and multiplexing ability.

We do not have full technical details on the Dorren system (another one of these patent pending situations). The system is a 38-kHz switch synchronized by the 19-kHz pilot tone of the standard stereo generator. A "black box" is placed ahead of the stereo generator. Four channels of audio are fed into the input of the black box. The box switches at a 38-kHz rate between various audio channels. The left front channel is present in the output of this black box for ¼-cycle of the composite stereo signal. This process is the same for the other right front and rear channels. The output of the black box is a composite two-channel signal consisting of the left front plus the left rear channels and the right front plus the right rear channels. Only two composite audio channels come out of this black box which are fed directly into the stereo generator audio inputs. The results of this process are as follows (and according to Jim Gabbert, the head of KIOI, San Francisco, all measurements have been confirmed with a standard exciter, stereo generator and receiver).

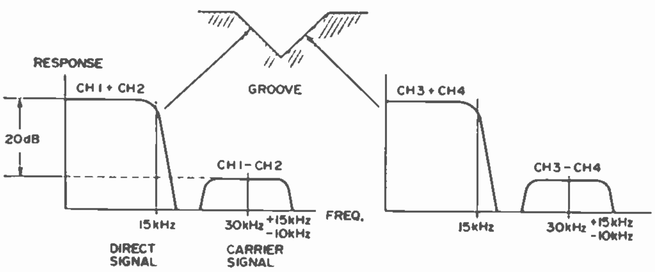
The Dorren system uses no more spectrum space than that which the standard two-channel system uses, thereby permitting the broadcasting of 4-channel stereo plus the SCA. Most other four-channel systems such as the Halstead-Feldman system would eliminate the SCA.

The Dorren system also has total compatibility. The stereo system between the channels is strictly a function of the current stereo system. In the laboratory tests the channel separation has been better than 35 to 40 dB between the left front and left rear signals and better than 25 dB between the left front and left rear and also the same for right front and rear. The distortion of the system is no greater than conventional stereo FM. The signal-to-noise ratio is also the same as in the current system.

For "pure" four-channel stereo to move ahead and to be broadcast regularly on stereo FM stations (not a negligible market), it must have a four-channel stereo disc that can reproduce four discrete high-quality channels. For though there are now on the market many tape recorders that can play four-channel stereo tapes, the reel to reel library is limited and expensive.

Most of these four-channel recorders cost in the neighborhood of $500. Considering that one also needs another stereo amplifier plus two more speakers to play

TWO STEREO-RECORD CHANNELS can carry 4-channels of audio information. Here's a look at how all this information is put into the grooves. This is the system used by JVC.



FOUR-CHANNEL TAPE PLAYER FOR THE HOME is made by Gibbs Special Products Corp. Special quadrasonic matrix system converts this standard system to 4-channel playback.

four-channel viable reel to reel tape records, it will cost close to $1000 (excluding tapes) to enjoy today's available four-channel stereo.

History has clearly demonstrated that two-channel stereo never got off the ground but remained the province of the cognoscenti and a few audiophiles who could afford it, as long as it was available only on expensive reel to reel pre-recorded tapes. FM stations avoided it because the record was and still is their essential programming material. Until there was a stereo record, the FM industry made no attempt to push for an FCC-approved system.

Recently, JVC demonstrated a four-channel stereo disc at the AES show in New York that offers four discrete channels of high quality. The JVC disc will probably not be the last development of a true four-channel stereo disc, but married to the Dorren system, we now have a match that will spur the FM broadcasters and the record industry. Why? Because the disc is still the mass market for recorded sound.

The FCC has clearly indicated to me and other reporters that they will not approve any system that cannot deliver four discrete channels of equivalent quality to today's stereo broadcasting. Incidently, the many synthesized or matrixing systems should not require approval by the FCC because they are compatible with today's stereo FM broadcasting standards.

The JVC system neatly puts the sum of the left-front and left-rear on one 45° combination of vertical and horizontal stylus motion. The sum of the right-front and right-rear channels is recorded as a combination of lateral and vertical motion at 90° to that of the left channel.

Taking advantage of FM's multiplexing ability currently employed in stereo FM broadcasting, the JVC system utilizes subcarriers for the difference channels made up of left front minus left rear and right rear minus right rear (see diagram at left).

The JVC system is different from our present stereo records in that it uses a frequency range up to 45kHz. If played on ordinary two-channel stereo equipment, it reproduces only the sum signals, preventing leakage and giving satisfactory compatibility.

With a special playback processor, the system ends up with four discrete channels that looks this way:

$(Lf + Lr) + (Lf - Lr) = 2LF$
$(Lr - Lr) - (Lr - Lr) = 2LR$
$(Rf + Rr) + (Rf - Rr) = 2RF$
$(Rr - Rr) - (Rr - Rr) = 2Rr$

JVC claims record wear is equal to present stereo records. Records will cost the consumer approximately $1.00 more than present stereo records. The system will require a high quality phono cartridge with a response to 45kHz. Record cartridge manufacturers who I have talked to claim that this requirement is well within the state-of-art of top-of-line cartridges. A smaller stylus is necessary (0.5 x 0.2 mil.) with a stylus pressure of 1.5 grams. Cross talk is claimed to be satisfactory and no more than 25 dB in channel 1 to channel 3, channel 2 to channel 4, and 20 dB in channel 1 to channel 2, and channel 2 and channel 3 to channel 4.

The special processor attached to four stages of amplification will cost approximately $50. Four speakers and two stereo amplifiers will of course be necessary.

The disc when played on two-channel stereo equipment will not require a new cartridge and is compatible. (Although the higher-frequency information—above 20kHz—may be destroyed.) On my radio program I have played it to test for compatibility and received no complaints on this score.

What's ahead for the next two or three years? I don't want to wait for five or more years for an approved FCC system before enjoying four-channel sound. Approval will involve a complex mix of economic, political and technical matters and it will take much more time than many people expect. This is not only my view but the view of Harold Kassens who was recently "Mr. FM" at the FCC, William Halstead, sometimes known as "Mr. Multiplex", and Leonard Feldman who worked closely with Crosby to produce one of the most promising of the two-channel stereo systems in the 1950's. We'll have as many proposals for four-channel stereo as we had for two-channel stereo and it will take just as long to field test them—a laborious and time consuming process.

Recognizing the above factors, the hi-fi manufacturers and the record producers have promoted a barrage of synthesized four-channel systems that represent promising stopgaps until we have the genuine article. I have heard most of these systems and they represent a significant improvement over two-channel stereo.

Some of the systems such as Sansui enhance current discs and will give you even greater enhancement if you encode especially for it. Sansui has a unit costing $200 that synthesizes four channels from two by electronic delay, reverb techniques, phase shift and phase modulation. For complete details of this unit see page 71 in this issue. Their QS-I system samples signals by level and frequency and determines what would normally be heard as ambient sound and what would be heard as reverberant sound. The system is inserted between a two-channel stereo preamplifier and power amplifier having two inputs and four outputs, feeding into four amplifier channels and drives four speakers. Sansui has also offered a method of encoding four-channel material.

Many manufacturers use delay line processes, "quadraphony", which while fake, are very impressive to my ear, particularly if heard on a good system. Harman Kardon has such a system that even enhances mono records. There is some concern among the manufacturers of good component high fidelity that we will see a spate of cheap mass-produced products, using low quality extension speakers and poorly designed delay-units that will be labelled and advertised as four-channel stereo.

Should the consumer stop buying today's hi-fi equipment? No. All four-channel systems presently proposed require four speakers and four amplifier channels.

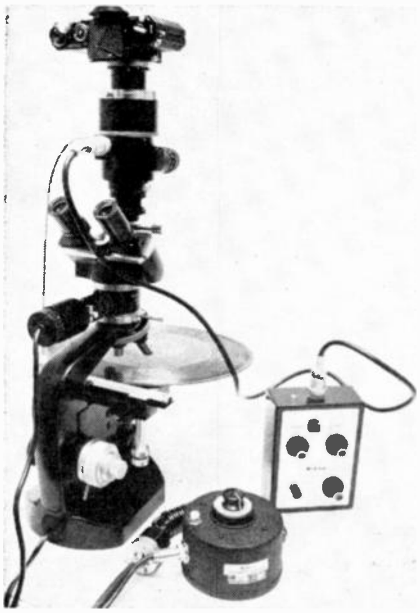
Perhaps you can't afford to invest in a four track stacked head tape recorder and join the elite in listening to reel to reel four channel tapes. You could, however, plug in an RCA Mark-8 4-channel 8-track system. For those able to afford it, Scott's new model 499, four-channel amplifier (110 watts of continuous power) will not become obsolete with any projected development in four channel stereo. Nor will Fisher's 701 receiver, which combines an AM-FM tuner with a 4-channel amplifier.)

To sum up, many stereo FM stations (like WCRB of Boston which already has) will promote synthesized systems as a stop gap measure to whet consumers' appetites for improved sound, and to call attention to their stations and their programming.

Stereo has been the big impetus to FM's ever growing success. Many FM stations built their considerable audiences by getting on the stereo bandwagon early. There is considerable evidence that many FM stations will see their future in what is obviously the next quantum leap forward in the history of recorded sound and FM broadcasting—4-channel sound. **R-E**

ON THE COVER

4-Channel Stereo Records



THOSE WIGGLY BROWN LINES RUNNING across the lower right hand corner of this month's cover are a greatly magnified photograph of the actual record grooves of a JVC four-channel record.

They were photographed using that conglomeration of photographic gear you see at the left. It's a Nikon Microscope for macrophotography using an internal EPI illumination system and Kodachrome II 35mm film.

A 40X objective combined with a 10X eyepiece were used for the cover photo. Exposure times were varied—minimum exposure was 30 seconds; maximum exposure was eight minutes.

After developing, the best shot was selected. This 35mm transparency was then duped to 4 x 5 size in Ektachrome.

During the processing of the 4 x 5, the film was pulled after the first developer and then re-exposed to various colors of filtered light. This produced the psuedo-solarization effect.

The other photo on the cover shows a new Dual record changer, was shot directly on 4 x 5 Ektachrome, then processed like the picture of the record grooves.

We used this dramatic photographic technique to enhance and reveal the inner workings of a 4-channel stereo record—a thing of the future that is just around the corner. This disc can be played on many existing record changers, though to get the 4-channel playback the cartridge used must have a frequency response to 45-kHz, and you must have a JVC decoder. There is no telling, at this stage, whether this will be the system finally adopted by the industry, but it is one of the contenders.

For more details on 4-channel stereo turn back to page 33, and find out what's happening today. **R-E**

PROGRAMMED

STEREO CASSETTES the electronic side

by LARRY ALLEN

Just read each easily digested frame of information. Then test your grasp of it by answering a multiple-choice question. If you choose correctly, you're guided automatically to the next program capsule. If you miss, don't worry; programed extra information helps you to the correct answer and shows you where you went wrong.

1

Cassette machines have taken the tape field by storm. Prices are 'way down. Young people dig them as a handy way to hear music. Businessmen use them for dictating. Millions have been sold. And that means a constant stream of them to be serviced.

Usually, it's mechanical troubles that bother technicians most. Yet cassette electronics includes more than just a simple amplifier. This quickie course teaches you about unusual electronic features.

True, a playback-only machine has little more than a tape head, an amplifier, and a speaker. But many machines record too. That alone entails at least switching the amplifers to drive the head, connecting a mike, activating an erase head and bias oscillator, and perhaps connecting a level meter.

If the machine includes a radio, there's switching for that—not to mention the radio's own electronics. The radio may be AM-FM. Usually, you can record off the radio; it's handy to have the speaker monitor what you're recording. There are even cassette machines in stereo now, with two of everything.

Question: What's the second head on a monophonic record/playback machine for?

- ☐ It's there in case you want to add stereo. **Check Frame 11** to see if you're right.
- ☐ It's the erase head. **Check your answer in Frame 6.**
- ☐ It's a spare in case the main head goes bad. **Go on to Frame 18.**

2

What nonsense. Magnetic effects work in the opposite direction. But, so you'll understand both erase methods, **go back and read all of Frame 14.** Then see if you can't do better picking an answer.

3

That's right. You DO NOT use the mike while adjusting bias current. It would make it nearly impossible to know when you have bias set right. You're progressing well through this mini-course in cassette electronics. **So move right on along to Frame 20** for some more.

4

That might sound plausible, but it's not what would happen. With R2 open, the transistor acts just as it would if its base were connected to nothing. **Go back to Frame 9** and see if you can dope out what the result really would be.

5

Once you understand the electronic ins and outs of a cassette machine, servicing is uncomplicated. Here are a few items you might forget or overlook.

(1) Clean the heads whenever they show even the slightest oxide coloration. Clean them once every six months, regardless.

(2) About once a year—oftener if you're doing something else inside the unit—squirt some cleaner into the Record/Play slide switch. Use the stuff you'd use in a TV tuner.

(3) Clean the controls, too, with a good cleaner. If they're scratchy, though, don't waste the time and cleaner: replace them.

(4) Before you waste time testing the machine, make sure fresh batteries are installed. Check the springs for corrosion or weakness, and be sure none of the wires are loose.

(5) Before you waste time testing, also try a known good cassette cartridge. Sounds obvious, but remember it.

(6) Keep your eye open for another mini-course like this on cassettes. It'll be about the mechanics. Meanwhile, you've just finished this one. R-E

6

Right the first time! Congratulations. You're off to a good start. A playback-only machine needs just one head. But a unit that can record too must have a head to erase whatever is on the tape before the main head puts something else on it.

Don't mistake that extra head for a record head. The main head serves for playback *and* recording. It fits into the center opening of the cassette cartridge.

The erase head fits into the left-hand opening. That way, the tape is pulled past it before reaching the main head.

With these things in mind, **proceed to Frame 14** and learn what activates the erase head. And pay close attention; there's more than just erasing discussed there.

7

Not a chance. A transistor simply won't work that way. **Read the definition of "forward alc" in Frame 17 again.** Surely you can figure "reverse alc" out from that.

8

Sorry, but it does matter. A voice signal would vary the reading on the ac vtvm and make it nearly impossible to know when you have the pot set right. But don't fret. You don't even have to go back. You know now that you DO NOT use the mike while adjusting bias current. **So, just skip along to Frame 20.**

9

A steady, pure source of dc power is important in a cassette recorder. It's particularly critical for the bias oscillator. A slight voltage variation can change recording characteristics, by altering head bias.

The answer is thorough filtering any ac ripple out of the dc produced by an ac power supply. One circuit that does that with greater than usual efficiency is shown in Fig. 6. It's called an electronic filter, or sometimes a capacitance multiplier.

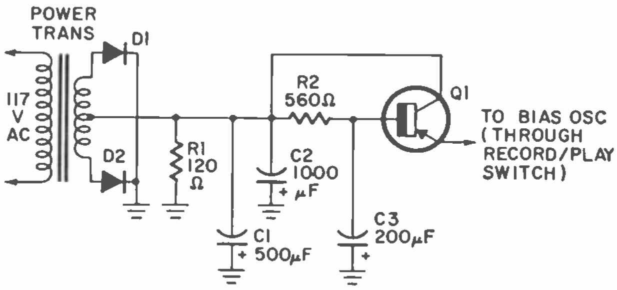


FIG. 6—ELECTRONIC FILTER STAGE reduces ac ripple to almost unmeasurably low level, makes dc for oscillator as pure as is feasible.

Whatever small amount of ac ripple remains in the dc by the time it gets to the base of Q1 is amplified by the transistor. The ripple thus appearing in the collector-emitter circuit is shifted in phase by 180 degrees from ripple is series with the transistor. The result is cancellation.

Question: What do you think would happen to the dc voltage at the emitter of Q1 if R2 were to open up?

- ☐ It would fall off to a very low value. **Take a look at Frame 28.**
- ☐ It would rise to he full value of voltage at the collector. **Turn to Frame 21.**
- ☐ There would be no dc change, only a slight increase in ripple. **See what Frame 4** says.

10

Mistake. Such a thing is impossible. **Read the definition of "forward alc" in Frame 17 again,** and think carefully what it means. You'll have the correct answer pronto.

11

You missed the first try. A stereo machine would have a different kind of main head, not an extra head. **Reread Frame 1** with a little more thought for what it says, and then try a different answer.

12

Yes. That's exactly what happens. Whether erase is by dc or signal, it merely records over whatever is on the tape. Since there's no audible modulation in the erase head, you can't hear what the erase head records. The tape "sounds erased."

You may have noticed in Fig. 1 (**Frame 14**) that power for the erase oscillator comes from the RECORD/PLAY function switch. The stage doesn't operate during playback. The switch is usually inside where you can't see it without taking the set apart. It's visible in Fig. 2, a photo inside a typical machine.

The function switch is a slide type. It's mounted on the circuit board. When the board is in place, the switch handle fits down into a holder on the mechanical RECORD slide. As you punch the RECORD button in, the slide moves back. The holder takes the switch handle with it, changing over the electronic functions from play to record.

Function changing usually works by the RECORD button. It's up to you to find the switch when there's trouble in it. Look beside, above, or at the rear of the slide that's actuated by the RECORD button.

12

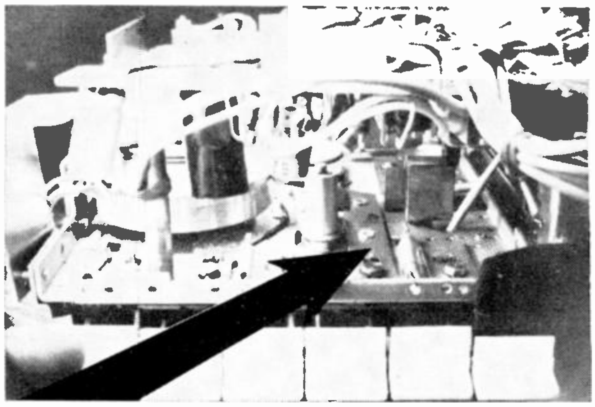


FIG. 2—HOLDER FOR FUNCTION-SWITCH handle is part of RECORD slide. As button pushes slide back, switch changes connections from playback to record.

Question: Why is the erase oscillaor disabled by the function switch when the PLAY button is engaged?

- ☐ It would overload the record/playback head if left in operation. **See Frame 19.**
- ☐ The extra set of contacts on the function switch has to be used for something. **Check this answer in Frame 27.**
- ☐ To keep from erasing the tape before it reaches the playback head. **Find out if you're right, in Frame 25.**

13

Wrong. There isn't much of a clue to this in **Frame 25,** but I thought you might figure it out for yourself. Don't worry about it, though. **Just go back and pick another answer.**

14

There are two popular ways to erase a magnetic tape. One is by dc. Voltage through a current-limiting resistor is applied to the erase-head coil. Direct current flowing in the head builds up a strong magnetic field. As the tape is pulled past the head, the magnetism "wipes" the tape clean. Inexpensive models almost always use this erase method.

A quieter way to erase a tape is to override what's on it with a new signal that's beyond the range of human hearing. An oscillator at 30 or 40 kHz (sometimes higher) is part of the electronics in a recorder anyway (its purpose is explained later). That signal is fed to the erase head. As the tape goes past, the ultrasonic signal is recorded on it.

The diagram in Fig. 1 is of such an oscillator. The

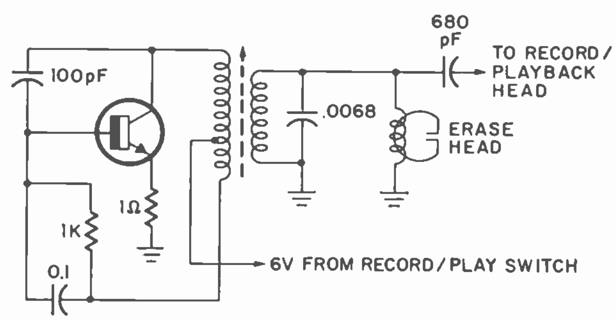


FIG. 1—HIGH-FREQUENCY OSCILLATOR serves two purposes in some cassette machines. In most, it biases the record head. In some, it also drives the erase head.

transformer and the .0068-μF capacitor set the resonant frequency, which in this version is adjustable. The erase head is connected directly to the output winding. A 680-pF capacitor also feeds some of the signal to the recording head (reason, later).

Question: What happens to the recording already on a

14

tape when the tape is pulled past an erase head?

- ☐ The oxide molecules are rearranged by the magnetic field around the erase head, obscuring whatever was on the tape. **Move to Frame 12.**
- ☐ The erase head soaks it up magnetically off the tape and shunts it to ground. **Go back to Frame 2.**
- ☐ It is bypassed to the record/playback head for use later. **Read Frame 23.**

15

That's not right. The meter is dc, so it has to be connected with one polarity or another. **Go back to Frame 20 and dope out another answer.**

16

Certainly. In fact, reducing bias is the time-accepted method of lowering gain of either tube or transistor. But modern transistors with more dependable conduction curves have made it possible to reduce gain accurately by pushing bias further forward. Hence, "forward" alc. So "reverse alc" is a description of the old method.

There are some other interesting stages in certain cassette machines. Many cassettes have ac power supplies. You can plug them into house current as well as run them from their self-contained batteries. **Turn to Frame 9** and learn about a circuit that's peculiar to a few models that have ac supplies.

17

Yes, the positive side of the meter goes to ground. Unless you guessed, you must have recognized that the anode end of the diode feeds the meter, so that end of the meter must be negative. That leaves positive going to ground.

A few very cheap cassette recorders have no level meter. You just guess at it. Several machines have an *automatic level control* (alc) and don't really need a meter.

Some machines have both. A switch disables the alc if you want to control recording level by hand. The level meter usually doesn't operate when alc is switched on.

The alc (sometimes tagged *automatic limiting control*) is usually a relatively simple form of gain control. The output level is sampled. A proportional dc voltage is developed, then fed back to an earlier amplifier stage to control gain there.

One version appears in Fig. 5. During recording, a

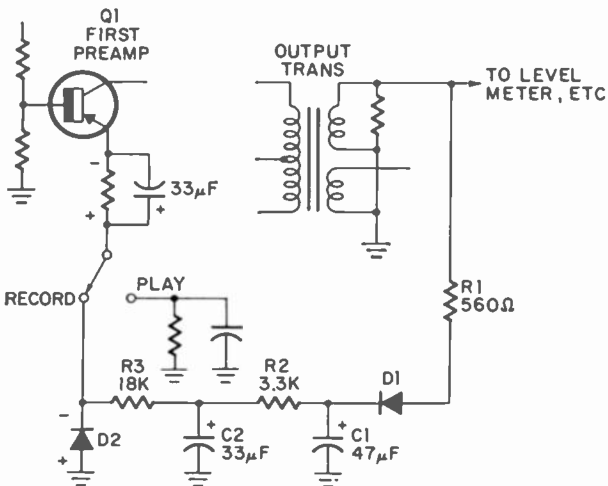


FIG. 5—AUTOMATIC LEVEL (or limiting) control is called alc. It's an automatic gain control that senses audio level and keeps it constant regardless of input.

sample of the output signal is rectified by D1. A positive voltage develops at the cathode. This dc is filtered by C1-R2-C2 and coupled to the cathode of D2 in the emitter-ground circuit of Q1. D2 conducts, completing the ground-return for Q1's emitter.

Suppose sound output goes up. More positive voltage comes from D1. Applied to the emitter of Q1, it drives the transistor collector current up past the saturation knee. That cuts gain down. (This is called "forward alc" because it reduces gain by *increasing* forward bias.)

If sound output drops down, the positive alc voltage from D1 becomes less. Forward bias on Q1 is proportionately reduced, and the conduction point of the transistor comes down off the knee. Gain goes up, restoring the original sound level.

When alc is in operation, the volume control of the amplifier is bypassed. The whole gain/alc loop is designed to hold recording level at optimum for the head being used in the machine.

Question: What would "reverse alc" be?

- ☐ Wiring the amplifier so the audio signals go through it backward. **Move on to Frame 10.**
- ☐ Hooking the controlled amplifier so the collector is input and the base is output. **Go to Frame 7.**
- ☐ Applying alc voltage to a transistor in a way that cuts down gain by reducing forward bias instead of increasing it. **Check this answer in Frame 16.**

18

That's only a guess, and it's wrong. The answer to the question is right there in **Frame 1**, but you have to give a little thought to what's said in the frame. Start again, and read a little more carefully. Then pick the right answer on your next try.

19

Nope. That's not the reason. Take a good look at the question and the three answers in **Frame 12** again and I think you'll do better on the second try.

20

If a cassette machine records as well as plays, it may have a record-level meter. In some, the same meter tells you the condition of the battery (see Fig. 4).

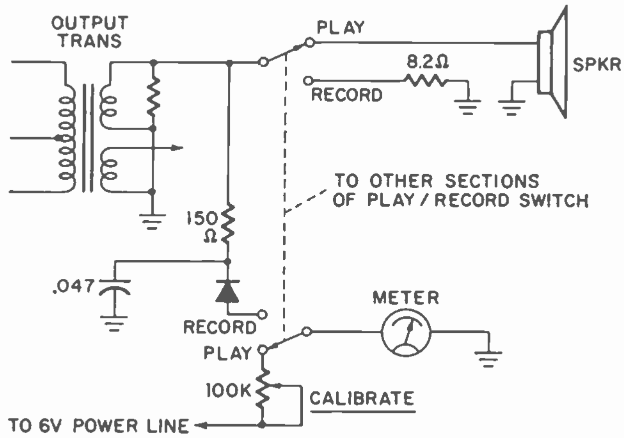


FIG. 4—METER ON FRONT of cassette recorder usually meters batteries as well as monitoring record level.

When the main switch of the machine is turned on, 6 volts (or whatever the battery voltage is) appears on the dc feeder line throughout the set. As long as the function switch is on PLAY, the meter stays connected to the battery line. A calibration pot drops the voltage just right so that fresh batteries give a reading above the "normal" line.

With the RECORD button pushed in, the meter is connected to a diode that rectifies the sound signal from one of the output transformer secondaries. The meter indicates when there's too much or not enough signal.

Question: Which polarity of the meter is connected to ground in the diagram?

- ☐ Positive. **Go to Frame 17.**
- ☐ Negative. **Jump to Frame 26.**
- ☐ Either one. **Check Frame 15.**

21 **No, it wouldn't.** The natural resistance between emitter and collector should be very high with the base floating. Think about that and **answer the question in Frame 9 again.**

22 **Not on any machine I've ever heard of.** The method would be expensive, noisy, and sloppy. And there's no need. The switching can be done along with setting up the mechanism for recording. A mechanical slide that moves when you push the RECORD button can do it with no other effort at all. And that's the way it's usually done. **Now proceed to Frame 5.**

23 **This is worse nonsense than the middle answer,** which I hope you avoided. If you picked either one of these, **just go back and read Frame 14 over again.** You aren't absorbing the information that's in there.

24 **Yes, it's done mechanically.** The slide that engages the mechanics for recording also moves the handle of a function switch. Troubleshooting a function problem rarely involves mechanical parts, though. Usually, the switch isn't changing one or more of the functions listed in Fig. 7 (in Frame 28). **Now, for more about troubleshooting, move on to Frame 5.**

25 **Yes, you're right.** If the erase head continues to have dc or signal applied, it erases whatever is on a tape that moves past it. Special mechanical arrangements keep you from pushing the RECORD button down when a prerecorded tape is in the machine.

Remember I mentioned **(in Frame 14)** the electronics of a cassette recorder includes an oscillator *anyway?* That's true. It's a bias oscillator. It's for tape bias.

It was discovered long ago that a tape head does a much better job of recording if it is biased. Not in the sense of tube or transistor bias, because a tape head is biased with a signal. The bias oscillator, operating above the audio range, supplies that signal. You already saw how ultrasonic signal is sometimes also used in the erase head.

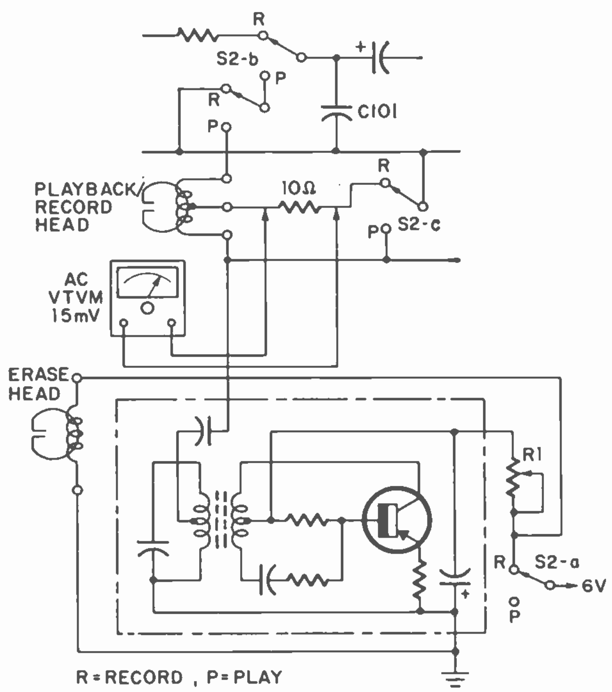


FIG. 3—BIAS OSCILLATOR ONLY. Connections that go to erase head carry only dc. A series resistor adjusts level of bias signal fed to recording head.

Fig. 3 shows an oscillator for bias only. The erase head is dc, connected from a switched dc source (at R of S2-a) to ground.

The oscillator is similar to the one you already saw. But it has these differences: (1) The output winding of the transformer is only for tuning and impedance matching. A capacitor couples the bias signal to the record head. (2) A potentiometer (R1) in series with the switched 6 volts sets how much dc power the oscillator transistor gets. It is used to adjust output level to just the right amount of bias signal for the record head. Sometimes the adjustment pot is between the output coupling capacitor and the head.

The ac vtvm in Fig. 3 measures voltage across a 10-ohm resistor in series with the record head. That's the way you tell how much signal current is flowing in the head. If the recorder you're working on doesn't have the 10-ohm resistor, you can open the lead and insert one long enough to adjust bias.

The ac voltmeter should read from 5 to 15 mV, depending on the head. Service notes for the machine should tell the correct bias. A 10-mV signal across the 10-ohm resistor figures out to 1 mA of signal current. There's no practical way to measure the signal current directly. Use the 10-ohm resistor and ac vtvm.

Question: Should you hook up a mike and speak into it while adjusting bias, to make sure it's adjusted under operating conditions?

- ☐ Yes. **Move to Frame 13.**
- ☐ No. **Go to Frame 3.**
- ☐ It doesn't matter. **See Frame 8.**

26 **No.** The clue is in the way the diode is connected. You'd have another clue if battery polarity were shown, but it's not. **Go back to Frame 20 and study the diagram before you try another answer.**

27 **Come on.** You surely just picked this answer to see what this frame says. Well, it says nothing except that you chose the wrong answer. If you picked this one seriously, **read Frame 12 over again.** Otherwise, just go back and pick out the right answer.

28 **That's exactly right.** A transistor with its base open has very high resistance from emitter to collector—unless leakage is very bad. So, the transistor would be a high resistance in series with the voltage, if R2 were to open. The voltage at the emitter would become very low.

Another electronic mystery to some technicians is

FUNCTIONS OF RECORD / PLAY SWITCH

SWITCH DECK	POSITION	CONNECTS	TO
1	P	INPUT AMPL	PLAYBACK HEAD
	R		MIKE
2	P	INPUT AMPL	PLAYBACK HEAD
	R		N.C.
3	P	OUTPUT TRANS	GROUND
	R		RECORD HEAD
4	P	EMITTER OF INPUT AMPL	FIXED BIAS
	R		ALC
5	P	FEEDBACK A	SECOND AMPL
	R	FEEDBACK B	
6	P	TONE CONTROL	THIRD AMPL
	R	FIXED TONE NETWORK	
7	P	METER	BATTERY
	R		AUDIO RECTIFIER
8	P	OUTPUT TRANS	SPEAKER
	R		MONITOR SWITCH
9	P	6 VOLTS	N.C.
	R		ERASE HEAD BIAS OSC

P = PLAY R = RECORD N.C. = NO CONNECTION

28

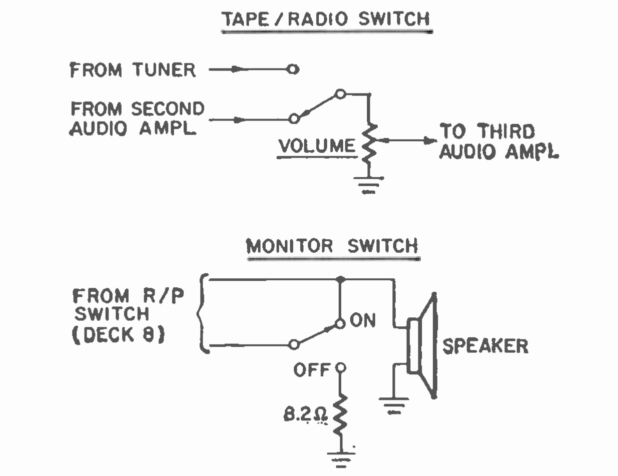


FIG. 7—THESE ARE THE SWITCH FUNCTIONS in the electronic section of a typical cassette machine. If you know them well, troubleshooting is simplified for you.

the switching system in a cassette machine. If you know what it switches, you're halfway to knowing how to approach a trouble.

The big, important switching changeover is from play to record. It is illustrated in rather simple fashion in Fig. 7. Some machines switch only a few of the functions listed; others may switch even more.

28 **Question:** How is the Record/Play switch actuated in most cassette machines?

- ☐ Manually (by hand). **Go on to Frame 29.**
- ☐ By a solenoid. **Skip to Frame 22.**
- ☐ Mechanically, by the RECORD button. **Check your answer by reading Frame 24.**

29 **Not on most.** A few cheap units may have this unhandy system. But mostly the function switch is changed over by the movement of a mechanical slide in conjunction with the RECORD button. **Proceed to Frame 5.**

PHOTOELECTRIC PHONO PICKUPS

by FRED SHUNAMAN

PHOTOELECTRIC PHONOGRAPH PICKUPS are not absolutely new—experimental ones have been demonstrated and—in 1940—Philco put one on the market—a unit with a tiny mirror mounted on the stylus. A lamp powered by rf current shone on the mirror, which reflected the light to a photocell. The movements of the stylus in the groove modulated the light reaching the photocell, thus reproducing the recorded material.

The size of the available light sources and phototubes, combined with problems of service and adjustment, caused the photoelectric pickup to fall behind other models in the race for popularity, and little was heard of photoelectric pickups for years. Recently a new type of pickup that avoids these difficulties has become popular in Japan. Pioneered by Toshiba, it is now available in several European countries, and we will be seeing it soon.

The Toshiba C-100-P—introduced at the last Audio Fair in Tokyo—operates very simply. A moving vane in the shape of a parallelogram is fixed firmly to the stylus and is moved by it in front of two elliptical openings in a fixed screen (Fig. 1).

How it works

Light from a miniature incandescent lamp powered by dc shines past the edges of the vane and through the elliptical "windows," to fall on a pair of phototransistors (Fig. 2). As the program material in the groove moves the stylus, the vane is moved in such a way as to increase or decrease the amount of light that shines through the windows.

When playing mono records the stylus moves from side to side (laterally). Thus the vane increases the amount of light in one channel while decreasing that in the other channel by the same amount. Vertical motion increases or decreases the amount of light in both channels equally. The stereo (45/45) record moves the vane in such a way as to produce exactly the same type of output as from other stereo pickups. The various motions are shown by arrows in Fig. 1.

The phototransistors are connected as emitter followers, and their signals fed to the right and left channels of the preamplifier over this low-impedance circuit, thus avoiding noise and parasitic capacitance effects. The cartridge has four leads, two for the left and right signals, one common ground and one for the hot filament lead of the exciter lamp.

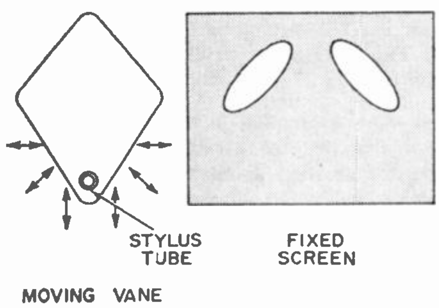


Fig. 1

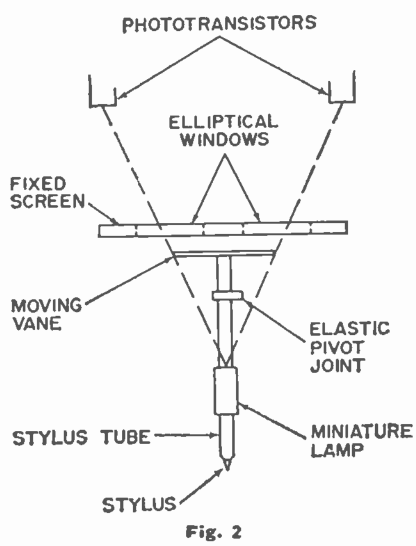


Fig. 2

The physical arrangement of the components in the cartridge is much as shown in Fig. 2. Note that the elastic joint on which the stylus arm is suspended is placed between the stylus and the vane instead of at the extreme rear as in most mountings. This permits better balance and greater flexibility in the ensemble. The whole assembly is mounted in a sphere of about 25 mm (roughly 1 inch) diameter placed at the end of a demountable head, making a cartridge of about the same size as the familiar Ortofon.

One of the weaknesses of early photoelectric cartridges was the difficulty of exchanging or adjusting the exciting lamp. This made it necessary to return the equipment to the factory—a serious problem since the lamp life was only about 300 hours.

Toshiba's engineers have made it possible for the user to replace the lamp. The stylus, vane and stationary screen are mounted in a sort of plastic stirrup, easy to reach and remove, under the lower part of the sphere that encloses the exciting lamp and the two phototransistors. The lamp is replaced by removing the upper half of the protective sphere.

The diamond stylus is elliptical (0.3 x 0.7 mil approximately) with a dynamic mass of only 0.3 milligram. The compliance—horizontal and vertical—is 30 x 10^{-6} cm/dyne. Consequently, mounted in a low-inertia pickup arm, the C-100-P can be used with a tracking force of 0.5 gram.

The sensitivity, remarkably, is 14.5 mV cm/sec—a figure that may be compared with the 1 to 1.5 mV output of the conventional high-quality cartridge. Response is practically flat from 20 Hz. and is +1 dB at 40 kHz. Separation is 33 dB at 1 kHz and is not less than 25 dB at any point in the range from 20 Hz to 20 kHz. **R-E**

Design for STEREO

how to design your own solid-state audio amplifier

by MANNIE HOROWITZ*

Part IV: Biasing the bipolar transistor isn't as difficult as you might think. Let our expert show you how it should be done

WHEN A SINE WAVE IS FED TO THE INPUT side of a transistor audio amplifier stage, the goal may be to recover this sine wave, unaltered except for amplitude, at the output of the device. In other types of amplifier stages, it may be desirable to recover half or even less than half of the sine wave at the output. A major factor in determining the type of signal that appear at the output is the bias current, or the current flowing through the transistor when it is idling.

Common emitter circuit

A very rudimentary transistor circuit is shown in Fig. 1. It is referred to as the *Common-* or *Grounded-Emitter arrangement.* In this type circuit, the input signal is applied between the base and emitter. The output signal appears across load resistor R_c, which as far as signal voltage is concerned, is between the collector and emitter. With this type of circuit, it is possible to get voltage, current and power gain.

Now let us examine the collector circuit. The maximum direct current that can flow in this circuit is equal to (by Ohm's law) supply voltage E_{cc} divided by all resistance in the circuit. This resistance consists primarily of R_C, the internal resistance of the battery and the collector resistance of the transistor. To facilitate matters, the internal resistance of the supply is considered zero and may be entirely ignored. As maximum current flows when the voltage drop across the transistor is zero, the collector resistance may also be ignored. At times, it is considered by assuming that there is 1 volt across the transistor when the maximum current flows. This 1 volt, opposing the battery voltage, is then subtracted from E_{cc} when making the calculations.

With little error, we can assume that the maximum current, $I_c(max)$ that will flow in the collector circuit is E_{cc}/R_C. The voltage V_c at the collector is then equal to the supply voltage E_{cc} less the voltage drop across the collector resistor, $I_c(max) \times R_c = V_c$, or zero.

The minimum collector current, $I_c(min)$ that can flow is, of course, zero. With no current flowing, no voltage is developed across R_c, so the collector voltage is equal to the supply voltage less the zero volts across R_c, or simply the supply voltage. Hence $V_c = E_{cc}$.

Let us now assume that a complete sine wave must be reproduced at the output. Collector current must flow at all times throughout the cycle. At the peak of the cycle, the current must never exceed E_{cc}/R_c and the collector voltage must never be less than zero. A circuit which has collector current flowing through the entire cycle is said to be biased in a Class-A mode.

The best way to establish a Class-A state is to set the idling or quiescent conditions so that half the maximum collector current flows when there is no audio signal. In this way the collector current can swing equal amounts during both halves of the cycle—from zero to $\frac{1}{2} I_c(max)$ during half of the cycle and from $\frac{1}{2} I_c(max)$ to $I_c(max)$ during the second half of the cycle. The identical condition is established if the collector voltage is set at $\frac{1}{2} E_{cc}$ so V_c can then swing from zero to $\frac{1}{2} E_{cc}$ and from $\frac{1}{2} E_{cc}$ to E_{cc} on alternate halves of the cycle. Ideal collector current and collector voltage conditions would then exist simultaneously.

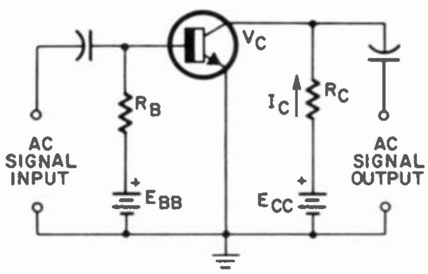


FIG. 1—COMMON-EMITTER CIRCUIT provides voltage, current and power gain.

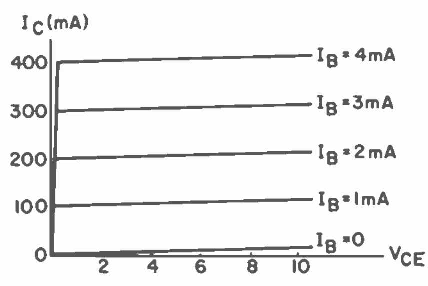


FIG. 2—COLLECTOR CURVES of a theoretical transistor with a Beta of 100.

A theoretical curve describing collector characteristics of a transistor is shown in Fig. 2. Each curve shows the amount of collector current that flows when specific amounts of current flow into the base. Notice that collector current is theoretically independent of the voltage applied between the collector and emitter of the transistor, as the characteristic curves are perfectly horizontal. For the actual transistor, there is a dependence since the I_B curves do vary from the horizontal and rise with increasing collector-emitter voltage.

Using the curves, collector current flow can be determined from the amount of base current flowing. Two equations must be plotted on one graph to determine the one point (or series of points) relating the output to the input. The first and extremely complex equation describes the transistor curves. No mathematical relationship must be stated, as the plot is already present in Fig. 2. The second equation is that of the collector circuit of Fig. 1. It is

$$E_{cc} = I_c R_c + V_{ce}.$$

Plot this equation on the graph, as shown in Fig. 3. This will be the solution to the simultaneous equation. The combination of these two equations will determine the operating points of the transistor.

From the equation stated, when $I_c = 0$, $E_{cc} = V_{ce}$. Plot this one point on the graph. It is on the horizontal V_{ce} axis. A second point can be found from the equation when $V_{ce} = 0$. It is $I_c = E_{cc}/R_c$. Plot this on the vertical I_c axis. Connect these two points. This line is the *load line* for the circuit. Circuit operation is thus defined by the

*Chief Project Engineer, EICO Electronic Instruments Co., Inc.

intersection of the load line and the various characteristic curves. For any value of current fed to the base, there is a specific voltage and current flowing, as determined from the various points of intersection. All conditions of operation must lie along this load line.

Try a numerical example. Assume the transistor has a beta of 100. The collector supply is 12 volts and R_C, the load, is 3000 ohms. A sine wave is amplified by the transistor and a sine wave is to appear at the output. First, plot the load line on the curve of the transistor in Fig. 4 as follows:

When no collector current flows, $I_C = 0$, and the voltage at the collector is equal to the supply voltage. Then $I_C = 0$ and $V_{CE} = 12$ volts is one point on the graph.

When the maximum current flows, the voltage at the collector is zero. At that instant, $I_C = 12$ volts/3000 ohms $= 4 \times 10^{-3}$ amperes. Plot this point and then connect it with a straight line to the point previously plotted. This is the load line.

Choose an idling current point ($\frac{1}{2} I_C$ max or $\frac{1}{2} E_{CC}$) on the load line. Use the point where $V_{CE} = 6$ volts and $I_C = 2 \times 10^{-3}$ amperes. This is the quiescent or bias collector current.

Let the sine wave at the input to the transistor swing the base current up to 3×10^{-5} amperes. The base current crosses the load line at a point corresponding to 3 collector volts and 3×10^{-3} amperes collector current. Should the peak of the sine wave force the base current further, up to 4×10^{-5} amperes, the collector current would be 4×10^{-3} amperes while the collector voltage is zero. If the next half-cycle of the input forces base current to zero, the collector swings to 12 volts with zero current flowing. The maximum sinusoidal output is possible only if the collector voltage is set at $\frac{1}{2} E_{CC}$ and the collector current is half its maximum value.

In this example, if the input signal drives the base so hard that it conducts more than 4×10^{-5} amperes at the peak, the collector current is limited to 4×10^{-3} amperes. The top of the signal is flat at the 4×10^{-3} amperes of collector current or at zero collector volts.

Likewise if the base current were forced below zero, a similar flattening occurs on the other half of the output sinewave.

If the bias is set so collector current flows for only half of the cycle, we have class-B operation. In this case, base current is normally set at $I_B = 0$. Only the positive portion of the input signal causes the transistor to conduct. It would not conduct during the negative portions of the cycle. However, now the swing of the conducting half cycle is not limited to $\frac{1}{2} E_{CC}$ as in class A, but it can swing the collector the entire E_{CC} volts of the supply.

Normally, class AB is used in audio output stages. In this case, the transistor conducts for slightly more than half the cycle.

The quiescent base bias current is easily established once the requirement has been determined. An equivalent of

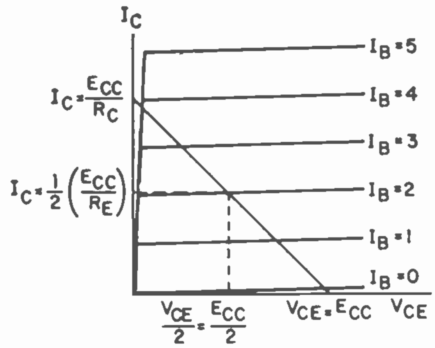


FIG. 3—COLLECTOR LOAD LINE on curves determines unit's operating locus.

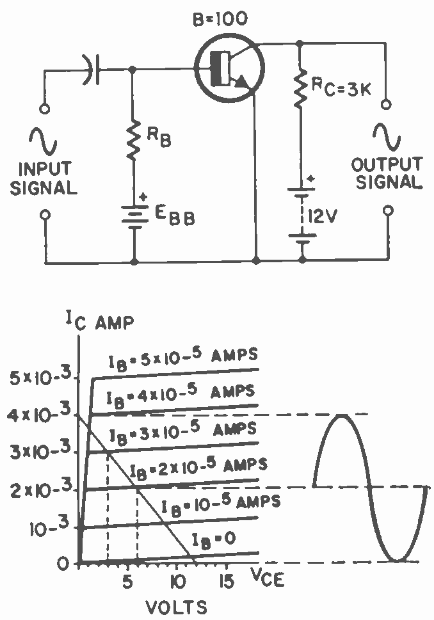


FIG. 4—TRANSISTOR CIRCUIT used to plot load line and performance curve.

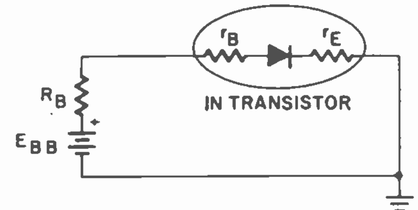


FIG. 5—EQUIVALENT CIRCUIT of the input side of a forward-biased transistor.

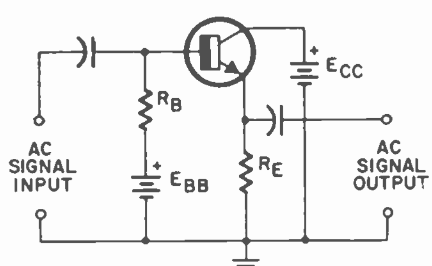


FIG. 6—COMMON-COLLECTOR CIRCUIT provides current and power gain only. Has high input and low output impedances.

the forward biased base-emitter circuit is shown in Fig. 5. A number of factors apply to this circuit.

First, a voltage supply is necessary to establish the forward base current. Then there is the dc resistance in the base material and the dc resistance in the emitter material of the transistor. Both of these items may be considered as negligible. The only resistance in the circuit of any significance is R_B, the external resistor used to establish the base bias current.

Finally, there is the voltage drop across the base-emitter junction. As with the diodes, about 0.2 volt appears across this junction if the transistor is made of germanium semiconductor material and 0.6 volt if it is a silicon device. From Ohm's law, the base bias current is $(E_{BB} - 0.6)/R_B$ assuming we are using a silicon transistor.

The effect of r_E is negligible only because r_E is very small. If a sizable resistor, R_E, is placed in the emitter circuit, between the emitter lead and the common ground, the effect of the resistor would be far from negligible. The emitter resistor appears to the base bias circuit as if it were a resistor in series with the base, but multiplied by beta. (It is actually $\beta + 1$), but a small error is involved if the "1" is omitted from the multiplication operation.) For example, if the resistor in the emitter lead were 270 ohms, and the beta of the transistor were 100, it would appear as a (270 ohms) (100) = 27,000-ohm resistor in series with R_B.

Common collector circuit

This arrangement does not require a resistor in the collector circuit, but does use a load resistor in the emitter. The basic amplifier stage is shown in Fig. 6. The input is fed between the base and collector while the output is between the emitter and collector. This may not be obvious at first, but can be seen clearly when you remember that a battery or most other dc power supplies have low impedance. They appear as short circuits to all ac or signal voltages.

The output load resistor is R_E. All output voltages appear across this resistor. The load line is drawn as for the common emitter circuit using R_E as the load.

In calculating the base current, R_B is a very important factor because of its resistance. The base bias current for the silicon transistor in Fig. 6 is $(E_{BB} - 0.6/(R_B + \beta R_E)$.

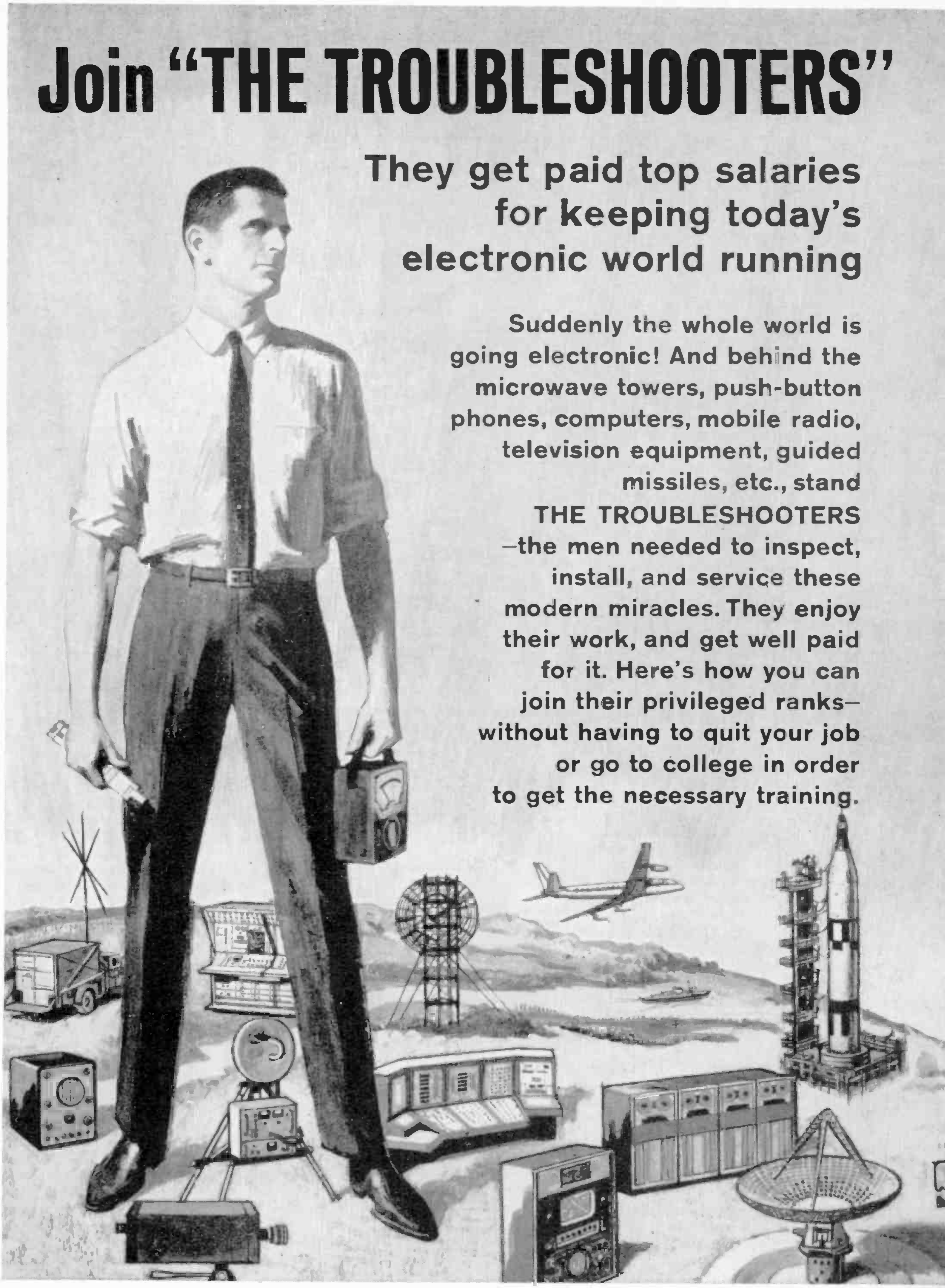
Common base circuit

Voltage gain and power gain, but no current gain, are characteristics of the common base circuit in Fig. 7. The input signal is applied between the emitter and base while the output is developed across R_C between the collector and base. (The supply is a short circuit for all signal frequencies). A set of characteristic curves is in Fig. 8.

In the curves drawn, the collector current is plotted against the collector to base voltage. Each line represents the collector-base voltage and the collector-current that will flow for different values of emitter current. The load line can be plotted as before, but this time on a different set of axis.

In establishing the bias here, the quiescent emitter current is adjusted to provide the quiescent collector current.

(continued on page 50)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SOLID-STATE DESIGN

(continued from page 45)

The idling emitter current in the circuit in Fig. 7, for a silicon transistor, is approximately $(E_{EE} - 0.6)/R_E$. If there is a resistor in the base circuit, it is reflected into the emitter circuit by a factor of $1/\beta$.

Bias circuits

There are numerous bias circuits that can be applied to all the circuit arrangements. Each is illustrated and discussed. The reasons for many of these variations may not be evident now, but will become more obvious when stability is discussed in the next article.

From here on we will not show the power supply in the schematics. Instead, a notation indicating a supply and the polarity of one end of the voltage source will be shown. Remember, the remaining end of the supply is connected to a common or ground return point.

Figure 9 shows the simplicity of the power supply notation we will be using compared with the one used until now. It is also a drawing of the simplest of bias methods, sometimes referred to as fixed bias.

This method was discussed when bias requirements were presented. The design procedure begins with deciding upon the idling voltage needed at the collector. Next, determine the quiescent collector current from Ohm's law, $I_C = (E_{CC} - V_C)/R_C$. Base current I_B is equal to this divided by beta.

Now turn to the base circuit. The base supply voltage in Fig. 9 is E_{BB}. Although collector supply E_{CC} frequently doubles in this function. The current flowing into the base starts at $+ E_{BB}$, flows through R_B, the base-emitter junction, and finally through R_E. Assuming a silicon transistor where the voltage drop across the base-emitter junction is about $V_{BE} = 0.6$ volts, the supply voltage available is $(E_{BB} = 0.6)/(R_B + \beta R_E)$.

(Note: Throughout the remainder of the discussion of bias, the 0.6 base-emitter volts will be ignored. This voltage is usually negligible when compared to E_{BB}. If you wish to include it by yourself in your calculations, merely subtract it from the base supply voltage supply considered, such as V_{TH} below.)

If we take the circuit in Fig. 9 and add resistor R_X from the base to ground, the more complex but more stable circuit of Fig. 10 evolves. To a first approximation, R_X is usually specified at less than ten times the size of R_E.

To analyze this circuit, the simple but extremely useful Thevenin's theorem must be used. By applying this theorem, any linear complex circuit consisting of a voltage source and a passive network can be reduced to an equivalent series combination of a voltage source and a series resistor. This can be done in a few easy steps. For an example of the procedure, let's Thevenize the circuit in Fig. 10. Follow the procedure using Fig. 11.

The simplification of the circuit begins with splitting the power supply for

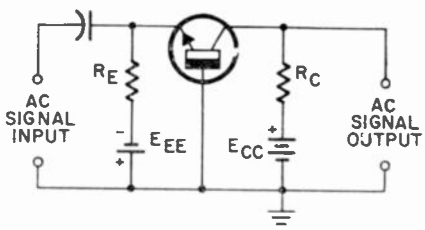


FIG. 7—COMMON-BASE CIRCUIT has current loss; power and voltage gain.

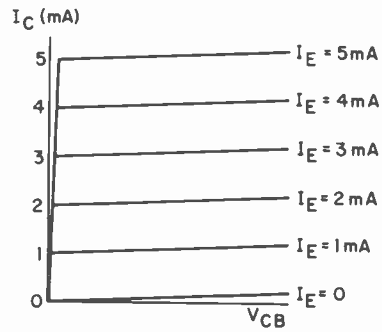


FIG. 8—COMMON-BASE CURVES show that emitter current exceeds collector current so I_E is slightly greater than I_C.

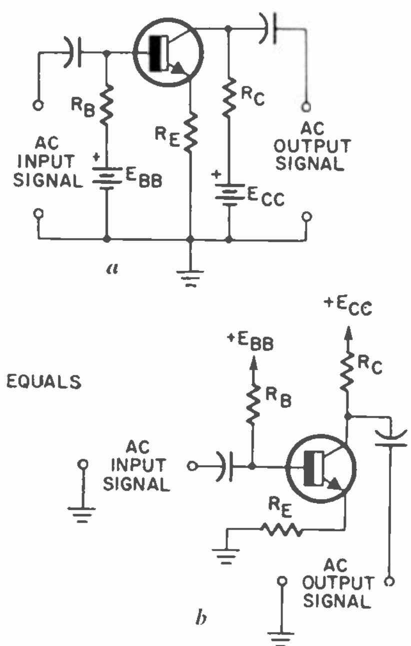


FIG. 9—(a) FIXED-BIAS circuit. (b) Simplified version makes operation clearer.

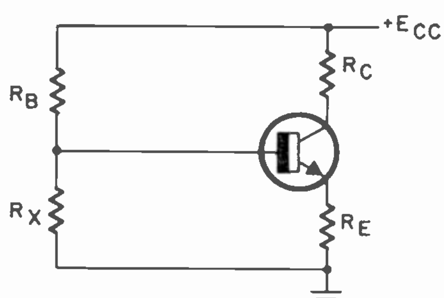


FIG. 10—A SECOND BIAS arrangement designed for improved stability.

the base and collector circuits. As both circuits are connected to one supply, E_{CC}, the "splitting" is done by simply indicating two identical supplies—one for the collector circuit and the second for the base circuit.

Now for the various steps to apply the Thevenin Theorem.

1. Separate the supply circuit from the load circuit. In Fig. 11-a, this means breaking the circuit at A — B. Redraw the circuit to the left of A — B as shown in Fig. 11-b.

2. Next find the voltage across the terminals where the load was formerly connected. This is the Thevenin voltage, V_{TH}. In the example, R_X and R_B from a simple voltage divider, so that the voltage at A — B is $V_{TH} = (E_{CC})(R_X)/(R_X + R_B)$.

3. The third step is to determine the resistance looking into the open terminals. This is done by shorting all voltage sources in the original circuit. In the example, E_{CC} is shorted so that the end of R_B formerly connected to $+ E_{CC}$ now connects to B. R_B is effectively in parallel with R_X. The Thevenin resistance, R_{TH}, is this parallel resistance; R_{TH}

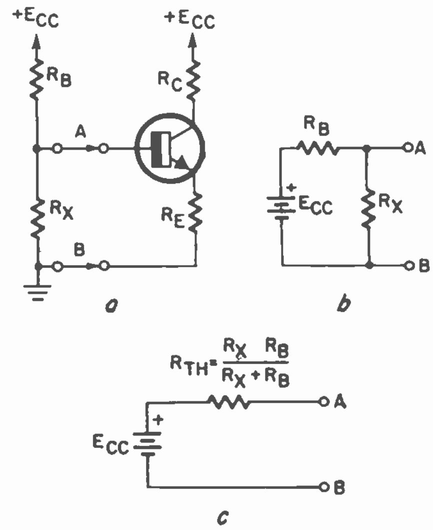


FIG. 11—THEVENIN EQUIVALENT of the bias arrangement shown in Fig. 10.

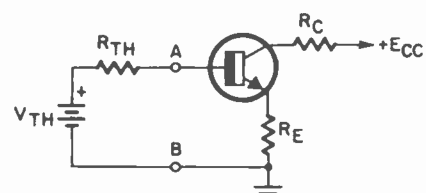


FIG. 12—THEVENIN EQUIVALENT of input circuit reverts it to Fig. 9.

$= R_B R_X/(R_B + R_X)$.

4. Draw the complete Thevenin equivalent circuit. For the bias network in Fig. 11, it is shown in Fig. 11-c.

Returning to our bias circuit, it can be analyzed by connecting the Thevenin equivalent network back to the base circuit, as shown in Fig. 12. By applying this theorem, the circuit reverts to the one previously discussed for Fig. 9. Here the bias current is $V_{TH}/(R_{TH} + \beta R_E)$ while the collector current is once again equal to the base current multiplied by beta.

A common variation of the circuit in Fig. 10 involves adding a second power supply connected to the bottom of R_X. The circuit is shown in Fig. 13. Here, in addition to the Thevenin equivalent circuit, the superposition prin-

(continued on page 89)

TECHNICAL TOPICS

by ROBERT F. SCOTT
SENIOR TECHNICAL EDITOR

Receiver selectivity is related to the i.f. See how and why this happens and how it affects the designer and user

EVIDENTLY I MUST CLEAR UP A FEW points made in this column last July because one reader wrote to say "You state that the *lower the i.f.*, the greater the selectivity available from a given number of stages or tuned circuits. This does not appear feasible since an ordinary radio obviously has more selectivity at the higher frequency (1600 kHz) than it does at the broad-tuning lower frequencies (550 kHz). If this is true, then why doesn't the circuit in Fig. 2 use the greater selective i.f.'s (90 kHz) in the first i.f. stages rather than in the second i.f. stages?"

Well, first of all, the selectivity of the average receiver falls off at the high end of a given tuning range. Perhaps the reason that you feel that a receiver is more selective at the high-frequency end is because the station density is much greater and you can tune from one station to another at a mere touch of the dial. Table I shows the approximate number of stations on three frequencies at the low-end, middle and high-end of the band. Note that there are at least three times as many stations on a given frequency around 1600 kHz as there are up around 550 kHz.

The selectivity of a receiver is a measure of its ability to separate a desired signal from an unwanted signal, noise or other interference and depends on the number of tuned circuits and on the bandwidth of each.

If you have a couple of test instruments, you can check the selectivity of your receiver. Connect an AM signal generator to the receiver's antenna terminals through a dummy antenna. (You can use a 410-ohm ½-watt resistor and a 250-pF capacitor in series to simulate the loading of the long-wire antenna generally used.) Connect a vtvm to the input of the dummy antenna through an rf probe and tie an output meter or audio voltmeter across the speaker terminals as in Fig. 1.

Tune the receiver and signal generator to the test frequency. Modulate the rf signal at the 30% level with a 400-cycle tone—usually available in the signal generator. Set the signal generator's output level for a standard output voltage; say 2.0 volts. Measure and record the rf signal level at the input to the dummy antenna. This establishes your O-dB reference level at the test frequency.

Now, tune the signal generator (don't touch the receiver tuning and volume controls) 10 kHz above or below the test frequency and increase the generator output until the output meter reads the initial standard voltage. Measure the rf signal voltage. Determine the ratio or the loss in gain in dB and record. Run the plots in 10-kHz steps out to about 100 kHz above and below the test frequency. Make these selectivity runs at 600, 1000 and 1600 kHz. Plot your results on semi-log graph paper and you'll get a selectivity curve that resembles the one presented in Fig. 2.

From Table I and Fig. 2, you can see that there are many more stations and that the receiver is *less* selective on the high-frequency end of the band. The curves in Fig. 2 represent the overall selectivity of the receiver at the test frequencies.

To answer the second part of the reader's question; the higher i.f. is used immediately following the mixer for best image-frequency rejection. (Remember that the image is twice the i.f. above the desired signal.) The higher we make the i.f., the greater the frequency difference between the desired and image signals. Thus, the

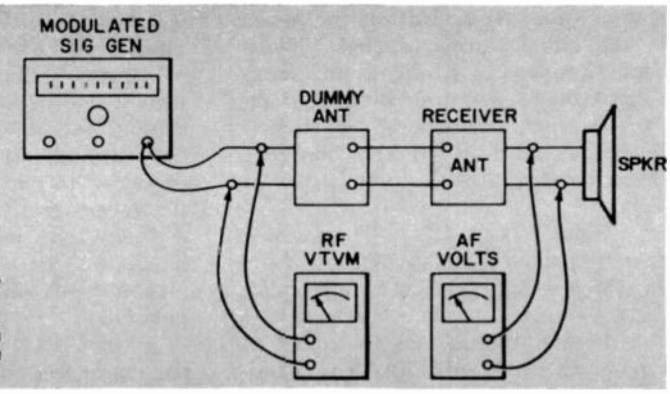


FIG. 1—TEST HOOK-UP for measuring receiver selectivity. You need an rf generator, a dummy antenna and a vtvm.

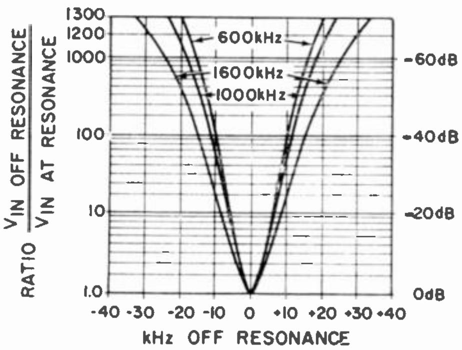


FIG. 2—RECEIVERS ARE LESS SELECTIVE on the high end of the band. Also, there are usually more stations at higher frequencies.

TABLE I
AM Broadcast Station Density

540 kHz—13	**990 kHz—41**
550 kHz—25	**1000 kHz—22**
560 kHz—21	**1010 kHz—37**
1580 kHz—71	
1590 kHz—72	
1600 kHz—72	

higher the first i.f., the greater the image rejection.

Let's look into the basics of tuned circuits and see how they affect a receiver's performance. Fig. 3 may

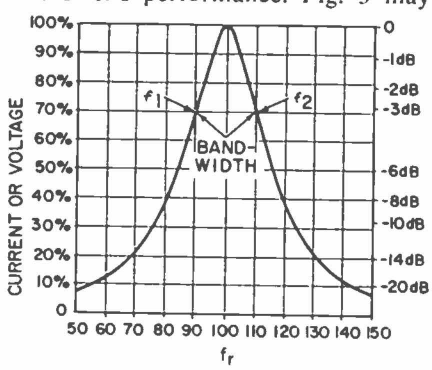


FIG. 3—RESPONSE CURVE of a single tuned circuit such as an antenna or rf transformer or an i.f. transformer.

be the response curve of a single tuned circuit such as an antenna or rf transformer or it may be that of an if. transformer. The *band-width* of the circuit is measured between the two frequencies where the off-resonance current or voltage drops to 70.7% of the level at the center or resonance frequency f_r. The drop in voltage to the 70.7% level corresponds to a loss of 3 dB as the *power* in the circuit drops to 50%. Therefore, frequencies f_1 and f_2 are sometimes called *half-power points*. At the 70.7% level, frequency f_1 is 10 kHz below f_r and f_2 is 10 kHz above f_r. Thus bandwidth is f_2 minus f_1 or 20 kHz.

Since $f_r - f_1 = f_2 - f_r$, we have two frequencies, equally spaced about f_r, which we call Δf. Bandwidth equals $2\,\Delta f$.

Figure 4 illustrates the affect of circuit Q on bandwidth. The band-

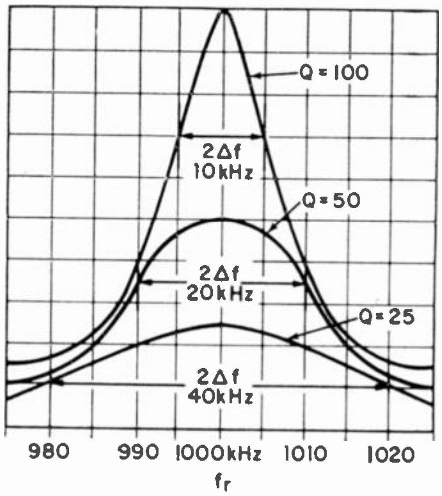


FIG. 4—EFFECT OF CIRCUIT Q on bandwidth is shown in this chart.

width at half-power or 70.7% points is equal to f_r/Q. Curves are shown for Q's of 100, 50 and 25. Note that the slope or skirts of the curves steepen and bandwidth decreases as Q increases. Let's see how all this affects rf and i.f. selectivity.

Assume a simple 2–4-MHz superhet using an antenna coil with a Q of 100 at 2.5 MHz. There is a single i.f. stage (two i.f. transformers) and we can select either a 90- or 1600-kHz i.f. The graph in Fig. 5 shows the *universal* response curves for a single tuned circuit and for a double-tuned transformer with the windings adjusted for critical coupling. (Critical coupling produces the sharpest peaked response along with maximum voltage in the transformer secondary.) The values of *a* along the baseline are derived from

$$a = Q \times \Delta f/f_r$$

where Δf is the difference between f_r and an off-resonance frequency. S is the ratio of the voltage at f_r to the voltage at Δf for equal output voltages.

If we select 90 kHz as the i.f. for our receiver, the image frequency is 2500 plus 2 × 90 kHz or 2680 kHz; 180 kHz above resonance. The response of the antenna circuit at the image frequency can be found from the curve for the single circuit in Fig. 5. With the image represented by Δf, *a* is 100 × 180/2500 or 7.2. S is 14.4 and Δf is 23 dB below f_r.

Thus, if the station on 2500 is a distant one developing, say, 10 μV, a station on 2680 kHz need develop only around 144 μV at the antenna to produce the same amount of signal at the mixer grid as the desired signal. Actually, the interference signal can be quite a bit weaker and still make reception of the 2500-kHz signal impossible.

Now, let's see what happens to the image response if we use a 1600-kHz i.f. The image frequency (5700 kHz) now is 3200 kHz above the resonance frequency. On the curve, *a* is now 128 and the ratio of signal voltages is about 240 or approximately 48 dB. Now the image signal would have to be 2.4 millivolts to create the same level of interference as a 144-μV signal in a set with a 90-kHz i.f.

I.F. selectivity

We've seen how a high i.f. improves the *apparent* front-end selectivity, so let's see how the i.f. affects the set's overall selectivity. The second curve is for a double-tuned transformer as might be used in a single-frequency rf amplifier or in an i.f. circuit. Here again, the bandwidth at any given point is directly related to Q.

Normally, we express i.f. bandwidth in terms of frequency range at specific points on the curve. For example, an i.f. transformer may have a response curve where the bandwidth is 6 kHz at −6 dB (also called 6 dB down), 16 kHz at −20 dB and 25 kHz at −26 db. "Six kHz at 6 dB down" means that for a constant voltage applied to the transformer, the output voltage drops to one-half at 3.0 kHz above and below the center frequency.

However, when comparing transformers designed for different frequencies, it is often better to specify loss in terms of percent-bandwidth. The reason for this is that, regardless of frequency, transformers having the same Q and coupling coefficient will have identical percent-bandwidths characteristics.

For example, assume that a 90-kHz i.f. transformer's drops to −6 dB at frequencies 6 kHz above and below resonance. For this transformer Q, the percent-bandwidth at −6 dB is 6/90 or 1/15. Now, for a 1600-kHz transformer of the same Q and degree of coupling, the −6 dB response occurs at points 1/15 of the center frequency or 106 kHz above and below f_r.

Let's look at the transformer from another angle. Bandwidth between half-power points equals f_r/Q. Assuming 90-, 455- and 1600-kHz i.f. transformers with critical coupling and a Q of 50, the respective bandwidths are 1.8, 9 and 32 kHz, respectively. *Bandwidth varies directly as frequency. High i.f.'s provide good image rejection and low values give greater rejection of signals on frequencies adjacent to the one we want.*

Suppose that you need a receiver that will reject a strong signal 5 kHz from one on 3750 kHz. You have a choice of i.f.'s. You know that a 90-kHz i.f. is sharper than 455 or 1600 kHz; but do you know just how much sharper it is?

The set will have a single i.f. amplifier (two transformers). The transformers have critical coupling and a Q of 100. Regardless of the i.f., the interference frequency is, in this case, 5 kHz away from the center of the i.f. The transformer curve in Fig. 5 can be used to plot i.f. selectivity. Note that the values of S and dB attenuation are for *one* i.f. transformer. For two transformers, use the square of S or double the attenuation factor. If you have three transformers, the value of S is the *cube* of the single-transformer value and the attenuation factor is multiplied by 3.

(With two or more identical i.f. transformers, the value of S is approximately $(4a^4 + 1)^{N/2}$; where a is $Q\ \Delta f/f$, and N is the number of transformers.)

Back to the problem of the three i.f.'s. Constant a is approximately 5.5, 1.1 and 0.3 for 90-, 455- and 1600-kHz i.f.'s respectively. At 1600 kHz, S is around 1.05 (for a single transformer) or 1.1 for the pair. The ratio of desired to unwanted signal strengths is so small that both will be received with about equal strength.

With a pair of 455-kHz i.f.'s, S is 4 and the interference is 12 dB down. By the same token, a pair of 90-kHz i.f. transformers will drop the unwanted signal more than 40 dB. Thus, for a given level of interference at the antenna, the interference at the output of the i.f. is over 100 times stronger with a 1600-kHz i.f. than with one tuned to 90 kHz.

NOTE: In discussing i.f. transformers, we assumed critical coupling and identical primary and secondary Q's. In actual practice, the Q's of the individual windings will be degraded by the impedance of tubes or transistors shunted across them and the bandwidths at any given level will be somewhat greater than calculated from the curves.

With selectivity, bandwidth and Q cleared up, you'll be better able to under Q multipliers and crystal, ceramic and mechanical filters when they are discussed in later columns. **R-E**

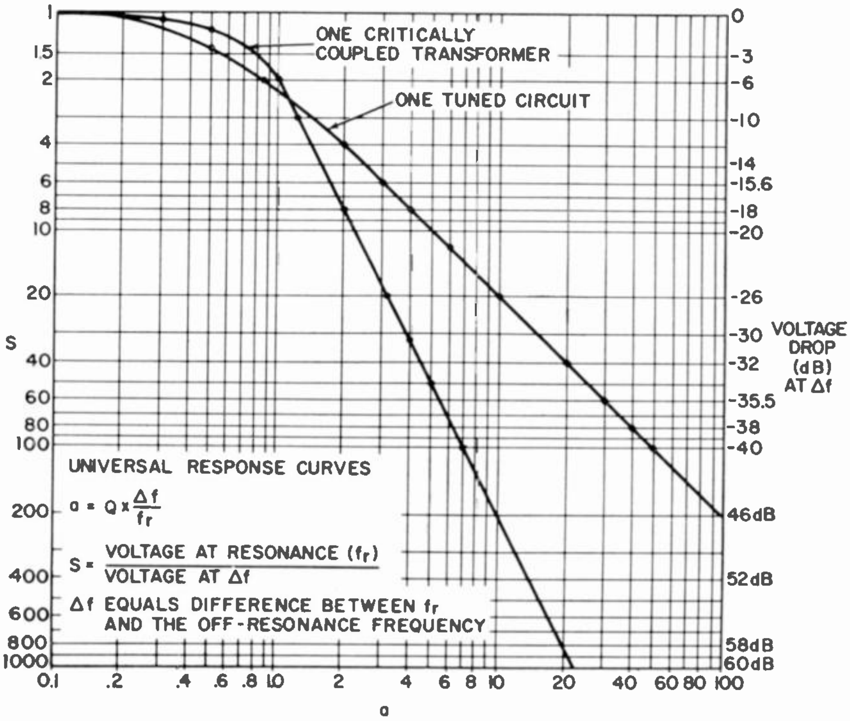


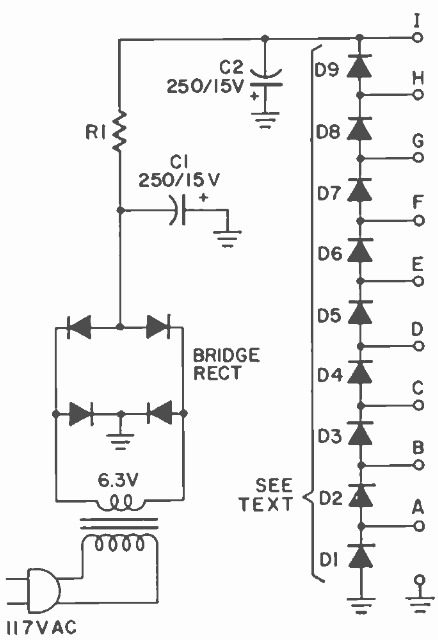
FIG. 5—ANTENNA CIRCUIT RESPONSE can be found using this graph. This curve can also be used to plot i.f. selectivity.

"Millie Volts" Power Supply

When experimenting with solid-state devices such as tunnel diodes we need a good, very-low-voltage power source. Multivibrators need 300 mV, amplifiers 400 mV, and to plot a curve or test, a variable supply.

The common method of placing a resistance in series with a 1.5-volt cell, while operable, is not appealing due to the high internal impedence with its inherent lack of stability. A low-Z regulated source is needed.

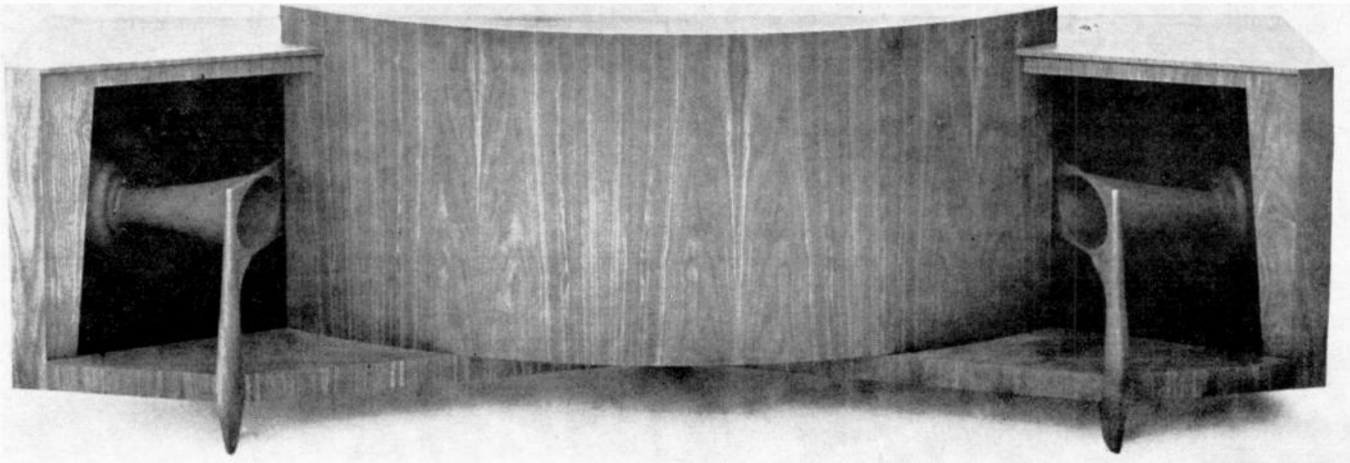
Short of a very elaborate electronically regulated power supply with go to zero provisions, Millie Volts offers the best source for the size. A look at the schematic diagram shows a 6.3-volt filament transformer with an epoxy bridge rectifier giving 8 Vdc at C1. R1 is chosen to drop the voltage to that appearing across forward biased diodes D1–D9. With a maximum load, (external load plus regulator drain) of 50 mA, a 75-ohm 1-watt will do nicely. For other values of voltage and current, use Ohms law: $R = \frac{E}{I}$ where E is the voltage to be dropped across R1.



Circuit of the simple low-impedance regulated power supply.

Since the voltage drop across a forward biased germanium diode operating above the square-law region is 220 mV and a silicon diode drops 700 mV, diodes 1 through 5 should be medium current germanium such as 1N91. This will give steps of: 220; 440; 660; 880; 1100 mV for points A through E. Diodes 6 through 9 can be general replacement type silicon of a suitable current rating. This giving voltages of: 1.8, 2.5, 3.2 and 3.9 Vdc at points F through I.

The entire unit was constructed on a phenolic board housed in a Minibox. Points A through I were brought out on a barrier terminal strip allowing several voltages to be taken at once. Or, by grounding point G, in the external circuit, a balanced power supply of 1.4–0–1.4 Vdc can be taken between points I and E.—*P. Roger Magriney* **R-E**



6 ways to improve your HI-FI system

The suggestions made here are simple, but you'll be surprised at the improvement they can make in your system

by MATTHEW MANDL
CONTRIBUTING EDITOR

MANY OF US USE OUR RADIO, PHONO, or tape machines only as a convenient source of background music and bother with it only when it becomes defective. Others collect components with care and use them with pride, observing all the rules they know for getting the most from the equipment. It's for this latter group that this article is written. If you've been at it for a long time, it will re-emphasize facts you need to know or may have neglected. For newcomers, it gives the essentials for getting the most from your gear in six major areas.

Cartridge and record factors

If you've never checked the stylus pressure on your records by the cartridge and pickup arm weight the chances are it's higher than need be for the cartridge in use. The term *tracking force* is used in relation to grams of stylus pressure. If the tracking force of a cartridge is specified as from 3 grams to 5 grams, the weight adjustment of the arm should be set for 3 grams unless poor design of the arm or turntable does not permit good tracking at this pressure, as evidenced by the stylus jumping grooves.

If the pickup arm permits, it is highly desirable to use a cartridge with a tracking force down around 1 gram. This will minimize record wear and increase stylus life. Many experts claim record wear increases dramatically above 2 grams, with subsequent distortion of low and high tones after a few playings. How soon this occurs also depends on stylus wear, since a worn stylus can chew up new records in short order.

For a tracking force of less than 1 gram you need a well-designed pickup arm which is finely balanced, free-moving vertically, and properly damped horizontally. Thus, as you seek cartridges with lower tracking forces, the cost of all items rises, and it becomes a matter of what you can afford. With the volume range incorporated in some of the newer record releases, a tracking force of at least 1 gram is often a necessity. I've been using a cartridge with 1¼ gram tracking force for some time with excellent results. After repeated playings the records still sound crisp and fresh, even those with high and shrill violin or brass passages.

If you don't have a stylus-pressure guage you can improvise one easily with a piece of stiff cardboard, a pencil, and some coins. Did you know that a US nickel weighs exactly 5 grams? A new dime weighs 2¼ grams, a penny slightly over 3 grams (about 3⅛ g), and a quarter weighs 6 grams. To use these coins as a scale for your stylus pressure, cut out a section of cardboard measuring 5" x 1¼" as shown in Fig. 1.

Draw a line exactly across the center of the cardboard at the 2½" point. Also draw a line ½" in from each side, plus a line 1½" in from one side as shown in Fig. 1. Place the cardboard center line over a round pencil or piece of dowel and use a strip of tape along the bottom to hold it in place. Now you have a fairly accurate balancing scale.

Place it on the turntable and lift the pickup arm onto the cardboard so the stylus rests on the right ½" line. Place a nickel on the left ½" line. If

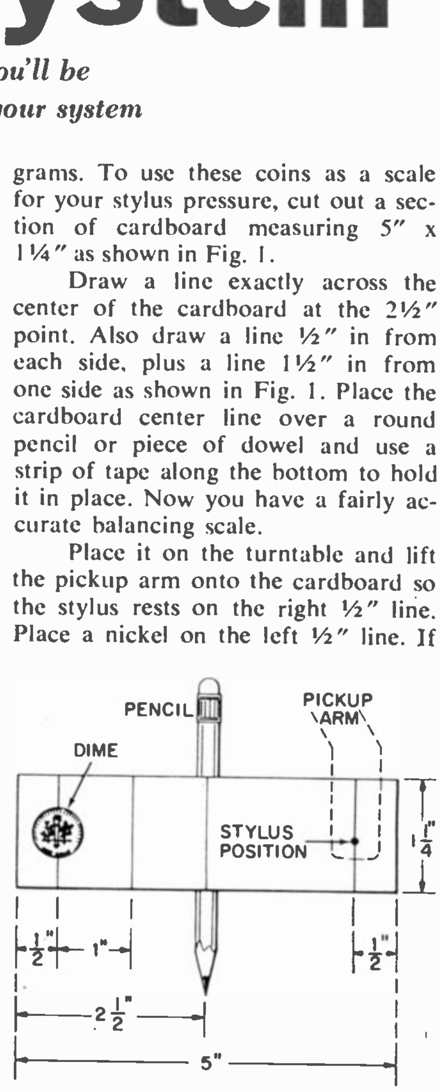


FIG. 1—STYLUS-PRESSURE GAUGE made from a few easy-to-obtain parts.

the pickup side goes down you know your cartridge-needle weight is over 5 grams.

If it is less, use a dime to see if it is less than 2 grams. Placing the dime on the next line (nearer the center) lets you check with approximately a 1-gram weight. For accuracy, use the back of the dime and align the torch symbol with the line 1½" in from the left.

If your phono has a turnover ceramic cartridge, make sure the stylus rests in the record grooves while in a true vertical position. Use a thin-nose pliers and bend the stop flanges at the rear of the cartridge until you get good alignment. Some cartridges do not have stop flanges. If the stylus is off in these you will have to use your own judgment as to the proper corrections.

If you plan to change from a ceramic cartridge to a magnetic, make sure your amplifier has a magnetic cartridge input (using preamps). When selecting a new cartridge, check for designated tracking force, channel separation, compliance, and frequency response. There is a 30-dB separation during FM broadcasting, so if the cartridge has a 30- or 35-dB separation it is excellent in this regard. Less than 20 dB is rather low compared to the many cartridges which do better.

Compliance is the ability of the stylus to move freely and follow accurately the groove variations of the record. Consider a rating of 35 x 10^{-6} excellent and a 15 x 10^{-6} good. Most good cartridges have a frequency response from 20 Hz to 20,000 Hz which should satisfy all but the absolute purists. For them there are cartridges available that cover from 6 Hz to 40,000 Hz. Keep in mind, however, that the frequency response of a system is only as good as the weakest chain in the link of amplifier, cartridge, and speakers. Also, below about 16 Hz the ear no longer recognizes the sound as a musical note—only a flutter. Similarly, 20,000 Hz is pushing the upper hearing limit of most of us.

The dust and lint which accumulates in record grooves will eventually clog up the stylus area in the cartridge. So check this often and use a small camel-hair brush to clean the area. Record dust is an abrasive and wears the record and stylus faster than normal. Special cloths and brushes are available for cleaning. If the dust can not be eliminated, brush it into one area on the record and use Scotch tape to blot up the filled grooves. This system often works where other methods only do half the job. Keep those inner jackets when you buy a new record. They're a little more trouble when you remove and replace a record, but they do help keep out dust.

When a stylus is worn, the highs become fuzzy and the lows distorted and muffled. Waiting until this happens, however, is a poor way to find out the stylus needs replacement, because it is already damaging your records. Small 50-power pocket-size magnifiers are available at most hi-fi outlets and this (or a microscope) is best for periodic checks.

Often a separate plug-in cartridge is used for older (and mono) records which usually have a higher noise surface. This reserves the stereo cartridge for your newer and better records.

Turntable pointers

We often start using a new turntable without checking to see if it's level. If the turntable tilts slightly, it increases the possibility of record groove skipping or cartridge skating across the record. Good leveling is increasingly important as cartridge tracking force is decreased into the 1-gram region. So use an accurate carpenter's level at front and side and adjust for any tilt by resetting the bolt-spring nuts (if provided) or with cardboard shims under the sides of the unit.

Study the instructions which come with the turntable and familiarize yourself with the set-down adjustments, needle-pressure spring levers, etc. Use a lightweight machine oil and lubricate parts which turn or swivel, making sure the arm has free vertical and horizontal movement. If the turntable has an anti-skate device make sure it is set to conform to the tracking force of the stylus. If you use a stylus brush (usually attached to the front of the cartridge) you may have to readjust the weight, since the brush has some lifting force and may cause groove skipping.

If your turntable doesn't have an ac output plug for the amplifier, you can install one yourself as shown in Fig. 2. This saves wear and tear on the on-off switch of the amplifier and with automatic shut-off turntables, the amplifier will also turn off. The extra switch nearest the motor is necessary if the amplifier is combined with the radio. This permits motor turn-off while the radio is being used.

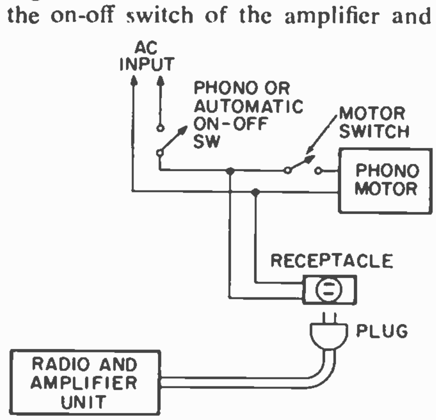


FIG. 2—AC OUTLET FOR AMPLIFIER lets phono switch control entire system.

Speakers and switches

With the amplifier shut off, check the wiring connections to the speakers. Tighten loose connections to avoid noise, intermittent operation and possible damage to the output stages of the amplifier. Avoid using thin (No. 20 or higher) wires. I prefer lamp cord or good twin-lead with No. 18 stranded wire. The twin lead has lower capacitive losses for highs in lengthy speaker connections.

A phasing switch is handy if you like to try various speakers (or for testing on the work bench). If your system doesn't include one, you can wire one in as shown in Fig. 3. Only one such switch is needed, since a phase change for one speaker is in relation to the other.

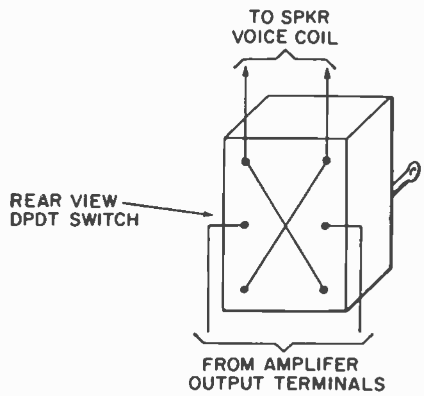


FIG. 3—ADD PHASING SWITCH if you like to try various speaker arrangements.

You can test for correct phase by throwing the mode switch on the amplifier to mono, or by playing a monaural record in the stereo mode. When playing mono the sound should appear to come from between the two

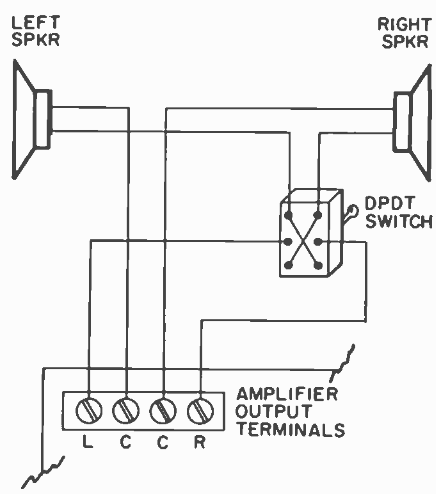


FIG. 4—CHANNEL-REVERSAL SWITCH lets you switch sounds right-to-left.

speakers (provided the sound level for each channel is balanced).

A channel-reversal switch is also a handy device since it permits you to switch the sound which normally comes from the right speaker to the left speaker and vice-versa. This adds a different approach to your favorite records and provides for additional variety. The hook-up is shown in Fig. 4. Again a double-pole double-throw switch is used. Note that this system is based on having common ground wiring for one leg of each speaker. Check the markings on the outlet terminal or the schematic to make sure one leg of each speaker terminal is at ground.

If the phasing switch of Fig. 3 is also used, it can follow the reversal switch wiring and tap in near either speaker.

Tape machines

Tape recorders, decks, cassette and cartridge units all need frequent cleaning of the head and occasional head demagnetization to remain in peak operating condition. After repeated plays some of the tape oxide piles up around the gap of the playback (and recording) head and results in fuzzy and weak tone. It is surprising how many tape machines are turned in for repair, that only require a good cleaning of the heads.

A cotton swab dipped in rubbing alcohol is ideal for cleaning heads, and while you're at it also wipe off the capstan drive roller. Slippage here results in uneven speed. If the heads have an abnormal accumulation of oxide or haven't been cleaned in some time, a stronger cleaner may be needed. You can get a small bottle of acetone from your druggist. It makes very effective cleaning fluit. **Don't get the acetone on plastic parts, since it acts as a solvent for some. Also, keep the bottle tightly corked as it is very volatile and can completely evaporate over night!**

If you need a thin ribbon-type applicator you can use a shoe string. The best material I've found is ½" *twill tape* available in dime stores (sewing accessories departments) at about 25¢ for 3 yards. Cut off a 6" section, dip it into the cleaner fluid, and you have a good cleaning ribbon which you can pull through over the tape heads. A white ribbon is best because it shows how much oxide is being removed and gives you an idea of when the head is finally cleaned.

Head demagnetizers are available from many mail-order houses and local radio parts distributors. After repeated playings, the heads accumulate some residual magnetism and can affect the tape as it rides over the heads. Thus, the quality of reproduction as well as the recorded material can suffer. Head demagnetization (degaussing) need not be done as often as head cleaning, but it should become a routine matter every few months for equipment used often.

Sections of recorded tape which have been stretched or creased because of rewind or threading troubles will clog heads after only one or two plays because of the loosened oxide coating. Such sections should be cut out of the tape, even at the sacrifice of a portion of the recorded material.

The moving parts around the heads, including the capstan drive roller, should be lubricated with light machine oil every few months; more often if the machine is used heavily. Make sure no oil runs over the drive roller or on the heads.

Noise reduction

Often the built-in ferrite-core antenna in an AM receiver provides satisfactory results except in very remote areas. With FM, however, a better antenna system is needed to eliminate or reduce background noise for stations beyond the immediate area. An outdoor antenna is best, though not always practical when a TV antenna is already on the roof. A two-set coupler can be acquired, thus permitting use of the FM set as well as the TV. However, some TV antennas deliberately attenuate the FM band. These antennas cannot deliver good FM reception.

A separate antenna can be constructed from twin lead and positioned as high in the room as possible (or in the attic). As shown in Fig. 5-a, a 5'6" long section of twin lead is used. The wires at the ends are stripped and soldered and one of the wires at the center is broken and fastened to a length of twin-lead that connects the antenna to the receiver. The pick-up pattern is shown in Fig. 5-b. You can

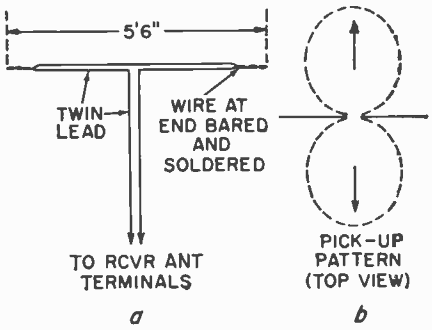


FIG. 5-a—SIMPLE FM ANTENNA. Its directivity pattern is illustrated at b.

bend the antenna portion in an "S" shape for pickup in a circular pattern. If stations are received only from one or two directions, however, you get more gain by keeping the antenna section straight.

Other noises can be caused by loose connections between amplifier and speakers, between amplifier and tape deck, etc., and these should be checked. Sometimes noise from motor brushes or arcing comes in through the ac line. Most receivers have a noise-filtering capacitor or two in the primary side of the power transformer as in Fig. 6. Check the schematic of your unit and add this filter if it isn't already there. In Fig. 6-a a single filter

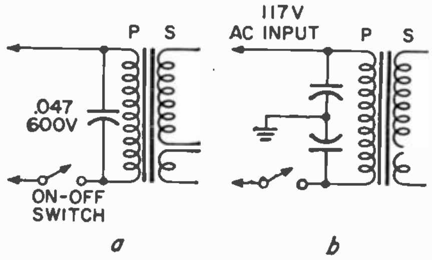


FIG. 6—TWO SIMPLE FILTERS that keep line noise out of your equipment.

is used, assuming we have a good ground system in the power mains. In Fig. 6-b two capacitors are used, with the common center junction connected to ground.

Often noise is also generated by nearby fluorescent fixtures. Turn these off and check to see if the noise stops. If so, try a new light initially and also check the starter. On rare occasions the internal inductor may be at fault and must be replaced.

And in conclusion . . .

If your radio or amplifier is several years old you might make quite an improvement by acquiring a newer model. Features include field-effect transistors (FET) in front ends for greater sensitivity, reliability, and performance, providing gain advantages comparable to the pentode vacuum tube without its faults. Most models have eliminated output transformers, providing better frequency response.

A variety of models and price ranges are available, depending on power output, circuit refinements, the number of front panel switches available, etc. My preference is for an amplifier with *at least* 40 watts of music power (20 watts per channel). Presently I'm running 60 watts total music power (8 ohms, with 75 watts into 4 ohms). This provides enough reserve for the increased dynamic range of some of the newer recordings and also permits me to put on an impressive demonstration for my visiting hi-fi friends.

Four-channel tape decks and receivers must also be considered now and you should listen to these and become familiar with their capabilities. Keep up with the new developments in the field for increased and sustaining fun with a fine hobby! **R-E**

REPLACEMENT TRANSISTORS

by JACK DARR
SERVICE EDITOR

Part II

Finding a suitable transistor substitute is often quite a job. Here is a sure-fire way to find the transistor you need

In concluding Part I, we introduced the Darlington pair (Fig. 6), two transistors with the emitter of the first direct coupled to the base of the second. This is a common-emitter circuit displaying low input impedance and high voltage gain. So, the combination of the two gives us a unit with a very high beta, often up to 1,000 or even more, a high input impedance, for getting the best results from high-impedance phono cartridges, microphones and guitar pickups, and all in a single case. The emitter-base connection is internal. Both collectors are tied together to a common collector terminal. Transistor Q1's base and transistor Q2's emitter are brought out at terminal B and E, respectively.

You will often find these units drawn on schematics as a *single* transistor! Look out for this. In the parts list, they will be identified as a Darlington pair. (They *look* like a single transistor, too.)

Testing Darlingtons

You might think that these could be tested on a standard transistor tester. They can, but they display some unusual characteristics. If you don't know about this, it could fool you. Leakage can be read just as before. (They can be either pnp or npn) However, for a beta reading,

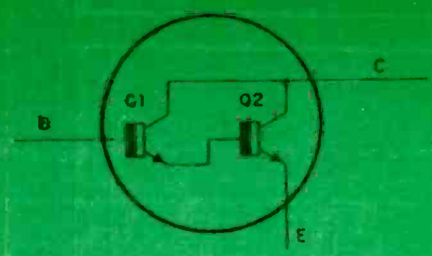


Fig. 6—INSIDE THE DARLINGTON PAIR composite transistors.

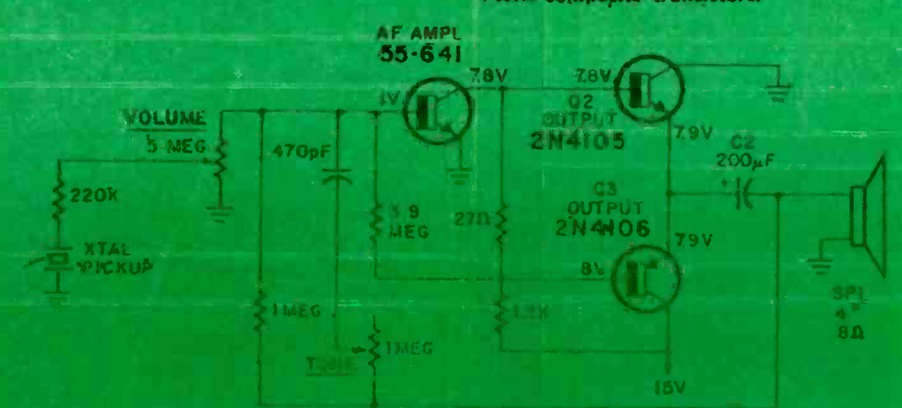


Fig. 7—DARLINGTON-PAIR is shown as a single transistor in some schematics as in service data for Truetone 4DC5963.

you'll find that you can't get the meter to "Calibrate" to full scale, as it will with a single transistor. Sometimes it will go only to half-scale, or maybe even less. Push the TEST button, and the needle will go off scale to left (or right, depending on your tester) indicating a very high beta reading.

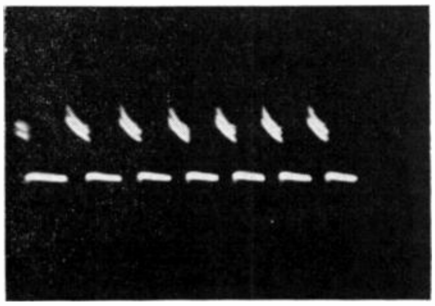


Fig. 8—DISTORTED WAVEFORM resulted when silicon and germanium transistors were used as complementary-symmetry pair.

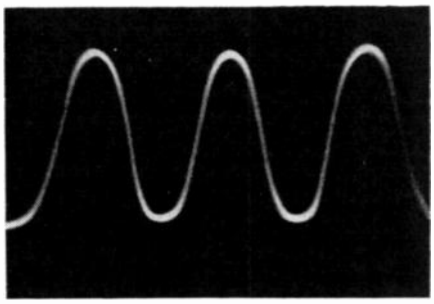


Fig. 9—DISTORTION CLEARED UP when two silicon transistors were installed.

If you want to verify this, take any two small-signal transistors, such as HEP-53's, SK-3020, etc. and make up a Darlington by twisting the leads together. Now, test this combination, and you'll see what a normal reaction will be.

Replacement

The best replacement for these is an exact duplicate, of course. However, we did make up a test Darlington connection, and tried it in a little phonograph amplifier. It worked very well. (See the case history on the Truetone 4DC6963.) In this particular unit Fig. 7, the Darlington was used as a direct-coupled driver for a complementary-symmetry output pair.

The collector voltage (base voltage of the output pair) was slightly higher than it had been. This was probably due to the transistors I used having a little bit higher beta than the originals. However, collector currents were not out of line, and the scope showed no distortion and ample peak-to-peak output voltage, so that it would probably be all right. If you get too much bias difference, in these direct coupled circuits, try another replacement transistor, with a lower or higher beta, to see if you can get the bias back to its original value, or very near it.

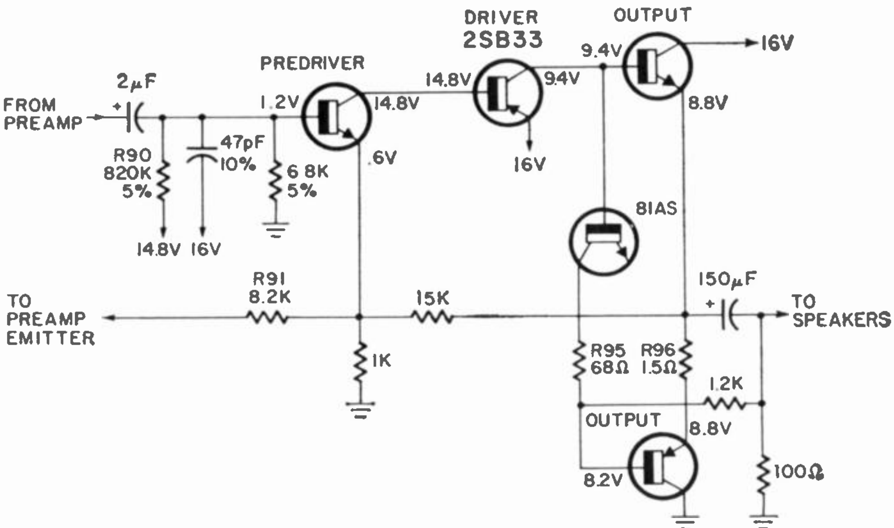


Fig. 10—DRIVER TRANSISTOR WAS BAD in one channel of a stereo combo.

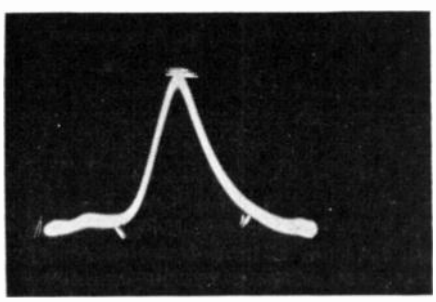


Fig. 11—NORMAL RESPONSE CURVE of AM radio. Input 1200 kHz, swept 25kHz.

If you get an audio amplifier in for repair, and it has very low gain, quite a bit of distortion, yet the single driver or preamp transistor (obviously a general-replacement type) checks perfectly *good*, check the schematic! The original preamp-driver may have been a Darlington! I tried *one* of the replacement transistors in place of the Darlington, and that's what I got; very low volume, very severe distortion, and the bias voltage on the output was farther off than ever. This, very likely, was the cause of the distortion, and the reduced gain.

Summation

Now, before we get into the actual case-histories, let's sum up this method. It's really a lot simpler than it sounds. For small-signal transistors, what do we need to know? This:

1. The breakdown voltage, which must be greater than the applied voltage, by at least a 25% or more safety factor.

2. The type; pnp or npn, and the material—germanium or silicon.

3. The base connections, in the circuit. (To avoid confusion, we should say "terminal connections" or something, but knowing us, we'll probably go on saying "base" as in a tube. As long as we know which is which, OK.)

With this information, we've got it made. For small signal audio transistors, this is all we need. For any transistor in a tuned circuit, we need one more: the high-frequency cutoff.

4. This must be well above the upper frequency limit in the circuit. For example, in TV i.f.'s, at 40 MHz, use transistors with a cutoff at least 150 MHz or better. The higher the better. For an rf amplifier in a TV tuner, vhf, at least 300 MHz, uhf, much higher. They're there; one transistor, RCA's SK-3039 goes to 1200 MHz! HEP-720 goes to 800 MHz, and so on.

For audio, rf, i.f., and similar transistors, the current rating will always be ample. We won't have to worry about this yet. Actual circuit currents will be very small.

Power transistors

For power transistors, all of the previous items apply, except the upper frequency cutoff. This isn't important, in power transistors; all of these will have a cutoff up to at least 600–700 kHz, which is pretty well outside the audio range, and some go to 2 or 3 MHz. However, you will now have to check for:

5. Maximum current rating. This should be the maximum in-circuit current plus at least a 25% safety factor, or more. (Better have too much than not enough!)

So, there you are. It takes more time to do it than it does to read about it! Make up this written list of the required characteristics, then look through the characteristics charts and lists in the replacement manuals, and come up with several types that will probably work. This is the method we used when making these tests, and it worked every time.

CAUTION: Due to the tremendous number of transistors listed, once in a while you will run across a typographical error! No one's perfect, especially computers. So, when you find a certain type listed as a replacement, take the time to cross check its characteristics against your list.

In one case, I found a certain type listed as a replacement for a video output transistor in a b-w TV set. Everything was fine, but the in-circuit collector voltage was 120 volts. The replacement type had a collector breakdown rating of only 30 volts! Checking back later, I discovered that *one* digit had been incorrect.

You might be interested to know that I installed the first type, and it worked! When I turned the set off after a few minutes of operation, and started to take the transistor out again, I found out that it was hotter than a two-dollar pistol! (The hard way, of course.) THEN I checked the list and the characteristics and found out *why*. Despite the high overload, the transistor wasn't damaged! Modern junction transistors can be pretty rugged little beasts. If you insist, you can even install transistors with the leads in the wrong holes. They don't work particularly well, but it doesn't seem to hurt them. Not recommended as general practice, but it does happen now and then (and the less said about the source of that little nugget of information the better).

So, make it a habit, and most especially in circuits where you're apt to find high voltages, to cross check *before* you install the new transistor. This includes video and audio output, certain types of driver circuits, color oscillators, color difference amplifiers, and so on. Only takes a moment, and it can save trouble later.

Truetone 4DC 5929A-86

Output transistors bad. Someone had replaced these, but there was still considerable distortion. Cross-checking in the list showed that the previous technician had used one silicon and one germanium transistor, in a complementary-symmetry pair! This gave us an output waveform something like Fig. 8.

Checking the circuit and the list, we picked SK-3024/SK-3025, silicons. Voltages went back to normal, and the output now looked like Fig. 9. Tone was now very good.

As an example of "Don't stop till the job's done," after the output transistors had been replaced, I found that with no signal, the left channel output transistors were still *warm*. (Class-B outputs, like this, should draw practically NO current, without a signal.) The right channel outputs were cool.

Checking the bias, the base of the top transistor read about +11 volts; its "opposite number" in the other channel read the correct +9.4 volts. This one was running cool. Resistor tests showed these were OK. The driver transistor, direct coupled to the output, was taken out and checked (suspecting leakage). No leakage; however, replacing this with a HEP-54 cleared up the trouble. Bias returned to normal, both channels ran cool with no signal.

Removing the new transistor, and comparing the two on the transistor tester showed that the beta of the original was considerably greater than that of the replacement. So, it was allowing too much "resting current" to flow and forward-biased the output transistor's base much too far. (Takes only a few tenths of a volt!)

Truetone DC-1046

The 2SB33 af driver transistor (Fig. 10) was out in one channel. The list of characteristics showed a pnp germanium, low voltage, so we picked a HEP-250 or RCA SK-3003. We were happy to find that the replacement lists agreed with us!

Original voltages	Replacements
E −0.2 V	E −0.2 V
B −1.0 V	B −1.0 V
C −1.5 V	C −1.5 V

Truetone DC-5925A86 AM radio

Figure 11 shows the original response curve, all the way through from the antenna, 1200 kHz swept 25 kHz. No change in curve, when original mixer and rf amplifier were replaced by SK-3018 RCA. HEP-54 same characteristics.

Truetone 4DC6963

This three-transistor (Fig. 7) phonograph amplifier uses a Darlington pair af amplifier driver. Note that it is *drawn*, and connected, exactly like a single transistor. Only a note in the parts list identifies it as a Darlington type!

A substitute Darlington was made up by twisting leads of a pair of HEP-53's, and this was connected in place of the 55-641 original. It worked. Output was normal, and distortion very low. Just for luck, a single HEP-53 was tried in the circuit; very low output, very high distortion resulted. Watch out for these: check the parts list, or test the original.

Truetone DC-1046 FM/AM radio

Original second i.f. transistor 2SA267, pnp germanium. Making the list, this showed a HEP-639 or SK-3006. Books confirmed this choice.

Original	HEP-53	SK-3006
E −0.3 V	E −0.2 V	E −0.2 V
B −0.6 V	B −0.5 V	B −0.5 V
C −6.0 V	C −6.0 V	C −6.0 V

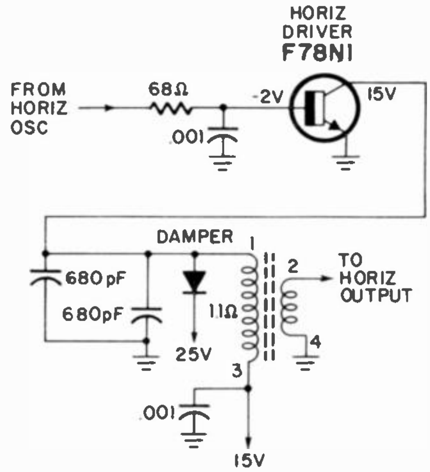


Fig. 12—HORIZONTAL DRIVER CIRCUIT. Many audio transistors are OK as replacements.

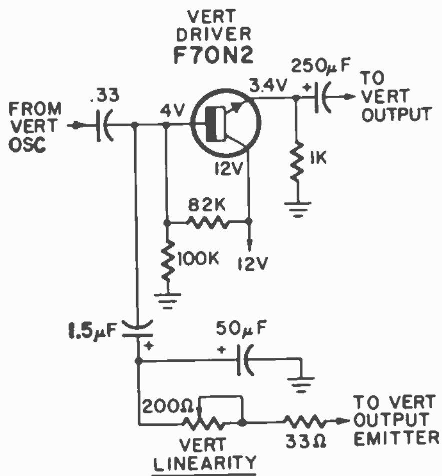


Fig. 13—VERTICAL DRIVER in Magnavox 908. Replacement transistors are plentiful.

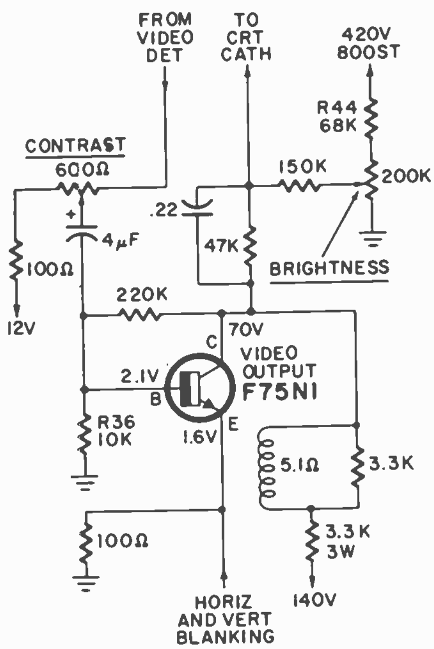


Fig. 14—VIDEO OUTPUTS have high voltages. Make sure replacement is adequate.

Zenith 8AT18X

FM converter. Original 921-56B, npn silicon.

Original	HEP-56	SK-3018
E + 0.6V	E + 0.6V	E + 0.6V
B + 1.35V	B + 1.35V	B + 1.35V
C + 13.0V	C + 13.0V	C + 13.0V

No change in sweep-output curve at 10.7 MHz: amplitude and curve shape same as normal. No change in dial frequency or calibration.

Zenith 8AT18X

FM rf amplifier. Original 921-55B, npn silicon.

Original	HEP-56	SK-3018
E + 0.3V	E + 0.3V	E + 0.3V
B + 0.7V	B + 0.7V	B + 0.7V
C + 17.5V	C + 16.5V	C + 16.0V

No change in output. Sensitivity good. Note: Rf and mixer transistors in FM must be reset exactly where original was, or you *will* detune the stage. Rf stages easy: can be realigned on air signal. Touch up rf trimmer capacitor.

Zenith 8AT18X

AM Converter. Original 921-57B, npn silicon.

Original	HEP-56	SK-3018
E + 1.65V	E + 1.6V	E + 1.6V
C + 11.0V	C + 11.0V	C + 11.0V
B + 2.5V	B + 2.2V	B + 2.2V

No change in performance or calibration.

Magnavox 908 b-w TV

Horizontal driver transistor F78N1 (Fig. 12). (Here, the "open holes" test was used.) Voltages were: E 0, B 0, C + 15 volts. This showed that the original was an npn. Making up the list, a HEP-54 was chosen, and the book agreed with us. SK-3020 also OK. In both vertical and horizontal sweeps, *audio* transistors are satisfactory; even 15,750 Hz is within the audio range. Both substitutes worked very well. Voltages checked with the schematic, and output were normal.

Magnavox 908

Original vertical driver is F70N2 silicon Npn medium-power audio transistor (Fig. 13) SK-3020 listed as replacement. OK. HEP-726 listed; since this was not in stock at the moment, a HEP-53 was substituted, from the characteristics chart. Worked nicely. All voltages returned to normal, vertical sweep good.

Magnavox 908

Original video output 75N1 (Fig. 14). On all video output transistors, watch out for high collector voltage. Some of the replacements given have too low breakdown. HEP-712 (200 volts) and SK-3040 or SK-3045, with 120- and 300-volt ratings, will do. All of these proved very satisfactory in use.

(NOTE: There are no replacements given for horizontal and vertical output transistors in this chassis. 63N1 and 64N1, respectively. From your list, see if a HEP-707 doesn't look as if it would work for either of them. It will! Also, SK-3021.)

For the 71N1 audio output transistor, SK-3045 has enough voltage rating (original has almost 100 volts on collector), and in the right case, TO-66. HEP-240 same characteristics.

Motorola TS-612A TV

Agc amplifier transistor (P1C) out. Pnp types HEP-716 and SK-3025 both work very well. Agc action very good, no problems in picture, etc.

While we had this set, we tried a HEP-716 and SK-3025 in the horizontal pulse-shaper stage, thinking that this would be a fairly critical application. Both of them worked beautifully. Trying our list, we also checked a HEP-52, with the right characteristics. This works also.

The sync-separator, another critical stage, uses an A1V transistor. HEP-50 and SK-3020 both gave perfect results; plenty of sync, no change in waveform, etc. Voltages the same.

In the agc keyer stage, an A2B transistor was replaced by HEP-53, HEP-736 (the one listed in the book) and SK-3024. All worked very well.

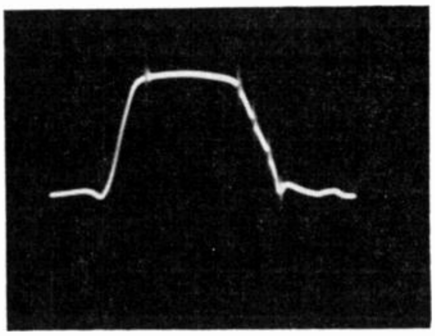


Fig. 15—RESPONSE CURVE with original first and second i.f. transistors in set.

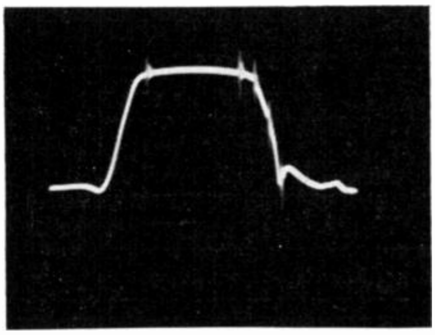


Fig. 16—RESPONSE CURVE unchanged when universal replacements were substituted in the first and second video i.f.'s.

No change in agc action or voltages.

The A2T video amplifier was checked for replacement with a HEP-50 and SK-3018. HEP-738 listed. All worked fine. No change in video waveform, sync, sound, etc. Be sure to make scope check for possible sync clipping.

Video output stage, A1S. Watch for high collector voltage again! SK-3040 recommended; works. HEP-706 listed. Both of these have ample voltage ratings. Performance perfect. Be sure to replace the heat-sink!

For the A3F horizontal oscillator, the SK-3024 works. Also a HEP-53. Normal sweep, high voltage and drive to output transistor.

A2Y first and second video i.f. transistors. Sweep generator fed to antenna input, scope connected to video detector, markers set up on curve, and spotted on scope screen with grease pencil.

Both i.f. transistors replaced; SK-3018 or HEP-734 work well. No change in i.f. response curve shape or amplitude. Picture and sound good.

Magnavox 936; hybrid color TV

Original 100N1 transistors in first and second video i.f. Curve set up on scope as before, but with 45.00-, 41.25-, 42.17-, 42.67- and 41.67-MHz (color bandpass) markers. Figure 15 shows the set's original i.f. curve, with the vital markers. Figure 16 shows the curve with SK-3018 transistors in both first and second video i.f. stages. No change was seen in the curve waveform, p-p amplitude or slopes. No change in dc voltage. Color picture was perfect.

The 100N1 transistor in the chroma amplifier was replaced by the SK-3018. All voltages were the same, p-p output (color bar pattern read with demodulator probe at output) of "comb" was the same. Color on the screen showed no tint shift, loss of saturation or definition.

The 73N1 chroma bandpass amplifier was replaced with a HEP-53 and the SK-3018 under the same test conditions. No dc voltage changes at all were seen. Waveform, p-p amplitude and screen color pattern were all normal. No tint shift or loss of saturation.

The 83P1 sync separator in the Magnavox 936 was replaced with a HEP-57. No change in dc voltages in sync output, p-p amplitude or waveform.

The agc amplifier in this set, a 79P1, was replaced with a HEP-716. There were very minor changes in the dc voltages, only a few hundredths of a volt, but the agc action was very

(continued on page 82)

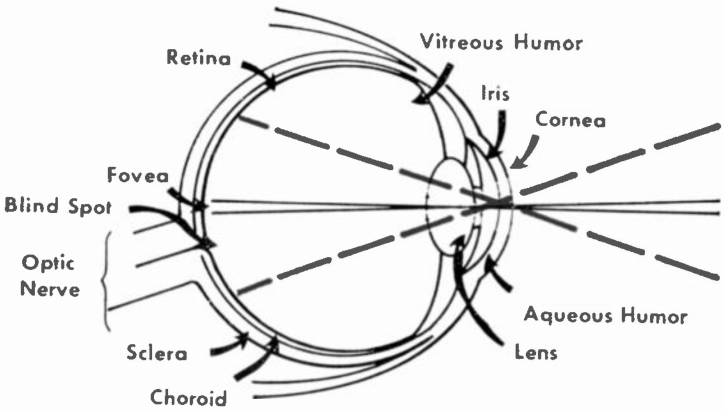


FIG. 11—THE EYE. A detailed drawing of all its elements.

THE LASER

by U.S. BUREAU OF RADIOLOGICAL HEALTH

Properties of laser light is the major subject area this month. Laser safety techniques and potential hazards are also detailed.

When we ended last month's section on the laser, we had just described how it can be used to destroy cancer cells. Unfortunately, like all good things, using the laser in this fashion also had disadvantages. Here are the two problems that must be faced when the laser is used medically for this purpose.

There are two problems with this treatment. First, the plume of debris from the laser impact contains viable cancer cells, posing a possible hazard to operating room personnel. Second, the impact drives some of the tumor cells deeper into uninfiltrated tissue, thus spreading the cancer. The first problem has been solved by placing a cone over the laser head which catches the plume from the impact. This cone may even be attached to a suction device for vacuum cleaner action. The second problem may be overcome by improved techniques. Two types of cancer treatment have been practiced. A low energy beam has been used to selectively disrupt tumor cells. Higher energy beams are used to excise nodules from deeper tissues.

Bloodless surgery: The possibility of bloodless surgery with a laser scalpel has led to many new surgical techniques. It facilitates surgical procedures on organs such as the liver and kidney where blood loss is a problem. High energy argon lasers should soon become a tool for liver operations, with concurrent use of plastic adhesives to complete closure.

Transillumination: This is a technique for projecting a strong light through soft tissues to aid in detecting tumors. The skin is relatively transparent to light. You can demonstrate this by placing your thumb over a flashlight. Lasers hold promise for this type of examination allowing, for example, an immediate examination for breast cancer without the potential hazard or wait associated with X-rays.

Neurosurgery: Another promising area for laser use. Precisely controlled cutting is extremely important and can be done with lasers. Transection and tumor treatment will benefit from the use of lasers, and bloodless tumor removal may be within reach. A number of operations may be done in the brain using the laser, thus lowering the possibility of infection.

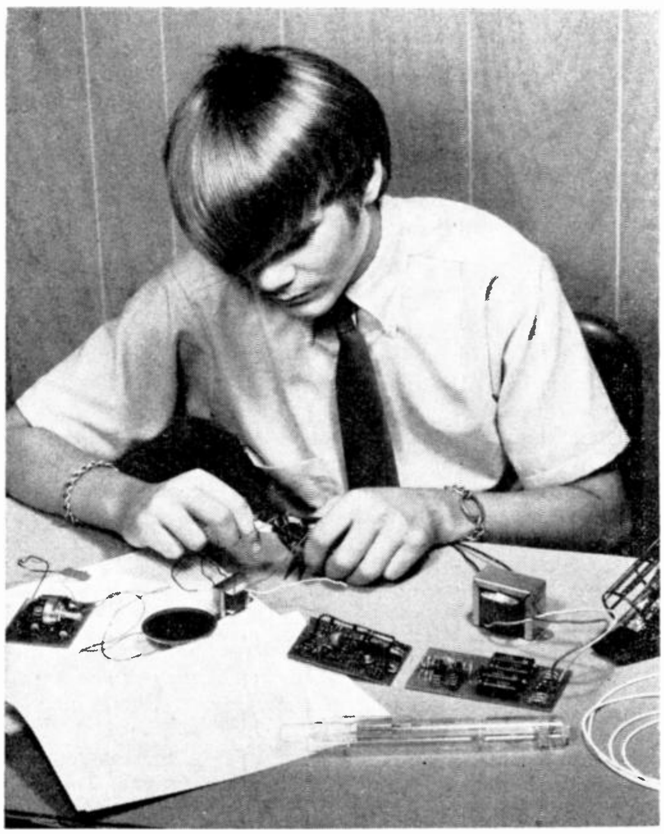
Dentistry: Some experimental work has already been done in the field of dentistry. Glazing teeth with a laser has been shown to reduce significantly the demineralization of enamel, and may also be effective against cavities. Dental cavities have been exposed to laser impact with favorable results. If cavities can be retarded or stopped by laser impact, dentistry will have gained a valuable tool.

Cell identification: A new method of instant and positive identification of micro-organisms and tissues is being produced commercially. The sample in question is cooled to a low temperature and irradiated with ultraviolet laser light. Under these circumstances the sample produces phosphorescent light whose frequency and decay time are unique for the organism. A small computer matches the frequency and decay time data with information previously stored and can identify instantly the presence of specific micro-organisms or tissues.

Laser safety for everyone

The U.S. Public Health Service has not, at the time this article was written, established radiation protection guides for laser irradiation. However, a number of private corporations, laboratories, and military and government groups have formulated internal standards for safe laser use. You can use these formulations to evaluate your own criteria for laser safety.

One note of warning. Most of the guides are compiled from work performed in determining the damage threshold for visible eye lesions. Because of the importance of these lesions to sight, the term "threshold" must be



GAS LASERS KITS are available for about $100. The one shown here is made by Metrologic Laboratories.

carefully scrutinized. Just what is the lowest level of biological change one should use as the criterion for damage? No general agreement now exists.

PROPERTIES OF LASER LIGHT

THE LIGHT OUTPUT OF A LASER DIFFERS FROM THE OUTPUT of ordinary light sources. Four properties characterize the laser's output: small divergence, monochromaticity, coherence, and high intensity. These four properties are what make the laser so valuable and account for the ever-lengthening list of laser applications.

When light emerges from the laser, it does not diverge (spread) very much at all. *Thus the energy is not greatly dissipated as the beam travels.* Laser beam divergence is measured in milliradians or 1×10^{-3} radians. There are 2π radians in a circle so one milliradian equals about 3 minutes of arc. A typical He-Ne laser has a rated divergence of 0.5 to 1.5 milliradians.

Laser light is very close to being monochromatic. The term "monochromatic" means one color, or one wavelength, of light. Actually, very few lasers produce only one wavelength of light. A typical He-Ne laser emits light at 632.8 nm, which is orange-red, and at 1,150 nm and 3,390 nm in the near and middle infrared regions. The He-Ne laser is usually designed to emit only one of these three wavelengths of light and the variation in this wavelength is slight.

Coherence is a term used to describe particular relationships between two wave forms. Two waves with the same frequency, phase, amplitude, and direction are called spatially coherent.

No source of perfectly spatial coherent light is known. However, laser light comes so close that for most practical purposes it can be considered perfectly coherent. Sophisticated equipment is necessary to detect the variation from perfect spatial coherence.

Laser light can be very intense. The sun emits about 7×10^3 W/cm²/Sr/μm at its surface. Lasers can deliver more than 1×10^{10} W/cm²/Sr/μm. (Sr = steradian) (A source of light that exceeds the sun in intensity is extremely hazardous to vision.)

The magnitude 1×10^{10} W/cm²/Sr/μm is somewhat misleading, for it represents only a single pulse of light. Energy is a measure of capacity for doing work and is usually classed as potential or kinetic energy. It is commonly measured in joules (J) in the metric system. Power is the rate at which work is being done and is measured in watts (W). The following relationships hold:

1 joule = 1 watt-second
1 watt = 1 joule/second

Thus, a laser that can emit 10 joules in one second is a 10-watt laser. If those same 10 joules are emitted as a single pulse of 1/100th second duration, then the laser is a 1,000-watt laser.

The output of pulsed lasers is usually indicated in terms of J/cm². The effect of the laser pulse is strongly dependent upon the amount of time it takes to deliver the pulse. Consequently, pulsed laser output is sometimes referred to in terms of $\frac{J/cm^2}{sec}$ or W/cm².

Biological effects of laser light

Laser light can damage living tissue. The extent of the damage depends primarily upon the frequency of the light, the power density of the beam, the exposure time, and the type of tissue struck by the beam.

Damage occurs in three ways: (1) a thermal effect; (2) acoustic transients; or (3) other phenomena. *The latter two effects only occur with high power density laser pulses.*

When laser light hits tissue, the absorbed energy produces heat. The resulting rapid rise in temperature can easily denature the protein material of tissue, much as an egg white coagulates when cooked. Since tissue is not homogenous, light absorption is not homogenous and the thermal stress is greatest around those portions of tissue that are the most efficient absorbers. Rapid and localized absorption produces high temperatures, steam, or results in explosive destruction of the absorber. Steam production, readily evident only at high exposure levels, can be quite dangerous if it occurs in an enclosed and completely filled area such as the cranial cavity or the eye.

A second interaction mechanism is an elastic or acoustic transient or pressure wave. As the light pulse strikes tissue, a portion of the energy is transduced to a mechanical compression wave (acoustic energy), and a sonic transient wave is built up. This sonic wave can rip and tear tissue and if near the surface, can send out a plume of debris from the impact.

Other phenomena such as free radical formation, are believed to exist during laser impact on biological systems, but have not yet been conclusively demonstrated.

The laser is usually a hazard to only those tissues through which the light beam can penetrate and which will absorb the wavelength involved. With potential hazard evaluation and safety in mind, the concern is primarily with the eye and the skin.

The eye hazard

Eye damage from light exposure has been recognized for over one hundred years. Retinal burns in rabbits were produced by using sunlight in the mid-1800's. In 1916, solar eclipse burns on the retina of observers were described.

The hazard to the human eye posed by the use of lasers is obvious. A source of light energy that exceeds the sun in irradiance must surely be considered as a hazard to the eye. To better understand this, let's look at the anatomy of the eye. Its cross-section is illustrated in Fig. 11.

The outer surface of the eye is a tough white tissue called the sclera. The anterior portion of the sclera is specialized into the cornea which is transparent to light. The cornea is the major focusing device of the eye.

Inside the eye are two fluid-filled cavities. Both are under pressure to give structural rigidity to the eye. The anterior chamber contains a slightly viscous liquid, the aqueous humor. The rear chamber is filled with a very viscous, collagenous suspension, the vitreous humor.

Separating the two chambers is the lens. It is attached by ciliary muscles to the sclera. These muscles alter the lens' shape for fine focusing of the incoming light beam. Overlying the lens is the pigmented iris, a muscular structure designed to expand or contract to regulate the amount of light entering the eye.

Lining the rear fluid filled chamber is the retina which contains the sensory cells for light perception. The retina itself is composed of tissue of two origins. The retinal tissue which the light encounters first is of neuro-ectodermal origin (about 150 μm thick) and contains the nerve cells for light perception. The underlying tissue is the pigment epithelium (about 10 μm thick) and contains great numbers of melanin granules. It stops light reflection, absorbs any scattered light, and supports the photoreceptor cells.

It is one of nature's quirks that light, before reaching the light sensor cells in the primate eye, must first pass through several membranes, nerve fibres, ganglion cells, bipolar cells and amacrone cells, and then must strike the photoreceptor cells from the rear.

The retina's photoreceptor cells are of two types: rod and cones. Rods are quite sensitive to low light levels but cannot distinguish color. Cones are not as light sensitive but can distinguish color. The two types are intermixed in the retina with cones dominating near the center of the retina and rods near the periphery.

At the focal spot of the cornea-lens system lies the macula, an area of cones only. Within the macula is the fovea, a small region perhaps 250 to 300 μm across, in which the cones are densely packed. This is the center for clear or critical vision. To one side of the macula is a blind spot at which point the nerve fibres from the photoreceptors exit the eye to form the optic nerve. The retina subtends, in cross section, a visual angle of about 240°. It is loosely bound by connective tissue to the muscular choroid, which in turn is firmly attached to the sclera.

Light is focused by the *cornea and lens* onto the fovea of the retina. In this process, the energy density of the light is concentrated by a factor of 10^4 to 10^6 over that falling on the pupil. This is why laser light can be a serious hazard to the eye.

The human eye is relatively transparent to light between about 400 to 1400 nm. This includes not only the visible range of 400 to 700 nm, but also a portion of the infrared which is not perceived. Fig. 12 is a curve of optical transmission of light through the ocular media for both human and rabbit. As you can see, the greatest transmission occurs in the visible range.

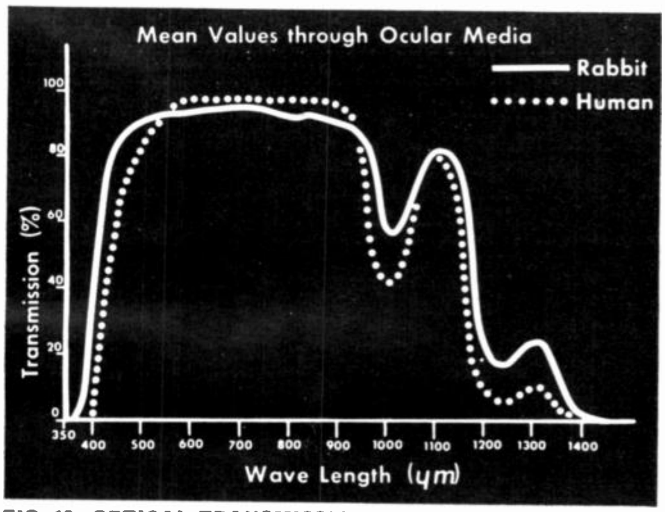


FIG. 12—OPTICAL TRANSMISSION OF LIGHT through the eye. Note that response is greatest in the visible light area.

The portion of the eye affected by the laser depends upon the wavelength of the light. The ruby laser, for example, emits at 694.3 nm. From the transmission curve, you can see that more than 90% of the light is transmitted through the ocular media to the retina. Of the light reaching the retina, about 60% is absorbed in the neuro-ectodermal coat. Almost all of the rest of the light, 40%, is absorbed in the pigment epithelium. Since the pigment epithelium is only 10 μm thick, the greatest absorption per unit volume of energy occurs here, and this layer is the most susceptible to damage. Lesions can be produced here without the receptor cells being damaged. Helium-neon, krypton, argon, and xenon lasers all operate in the visible range, and all affect the eye in a manner similar to the ruby laser.

Neodymium laser light at 1060 nm is absorbed to a greater extent in the ocular media and less of its energy reaches the retina than visible light. Thus there is a greater chance of damage by steam production than from other lasers. The aqueous and vitreous bodies are colloidal suspensions in water, and the absorption characteristics of the media are similar to those of water.

Carbon dioxide lasers produce light at 10,600 nm. The eye is not very transparent to this frequency range and danger at low power densities comes from lesions produced on the cornea.

Research on eye damage has been under way for some time. The search for laser effects began shortly after the invention of the laser and is continuing. Most of the work has been aimed at determining the minimum amount of irradiation that can cause a visibly detectable retinal lesion from an acute exposure. Current studies have been conducted with monkey, rabbit, and human eyes. The latter were eyes with some medical problems.

In truth, power density *at the retina* cannot be measured but must be calculated on the basis of transmission and focusing of the beam. The power density which can be measured is that *on the cornea*. Measuring at the cornea, lesions can be caused by as little as 10^{-6} J/cm² from a pulsed ruby laser.

At present, threshold values for visible lesion production are approximately:

Q-switched ruby laser	@ 0.07 J/cm² on the retina
Pulsed ruby laser	@ 0.8 J/CM² on the retina
Continuous white light	@ 6.0 W/cm² on the retina
CO_2 laser	@ 0.2 W/cm² at the cornea

Light levels below those producing visible lesions can also produce some permanent damage such as partial "bleaching" of the pigment for one particular light color. Work is now under way to detect such damage by histochemical means as well as by electroretinography.

Damage can result from laser impact on numerous eye structures. (See Fig. 13.) Oblique beam entrance can cause a lesion in the retina which goes unnoticed. A hit upon the optic nerve could result in complete destruction of vision. The iris is dark colored and quite susceptible, while the whole sclera can fall victim to high energy beams.

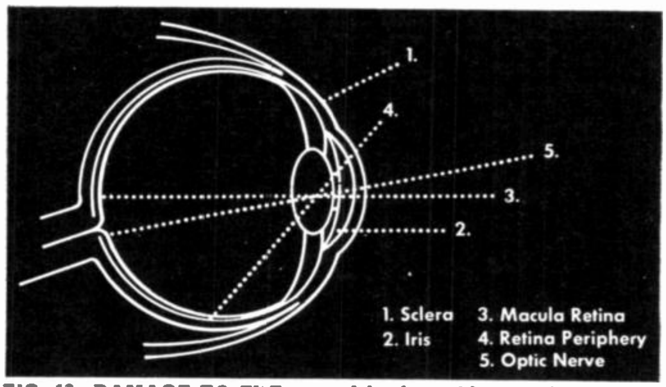


FIG. 13—DAMAGE TO EYE caused by laser hits can fall in any of the five areas shown in this illustration.

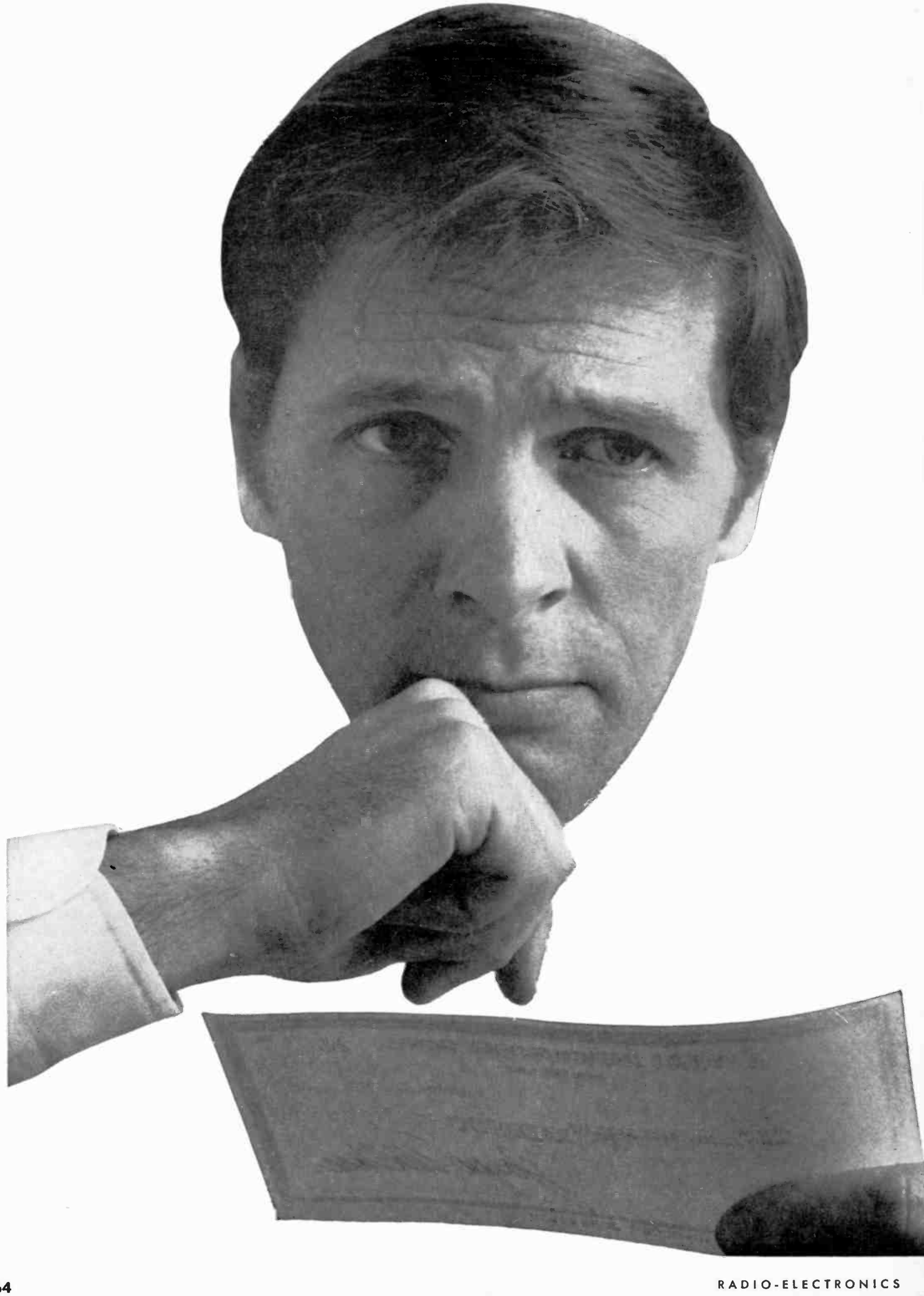
A special mention must be made of the CO_2 laser, whose infrared emission can destroy the cornea. Corneal opacities are produced at a level of 0.2 W/cm² for 30 minutes continuous irradiation. This is a rather high intensity as compared with other threshold levels, but CO_2 lasers produce very intense beams and users are quite likely to encounter CO_2 lasers with continuous kilowatt outputs.

Maximum permissible exposure levels are calculated on a "Worst Case" analysis of the hazard. The laser beam is assumed to be aimed directly at the fovea, the iris is dilated to produce a large pupil diameter, and the eye is focused at infinity. These circumstances produce maximum irradiation of the retina. *(continued next month)*

FRAZER AND HIS LASER

A lazy researcher named Frazer
decided to shave with a laser;
using too many joules
shot his chin full of houles,
so he's back to his old-fashioned razor.

Jack Darr



BUILD

FM stereo adapter

No coils or transformers are needed for this add on. That means no tricky alignment is required. Add it to your FM radio

by LEONARD D'AIRO

AS TRANSMITTED BY AN FM BROADCAST station, a stereo multiplex signal consists of an upper channel containing the so-called left minus right information, a lower channel containing left plus right information, and a 19-kHz pilot carrier. It is the 19-kHz signal that is multiplied to 38 kHz in the stereo multiplex adapter and used to separate the composite multiplex signal into its left and right components.

Conventional multiplex adapters use tuned transformers to generate the 38-kHz signal, but in the transformerless version described here the tuned transformers are replaced by simple R-C type notch filters. The advantage of using these filters is simplified alignment by eliminating the need for a stereo multiplex generator, and no special components are required, thereby reducing overall cost.

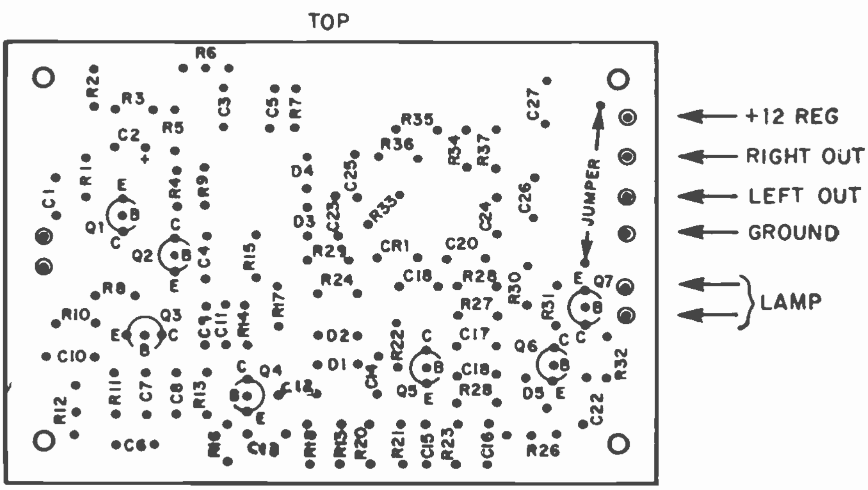
The notch filter has a very sharp reject capability (Fig. 1) and can be tuned over a limited range by an inexpensive potentiometer. When used in the feedback leg of a high-gain amplifier stage, it will cause the stage to act as a narrow bandpass filter (Fig. 2). This characteristic occurs when the signal frequency is the same as the notch frequency of the filter. At this point the series resistance of the filter approaches infinity, the signal fed back to the base from the collector is reduced to almost zero and the output signal approaches maximum. At frequencies other than the notch frequency, the series resistance of the filter is low, the signal fed back is large, and amplifier gain is reduced. Thus we have in effect a tuned amplifier stage without the use of inductances.

Multiplex adapter design

The major problem is designing any stereo multiplex adapter is to generate a clean and stable 38-kHz signal that is in the proper phase relationship with the 19-kHz signal that is transmitted by the broadcast station. Unless this is done, separation of the composite signal into its left and right components will not occur and a monophonic output will result.

The required conditions are met by this transformerless version. The 19-kHz signal is amplified, filtered, doubled, amplified again, and then applied to the demodulator matrix in proper phase.

PARTS LAYOUT AND PATTERN FOR PRINTED CIRCUIT. Both drawings are full-size. Note the two large holes near the center of left edge on the layout drawing. The upper one is the input and the lower is ground. On foil pattern, the left edge (as shown) corresponds to the top in the parts layout. Circuit board, G-10, drilled is available as part RE371B for $4.50. All semiconductors for this unit as part RE371T $4.75. Complete kit of all parts and board $19.50. Order from Photolume Corp., 118 E. 28th St., New York, N.Y. 10016.



Examining the schematic diagram (Fig. 3), the composite multiplex signal from the FM tuner is passed through a broadband, high-gain amplifier (Q1, Q2). This amplifier has an input resistance of about 100,000 ohms so as not to overload the FM detector output. Amplifier gain is high so it will operate with only a 5-mV signal. This makes it compatible to use with low output solid-state tuners. When used with high-output tuners, such as the vacuum-tube types, it is necessary to insert a 500,000-ohm potentiometer between the tuner and adapter to reduce the tuner output level to an operating level where overdrive and its resulting distortion will not occur.

After amplification, the signal is passed through a 19-kHz bandpass filter stage which amplifies only the 19-kHz signal. This is done with a notch filter and transistor (Q3).

The 19-kHz signal is then passed through a phase-splitter (Q4) and doubled to 38 kHz by diodes D1 and D2 in a push-push doubler circuit. The resulting 38-kHz signal is then amplified by the 38-kHz bandpass amplifier (Q5), producing a clean, stable signal that is in the proper phase relationship with the transmitted signal.

Now that the 38-kHz signal has been generated, the next step is to apply it to the stereo demodulator matrix along with the upper and lower channel information so it can be processed and separated into left and right channels. This is done by splitting off the upper channel information (through C5), combining it with the 38-kHz signal, and applying it to the diodes (D3, D4) of the demodulator matrix.

At this point, with just the upper channel information applied to the matrix, the output of the adapter contains only the left minus right information. If connected to a stereo amplifier system a monaural output on a stereo signal would result with no output on a monaural signal.

To get stereo output on a stereo signal from the matrix, the lower channel information must also be applied. This is done by resistive sum-

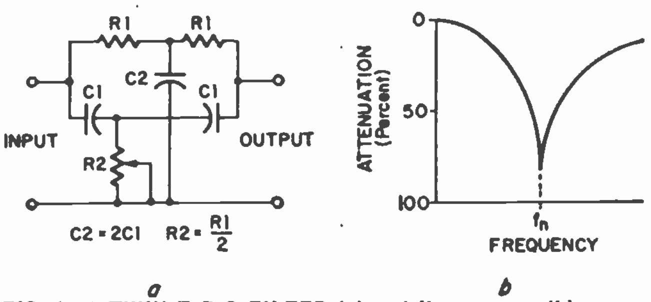


FIG. 1—A TWIN-T R-C FILTER (a) and its response (b).

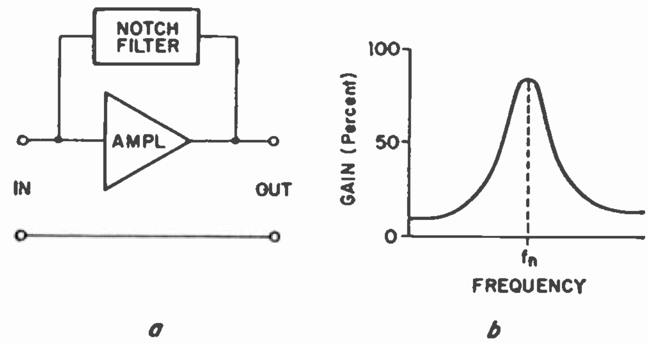


FIG. 2 (right)—FEEDBACK loop (a) provides bandpass curve (b).

All resistors ½-watt 10% unless noted
R1, R22—33,000 ohms
R2—390,000 ohms
R3, R8, Q25 R35—22,000 ohms
R4, R10, R23, R28—1000 ohms
R5—27 ohms
R6—potentiometer, 50,000 ohms, subminiature Lafayette 99T6145 or equal)
R7, R29, R30—10,000 ohms
R9—220,000 ohms
R11, R13, R21—5600 ohms
R12—potentiometer, 5000 ohms, subminiature (Lafayette 99T6145 or equal)
R14—470,000 ohms
R15, R16, R17, R18, R19, R24, R25, R27—4700 ohms
R26—potentiometer, 1000 ohms, subminiature (Lafayette 99T6142 or equal)
R31—2700 ohms
R32—100 ohms
R33, R36—68,000 ohms
R34, R37—47,000 ohms
All capacitors miniature ceramic disc, 50 WVdc, 20% unless noted
C1—.05 μF
C2—30 μF, 12V, submin electrolytic
C3, C22—10 μF, 12V, submin electrolytic
C4, C5—470 pF
C6—.003 μF
C7, C8—.0015 μF
C9, C11, C19, C20, C21—.01 μF
C10, C15—0.1 μF
C12, C13, C26, C23, C24, C25—.001 μF
C14—330 pF
C16—.004 μF (two .002 μF in parallel)
C17, C18—.002 μF
C27—100 μF, 15V, submin electrolytic
Q1, Q7—MPS3702 or equal
Q2, Q3, Q4, Q5, Q6—MPS3393 or equal
D1, D2, D3, D4, D5—1N60
LM1—miniature pilot lamp: 6V, 60 mA (Lafayette 99T6262 or equal)

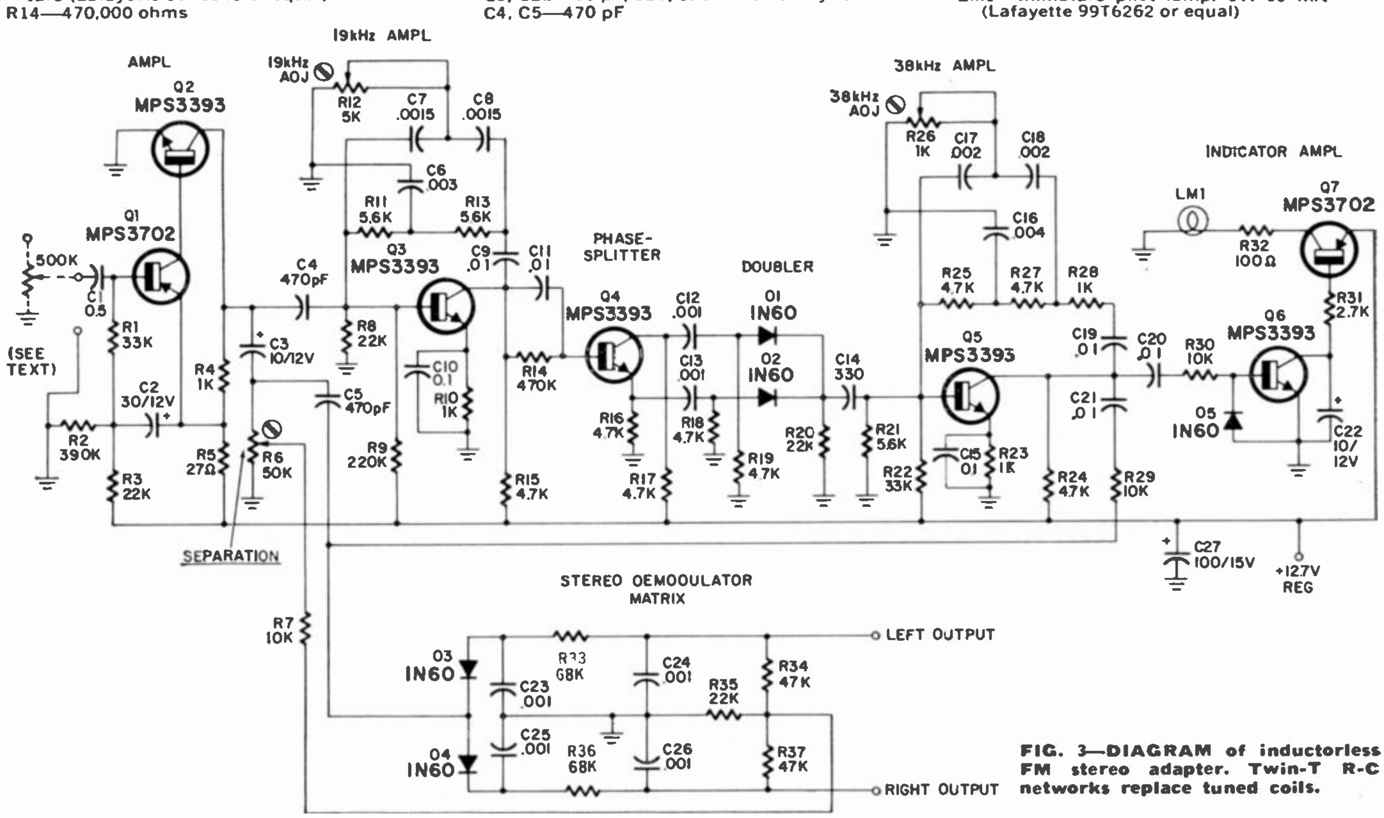


FIG. 3—DIAGRAM of inductorless FM stereo adapter. Twin-T R-C networks replace tuned coils.

ming of the lower channel information into the two legs of the matrix. When the amplitude levels of both channels of information are the same, then maximum stereo separation occurs. Matching amplitude levels is done via the separation control, R6.

An indicator lamp (LM1) is used to show when the multiplex adapter is operating. This lamp, connected in series with current limiter resistor R32 to Q7's collector, lights only when a 38-kHz signal is at the collector of Q5. The signal is detected by diode D5, amplified by Q6, and applied to Q7. The sensitivity of Q6 is such that the lamp will light to full brilliance only when the 38-kHz signal is strong enough to operate the demodulator matrix.

Proper adapter operation will produce a stereo separation of at least 30 dB from 50 Hz to 15 kHz, and 40 dB from 100 Hz to 10 kHz. Power requirements are approximately 8 mA at 12 volts, increasing by 60 mA when the indicator lamp is lit. A regulated power supply, such as shown in Fig. 4, should be used for optimum performance.

Construction and test

The adapter was built onto a 2½" X 3½" printed circuit board. Any method of construction suitable to the reader can be used. The only restriction is to be careful when wiring and keep lead lengths to a minimum.

Whether using a printed circuit board or any other method of construction, a simple and mistake-proof assembly method is to wire and test one circuit at a time.

The broadband amplifier is assembled first, making sure that the correct components are placed in their proper places. Upon completion, connect a scope to the collector of Q2, and apply a 5 mV, 19-kHz signal to the input. Watch the waveform on the scope to make sure no clipping or other distortion is present.

When operation of the amplifier is satisfactory, wire the 19-kHz bandpass amplifier. Connect the scope to the collector lead of this stage and apply voltage. With the 19-kHz signal still applied to the input amplifier, adjust R12 for maximum output. If the waveform is clipped or otherwise distorted, reduce the input level to the input amplifier, and again adjust R12 for a peak in output. If distortion still persists, or if R12 will not cause a peak, replace Q3 with another transistor or transistors to clear up the problem. Although the adapter was designed to accept and use almost any silicon transistor in the 50 to 200 beta range, it is still possible for a given type not to function properly in the circuit. In this case transistor replacement is the only remedy.

The next stage(s) wired is the phase-splitter (Q4) and frequency doubler. Connect the scope to the output side of the diode doubler. The waveform at this point will be slightly distorted due to diode unbalance, but the waveform amplitude should be constant. The frequency of the waveform should also be twice that applied to the base of Q4. That is, if four cycles appear at the base of Q4, then eight cycles should appear at the output of the diode doubler. If not, either replace the diodes or further reduce the input to the high gain stage.

Once the previous stages are operating satisfactory, wire up the 38-kHz stage next. Operation and test of this stage is the same as that of the 19-kHz stage, except for frequency. Any troubles encountered are to be corrected in the same manner as that previously described for the 19-kHz amplifier.

The indicator lamp is wired and tested next. The only precaution is to twist the leads for the lamp together to prevent the possibility of any 38-kHz signal feedback to the input which would cause a high noise level in the output.

Finally, the demodulator matrix is wired. Make sure the diodes are wired correctly. Testing the matrix is done with an "on the air" signal.

Alignment and operation

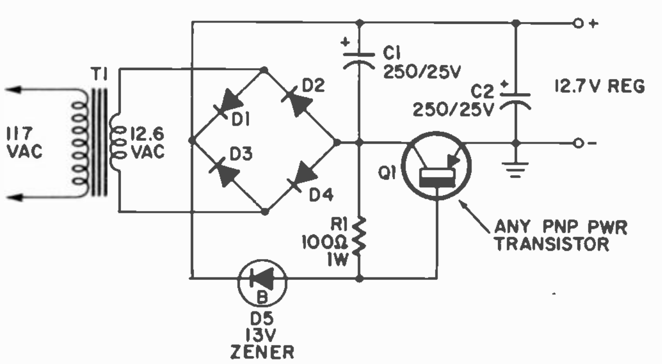
When the adapter is complete, connect the adapter input to the detector output of an FM tuner (ahead of the de-emphasis network) using the 500,000-ohm potentiometer mentioned earlier if necessary. The connecting cable should be short, preferably 18 inches or less. This avoids high cable capacitance that could attenuate the high frequency components of the multiplex signal. Tune to a station that is broadcasting stereo.

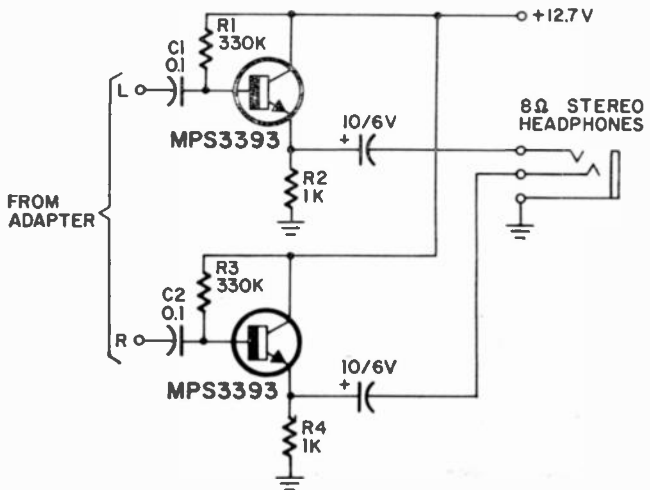
Connect an oscilloscope to the collector of Q3, apply voltage, and adjust R12 for maximum output. If you have trouble, reduce the input level to the adapter with the potentiometer. Next connect the oscilloscope to the collector of Q5 and adjust R26 for maximum output, adjusting the input level to the adapter as required. Make sure the waveform at this point has twice the amplitude as that observed at Q3. During this portion of the alignment, the stereo indicator lamp should light whenever R26 is adjusted for maximum output. The lamp should go out whenever the tuner is detuned from a stereo signal.

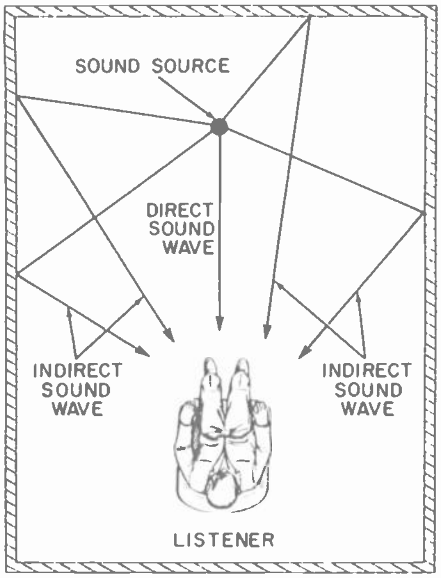
After alignment is complete, connect the left and right adapter output leads to a stereo amplifier system. Adjust the separation control, R6, for maximum separation. If separation does not occur, or is poor, then either the diodes are defective or backwards.

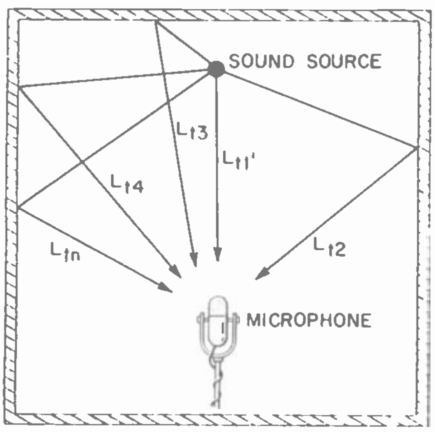
In field tests of this multiplex adapter, the FM detector output of a pocket portable FM receiver was used to provide the multiplex signal. The left and right output were connected to emitter-follower stages, the outputs of which were connected to miniature earphones of the type usually supplied with portable sets. Performance was excellent. Power for the adapter was supplied by 8 penlite cells. Fig. 5 shows the arrangement of this setup. **R-E**

FIG. 4—SIMPLE REGULATED POWER SUPPLY for the adapter operates from a 12-volt filament transformer and fullwave bridge. FIG. 5 (right)—AUDIO AMPLIFIER for stereo phones.









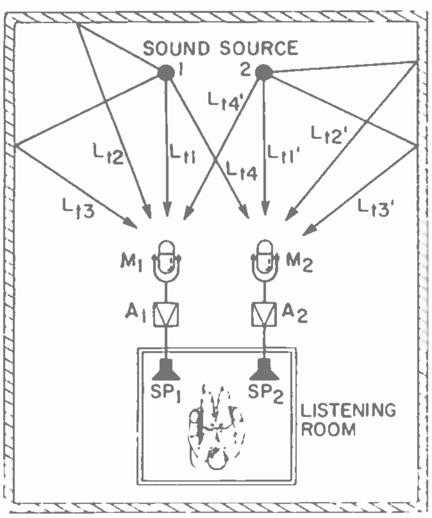
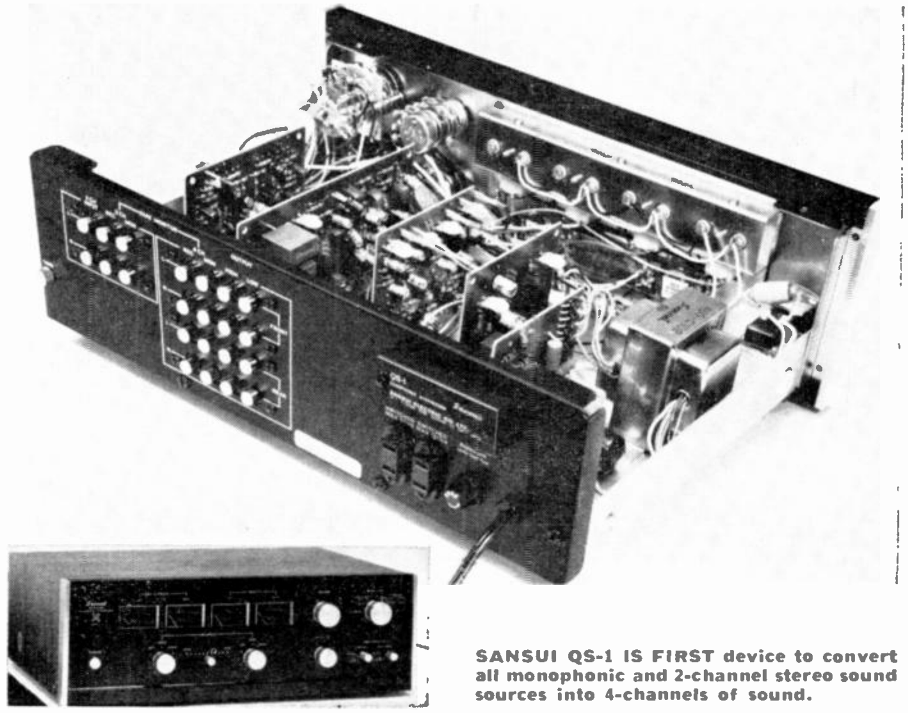


FIG. 1—(top) IN LIVE SOUND FIELD there are an infinite number of direct and indirect sound waves reaching the listener.

FIG. 2—(center) SINGLE MIKE records all sound waves that reach it. Unfortunately this eliminates presence.

FIG. 3—(bottom) FOR 2-CHANNEL STEREO a pair of microphones are used to pick up the sound field for recording.



SANSUI QS-1 IS FIRST device to convert all monophonic and 2-channel stereo sound sources into 4-channels of sound.

4-Channel Stereo Synthesizer

Get four-channel sound now. New device converts all existing program material into room-filling four-channels

by CHESTER H. LAWRENCE

AS ALL OF US HAVE LEARNED OVER the past several years, two channels of sound are better than one. And as I've been hearing in the past several months, four channels are better than two.

In a live sound field such as a concert hall, an infinite number of direct and indirect sound waves combine to create a feeling of presence (Fig. 1). The human ear feels this sound field by detecting the relative phase differences and time delays of these sound waves arriving from numerous directions.

If a single microphone is placed in such a sound field, it simply converts all these sound waves with their individual phase differences, into a single sum signal (Fig. 2). While this sum signal can be used to reproduce the sound of music, it cannot possibly reproduce the original sound field.

For 2-channel stereo, a pair of microphones are used to pick up the sound field (Fig. 3). In this way the numerous sound waves in the live sound field are converted into two sum signals which transmit far more information than the single sum signal of the monophonic system. But they still fail to reproduce the full effect of the original sound field.

In a 4-channel recording four microphones are used to pick up the sound waves, and four playback channels are used. The result is sound that is even more real than conventional 2-channel stereo. Even this falls short of the ideal arrangement (Fig. 4) where an infinite number (n) of microphones are used. So while the more channels we record, the truer the reproduced music, 4-channels is the maximum number of practical sound information bearing channels that can

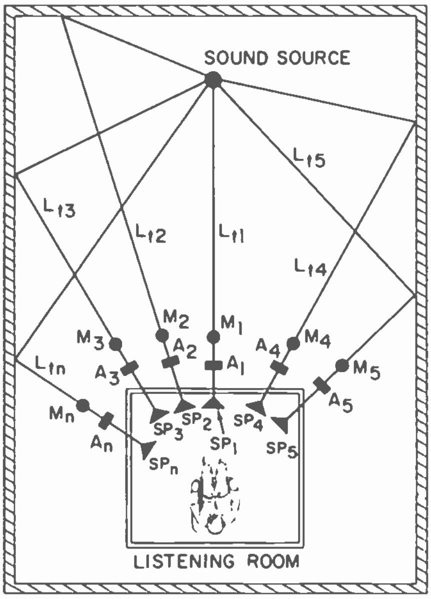


FIG. 4—IDEAL SYSTEM uses an infinite number of mikes to record and an infinite number of playback channels.

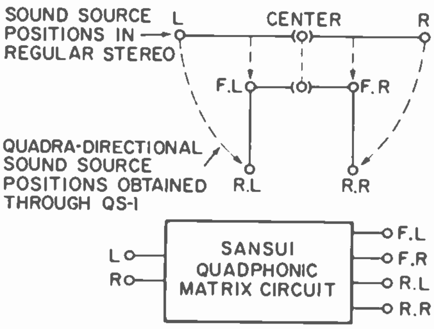


FIG. 5—MATRIX CIRCUIT rearranges sound on playback to create the type of room-filling effect shown here.

be recorded and reproduced at this time. And as the more channels you have the more real the sound is, 4-channels are better than two for re-creating the atmosphere of the original live performance.

As we have seen, 4-channels are better, but they are also a problem—what do we play through them. Existing material for 4-channel reproduction is available but quite sparse. There are 4-channel reel-to-reel tapes and RCA's new 4-channel tape cartridges, but that is about it. Sure, there's experimental FM broadcasts today and 4-channel records just over

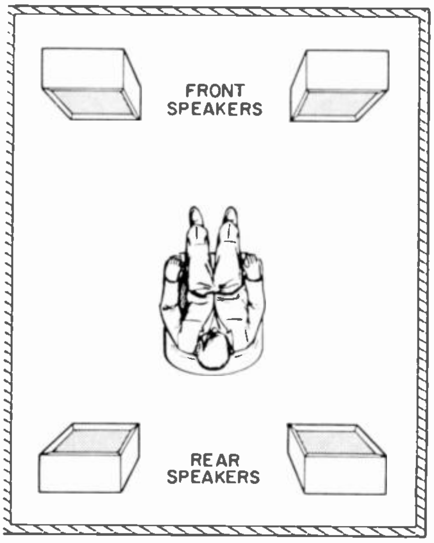


FIG. 6—LISTEN TO 4-CHANNEL playback with four speaker systems situated in the corners of the listening area.

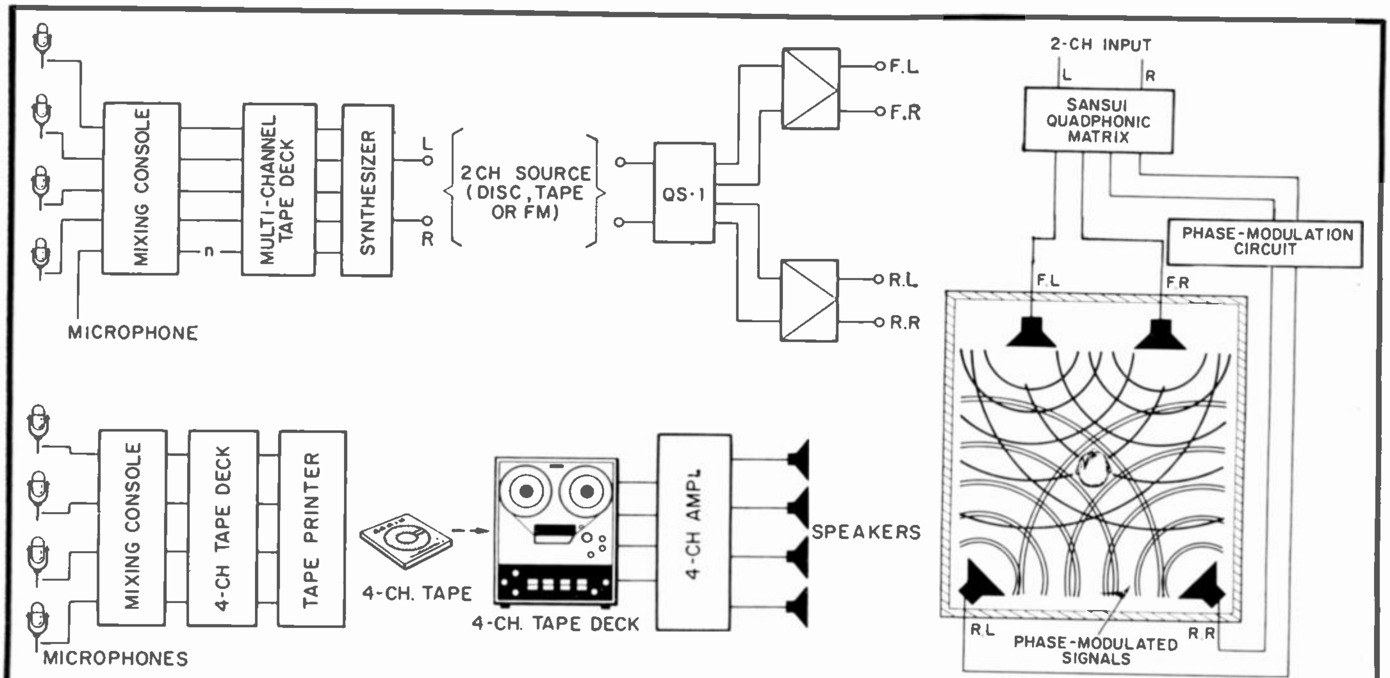
the horizon, but they are not here in real numbers today.

Fortunately, there is equipment available that will turn existing two-channel stereo sources—tape, disc, FM or whatever, into 4-channel sound. The newest piece of equipment to do this is the Sansui QS1 Quadraphonic Synthesizer.

You simply feed your two-channels input into the unit and take out four. But what happens in between isn't this simple. Inside the QS1 is a patented reproducing matrix that analyzes and synthesises four separate direct and indirect sound component-channels from standard 2-channel stereo signals. Through this process the unit re-organizes the left and right stereo channels into a comprehensive sound field comprised of four sound sources, front left and right; and rear, left and right (see Fig. 5).

Using this system any musical instruments or voices located at the left end of the stage when recording are heard near the rear left corner; any sound sources located slightly to the right of those just mentioned are heard near the front left corner; sound sources in the center of the stage remain there; sound sources located to the right of center are heard near the front right corner; and finally, any sound sources heard near the front right corner would be heard near the right rear corner.

No mechanical echo or delaying devices are included. They are not



Here's how the Sansui QS-1 system operates. At the top left you can see how the synthesizer is used with a 4-channel recording setup to combine 4-channels of input sound into a conventional 2-channel recording (tape, disc or FM). Then playback is through the synthesizer and on to 4 playback channels. At the bottom left is a setup for conventional 4-channel recording and playback. Unfortunately, this is currently restricted to tape as this is the only available 4-channel source right now. At the far right you can see how the 2-channel inputs are fed through the synthesizer, which includes the phase modulation circuit, and then on to the speakers. The field inside the listening room is also illustrated.

needed since most (but not all) 2-channel recordings already contain enough echo components, so that when they are matrixed by the QS1 into 4-channels they fill the room with a natural performance atmosphere. These echo components are usually stored in opposite channels (the echoes of the right channel sounds are recorded in the left channel and vice versa).

A live sound field comprises an almost infinite number of sound waves with their individual phase differences. While the QS1 matrix does create a 4-channel effect, the total amount of information transmitted is much smaller than that in a live program. To correct for this and expand the information, the indirect sound components separated by the reproducing matrix are phase-modulated before being fed to the rear speaker systems. As a result, when they rejoin the untreated direct sound components from the front speakers, they create an enhanced atmosphere. This phase modulation effect takes advantage of a well-known phenomena.

When two speakers are connected in phase, the reproduced sound they deliver is located at a point between them. However, if you connect these same speaker systems out-of-phase, they fail to produce a clear sound image. Phase modulating the signals of either speaker system (even if the pair is connected out-of-phase) produces the same effect as several speaker systems placed between the two speakers—a living wall of sound.

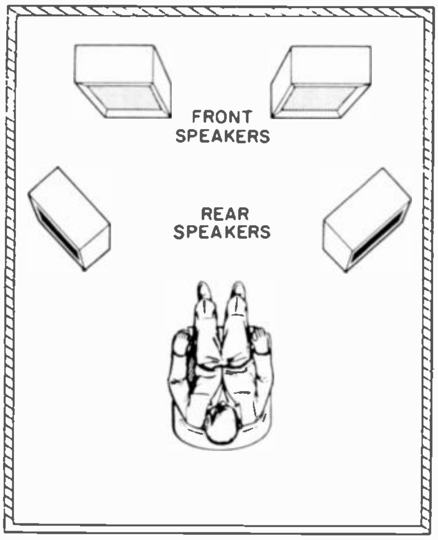


FIG. 7—SPEAKER POSITIONS can be varied to conform with this arrangement for some types of music reproduction.

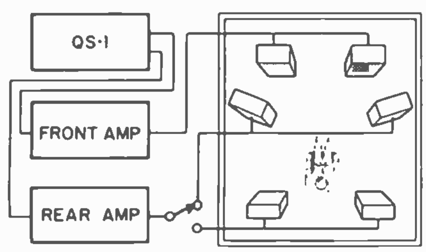


FIG. 8—SIX SPEAKER SYSTEMS and a switch provide a combination of speaker arrangements shown in Fig. 6 and Fig. 7.

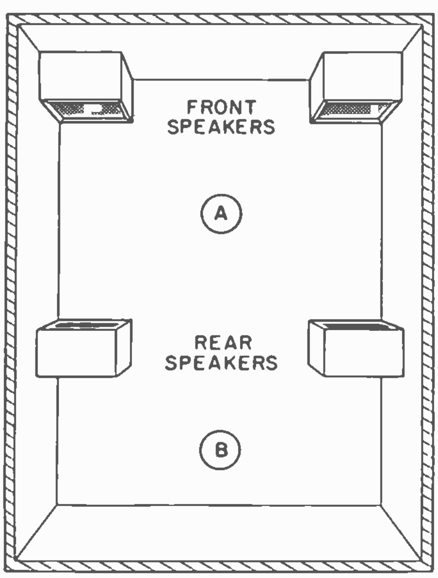


FIG. 9—DUPLICATE EFFECT of speaker arrangement in Fig. 8, but use only four speaker systems.

Positioning speaker systems

There are two ways to position speaker systems with the QS1 for the best possible sound. The method shown in Fig. 6 can be called a *2-2 system*. Here the four speakers are located in the four corners of the room and face each other. It's great for mood music, 4-channel ping-pong, and popular vocals.

The second basic system is in Fig. 7. This is called the *front 2-2 system*. Here all four speakers are located in front of the listener. This approach is excellent for reproducing concerts, operas, chamber music and big-band jazz.

For actual use the ideal setup would use six separate speakers connected as in Fig. 8. Here, simply throwing a simple switch converts the listening system from a standard *2-2* to a *front 2-2*, which lets the listener easily determine the arrangement that produces the best possible 4-channel effect.

Another commonly used setup is in Fig. 9. This time the speakers in the rear of the room are moved forward. When the listener sits at point A he is in the middle of a *2-2* system. If he moves to position B he is listening to a *front 2-2* system and has avoided the expense of two extra speaker systems as used in the "ideal" system.

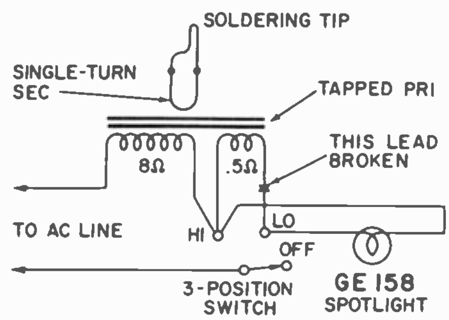
We hope you will try some of these speaker setups with your 4-channel setup. If you do, drop us a line, tell us what you have tried and what you think of the results. We'll pass the word to other readers. **R-E**

SERVICE NOTES

GUN TROUBLE

I own a Weller model 8200-N, dual-heat soldering gun. One day, during use, the spotlight burned out. I found that even larger radio supply houses do not stock this item (G-E No. 158), and finally located a pair of them in a large electrical supply house. In the meantime, I had continued to use the gun but found that it was effective only on high-heat. I presumed the switch had broken down. It has 3 positions: OFF, LOW-HEAT and HIGH-HEAT.

I inserted a new lamp, but it burned out instantly when I pressed the switch to the LOW-HEAT position. It appeared that the lamp may have



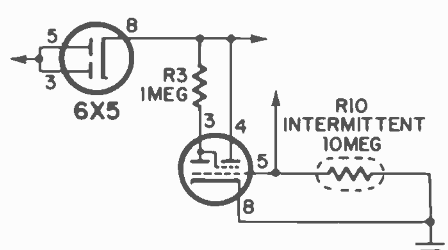
been defective, so I plugged in my last one. Again, a bright flash! That did it!

I took the gun apart and discovered a broken lead. See diagrams. Note how this break prevented a low-heat connection (without the lamp), and also caused instant burnout of a good lamp. The lead that broke is very short (perhaps accounting for the break) so I extended it about one-half an inch with additional wire before resoldering it to terminal.

If you run into the same problem, investigate before you plug in a new lamp. They are difficult to find, and they cost about 25¢ apiece!—*I. Queen*

EICO 950B R-C BRIDGE

The shadow on the 1629 electron-ray indicator became intermittent, making accurate measurements difficult. The trouble was traced

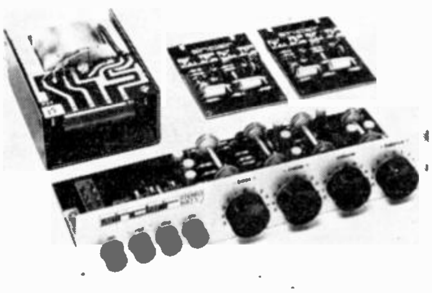


to resistor R10, a 10-megohm resistor in the grid return of the 1629. A replacement restored normal operation.—*Pierre Cappaert* **R-E**

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 on page 101 and circle the numbers of the new products on which you would like further information. Detach and mail the postage-paid card.

STEREO AMPLIFIER, *Project 60*, consists of a stereo preamplifier/control unit, choice of two audio amplifier modules, three power supply modules, optional filter module. *Project 60* group utilize silicon epitaxial transistors throughout.



Wideband response, ultra low distortion, low cost are key factors. Items may be purchased separately. *Project 60* complete with 2 *Z-30's*, one *Stereo 60*, one *PZ-6*, $84.95.—**Audionics, Inc.**, 9701 S.E. Mill, Portland, Ore. 97216.

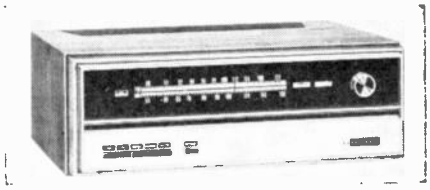
Circle 31 on reader service card

AEROSOL DEGREASER, LUBRICANT, COOLER. Several aerosol can spray products include: *Tuner Cleaner*, which dissolves and flushes away foreign material to restore tuner contacts, clean switches and relays. 24 oz. cans. $3.25. *Tape Head Cleaner* removes dirt, film and tape oxide. 6 oz. cans. *Chroma Foam*

is a TV tuner cleaner and lubricant which removes built-up grease, dirt and corrosion. After spray dries protective lubricant remains. 8 oz. and 16 oz. cans. *50° Below*, cools components to —50° F. Use to troubleshoot intermittents. 15 oz. cans.—**Channel Master**, Ellenville, N.Y. 12429.

Circle 32 on reader service card

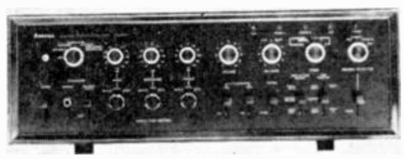
TUNER AND AMPLIFIER, *models AJ-29* and *AA-29*, are separate component versions of Heathkit's Stereo Receiver *AR-29*. The amplifier, *AA-29*, delivers 50 watts IHF per channel at 8 ohms, 35 watts rms per channel. Harmonic & IM distortion is below 0.25% at full output. Frequency response is flat from 7 Hz to 60,000 Hz. Separate input level controls for each input of each channel are provided. The rf tuner, preassembled, factory



aligned, provides 1.8-μV sensitivity. Computer-designed 9-pole LC filter eliminates i.f. alignment and gives greater than 70 dB selectivity. Push-button "Blend" function attenuates any on-station FM hiss; push-button "Mute" control attenuates between-station noise without affecting tuner sensitivity. *AA-29* kit less cabinet $149.95. *AJ-29* kit less cabinet $169.95.—**Heath Company**, Benton Harbor, Mich. 49022.

Circle 33 on reader service card

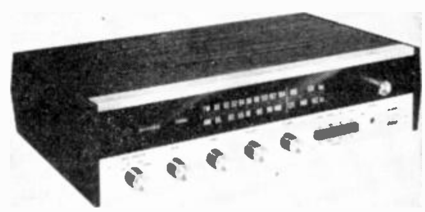
CONTROL AMPLIFIER, *model AU999*. Combines two recorders or decks in tape-copying operation while independently handling other program material. Basic power amplifier boasts frequency response of 5 to 100,000 Hz ± 1 dB at normal listening levels, music power output of 180 watts (4 ohms, IHF), and



distortion less than 0.4% (either total harmonic or intermodulation) at rated power output. Features include a frequency-equalizing system using three tone controls, each calibrated, stepped selector switch, with separate selection of crossover frequencies. $299.95.—**Sansui Electronics Corp.**, 32-17-61 St., Woodside, N.Y. 11377.

Circle 34 on reader service card

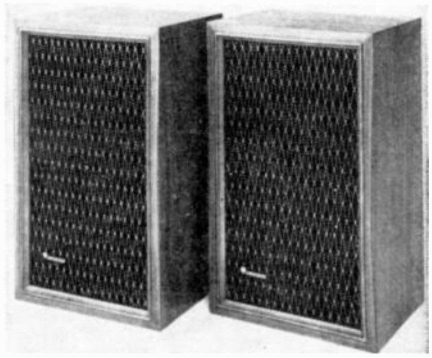
ALL-SILICON SOLID-STATE UNITS, *Cortina models 3780, 3080, 3300*. Quality stereo kits: 50-watt AM-FM receiver, 50-watt amplifier, and an AM-FM tuner.



FM section features tuning range of 88 MHz to 108 MHz, usable sensitivity (IHF): 3.5μv for 30 dB quieting, harmonic distortion less than 1.75%. All prices include vinyl-clad cabinet. Receiver, *3780*, is $109.95 for kit. Amplifier, *3080*, and Tuner, *3300*, are each $69.95 for kit.—**EICO Electronic Instrument Co., Inc.**, 283 Malta St., B'klyn, N.Y. 11207.

Circle 35 on reader service card

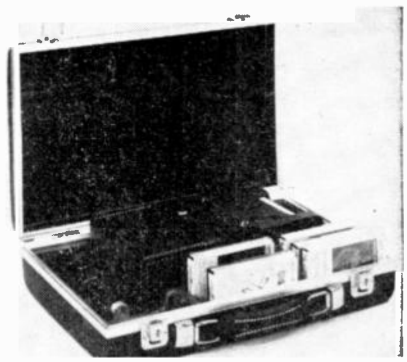
3-WAY, 4-SPEAKER SYSTEM, *model KL-5060*, features a 12" free-edge woofer, 6½" cone squawker, and two horn-type tweeters. With a power input of 60 watts and an impedance of 8 ohms, the



unit has a crossover frequency of 600 Hz and 5,000 Hz, a frequency response from 30-22,000 Hz, and a crossover network of 12 dB/octave. A built-in tone selector provides midrange and high frequency level adjustment. $139.95.—**Kenwood Electronics**, Dept. P, 15711 S. Broadway, Gardena, Calif. 90247.

Circle 36 on reader service card

CASSETTE ATTACHE CASES, *Kari-A-Tape*, consists of 3 models. *KA-27* holds 27 4-track cassettes in their plastic cases. *8T-27* holds 27 8-track cartridges showing labels up for easy identification. *KAM-9* holds 9 cassettes plus most portable cassette machines. All units are



scuffproof with washable leatherette covers. Available in two color combinations. $14.95 to $16.95.—**Modern Album, Inc.** 119-01 22nd Ave., College Point, L.I. N.Y. 11356

Circle 37 on reader service card

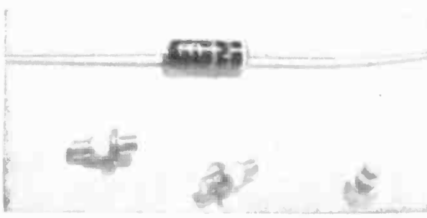
RHYTHM CONSOLE, *model KG-393*, electronically creates the sounds of bass drum, snare drum, claves, cowbell, maracas, and high and low bongos through a microphone or instrument amplifier. Volume and tempo of the beats can be

controlled. Cymbals can be added in varying degrees to all rhythms except the rhumba, mambo, and cha-cha.

Assembly of the solid-state kit is simplified as most parts are already soldered to the printed circuit boards. Critical circuits are wired and tested at the factory. Complete with 10 foot output cable for connection to any amplifier. $99.95—**Allied Radio**, 100 N. Western Ave., Chicago, Ill. 60680.

Circle 38 on reader service card

AMATEUR RADIO VARACTORS, *Models* #VC6607, #VC6615, *and* #VC6633 are high Q, medium-capacitance varactors designed to provide high circuit efficiency from 6 meters to 160



meters, good efficiency on 2 and 1¼ meters, and fair at higher frequencies. Other uses include afc, fine increment tuning of transceivers, remote tuning of VFO, and in rf/i.f. filters to provide variable characteristics. All models have a temperature compensating stabistor, type ST24 for stable operation over wide temperature ranges, as in mobile ham equipment. $6.50 each.—**Eastron Corp.**, 25 Locust St., Haverhill, Mass. 01830.

Circle 39 on reader service card

4-CHANNEL TAPE DECK, *model TCA-40, Simultrak.* ¼-track, 2-channel stereo playback and 4-channel stereo playback (in-line). Includes ¼-track, 2-channel erase and record heads, auto-

matic reverse, built-in solid-state preamplifiers. *Model TCA-40* suitable for duplicating or copy deck use. $365.00.—**Marketing World, TEAC**, 11 E. 44th St., New York, N.Y. 10017.

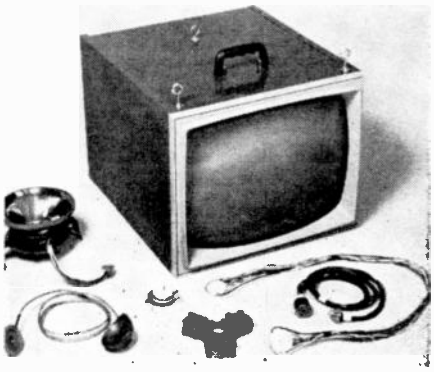
Circle 40 on reader service card

HI-FI STEREO TURNTABLE, *model PL-A25*, 33⅓ rpm and 45 rpm. 4-pole outer rotor high torque hysteresis synchronous motor for constant turntable speed. Less than 0.1% wow and flutter. *PL-A25* provided with stylus-protecting automatic lead-in device, adjustable for use with 7", 10" or 12" records. Fea-

tures automatic cut, return, and repeat device, comes complete with cartridge, base and cover. Unit mounted in oil-finished walnut cabinet with smoked acrylic dust cover. $129.95.—**Pioneer Electronics**, 140 Smith St., Farmingdale, N.Y.

Circle 41 on reader service card

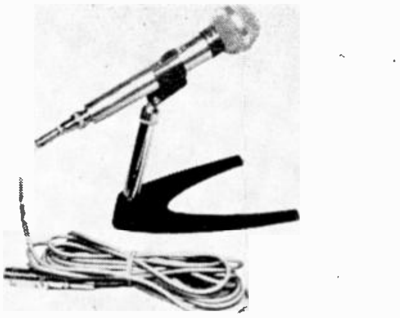
TEST-JIG KIT, *Econo-Jig*. 19" color kit complete with all necessary components including deflection and convergence yokes, anode, CRT, and yoke extensions, except a 19" CRT. Unit will accept any 19" color tube now on market. *Econo-Jig* is housed in a wood grain finished com-



pact metal cabinet designed for portable or bench operation.—**UXL Corp., Telematic,** 2245 Pitkin Ave., B'klyn, N.Y. 11207.

Circle 42 on reader service card

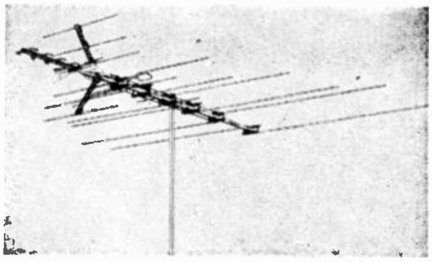
CARDIOID MICROPHONE, *model*



37-105. Undirectional mike is hand-held model. Has a dual impedance of 600 and 50,000 ohms. Sensitivity: −60dB/1,000 cps. Complete with mike-holder, shielded cable, and built in off/on switch, $29.95.—**Weltron Co.** 514 E. Peabody St., Durham, North Carolina 27702.

Circle 43 on reader service card

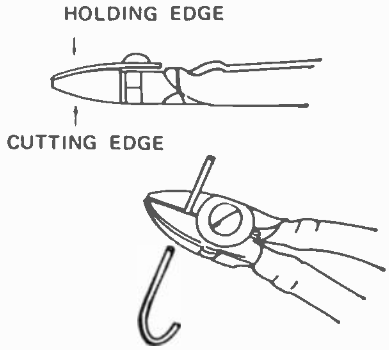
OUTDOOR ANTENNAS, *Permacolor model 4BG23,* has polypropylene insulators with a permanent connection strap riveted to element and feed line, to eliminate reception problems caused by poor continuity. Insulators pivot and lock together to form rigid, truss-like struc-



ture. Line includes uhf-vhf-FM combinations, as well as vhf-FM models. All but three largest models are completely assembled, ready for installation, in a blue and gold vinyl finish.—**RCA Parts & Accessories,** 2000 Clements Bridge Rd., Deptford, N.J. 08096.

Circle 44 on reader service card

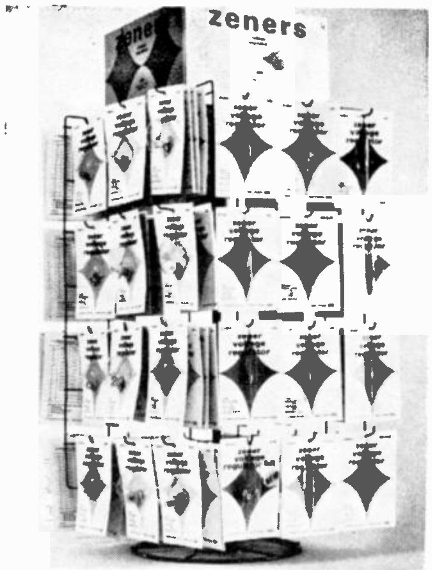
DIAGONAL CUTTING PLIERS, *Copaloy,* hold cut-off pieces of wire, preventing them from dropping into hard-to-reach places or flying out and causing injury. *Model MS54W* is standard pliers with new wire holding feature, *model*



MS54GW is similar, but blades cut flush. Both have recoil springs and dipped, bonded plastic handles.—**Diamond Tool and Horseshoe Co.** Duluth, Minn.

Circle 45 on reader service card

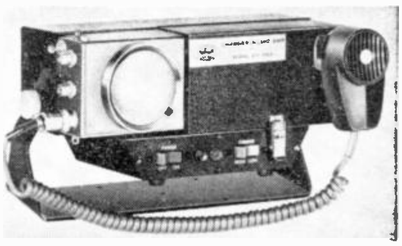
ZENER DIODE LINE, for hobbyists. 48 most popular Zener voltage regulator diode types, including 400 milliwatt, subminiature glass, 1 watt axial lead,



metal case, 10-watt stud mounted, and 50-watt power types.—**International Rectifier,** Semiconductor Division, 23 Kansas St., El Segundo, Calif. 90245.

Circle 46 on reader service card

BATTERY ADAPTER, *model CH 2913,* is a mobile adapter with Charger and Audio Booster. Allows full use of any 2300 series FM transmitter receiver. Designed for continuous duty operation, it combines a nickel-cadmium battery charger and a 5-watt audio amplifier as



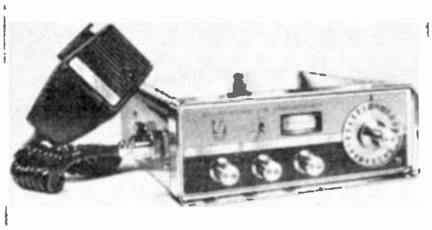
a single unit. Its all solid-state circuit is designed for low power consumption and can be used in any vehicle having a 12-

volt dc, negative ground electrical source. Features two charging rates, the high rate capable of recharging a fully depleted battery in 12-14 hours. The low rate can be used for an indefinite recharging period with no danger of overcharging. It has provisions for connecting an external trumpet speaker. Size 9½" x 4¾" x 4½". $135—Sonar Radio Corp., 73 Wortnan Ave., Bklyn., N.Y.
Circle 47 on reader service card

POWER SUPPLY, *Blulyne PS-60 Series.* Continuously variable regulated power supply delivers output voltages from 1 to 30 volts while continuous current ratings as high as 2 amperes are available. May be purchased in package of one, two or three basic units. Output of each basic unit can be combined in any manner, series or parallel, to meet requirements including voltages to 90 volts and currents to 6 amperes.—Blulyne Electronics Corp., 3 Sand Springs Rd., Williamstown, Mass. 01267.

Circle 48 on reader service card

MOBILE TRANSCEIVER, *Guardsman SFT-900.* Features 23 channels with all crystals supplied plus a built-in PA with on/off volume control, auxiliary speaker/phone jack, delta tuning, squelch control TVI suppression trap, 5" x 3" speaker, detachable noise cancelling



microphone, and an S-rf meter. Automatic noise limiter reduces ignition noise when receiving weak signals. Battery drain 0.2 amperes.—Fanon Electronics, 100 Hoffman Place, Hillside, New Jersey 07205. R-E
Circle 49 on reader service card

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 Service Card on page 101 and circle the numbers of the items you want. Then detach and mail the card. No postage required!

VOLTAGE AND CURRENT PROBE, Model 650 is an easy to operate instrument to check the CRT high voltage and monitor the cathode current. Catalog sheet presents details.—**Polaris Industries Inc.** P.O. Box 4222, Pasadena, Texas 77502.
Circle 50 on reader service card

HEADPHONE CATALOG SHEET, *model 7.* Describes new addition to Sharpe's stereo headphone line. Complete characteristics are presented.—**Sharpe Audio Division Scintrex,** 400 Creekside Dr., Tonawanda, N.Y. 14150.
Circle 51 on reader service card

(Write direct to the manufacturer for information on the following items.)

CCTV CATALOG, *#970 S 1,* presents an illustrated selection of new and used TV cameras and associated equipment, broadcast and closed circuit TV audio and video systems. Listing of amplifiers, lasers, lenses, microphones, oscilloscopes, projectors, test equipment, transmitters, tubes, and other items. 143 pages. $1.00—**Denson Electronic Corp.,** P.O. Box 85, Longview St., Rockville, Conn. 06066.

PSYCHEDELIC SHAK 1971 CATALOG offers a large collection of psychedelic lighting. Includes items such as the Lite Monster that creates moving, blending, and shape changing of all the colors of the rainbow. Also features high intensity strobe lights, color organs, light boxes, plexiglass cubes, and op lights. $1, which is applied towards first order.—**The Psychedelic Shak,** 5920 S. Dixie Highway, South Miami, Fla. 33143.

SEMICONDUCTOR AND IC's, 1970 catalog, includes semiconductor devices, digital and analog integrated circuits and memory networks made by a large number of manufacturers. All products tested and certified to current military specifications, when appropriate.—**Starnetics Company,** 10639 Riverside Drive, North Hollywood, Calif. 91602.

INDUSTRIAL ELECTRONICS 1971 CATALOG lists over 70,000 items from more than 700 manufacturers. Detailed specifications, descriptions, and illustrations covering semiconductors, integrated circuits, tubes, relays, transformers, etc. Other sections feature test instruments, power supplies, sound equipment, and technical books. $2.—which is applied to first order. **Allied Electronics,** 2400 West Washington Blvd. Chicago, Ill. 60680. R-E

If You Were the BOSS and Had to CUT BACK,

WOULD YOU FIRE YOU?

If you were the boss, how would you choose who to let go?

1. You'd probably fire the man who never completed his electronics education. This man may have a solid foundation, but he *quit learning* before he went far enough.

2. You'd probably fire the man who is only a "tinkerer" because his electronics education went *far* enough but *not deep* enough. A specialist must really understand before he can really perform.

3. You'd probably fire the man who has been in electronics for many years but has *not kept up to date* in this rapidly changing industry. Nothing becomes obsolete so quickly as the man who does not study.

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REPLACEMENT TRANSISTORS
(continued from page 60)

satisfactory. Agc voltages unchanged.

The HEP-716 was also used to replace the first and second video amplifier transistors in the Magnavox 936. Voltages once again came out exactly the same, and there was no change in the video signal, either waveform or amplitude.

RCA CTC-44 Solid-State Color TV

Color-difference amplifier (3552 npn silicon) is another of those high-collector-voltage cases (110 volts applied). A HEP-712 and SK-3024 were substituted, using a color bar pattern, and scope

No difference in the color bar pattern; no hue shift, no change in saturation. Dc voltages came out exactly the same on the original and both replacements. This replacement was made with the R-Y color-difference amplifier. Other colors use same transistors and circuit.

The 3.58-MHz color oscillator (Q708, 3546). Nothing listed in replacement books yet for this npn silicon transistor. Chose HEP-724 and SK-3018.

Very minor variations in dc voltages, but no difference in CW output. No hue change, no loss of saturation.

Burst amplifier Q701 (3545). A npn silicon with +84 volts on collector. HEP-712 and SK-3040 chosen as replacements. No change in dc voltages in hue or saturation. Burst amplitude same at output, on color-bar signal.

This leaves us with only one thing not so far discussed: transistor tuners. Frankly, these are going to be the most difficult of all. Not where the selection of replacement transistors is concerned. Here, we'll still be able to use our lists, characteristics charts and all of the other helpful things.

However, tuners are undoubtedly "tight." In a great many of them, the transistors are mounted on the *inside* of the chassis; even in the turret tuners, the turret or drum must be removed to get at the transistors.

When replacing tuner transistors, be *sure* to make a sketch of the location, and placement of the original unit. Try to get the new one in exactly the same position, with the same lead lengths, etc. If you're lucky, you may not have to do any touchup alignment after you get through.

I would recommend that you *always* run a sweep-curve check on a tuner after replacement of transistors. This is not so much for any difference in the transistor characteristics, but for the simple mechanical placement of the new transistor, with the resulting change in stray capacitance. This will cause some detuning that will show up on the sweep curve. It would probably be best to make a "link alignment" check, using the loading networks provided with such generators as B & K 415 and Heathkit IG-57, to get only the results of the tuner's response.

Realignment, from our experience, has not been difficult. In some cases, you will be able to straighten it up by simply moving the transistor with an insulated screwdriver or alignment tool. In others, a touchup of the trimmer capacitors will take care of it.

Replacement transistors aren't hard to find. An SE5020, for example, used very often in rf and mixer stages, can be replaced by a HEP-709 or SK-3018. Just make sure that the replacement you choose has a good high-frequency cutoff, higher than the highest normal frequency to be handled.

Conclusion

So, there you are. Because of space limitations, we haven't been able to cover all of the possible circuits, (Couldn't anyhow; too many of 'em!) but these were all real circuits in real sets, and we used commonly-available replacement transistors and standard test equipment. However, I believe you'll find at least one of every possible standard circuit in here.

Using the methods outlined in this article, you should be able to make replacements for unknown transistors without a great deal of trouble. If you have *any* data at all, such as the schematic, it'll be a lot easier. Even without anything, you'll still be able to get the things working again. And that's the name of the game—good luck! **R-E**

"Mr. Sam, you were recommended to us by Fix-Fast TV Service."

HOME APPLIANCE ELECTRONICS
(continued from page 26)

peres. An auxiliary scale below the current scale is calibrated directly in watts, which are, of course, "E × I". Wattage is based on the standard ac line voltage of 117 volts. Conversion tables are included in the instruction book, so you can find the true wattage if the line voltage is high or low. The line voltage is indicated on the top scale as soon as the instrument is plugged in.

If you find a dead short, the instrument is protected by a 10-ampere circuit breaker and its meter by a shunt diode. This is a much safer way to find dead shorts than plugging it in and looking for smoke! In normal use you can plug an appliance in, turn it on with your hand on the line cord, and watch the meter. If the needle hits the peg and you know this thing's only supposed to draw 300 watts, *yank!* You can usually pull the plug before the breaker trips, but if you're a bit slow, no harm is done.

Another handy use is for checking such things as ac solenoids for possible internal shorts. Assume that a solenoid normally draws 100 watts, or roughly 1.0 ampere. You can disconnect one lead, hook the ammeter in series with the test-leads and turn it on. If the solenoid shows more current than normal, say 1.5 or 2.0 amperes, it has shorted turns and must be replaced.

As one last check, this instrument is invaluable for finding out whether a power transformer is really shorted, or whether overheating is due to external overloading. This works with all transformers; radio-TV-hi-fi, etc. and with any of the numerous small power transformers found in appliances, for supplying low-voltage control systems, sensing elements, solid-state control circuits, etc.

To find out, disconnect one side of the secondary winding to remove all external loading. Then, plug the primary into the wattmeter. If this isn't possible, break one side of the primary supply and hook the wattmeter in series with it. Now, under completely "no-load" conditions, turn it on. All you should see is a small wiggle of the wattmeter needle. This is the "iron-loss" current of the transformer, and even in good-sized transformers should be almost nothing. (Not over 5 watts.) If you see a reading as low as 30 to 40 watts, no-load, the transformer is definitely bad. Actually, this would be a very high-resistance short indeed. Normally, a transformer with a shorted turn will draw 300 to 400 watts or more and you'll be sure.

You can rely on "power-drain" as an accurate method of testing any ac-powered unit. Use it more often. R-E

DID YOU MISS?

4-Channel Stereo Synthesizer tells about an instrument that turns all your 2-channel stereo music into fill-the-room 4-channel stereo. It's on page 68.

NEW BOOKS

AUDEL™ TELEVISION SERVICE MANUAL by Edwin P. Anderson. Revised by Robert G. Middleton. Theodore Audel & Co., division of Howard W. Sams & Co., Inc., 4300 W. 62nd St., Indianapolis, Ind. 46206. 5½ x 8½ in. 535 pages. Hardbound, $5.95.

Completely revised and updated book reflects the present state of the art. Set up as an all-inclusive volume it encompasses the entire scope of video scope and transmission, providing a complete coverage of system and circuit theory, systems standards, installation and maintenance procedures. Explanations of transistor and integrated circuit developments in the TV field are also included. Space is also devoted to antenna arrays, transmission lines, and antenna system design and installation. Color TV is covered with particular concentration on those circuits which have no counterparts in monochrome receivers.

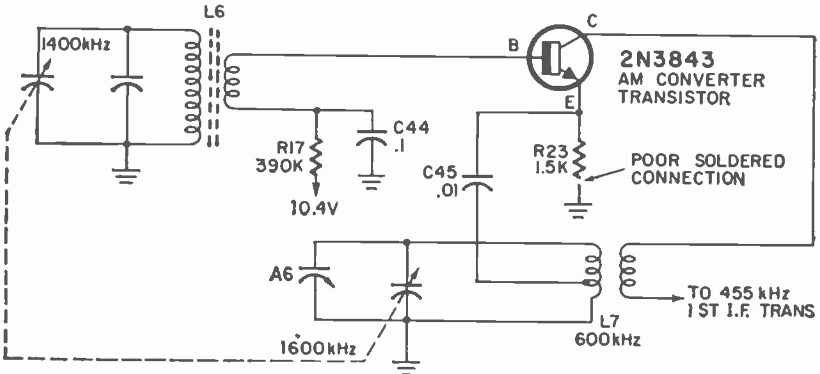
DIGITAL COMPUTERS MADE EASY, by Saul Heller. Ameco Publishing Corp. 314 Hillside Ave., Williston Park, N.Y. 11596. 128 pages. 6" x 8½". $1.75.

Primarily for the layman with no experience in technical fields. This guide explains the basics for understanding what a computer is, how it functions, and where it takes us. R-E

TECHNOTES

PHONOLA MODEL 5103

This AM-FM stereo combination came in with intermittent AM reception. Since the phono and FM section were normal the intermittent condition had to be in the AM converter section. The 2N3843 converter transistor was sprayed with cold spray and the radio cut out. Other in-circuit tests also pointed to a bad 2N3843.



We replaced the 2N3843 with a RCA SK3018 universal type. The radio played for two hours and then cut out. When the AM radio was in the non-playing condition voltage measurements were made upon the converter transistor. We found +11 volts on all three elements. This indicated an open emitter circuit.

Upon checking R23, we found a poor solder connection between the resistor and common ground return. A good solder connection and reinstalling the original 2N3843 restored the set to like-new operation.—*David Mark*

A CRAWLING VERTICAL PICTURE

This 6 months old CTC 17XE color chassis had a vertical crawling action in the picture. The picture would crawl and then spread out as it went up the screen.

Many times vertical crawling can be caused by filter capacitors. Shunting a 100-μF electrolytic capacitor across the various filter capacitors in the power supply located the defective one. An 80-μF electrolytic capacitor (C136A) feeding the vertical output section was defective.

The hookup wire was real taut and had pulled the capacitor positive terminal to one side so contact was actually broken inside the electrolytic, leaving C136A open.—*Homer L. Davidson*

THE INTERMITTENT FORD 4-TMF AUTO RADIO

This radio is actually a Motorola chassis. At times it would play like a champ. According to the customer, it did its best in cold weather. During the warmer season it would roar at him, growl, change stations, and stutter. If things got real hot, the radio would quit altogether until he kicked it—at which time it came on with a blast that made the good fender rattle. This is the customer's version.

Anyhow, after several dash-board withdrawals, as many reinstallations; after talks, discussions, arguments and telephone calls, the troublesome component finally was exposed. It wasn't a transistor—I had changed them. It wasn't a crack in the printed-circuit board. It wasn't anything anybody had ever heard of before, I believe. **It was something new that had been added!**

This set and many other listed models use a newly designed oscillator trimmer capacitor—a double ceramic type—which is rated at having a nominal fixed capacitance of 270-pF plus. The 'plus' capacitance of the component is adjustable with the spring-leafs, mica insulators, and the screw. The 270-pF fixed value of the unit is a silvered-mica insert placed between the bottom plates of the trimmer and adding their total value to the adjusted capacitance. This insert is easily cracked by adjustment pressure and the resulting oscillator voltage leakage does the rest.

Original part replacement, carefully installed and adjusted, is one way of solving the problem. The method I used was to carefully dismantle the trimmer, leaf-by-mica-spaced-leaf, until I discovered the silvered-mica insert. This section was taken out and the unit again assembled. I then added a fixed NPO 270-pF ceramic capacitor, bridging the trimmer. Adjusted the variable—and the customer didn't have to buy a new radio after all.—*George D. Philpott* **R-E**

EQUIPMENT REPORT

EICO 3780 AM-FM Stereo Receiver

For manufacturer's literature, circle No. 18 on Reader Service Card.

THIS NEW LINE OF AUDIO EQUIPMENT is comprised of three elements: a tuner, model 3300; an amplifier, model 3080; and the receiver reviewed here, (model 3780) which combines the tuner and amplifier into a single package. This combination forms a low-priced component stereo line bearing the name Cortina-2.

In any kit that includes an FM receiver, assembly and alignment of the tuner section can present major difficulties to the kit builder. EICO gets around these problems by supplying the tuner board—front end and i.f. strip—fully pre-assembled and aligned. The kit builder faces only assembling the amplifier, front panel, power supply and interconnections between these elements.

The amplifier consists of a single circuit board which speeds construction as well as simplifies it. Total construction time ran 14 hours. This is a bit more than the time EICO says the kit should take, but the kit builder was building his first major kit and this accounts for the difference.

The first step was to check the parts in this kit and this did turn out to be a time saver as we found that the stereo indicator lamp was broken. By ordering a replacement at the beginning, it had arrived by the time we were ready to install it.

Assembly went smoothly and before we knew it the tuner was complete. When plugged in, it did not work the first time. The trouble was exactly what might be expected—a cold solder joint. Another example of why it's worth spending the time to check all soldering carefully before going on to the next step. Well at least our beginner kit builder will know better next time.

A little reassembly, a little resoldering and the unit was back together—working properly this time.

We've used it with speakers and headphones and find its performance lives up to the published specifications (you'll find a detailed list at the bottom of this page.)

Front-panel controls provide all the versatility a music lover might desire. The wide range of the tone controls (see table below) is more than adequate to compensate for any personal tastes in sound emphasis. All controls and the headphone jack are on the front panel. All input and output connections are in the rear.—*Joe Shane*

MANUFACTURERS SPECIFICATIONS

FM SECTION:
Tuning Range: 88 MHz to 108 MHz
Usable Sensitivity (IHF): 3.5 μV for 30 dB quieting
Harmonic Distortion: Less than 1.75%
Capture Ratio: less than 4%
Signal-to-Noise Ratio: 60 dB
Image Rejection: 75 dB
Selectivity (alternate channel): 20 dB
Full Limiting: 100 μV
AM Suppression: 40 dB

FM MULTIPLEX SECTION:
Stereo Supression: 33 dB at 1 kHz
19 kHz Supression: 35 dB
38 kHz Supression: 35 dB

AM SECTION:
Tuning Range: 535 kHz to 1640 kHz.
Usable Sensitivity (IHF): 200 μV/m
Signal-To-Noise Ratio: 45 dB
Selectivity: 30 dB
Image Rejection: 40 dB.
IF rejection: 40 dB
Harmonic distortion: 2%

AMPLIFIER PREAMP SECTION:
Power (4-ohms):
50 Watts
32 Watts (IHF)
22 Watts (continuous rms into 8 ohms)
Frequency Response:
20 Hz to 20 kHz ±3 db
Harmonic Distortion
0.75% at 1 kHz at 8 Watts output
0.4% at 1 kHz at 4 Watts output
Hum & Noise:
70 dB below rated output
Channel Separation: 45 dB
Input Sensitivity:
3.8 mV mag phono input
300 mV all other inputs
Damping Factor: minimum 30 dB with 8-ohm load
Power Bandwidth: 20 Hz to 30 kHz at 1.5% distortion
Rise Time: 4.5 μsec
Tone Control Range:
Treble, ±13 dB at 10 kHz
Bass, ±13 dB at 100 Hz
Balance Range: ±20 dB
IM Distortion: 1.7% at 5 watts
Output Impedances: 4–16 ohms

In the Shop . . . With Jack

By JACK DARR
SERVICE EDITOR

SAME TROUBLE, DIFFERENT CAUSES!

THINGS CAN GET PUZZLING, NOW AND then. A while back, I was awarded the job of working over a pair of identical TV chasses with the same symptoms. Both had a vertical height of about 2 inches! Plenty of width, etc., but this was a little bit short.

Fig. 1 shows the vertical circuit used—both were Magnavox 908 solid-state black and white sets. My scope soon showed me that the drive signal waveform, on the base of the 64N1 vertical output transistor wasn't all that it should be!

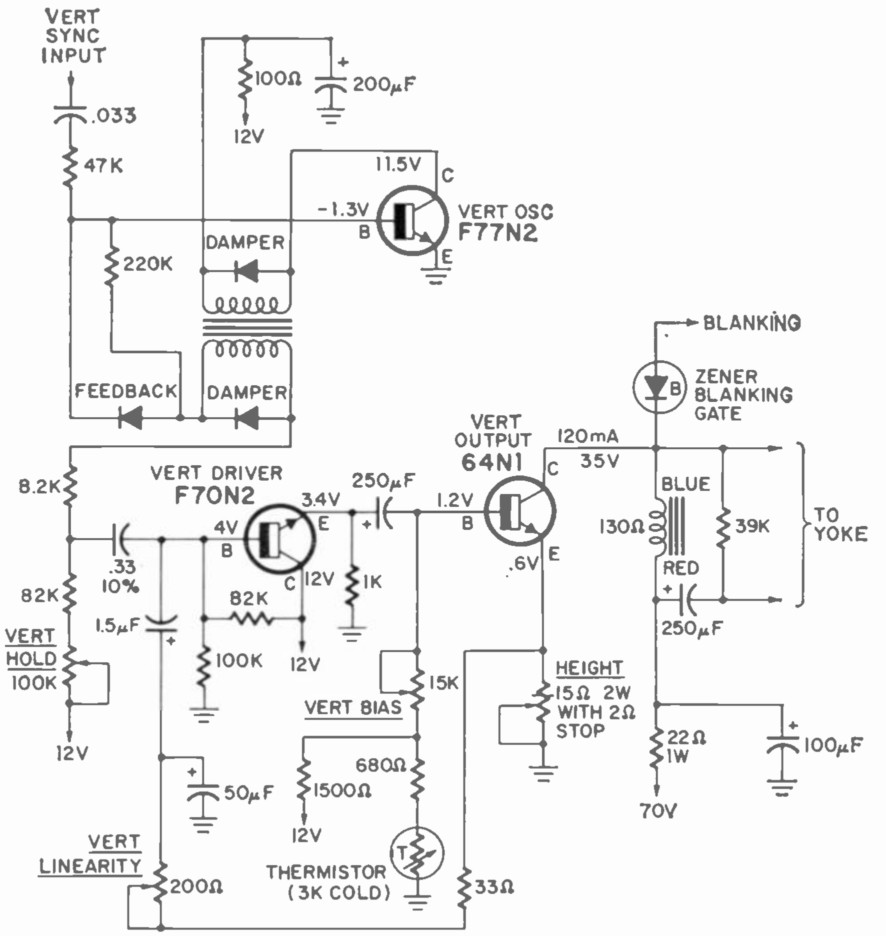


FIG. 1

It was on-frequency, all right, at 60 Hz. (In fact I could see a locked picture on the wee raster, so I knew that already.), but the amplitude left a bit to be desired. It was about 0.2 volt and the waveform was severely flattened, as you can see in Fig. 2.

Something was chopping this thing off right at the knees. A few dc voltage measurements around the driver stage brought me to the possibility of a bad transistor in the vertical driver stage. After some struggling the transistor was pulled and checked. Sure enough. Very bad (leaky).

The original was a type F70N2, an npn silicon. A GE-10 or HEP-53 is a good replacement. So I stuffed the leads through the holes, and tacked it in. Cross fingers, apply power. Waveform comes up almost instantly, now looking a lot more like "what it says in the book." When the single tube in this set (the picture tube) warmed up, I had a full raster. A few adjustments and a check on the collector current of the vertical output transistor to make sure that it wasn't pulling too much current, and that took care of that. Back in the box with you, Junior.

Now I get out the other one. Same symptoms. In fact, identical; my scope showed exactly the same waveform on the base of the vertical output transistor! Same amplitude, same clipping, everything. "Ho, hum. Gets monotonous doesn't it? "I say to myself, taking out the vertical driver transistor again.

Things were different now, though. You never saw a better transistor than this one. At least that's what my reliable transistor tester tells me! No leakage, plenty of beta, and everything. Huh? What's this? Just for luck I reached for a new replacement transistor and temporarily tacked it into the circuit from the underside.

Firing it up showed that I still had the same chopped-off waveform! No raster, or at least no more than I had to begin with. Well, well. Maybe this isn't so monotonous after all! So I set out after the cause.

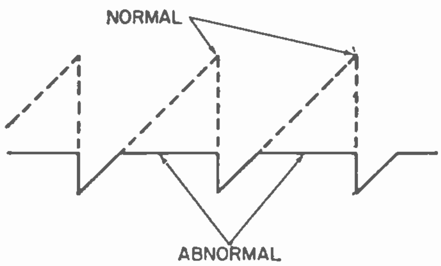


FIG. 2

A few resistance readings around the driver stage with the transistor out, showed something odd. There was not enough resistance to ground from the base. Since this was normally "blocked" by a 0.33-μF coupling capacitor back to the oscillator, and a 1.5-μF capacitor to the vertical linearity control, I should have had at least 50 to 60,000 ohms from the open base terminal. (100,000 to ground, 82,000 to the +12-volt source. Normal resistance should have been these two in parallel.)

Instead, I had about 2,000 ohms. Incidentally, base and emitter voltages on this transistor should have been 6.2 and 5.6 volts, and they were both very low, about 1.0 volt. (They had been the same on the other one, with a bad transistor!) A little judicious unhooking of things and rechecking resistances soon showed up the culprit.

It was a capacitor

The 1.5-μF shaping capacitor, from base to vertical linearity control, had about 2,000 ohms leakage. Since this went directly to a 50μF electrolytic, it was shunting the vertical drive signal and causing drive signal clipping and knocking down the bias voltages on the driver transistor, all at the same time. I had a hard time *finding* this capacitor! I'd pull the solder out of the terminals from below, then reach up and feel what I thought was it; however, it wouldn't pull out! I eventually turned the board over, and found that the offending capacitor was one of those mini-tantalum units that looks exactly like a silicon rectifier!

So, I replaced it and stuffed that one back, then sat there and looked at them. I finally decided that you never know *what* you're going to find, in this business. I guess that's why we like it. **R-E**

Service Clinic

By JACK DARR
SERVICE EDITOR

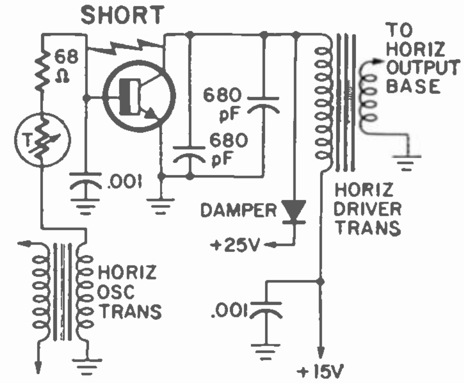
This column is for your service problems—TV, radio, audio or general and industrial electronics. We answer all questions individually by mail, free of charge, and the more interesting ones will be printed here.

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

MAGNAVOX 908; DRIVE LINES?

I had some problems in the horizontal circuits of a Magnavox 908 solid-state B/W TV. Replaced shorted horizontal output transistor with a HEP-707, and got my HV back. Now that I've got a raster, I've two very heavy, bright vertical lines in the raster.

One's near the center, like a drive-line, but the other is off to the left side. I get a high, sort of triple-peaked spike on the collector of the horizontal output



transistor. About 750 volts p-p. What is causing these drive-lines? Is it the new output transistor?—A. M., Rockford, Illinois.

No. Either the HEP-707 or HEP-747 (same as 707 but with higher peak voltage rating) will replace the original 63N1, which is a silicon npn. The most likely cause for this ringing, and the "drive-lines" (which aren't precisely drive-lines, though they look like them) would be an open .0082-μF yoke-damping capacitor, C615. It has caused this.

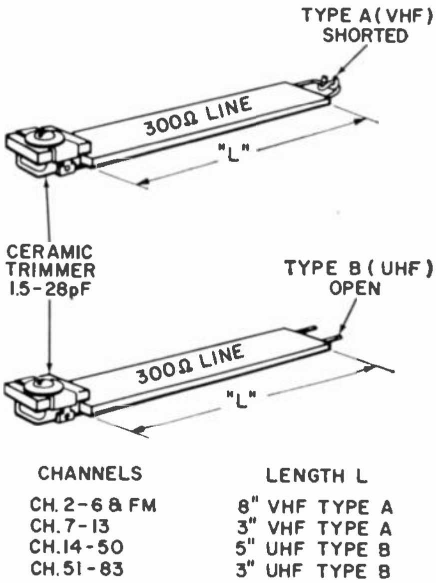
RCA TRAP WON'T WORK FOR TVI REDUCTION.

I've got a problem with TVI between stations. We're close to a strong local channel 10 station, and when we try to set an antenna for four other sta-

tions about 30 miles away, the channel 10 signal interferes! When we try to get the channel 8 station, we always have a channel 10 signal floating around in the background.

I've tried RCA's little trap, shown in their service publications, but it doesn't work at all. Any ideas on what we might do?—A. P., Tarpon Springs, Florida.

Yep. You're probably using the original RCA trap circuit, with a 4⅜" length of 300-ohm twin lead, shorted at one end, and a 2.5-14 pF trimmer across the other. If you'll look closely



at the diagram, you'll see that it "tunes sharply from 40 to 170 MHz".

Channel 10 is 192–198 MHz! So the original trap is out of its range. Try the later versions (see diagram) from the April 1967 *Plain Talk*. Cut your channel-10 trap to only 3 inches of twin-lead, and I think you'll find that it works a lot better. Also, use a 1.5 to 28 pF trimmer, of a lowloss ceramic type. Tape this to the leadin, preferably between the set antenna terminals and the tuner, as close to the balun as possible.

CONVERGENCE DRIFT ON CHANNEL CHANGE

I got a screwball symptom! When I change channels on this Zenith 23XC38, the convergence drifts off! After about 3–5 seconds, it slowly comes back to normal; shows up worse on a dot pattern. Even if you just move the channel-selector off-station then back, it pops out of convergence then slowly comes back. —R. C., Gorham, Maine.

You know, I'm kinda sorry you asked! Seriously, though, this seems to be due to the "switching transient" caused when you change channels. From the symptoms, you have an electrolytic capacitor somewhere in there that is either charged or discharged, and takes 3–5 seconds to "recover". During this time, it evidently affects the convergence waveforms.

I can think of one capacitor in this chassis that will do just that. It's the big electrolytic in the cathode of the vertical output stage. This looks like an ordinary cathode bypass, and is, but it has another function. It feeds dynamic convergence pulses into the convergence board.

So if this capacitor were intermittent, as many of them are, and can be "shocked in or out" by a transient, this could be the cause of the drift. I do know from personal experience that trouble in this capacitor; high power factor, or intermittent opening, can upset dynamic convergence. Try a new one in there. If that doesn't do it, look for other coupling capacitors which feed pulses to the convergence board.

STREAKS IN RASTER, WITH BRIGHTNESS CONTROL?

I've a weird symptom on a Magnavox 919. There are tiny horizontal streaks and flashes in the raster. They get worse as you turn the brightness control up, and disappear if you turn it down far enough. However, at that point you can barely make out the picture! High voltage ok, and so on, color ok. What is?—R. D., Cincinnati, Ohio.

Take the bottom plastic cover off the 3A3 socket, and push all of the socket pins firmly down, while holding the tube's plate-cap. In some cases, one of these will be just a little bit loose, making poor contact. This arcs, when you increase the beam current (turn up the brightness). The more current, the heavier the arcing.

Normally, this will hold until the tube is replaced, or taken out of the socket again. However, the socket ought to be replaced the next time this set is in the shop.

REPLACEMENT FLYBACK FOR OLD STROMBERG

I need a flyback transformer for a Stromberg-Carlson TC-19 TV set. Don't seem to be able to find a replacement flyback in any of my lists. Can you help?—J. H., Charleston, W. Va.

Not a heck of a lot I'm sorry to say! I went through my extensive lists and came up empty too. However, I finally found a listing on this chassis, in a very old Thordarson-Meissner catalog! The replacement given for the S/C 16124 flyback was a "FLY-1".

By some extensive cross-referencing, I also found that a Triad D-11 will work. The original was referenced to the very popular (in them days!) RCA 211T1/211T3 flyback. Many, many sets used it, and there should be one floating around somewhere. Hope you can find one. R-E

SOLID-STATE DESIGN
(continued from page 50)

ciple must be used. This method dictates that when more than one supply is used in a circuit, the effect of each supply upon a circuit factor must be considered individually. The sum of the effects of all supplies are totaled algebraically.

Let us apply this method to the circuit in Fig. 13, using the steps outlined below. Refer to Fig. 14 for clarification.

1. First break the connections between the load and the supply circuit at A — B.

2. Short the negative supply. The voltage at A — B due to + E_{CC} alone is $(+E_{CC})(R_X)/(R_B + R_X)$.

3. Short E_{CC}. The voltage at A—B due to $+E_{BB}$ alone is $(-E_{BB})(R_B)/(R_B+R_X)$. If this is not too obvious, note that when E_{CC} is shorted, the top terminal of R_B is connected to ground or point B. R_X and R_B form a voltage divider.

4. The total Thevenin voltage is the sum of the voltages due to these two sources. It is $V_{TH} = E_{CC}\ R_X/(R_B+R_X) - E_{BB}\ R_B/(R_B+R_X)$.

5. Short both voltage sources. Looking into terminal A–B. R_B is in parallel with R_X. The Thevenin resistance is this parallel combination or $R_{TH} = R_B\ R_X/(R_B+R_X)$

Now draw the total Thevenized circuit in conjunction with the base circuit of the transistor. This is shown in Fig. 14-b. Once again, the quiescent base current is $I_B = V_{TH}/(R_{TH} - \beta R_E)$, and the idling collector current is beta multiplied by I_B.

Another method of biasing a transistor, is shown in Fig. 15. It uses an emitter supply and not a base voltage source.

A resistor in the emitter is reflected as a resistor in the base circuit, but multiplied by a factor of beta. Thus R_E appears as a resistor βR_E in series with the base lead.

In a similar manner, any resistor in the base circuit is reflected into the emitter circuit as a resistor divided by beta. R_B appears as a resistor R_B/β in series with R_E.

The emitter (and collector) current flowing through the transistor is $V_{EE}/(R_E + \frac{R_B}{\beta})$. The base current is this value, divided by beta.

The final circuit to be considered, sometimes referred to as the self-bias circuit, is shown in Fig. 16. Note that the sum of the collector current and base current flow through R_C. The current flowing through the collector resistor is $(E_{CC} - V_C)/R_C = I_B + I_C$ while the base current is $I_B = V_C/(R_B + \beta\ R_E)$.

There are many variations of the circuits just described. These will be considered in the future as specific audio circuits are discussed. The next article covers bipolar transistor bias circuits.

(to be continued)

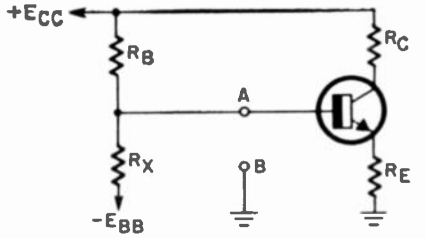


FIG. 13—TWO VOLTAGE SOURCES are used to bias the transistor base.

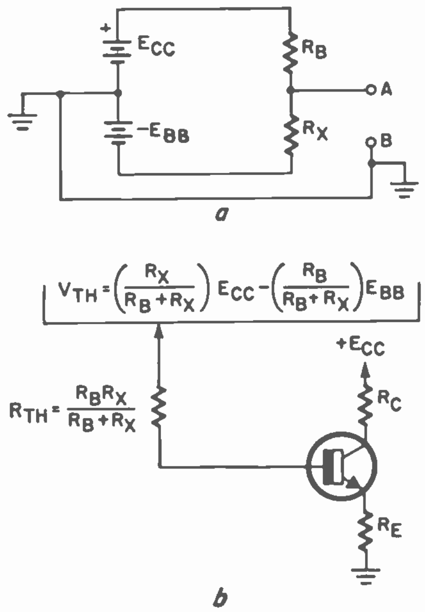


FIG. 14—APPLYING SUPERPOSITION and Thevenin methods to circuit in Fig. 13.

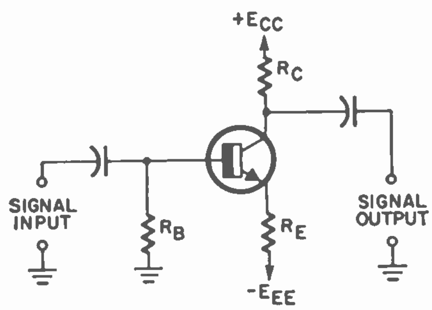


FIG. 15—CIRCUIT USING BIAS SUPPLY voltage in the emitter.

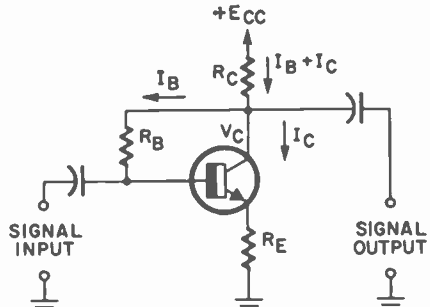
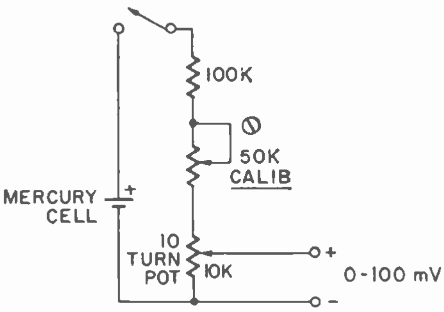


FIG. 16—BIAS CIRCUIT using a combination of both ac and dc feedback.

NOTEWORTHY

RECORDER AND MILLIVOLTMETER TEST SOURCE

On many occasions, when servicing industrial test or process equipment, a source of a few millivolts is required to test for operation and/or calibration of chart recorders or electronic millivoltmeters. Test equipment is available to meet this need; however in many cases the need is not great

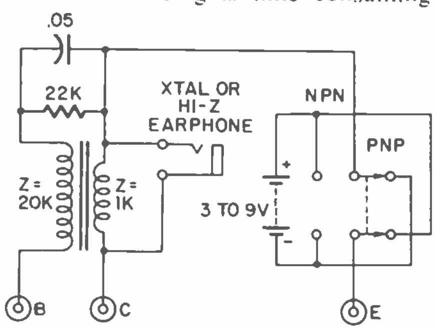


enough to warrant purchase. A simple solution is available in the form of the 10-turn linear potentiometers which are so often already in stock. A 10,000-ohm pot in conjunction with a fixed and variable calibrating resistor combination and a mercury battery makes a very simple and accurate substitute (see diagram). Initial calibration is made using a meter of known accuracy. When fitted with a 10-turn Duodial or similar knob, the dial will read out to 1/10 mV.

Actual values may be varied to suit the components available as long as the ratio is maintained. Bear in mind, however, that calibration retention and battery life will suffer if too much current is allowed to flow through the voltage divider.—*William P. Turner*

TRANSISTOR IN-CIRCUIT TESTER

When servicing inoperative solid-state equipment, unsoldering transistors for servicing is time consuming



and there is always the possibility that the part may be damaged when removing or replacing it. Here is a simple in-circuit tester that will detect most defective transistors.

To use the tester, turn off the equipment under test and connect the tester's E-B-C leads to the emitter, base and collector of the doubtful transistor. Set the switch to match the transistor type. If the transistor is good, the tester circuit will oscillate and you'll hear an audio tone from the earphone.—*Tang Quoc Cuong*

SOLID STATE FAIL-SAFE CIRCUIT

The circuit of Fig. 1-a was designed to provide automatic fail-safe power for a burglar alarm circuit. With the appropriate component alterations to suit particular dc circuit requirements, it may be useful in various other applications.

Diode D1 replaces the usual relay found in this application. When a relay is used, it is usually connected as illustrated in Fig. 1-b. It is across the primary line and is a continuous-duty type. When primary power fails, the relay drops out, connecting the load circuit to a standby power source.

There are several advantages to be realized in using the circuit in 1-a. A major one is cost, as the diode is usually priced at a fraction of that for a relay. Other important advantages are reliability, compactness, silence, no power consumption, simplicity, and freedom from the mechanical and electrical problems that dust can introduce for an open relay.

With the circuit as shown in Fig.

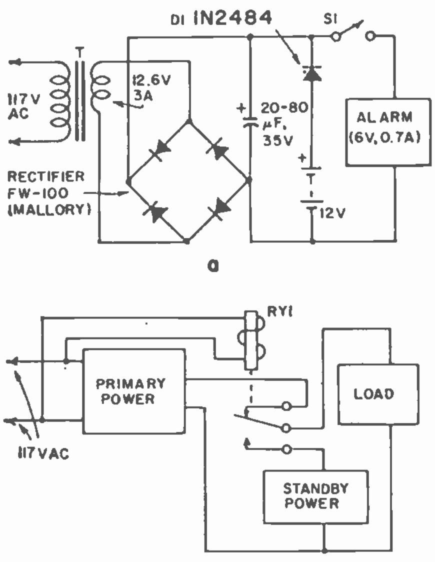


Fig. I

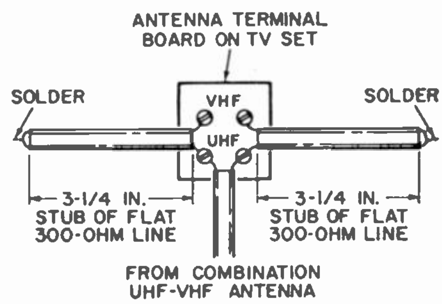
1-a, under normal conditions the alarm sounds when S1 is closed as a result of the activation of any of several intrusion sensors. The slightly higher primary voltage source cannot deliver power to the standby battery—a dry cell in this case—due to the blocking action of D1. The standby battery does not deliver power to the circuit due to this same potential difference, and also because of the blocking action of the rectifier elements.

If the primary source fails for any reason—a burglar cuts off the building power, for example—the standby battery will deliver power to the alarm circuit upon closure of any of the circuits shown as S1, due to the forward conduction of the diode in the load circuit. As was explained, the standby battery cannot discharge through the rectifier. No power is consumed by the diode fail-safe element, as there is where a continuous duty-relay is employed.

In selecting a diode, the main considerations are that it will safely pass the required load current (drawn by the alarm device) and has a prV (peak reverse voltage) rating reasonably greater then the circuit working voltages.—*Aaron W. Edwards*

VHF-UHF COUPLER

When you install a set in a location that has a single lead-in from the uhf and vhf antennas or from a combination vhf/uhf antenna, you can use the coupling network shown in the diagram if a standard coupler is not available. The lead-in from the vhf/uhf antenna system connects to the UHF terminals on the back of the TV set. The VHF terminals connect to



the lead-in and UHF terminals through 3¼-inch shorted stubs of 300-ohm ribbon line.—*Admiral Service News Letter* **R-E**

DID YOU MISS IT??

If finding the right replacement transistor is a problem, check Jack Darr's article on page 57. Here, with case histories, he shows how to solve this perplexing, yet common problem

EQUIPMENT REPORT

B & K Model 162 Transistor FET Tester

For manufacturer's literature, circle No. 19 on Reader Service Card.

THE B & K MODEL 162 TRANSISTOR FET tester is a lot of stuff in a compact case. As far as I know, it is the first self-contained tester of this type. Power for tests is supplied by small alkaline batteries inside the case. It will test all kinds of solid-state devices, from bipolar transistors to FET's, UJT's, SCR's, and Triacs—diodes too, of course, of all types. (And you'd be surprised how useful a good diode-check can be, at times! Next time you get into trouble in an acc circuit, try it.)

The Model 162 has an amazing range. It can check transistors with collector currents from a few microamperes up to power types with collector currents of 1.0 *ampere*. Five ranges are provided: 100 μA, 1.0 mA, 10 mA, 100 mA and 1.0 ampere. Polarity can be switched from npn to pnp.

Beta and Gm of FET's can be read either in-circuit or out of circuit. A special circuit permits balancing out very low shunt impedances present for accurate beta readings: as low as 6 ohms. This gives a more accurate beta reading for quick in-circuit testing.

Four color-coded leads on the front panel allow quick connection to devices in-circuit or out. Two sockets are provided on the panel, for small bipolars and FET's.

The collector-current selector switch (RANGE) allows all types of transistors to be tested in their actual operating range, from small-signal types up to fairly high-power audio and TV output transistors. The FULL LOADING sets the transistor under test much closer to actual operating conditions, giving a much more accurate indication of its condition.

Leakage tests for the three most important parameters of transistors are provided: I_{cbo}, I_{ceo} and I_{ces}. They will help detect transistors which could be avalanching under normal loading. It is especially handy for those very small, overloaded power transistors we find in small stereo amplifiers!

Beta calibration for in-circuit testing is very simple. The BETA-∞ knob is adjusted for a zero reading, after connections are made to the transistor. Then, the FUNCTION switch is set to BETA-CAL, and another knob adjusted to make the meter read to a "CAL" scale marking. The FUNCTION switch is then set to BETA, and the beta is read directly on the scale. There are three Beta ranges, 1 to 50, 10 to 500 and 100 to 5,000. These may be selected by resetting the RANGE switch. Just as in practically all transistor testers, failure to get a Beta reading means that the transistor is bad.

Leakage reading, of course, must be made out-of-circuit for accuracy. Leakage as low as 1.0 μA can be read, as in small-signal silicon transistors. Leakage readings are also simple. After the beta test has been made, the FUNCTION switch is turned on down to the I_{cbo}, I_{ces} then I_{ceo} positions, and the readings noted. I_{ceo} readings should be slightly greater than I_{ces}, if any leakage is shown. If both these readings are the same, the device is bad. If both of the leakage readings are very small, or zero, it's good.

Depletion FET's can be tested just as easily. The FUNCTION switch is turned to the left, and the "Zero-Gm" adjustment set. Turning to the next step reads Gm directly on the meter. Dual-gate FET's can be checked, each gate separately. The FET leakages, I_{gss} and I_{dss} can be measured by setting the FUNCTION switch to the next two positions. The I_{gss} reading is particularly important, since it is a measure of the gate's ability to control drain-source current.

A novel, and very complete, programmed instruction book comes with the Model 162. This is printed on very heavy, durable paper, ring-bound. Heavy plastic covers protect it, and these can be slipped into special notches on the back of the case. The book then lies open on the top of the case, so that the pages can be flipped over to expose only the test being made. Each of these is explained in detail. After you have memorized the manual (!!) it can be slipped into a metal pocket on the back of the case for safekeeping.

The condition of the internal batteries can be checked with ease. Set the Function switch to "BATT TEST" position, set RANGE switch to npn-100 mA position, and short the collector and emitter test leads. The meter will deflect into the "BATT OK" area of the scale if they're in good shape. There are two main battery cells, and life is good. A separate FET bias battery, since it draws no current, lasts for its shelf life.

The operation of the B & K 162 is simple, in theory. It applies collector currents in ranges between 1.0 mA and 1.0 ampere, then the meter reads the base current needed to get this collector current. The beta of the transistor is then computed automatically from the amount of this base current needed. This is for in-circuit testing, where the normal load impedance is present. For out-of-circuit testing, the 162 incorporates a simulated collector-to-emitter load, so that actual operating conditions for the transistor are duplicated as closely as possible.

This is very useful, when checking for thermal runaway, avalanche and other odd conditions which can make trouble for you; the "slow-heaters" which act up after the set has been running for some time. If you don't believe it, check one of those miniature "power transistors", and then touch the case with your hand. It will be warm! This is a useful test that can save you a lot of callbacks!—*Arthur Cunningham* **R-E**

COMING NEXT MONTH

APRIL 1971

AUTOMOTIVE ELECTRONICS MONTH

- **Look What Detroit's Putting Under The Hood**

  . . . and in the trunk, and behind the dash. A rundown of all those electronic items you can get in your next car.

- **Car Stereo Is In**

  Which tape system is best? 4-track cassette? 8-track cartridge? 2-channel stereo? 4-channel stereo? Here's a rundown on the various systems and a briefing on their comparative advantages and disadvantages.

- **Build Automatic Parking Light Operator**

  Automatically turns your parking lights on when it gets dark, and turns them off when you get out of the car. Easy solid-state project you'll want to try.

- **Build Low-Fuel Indicator**

  Don't ever run out of gas again. This little circuit warns you when you're down to the last couple of gallons.

- **The Mechanical Side Of Cassette Recorders**

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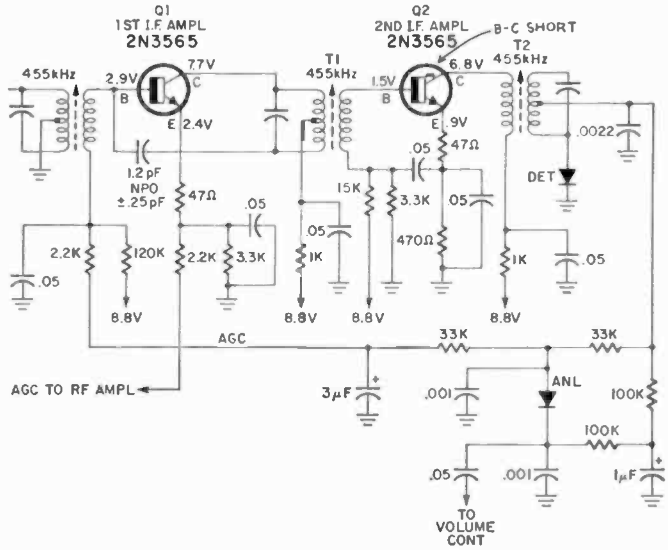
CB Casebook

Andrew J. Mueller*

Case 1: Unit does not receive. Transmit is ok.

Common to: Raytheon TWR-9



Remedy: Replace Q2.

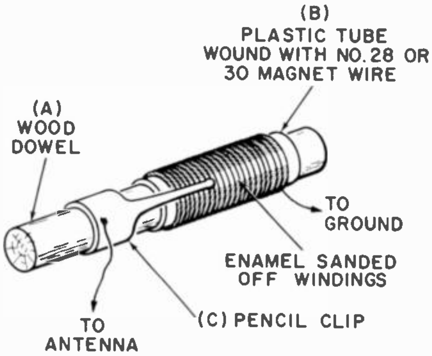
Reasoning: Q2, the second i.f. transistor, has a base to collector short. This, of course, renders the stage inoperative. Replacing Q2 and a little "touch up" alignment of T1 and T2 will restore normal operation. **R-E**

*Service Manager, Tel-Air Communications, Inc., Pewaukee, Wis.

TRY THIS ONE

ADAPTER FOR FERRITE ROD ANTENNA

It is sometimes desireable to add an outside antenna to a broadcast receiver with ferrite-rod antenna. A miniature "loose coupler" does the trick beautifully. Section A is a 3-in. length of wooden dowel that has been soaked in hot parafin. A 1½-in. length of plastic tubing (B)—selected to slide freely on dowel A is close-wound with 28 or 30 magnet wire. The enamel is scraped off the wire to form path for pencil clip (C) which is attached to an outside antenna.



The method of attaching coupler to ferrite rod assembly will depend on construction of receiver. If there is room inside the case or cabinet, place the adapter end on or parallel to the ferrite antenna. Hook up outside antenna. Adjust clip and sliding coil for optimum results. Tape in place and forget it.

If odd size coil form tubing is not readily available, wind a 1½-inch wide strip of paper that has been lightly coated with white glue around a suitable form (a scrap of dowel will do). Remove quickly and allow to dry. Note: measurements given are not critical and may vary.—*John H. Laurie*

CHECKING XTAL CARTRIDGES

Popular crystal phono cartridges can be checked with the aid of inexpensive penlight-type signal injectors. The injector output, usually a pulse at an af rate, can usually generate sufficient movement of the cartridge element to be heard.

Before touching the hot pin(s) of the cartridge, touch the ground pins with a finger to provide a high impedance return similar to what the cartridge works into.

(We assume the use of an injector with a case internally connected to the circuit ground as most are. If the injector has a ground lead, it should not be connected directly, as the high peak pulse output voltages of some may damage the cartridge element if the element is driven at a low impedance.)

Your skin resistance is a safety factor for the cartridge, and a convenient high impedance for the injector.—*Dan Sharp*

TWO HANDY TOOLS

Here are two handy tools for servicing printed circuit boards. The first (Fig. 1) is useful when checking voltages. It permits you to hold and manipulate two test prods with only one hand. It is made from a length of stiff wire with a 1-inch loop in the center and a loop at each end for a snug fit around the insulated part of the probe.

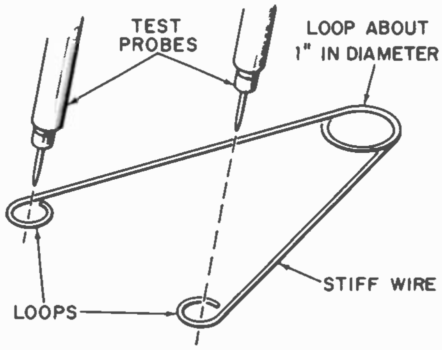


FIG. 1

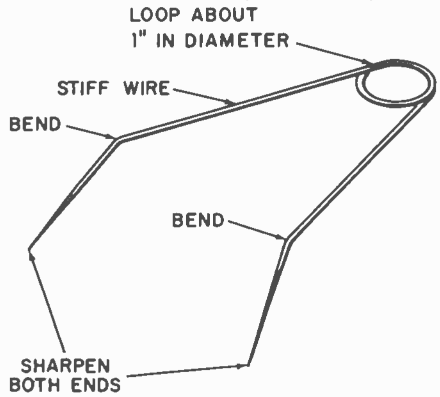


FIG. 2

The jumper in Fig. 2 is used to find broken connectors on circuit boards. Sharpen the ends and cover the wire with spaghetti tubing before bending.—*Enrique Garcia Rosas* **R-E**

NEXT MONTH

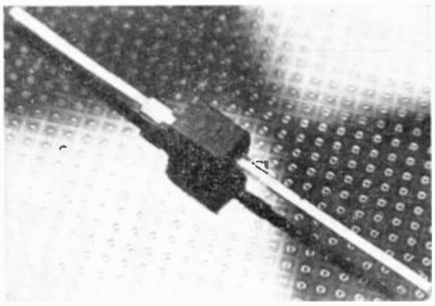
It's R-E's automotive month in the April issue. You'll find a variety of articles on the ways electronics can be and are being used in the new cars. Plus, there'll be some construction add-ons you can make for your car. So if you drive a car, don't miss the April issue.

NEW TUBES AND SEMICONDUCTORS

NEW VARACTOR DIODE

A new series of low-cost varactor diodes with high Q, linear response and a capacitance range of 5: to 1 at 3 to 30 volts has been developed by Kollstan (a facility of Standard Kollsman Industries) for use in solid-state television tuners, instrumentation, remote frequency controls and microwave circuits.

The unique junction in the Kollstan varactors provides linear capacitance versus voltage characteristics, eliminating the need for matching diodes where several are used, or where repeatability from circuit to circuit is



required. Elimination of matching simplifies equipment design, reduces production costs and eases service.

The Kollstan diodes are completely passivated devices encased in specially formulated plastic housings. They provide good mechanical shock resistance through solid junction-to-lead construction, and low series inductance and simple mounting through the use of gold plated leads.

Specification sheets on the new SK-210 (2–10PF), SK–420 (4–20PF) and SK–525 (5–25PF) variable capacitance diodes are available from Kollstan Semiconductors, Standard Kollsman Industries, 111 New York Ave., Westbury, N.Y. 11590.

HIGH-EFFICIENCY UHF/MICROWAVE COAXIAL TRANSISTOR

A new silicon npn overlay transistor, the 2N5921, brings higher efficiency to uhf/microwave power amplifiers, fundamental-frequency oscillators and frequency multipliers. This new coaxial transistor is intended for use in semiconductor equipment for microwave communications, S-band telemetry, microwave relay links, phased-array radar, distance measuring equipment, and collision-avoidance systems. Features include a 5-watt output with 7 dB power gain (minimum) at 2 GHz and a 10-watt output with 11 dB gain (typical) at 1.2 GHz. For coaxial, stripline, and lumped-constant circuit applications, the new device is contained in a ce-

ramic-metal hermetic package with low inductance and low parasitic capacitances. It provides highly stable operation in the common-base amplifier configuration.

For more technical information on the RCA 2N5921 transistor, write RCA/Electronic Components, Commercial Engineering, Harrison, New Jersey 07029.

LINEAR IC FOR TV SOUND SYSTEM

The CA3065 IC combines a multistage i.f. amplifier and limiter, FM differential peak detector, electronic attenuator, Zener diode regulated power supply, and audio amplifier designed to drive directly an npn transistor or high-transconductance vacuum tube.

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The RCA CA3065 utilizes a 14-lead quad-in-line plastic package with leads specially formed to facilitate automatic insertion of the device into printed-circuit boards. R-E

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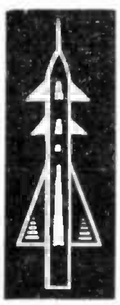

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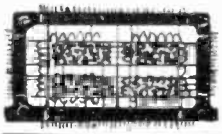

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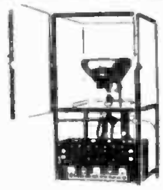

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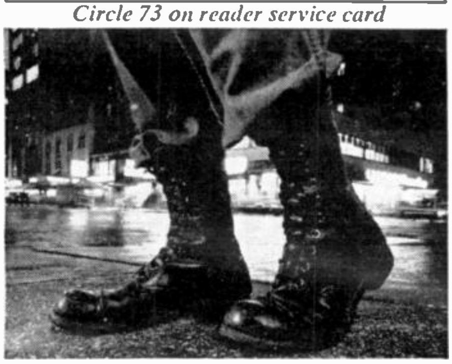

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☐ N-CHANNEL FET'S TO-18 plastic units, low noise, low leakage, 25 volts source to gate, 50 ma gate current Gain to 9000 μmho's. $ .60

2N4303. P channel FET with a Q ms of 2000 μohms ....$.95

LIGHT EMITTING DIODES (LED's) Infra red or visible . .$1.25 ea. Photo detectors for each . $1.00

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These kits are used to mount our SCR's Zeners and Rectifiers etc. 6x32 stud (3, 12 amp rectifiers, 7A SCR's) 6 sets/$1.00 ¼x28 stud (30 amp. rectifiers, 20 amps SCR's) 4 sets/$1.00

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Silicon Power Rectifiers

PRV	3A	12A	30A
100	.09	.24	.40
200	.12	.28	.60
400	.16	.35	.90
600	.20	.5D	1.10
800	.28	.7D	1.40
1000	.35	.90	

Terms: FOB Cambridge, Mass. Send check or Money Order. Include Postage. Average Wt. per package ½ lb. No. C.O.D.'s. Minimum Order $3.00

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1/32" 2.5 mil. fibers in PVC packet. $ .33/ft.

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Controlled Avalanche or Epoxy Rectifiers 1 AMP.

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400	.09	1000	.20

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SE 501 Video Amp $1.00

Silicon Control Rectifiers

PRV	3A	7A	20A	70A
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100	.30	.38	.85	3.50
200	.50	.60	1.10	6.50
300	.60	.68	1.30	
400	.70	.75	1.50	9.50
500	.80	.85	1.70	
600	.90	1.20	1.90	11.00

14 pin dual in line sockets 4/$1.00

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INTERNATIONAL

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- Extended Range Covers 950 MHz Band
- Pin Diode Attenuator for Full Range Coverage as Signal Generator
- Measures FM Deviation

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The FM-2400CH with its extended range covers 25 to 1000 MHz. The frequencies can be those of the radio frequency channels of operation and/or the intermediate frequencies of the receiver between 5 MHz and 40 MHz.

Frequency Stability: ± .0005% from +50° to +104°F.

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Self-contained in small portable case. Complete solid state circuitry. Rechargeable batteries.

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CURTIS MATHES: 7A11, 7A17, 7A38, 7A48, 7A050, 7A53-001, 7A056-001, 7A59-001

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GE: ET86X188, ET86X208, ET86X212, ET86X213*, ET86X214, ET86X215, ET86X221, ET86X224, ET86X227, ET86X230, ET86X231, ET86X232, ET86X236, ET86X242, ET86X244, ET86X255, ET86X256, ET86X265, ET86X277, ET86X281

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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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