Install Intercom/Music System in Your Home

60¢ ■ MAY 1968

Radio-Electronics

TELEVISION · SERVICING · HIGH FIDELITY

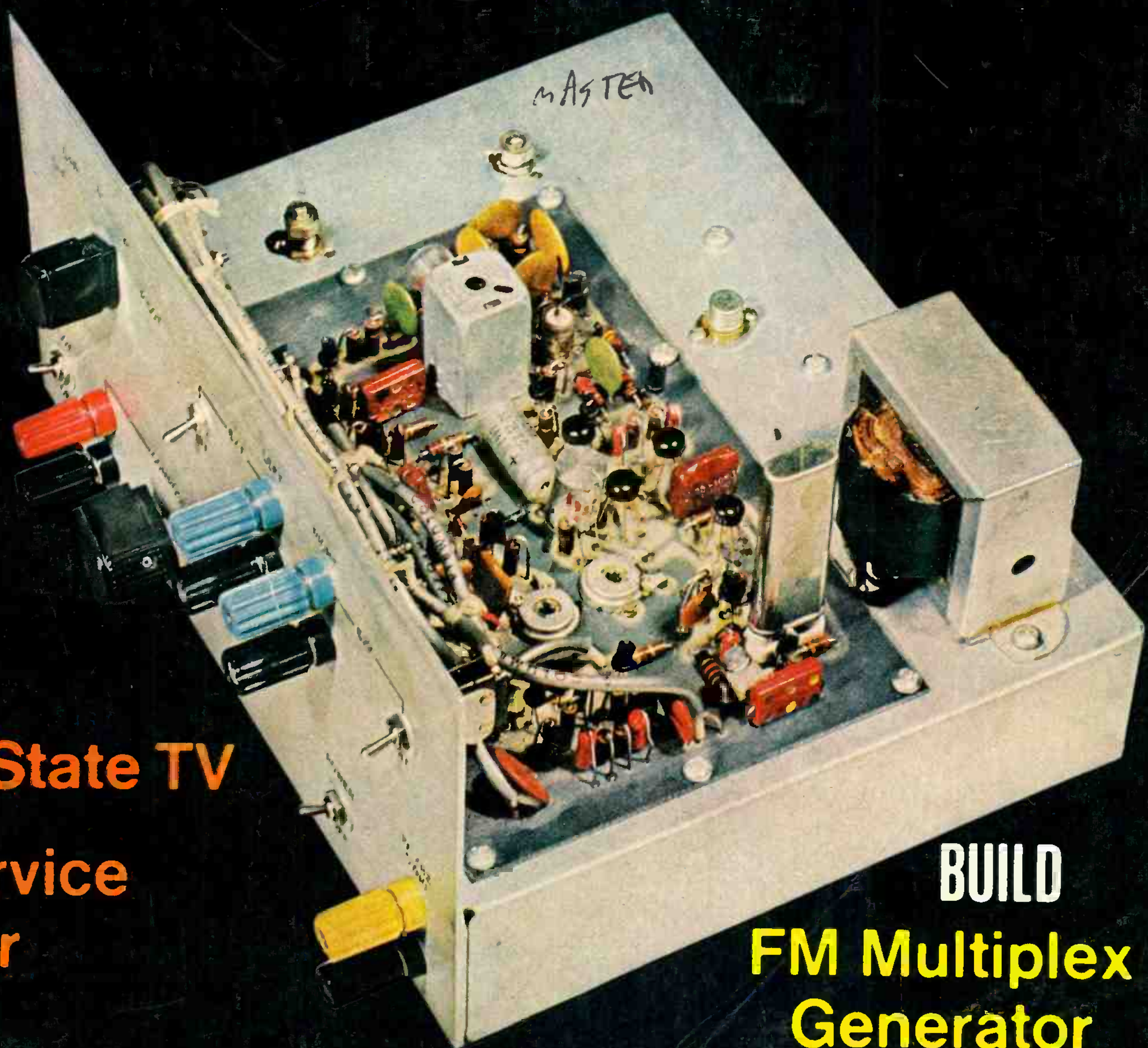
A GERNSBACK PUBLICATION

EXPERIMENT WITH...

Operational Amps

Vibrating Wire Filters

Get in on the Big Boom in Sound



SERVICE

Solid-State TV

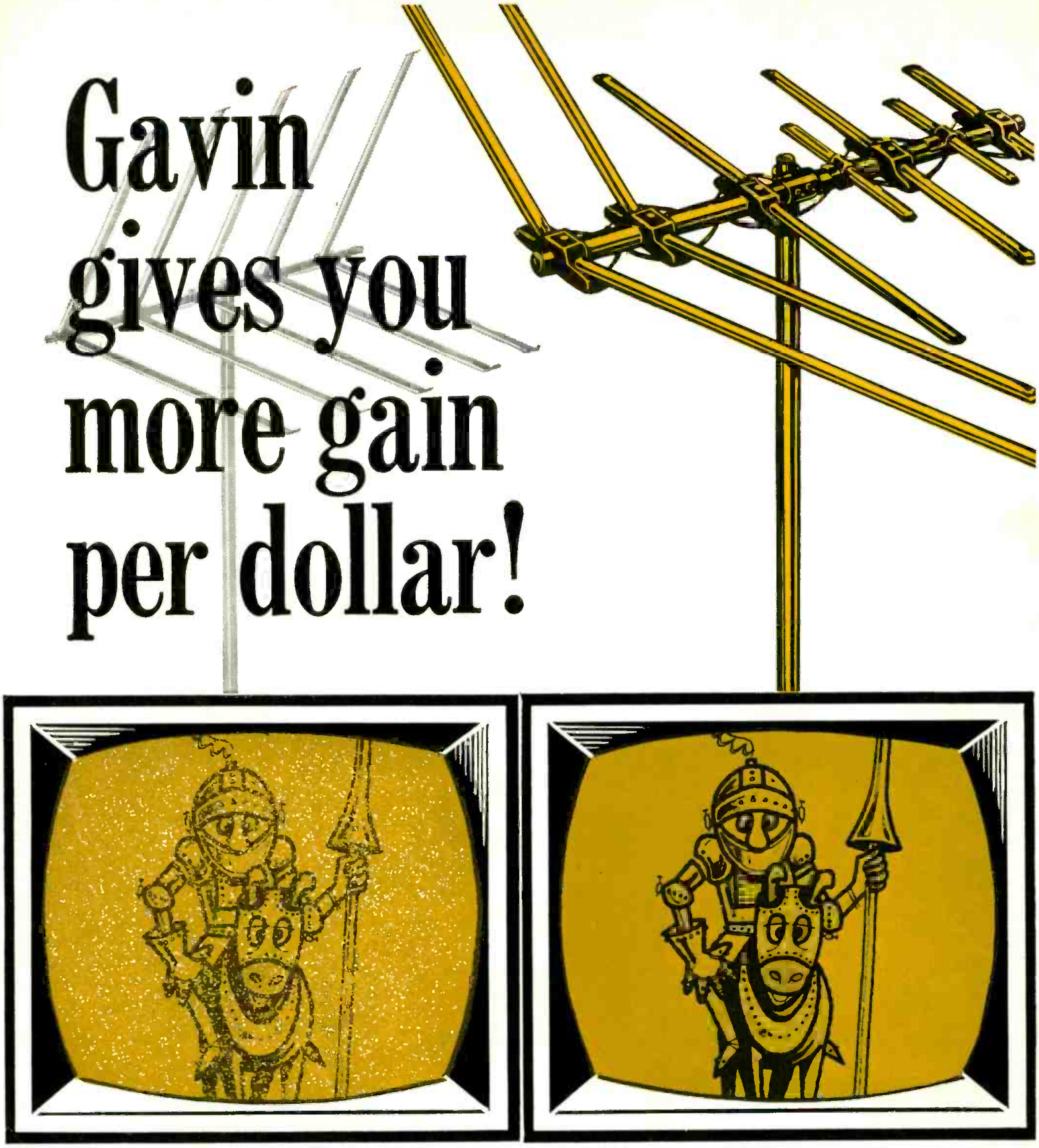
TV Service Puzzler

BUILD

FM Multiplex Generator

(see page 32)

Gavin gives you more gain per dollar!



Side By Side Tests Prove...

...that model for model, dollar for dollar, the new Gavin V-Yagi design outperforms any other type of antenna you can buy.

Here's how the test works: We hoist your favorite antenna up on our specially equipped van. We check the signal pick-up on a field strength meter and a color receiver simultaneously. Then, we replace your antenna with a Gavin antenna costing the same or less. The results are eye opening.

Ask us to set up a side-by-side test for you. Invite a representative of the antennas you now handle to observe the demonstration—or set it up himself if he likes. The field strength meter tells the truth no matter who's asking the questions.

Once you see this test, you'll probably switch to Gavin. What are you waiting for?

Circle 7 on reader's service card

Gavin

GAVIN INSTRUMENTS, INC.
Subsidiary of ADVANCE ROSS CORP.
Somerville, N. J. 08876 U. S. A.

LOOKING AHEAD

By DAVID LACHENBRUCH

This is the beginning of "Looking Ahead." In it each month newscaster, author, editor and prognosticator Dave Lachenbruch will present what appears to be at the moment, the most significant happenings in our industry with an eyeball on how these events may shape our future.—Ed.

Electronic TV tuning

The next major advance in TV receiver design will be the elimination of the sole major mechanical part—the clanking, failure-prone multicontact tuner. All tuner manufacturers are working on designs for electronic tuning devices, and the first one announced for production in this country (some are already in use in Europe) could appear in 1970 models to be introduced in mid-1969.

Standard Kollsman Industries' vhf tuner employs varactors—variable-capacitance diodes—to tune all resonant circuits, eliminating as many as 157 contacts. A uhf version is scheduled later. In the varactor tuner, all signal-carrying switches and contacts are eliminated. In addition to reliability, other potential advantages are extreme compactness and design flexibility—the actual tuner no longer must be mechanically connected to the channel selector. By using only a variable voltage source for tuning, the varactor makes practical some unique channel-selection methods, including signal-seeking, sliding bars and pushbutton panels.

Another advanced tuner, which could be in production TV sets somewhat sooner than the SKI varactor unit, is a completely integrated vhf–uhf tuner by Oak Electro/Netics, in which all components perform the same functions in both vhf and uhf bands. Another Oak development is a tiny sealed metal cube which contains virtually all the tuner's electronics in a hybrid thick-film circuit. It's expendable, can be pulled out and replaced like a receiving tube (predicted cost, $3 to $5) to eliminate many tuner overhaul jobs.

The long way home

Those who dream of a mass-market home video recorder are taking the longitudinal route again—fixed head, high speed, with tracks running the length of the tape. The slant-track (helical-scan), revolving-head approach of Ampex, Sony and others has been well received for industrial, commercial and educational closed-circuit use, but has never made it to the home.

You can now expect a new generation of lower-cost machines which work more or less like speeded-up audio recorders, following the trail blazed in 1963 by Telcan, but using a more sophisticated approach. Major interest now is centered on new tape-transport mechanisms designed to make more practical the high speeds at which longitudinal recorders must operate. One transport, developed by Newell Associates, uses a large capstan to guide tape from the feed reel, across the head, to the take-up reel, eliminating all drive functions of the tape itself.

An adaptation of this approach is used by Arvin Industries in a home color VTR scheduled for marketing late this year or early 1969. The Arvin recorder uses ½-inch tape in a 10-inch cartridge and records 10 longitudinal audio–video tracks, reversing itself every 6 minutes for an hour of playing time per reel. The picture is lost for less than a second during tape reversal. Arvin hopes to sell its unit, which combines the VTR with a 23-inch color set in a console cabinet, for $1000 to $1500.

New all-channel rules?

Despite these promises of better tuners, set manufacturers have been accused of dragging their feet on improvements in uhf tuning. Uhf broadcasters have asked the FCC to issue new regulations under the All-Channel Law of 1962 to specify that uhf tuning must be as simple and as sensitive as vhf tuning in any given set. The FCC seems likely to hold hearings on the subject. Among the uhf broadcasters' complaints: Vhf tuners have detent action, while uhf tuning usually is continuous. The uhf band is being discriminated against say the broadcasters, but the manufacturers grumble that if the FCC demands "tuning equality" they may have to reduce vhf tuner quality or raise prices to cover expensive uhf detent devices.

Reassurance on X-rays

Alarm is giving way to reason on the color TV X-ray front. Virtually unmentioned during the earlier days of the controversy were two significant facts: (1) There is no record of any detectable injury to anyone exposed continually to radiation at the levels emitted by "defective" color sets. (2) It has been demonstrated in the last decade that exposure to such low-level radiation is not cumulative. Dr. Victor P. Bond, associate director of Brookhaven National Laboratory, sums it this way: "While it is prudent to control and severely limit exposure to radiation (as well as to all other potentially injurious agents), it is quite clear that the probability of significant or even detectable medical effects from X-rays emitted from faulty television receivers is vanishingly small."

Something's got to give

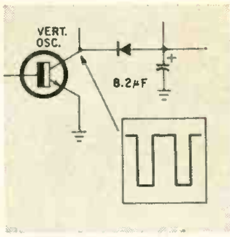
The various radio services' needs for chunks of the crowded spectrum are putting increasing heat on the sprawling TV band. Mobile radio desperately requires breathing space, and its users have their eyes on the lower uhf TV band, particularly channels 14 to 35. Most proposals envision the use of this space on a shared basis with TV broadcasters. The latest voice to be heard is that of Secretary of Transportation Alan Boyd. Noting that many uhf TV channels are still vacant, he has proposed that unused frequencies be leased to the land-mobile services until the assigned TV station is ready to go on the air. Many more mobile systems could be accommodated—one TV channel can support 240 radio channels. **R-E**

Radio-Electronics

May 1968 • Over 60 Years of Electronics Publishing

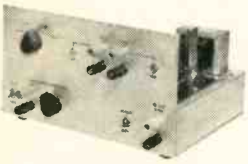
Get in on the new boom in sound. It's not what it used to be—new portable earsplitting equipment includes close-talking microphones, high-powered amplifiers and shatterproof speakers.

See page 46



Components closely knit to printed circuit boards resist separation without destruction. The finer the isolation of trouble, the less the destruction.

See page 36



Solid state stereo FM multiplex generator features audio preamplifiers with built-in pre-emphasis, 40 to 50 dB channel separation, hum and noise down 52 dB from reference output and simple construction. A printed circuit board is available.

See page 32

DEPARTMENTS

RADIO-ELECTRONICS, MAY 1968, Volume XXXIX, No. 5.
Published monthly by Gernsback Publications, Inc., at Ferry St., Concord, N. H. 03302.
Editorial, Advertising, and Executive offices: 200 Park Ave. S., New York, N. Y. 10003. Subscription Service: Boulder, Colo. 80302.
Second-class postage paid at Concord, N. H. Printed in U.S.A. One-year subscription rate: U. S. and possessions, Canada, $6. Pan-American countries, $7. Other countries, $7.50. Single copies: 60c.

POSTMASTER: Notices of undelivered copies (Form 3579) to Boulder, Colo. 80302.

Member,
Institute of High Fidelity.
Radio-Electronics is indexed in *Applied Science & Technology Index* (formerly *Industrial Arts Index*)

NEWS BRIEFS

BRIGHTEST COLOR PICTURE

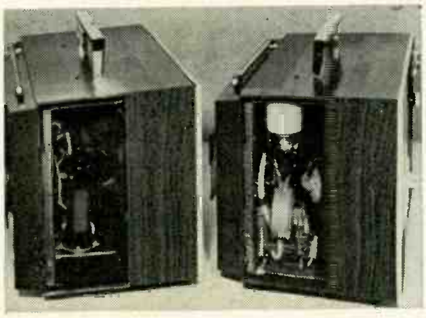
A new color TV picture tube developed by Sylvania is claimed 23%

to 69% brighter than other picture tubes. Several advances have contributed to the new tube, including improved phosphors, a new electron gun, a new temperature-compensated mask, and an advanced method of dusting phosphors onto the faceplate.

Photo shows a Sylvania engineer measuring brightness of the new tube.

NO-WINDING TRANSFORMER

Using the piezoelectric ceramic (PCM) characteristic, Matsushita Electric has developed a new TV high-



voltage transformer with no windings. An ac voltage of 200 volts applied to the driving section of new PCM transformer causes it to vibrate mechanically. Unit then produces a high voltage of 10,000 to 12,000 volts. It is 1/5 in size and 1/4 in weight of a conventional flyback transformer.

Photo shows transistor TV set using new PCM transformer (left); next to it is the same size set using a conventional flyback.

CARBON TET BAN SOUGHT

The Federal Food and Drug Administration has proposed that carbon tetrachloride be banned from interstate commerce. The agency recommended that the chemical—and mixtures containing it—be banned as hazardous to health. Also prohibited would be the use of carbon tet in fire extinguishers.

FDA cited the danger of inhaling carbon tet fumes, which can cause death or serious injury to internal organs.

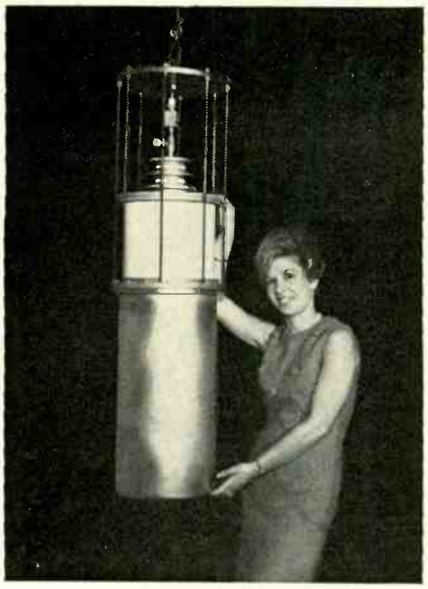
MICROWAVE COOKING

A 16-pound turkey normally takes about 4 hours to cook in a conventional oven, but by using the new RCA FE2100 tube cooking time can be cut down to a little more than an

hour. Only the food gets hot; the utensils remain cool. Tube operates at 915 MHz, requires only 20 seconds warmup and does without the heavy magnet structure employed in the formerly used magnetrons.

MONSTER FIRE BOTTLE

Who says vacuum tubes are obsolete? Not ITT Electron Tube Division, which has developed the world's most powerful single triode. The tube (see photo) has a plate dissipation of 390



kW, filament current of 1,025 amps (at 29 volts) and weighs more than 300 lb.

The gigantic thermionic-emission device can deliver 90-megawatt peak pulses as a hard-tube radar modulator driving a klystron. The tube can also be used in a nuclear research particle accelerator.

ARMED FORCES DAY MILITARY/AMATEUR TESTS

The annual Armed Forces Day military-to-amateur cross-band tests will be conducted on May 18, 1968. Certificates of merit will be awarded to persons submitting a perfect copy of the message from the Secretary of Defense that will be broadcast during the tests from 0900 May 18 to 0245 May 19 (GMT).

In addition, the Naval Communications Station in Washington, D.C., will be open for area amateurs who wish to participate in the test transmissions.

Initially, military stations will listen for calls from amateur stations within amateur bands. Since this is a test of military-to-amateur communications, no traffic handling or message handling will be permitted. Contacts will be limited to brief exchanges of location and signal reports.

Transmission of radioteletype and CW receiving contests will begin at indicated times with a 10-minute CQ call to permit participants to adjust equipment. The CQ will be followed immediately by the message from the Secretary of Defense.

Navy station NSS in Washington, D C., will transmit 25 wpm CW on 3357, 4015, 7301 and 14,480 kHz during the test period. A 14.0–14.2-MHz CW broadcast of the Secretary's message will start at 2300 (EDST) May 18.

Radioteletype transmissions will be made at 60 wpm on 4012.5 and 7380 kHz. NSS will listen for responses on 3.60–3.65, 7.0–7.05, 7.1–7.15 and 14.05–14.10 MHz. Radioteletype broadcast of the Secretary's message will begin at 2335 (EDST) May 18.

Additional send frequencies include 4040 kHz (SSB) and 14,386.5 kHz (USB). Additional receive frequencies include 3.8–4.0 and 14.2–14.35 MHz.

Provided it is consistent with operational and training commitments, radioteletype via audio-frequency-shift keying will be transmitted on 143.820 MHz from a Navy aircraft flying between Washington, D.C. and Boston during a major portion of the test.

Copies of the Secretary's message and QSL cards should be sent c/o Commanding Officer, US Naval Communications Station, Washington, D.C. 20390

DIAL-A-CLASS

Students at Tyler (Texas) Junior College will be using new individual study centers (see photo) this fall

when RCA's "Select-A-Lesson" dial-access system goes into operation. User looks up course number in directory, dials number, receives visual and aural program material from central tape processor.

ELECTRONIC TRIPS

A technique borrowed from aircraft pilot training, driving simulation is being used to determine what can

be done in an emergency on the road. General Motors engineers have coordinated visual and aural information (film and tape) which is fed into an electronic control console. Passenger compartment moves in response to driver's manipulation of the steering wheel, accelerator and brake pedal.

ELECTRONIC NIGHT WINDOW

A foot-square screen behind the windshield of a plane may soon give aircraft pilots their first clear, realistic view of night-darkened terrain.

The system uses an image-intensifying TV camera tube to pick up the scene ahead of the aircraft. As the photo shows, the video image is then

projected on the screen behind the windshield. To the pilot, the video images have the same depth, size and realism as daylight scenes and appear as real objects in their true positions. Since the system emits no radiation, it cannot be detected and jammed.

System, developed by Kollsman Instrument Corp. for the Army, is being tested at Fort Belvoir, Va. **R-E**

Correspondence

TECHNICIAN DEVELOPMENT PROGRAM

In News Briefs (January, 1968) there is an article entitled, "Technician Development Program." I am an instructor in a new vocational technical school in Chillicothe, Mo., and I would like to contact the E.I.A. about their films and seminars. What is their address? Also, can you give me the name and address of a professional organization now noted for activity in the Electronics field?

ROBERT J. CHENOWETH
Trenton, Mo.

Robert, E.I.A. offices are at 2001 Eye St., N.W., Washington, D.C. There are several national organizations of electronics technicians. NATESA, 5908 S. Troy St., Chicago, Ill., 60629 is one of them. Why not contact Otto Horak, President of TESA of St. Louis, Mo., at 4933 Delmar.

AC-DC CALIBRATOR

✓ p42

The "AC/DC Calibrator for Scope and Voltmeter", (February, 1968) was recently completed. Problems followed. The unit performs perfectly on dc, but not on ac. I am trying to calibrate a Heath IM-13 VTVM which measures rms and a Simpson 260 which is also in rms units. The meters work properly, but the readings are way off. If I apply 100 volts ac peak-to-peak to my voltmeter and adjust the calibration potentiometer so that the meter reads 50-volts rms, and then use the meter to check the 117-volt ac line, I get a 155-volt reading. The power company assures me this is not so.

DR. JACK STROM
Munster, Ind.

Your procedure is correct, but the rms voltage of the 100 volt peak-to-peak source is 35.4 not 50. (Sutheim must have been measuring his pulse rate at the time.) A sharp spiked waveform has very little rms voltage and in this case it would be better to predetermine what it actually is, by measurement with another properly

(continued on page 12)

Radio-Electronics

200 PARK AVE. SOUTH
NEW YORK, N. Y. 10003

HUGO GERNSBACK (1884-1967)
founder

M. HARVEY GERNSBACK, *publisher*
ROBERT CORNELL, *editor*
Robert F. Scott, *W2PWG, senior editor*
John R. Free, *associate editor*
Jack Darr, *service editor*
I. Queen, *editorial associate*
Matthew Mandl, *contributing editor*
David Lachenbruch, *contributing editor*
Linda Albers, *assistant to editor*
Wm. Lyon McLaughlin,
technical illustration director
Bruce Ward, *production manager*
Sandra Esteves, *production assistant*
G. Aliquo, *circulation manager*

Cover by Harry Schlack

RADIO-ELECTRONICS is published by Gernsback Publications, Inc.
President: M. Harvey Gernsback
Vice President-Secretary: G. Aliquo

ADVERTISING REPRESENTATIVES

EAST
John J. Lamson,
RADIO-ELECTRONICS, 200 Park Ave. South
New York, N. Y. 10003, 212-777-6400

MIDWEST/N.&S. Car., Ga., Tenn.
Robert Pattis, the Bill Pattis Co., 4761 West Touhy Ave., Lincolnwood, Ill. 60646, 312-679-1100

W. COAST/Texas/Arkansas/Oklahoma
J. E. Publishers Representative Co., 8380 Melrose Ave., Los Angeles, Calif. 90069, 213-653-5841; 420 Market St., San Francisco, Calif. 94111, 415-981-4527

UNITED KINGDOM
Publishing & Distributing Co., Ltd., Mitre House, 177 Regent St., London W.1, England

SUBSCRIPTION SERVICE: Send all subscription correspondence and orders to RADIO-ELECTRONICS, Subscription Department, Boulder, Colo. 80302. For change of address, allow six weeks, furnishing both the old and new addresses and if possible enclosing label from a recent issue.

MOVING? Or writing about subscription? Be sure to fill out form below.

For FASTEST service on address change, missing copies, etc., attach old mailing label in first space below. Otherwise please print clearly your address as we now have it.

OLD ADDRESS (Attach old label if available)

Name ....

Address ....

City .... State ....

Zip Code ....

NEW ADDRESS

Name ....

Address ....

City .... State ....

Zip Code ....

Mail to: RADIO-ELECTRONICS
Subscription Dept. Boulder, Colo. 80302

Discover the ease and excitement of learning Electronics with programmed equipment NRI sends you

When you train at home with NRI, you train with your hands as well as your head. You learn the WHY of Electronics, Communications, TV-Radio the NRI pioneering "3-Dimensional" way. NRI training is the result of more than half a century of simplifying, organizing, dramatizing subject matter, and providing personal services unique for a home study school. You get the kind of technical training that gives you priceless confidence as you gain experience equal to many, many months of training on the job.

NRI—The 53 Year Leader in Electronics Training

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

Earn $5 or more an hour spare or full time in

TV-RADIO SERVICING

Color Television has arrived. Sales are soaring, along with the continuing popularity of other home entertainment equipment like portable radios, tape recorders, hi-fi sets, phonographs and auto radios. TV-Radio servicing is one of your best routes to spare-time earnings, a good paying job or a business of your own. NRI not only trains you quickly and expertly, but also shows you how to get started in Servicing soon after you enroll, earning as you learn. NRI trains you in today's methods of installing and repairing all Electronic equipment for the home—including booming Color TV. You even build, experiment with and keep to enjoy your own solid-state radio and your choice of black-and-white or Color TV receiver. Like thousands of others, you can be earning $5 or more an hour extra in spare time starting soon.

There's money and success awaiting you in

BROADCASTING—COMMUNICATIONS

The experience you gain from intensely practical NRI training in Complete Communications equals as much as two years of training on the job. With NRI, you can train for a choice of careers ranging from mobile, marine and aviation radio to TV broadcasting and space communications. You learn how to install, maintain and operate today's remarkable transmitting and receiving equipment by actually *doing* it. You build and experiment with test equipment, like a VTVM you keep. You build and operate amplifier circuits, transmission line and antenna systems, even build and use a phone-cw transmitter suitable for transmission on the 80-meter amateur band. Whichever of five NRI Communications courses you choose, you prepare for your FCC License exams, and *you must pass your FCC exams or NRI refunds your tuition in full.*

Move ahead in America's fast growing industry as

ELECTRONICS TECHNICIAN

Electronics touches everyone's lives. This vast field of opportunity is open to you with NRI training. Industrial/Military Electronics training—like all NRI courses—prepares you quickly, thoroughly the practical "hands on" way. You build with, and learn to understand the functions of, today's miracle solid-state components like printed circuits, diodes and transistors. You build and experiment with Electronic circuitry used in automation, data processing, ultrasonics, telemetry. Whatever your interest in Electronics, NRI training can fill your needs. Prove to yourself what nearly a million NRI students could tell you . . . that you get more for your money from NRI. Check the postage-free card and mail it today for your FREE NRI Color Catalog. No salesman will call. NATIONAL RADIO INSTITUTE, Electronics Division, Washington, D.C. 20016.

YOU GET MORE FOR YOUR MONEY FROM NRI— Build, test, explore, discover. Everything you see here is included in one NRI course—including Color TV. Other courses equally complete. And you'll be surprised at the low tuition costs. Text for text, kit for kit, dollar for dollar—you get more for your money from NRI.

CORRESPONDENCE

(continued from page 6)

calibrated rms reading voltmeter or by following the scope comparison procedure as described in the article.

HEATHKIT VOM EQUIPMENT REPORT

Thanks for the kind words on the IM-25 "Equipment Report: Heathkit IM-25 Solid-State Vom," (March 1968). They are appreciated. I'm sending Mr. Tom Haskett a new probe. They are a bit tricky. Spring adjustment helps. By the way, you don't have to remove the cabinet back to replace batteries. Just take the bottom shell off, loosen 2 screws on the back panel and the battery holders drop out. The "unknown" engineer was E. A. (Bud) Taylor.

EARL F. BROIHIER
Mgr. Adv. & Sls. Promotion
Heath Company
Benton Harbor, Mich.

. . . The old VOM habit (erroneously carried over into VTVM use) of checking ohms zero with probes shorted, and then resetting full scale ohms, is a hard one to break! Thus, checking zero volts or by shorting the probes on a high ohms range should result in quite accurate readings. The footnote on Page 37 of the instrument's manual outlines a method for somewhat greater accuracy by splitting the non-linearity errors. Also, there should be no need for frequent adjustment because the ohms supply is regulated.

BJORN HEYNING
Chief Engineer, Instruments
Heath Company
Benton Harbor, Mich.

Tom reports that the new probe works fine, and the battery can be installed by loosening 2 screws on the back panel. Maybe it is better to get the ohms control off the front panel, but Tom says he is a diehard stick-shift man.

TIME SIGNALS

I sometimes calibrate shortwave receivers and have found the WWV signals on 2.5, 5, 10, 15, 20 and 25 MHz useful. But, recently I noticed their signal strength has dropped considerably and I have a hard time zeroing in a receiver on them. Can you offer an alternate?

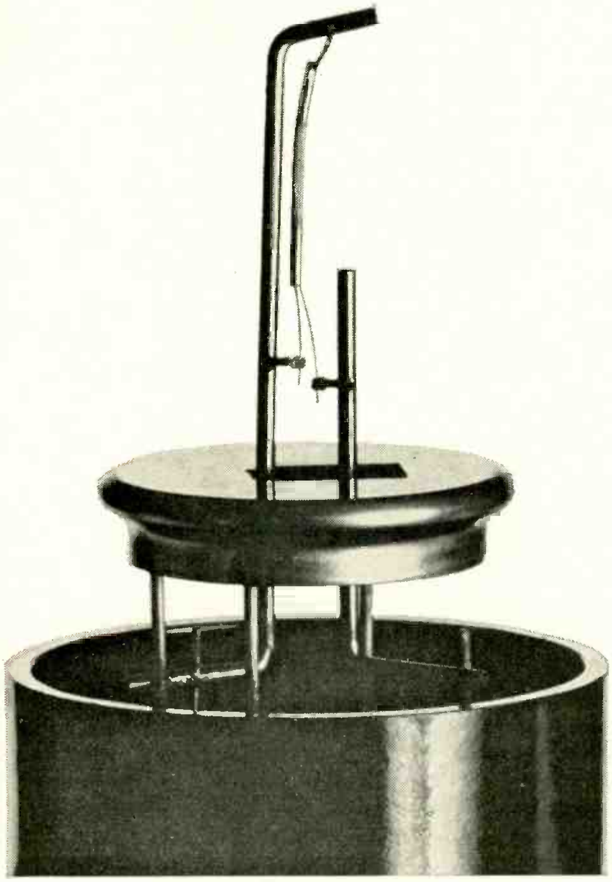
PAUL NORMAN
New York, N.Y.

In late 1966, WWV moved from Greenbelt, Md., to Fort Collins, Colo., which would explain weak signals on

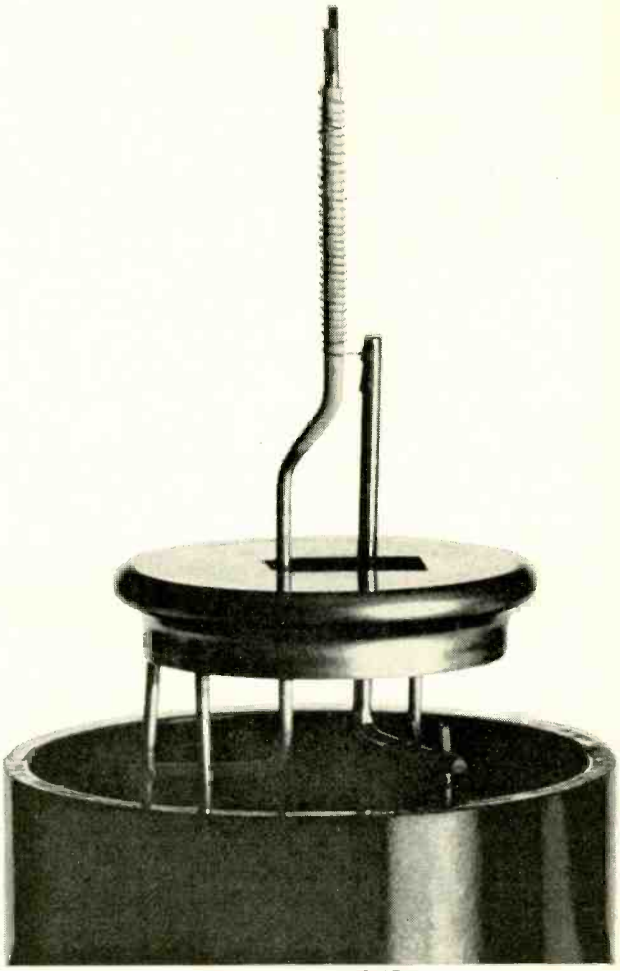
(continued on page 14)

12

We've rectified high-voltage rectifiers.



How it used to be.



Our new 3CU3

Take a look at our new "Posted filament" design.

There's no delicately suspended heater-cathode system. There's no need to heat up a metal sleeve and then an oxide coating.

It takes less than a second for the 3CU3 to start rectifying full swing.

In case of a break, there's no way for the 3CU3's filament to fall against the anode, creating a short and knocking out other components in the circuit.

The 3CU3's filament is always perfectly centered. It emits electrons uniformly in every direction. From a much larger surface than in the old design. There's no suspension post in the way to create an "electron shadow" that cuts down the plate current.

The uniform electric field around the rigid support reduces high voltage stresses. Arcing and its resulting troubles are eliminated.

The 3CU3 is interchangeable with 3A3 and 3A3A high voltage rectifiers. And it's made exclusively by Sylvania.

The 3CU3 is just one of a new "posted filament" family which includes the new 3BL2 and 3BM2. They're designed for use in new color TV sets. These tubes are especially good for transistorized TV where their fast warm-up fits in with the "instant on" feature of solid state circuitry.

The new construction has higher reliability and longer life and should give you fewer and less troublesome callbacks.

From the outside you can hardly tell it's changed.

SYLVANIA

A SUBSIDIARY OF GENERAL TELEPHONE & ELECTRONICS

Circle 15 on reader's service card

Circle 100 on reader's service card

Circle 17 on reader's service card

CORRESPONDENCE
continued

the East Coast. In the Eastern U.S. you will often find stronger signals from CHU, Ottawa, Canada. This station transmits from the Dominion Observatory. Frequencies and powers are: 3.33 MHz, 3 KW; 7.335 MHz, 5 KW and 14.67 MHz, 3 KW. A pulse (200 cycles of a 1000-Hz tone) is transmitted each second, with the following exceptions:

1. *The 29th pulse of each minute is omitted.*
2. *The 51st to 59th pulses inclusive of each minute are omitted.*
3. *The 1st to 10th pulses inclusive are omitted on the first minute of each hour.*

A voice announcement of the time occurs each minute in the 10-second gap between the 50th and 60th second. It refers to the beginning of the minute pulse which follows. The announcement is on the 24-hour system. It is given in both English and French, and takes the form "CHU, Canada, Eastern Standard Time, 10 hours, 21 minutes."

SPEED OF LIGHT HASN'T CHANGED

My compliments on your article "What Are Microvolts Per Meter" (In the Shop . . . With Jack, March, 1968). This article is very informative without becoming bogged down in complex field theory. However, I would like to bring to your attention that the speed of light and the theoretical speed of propagation in free space is 300,000,000 meters per second, not 300,000 meters per second as stated. I realize that this is your antenna and you can use it any way you like; however, light belongs to all of us and we are stuck with 300,000,000 meters per second.

D. A. DAVENPORT
Instructor
Cleveland Institute of Electronics
Cleveland, Ohio

Thanks for the lesson D. A. . . . Jack is a pro in this business, and like most pros he'd rather work with fewer zeros. Elsewhere in the text he does say, "300 MHz is 1 meter long." Even so, we're giving Jack three goose eggs.

MODIFICATION FOR COMPACTRONS

I have an old PACO T-60 tube tester which has 10 selector switches for connecting the tube elements. I decided to modify the tester so that it could accept the new 12-pin compactron tubes. The problem was that I had two more socket pins than selector switches, and almost no room on the chassis to add more switches. I solved it this way: Thumbing through the tube manual I discovered that all compactrons have the filaments wired to pins 1 and 12. Therefore I wired socket pin 1 permanently to the 0 volt (normal) bus, and socket pin 12 to the filament voltage selector bus. I connected socket pin 11 to the selector switch normally used for pin 1. Now the filament begins heating as soon as I plug the tube in. But a 10-switch tube tester checks 12-pin tubes.

EUGENE SHUBE
Elmont, N.Y.

VIBRATO, TREMOLO AND TREMULANT

The vibrato-tremolo trap was sprung in the, "Build An Electronic Tremolo" (February, 1968). Mr. Keenan has made the not uncommon mistake of oversimplification. He is correct in stating that vibrato and tremolo are not the same. He is also correct in calling vibrato a form of frequency modulation, but he neglects some important related factors. Tremolo is not rapid change of loudness, but is quick reiteration of the same or different tones. Its most perfect application is probably the bowed tremolo of stringed instruments. In wind instruments (including the pipe organ) a problem arises when this effect is attempted. Due to the elasticity of air the individual tones are not truly separated, but overlap. A wind player may effectively stop the air supply several times a second through muscular control. The more rigid mechanical components usually do not completely stop the organ's air supply. This is not for musical reasons, but to avoid secondary noise in the action. In either case, air continued to move and the result of this attempt to produce tremolo is *vibrato*. This overlapping (pulsation if you will) produces a lowering of pitch and intensity, and a change in the number and strength of overtones present (tone color). A critical listener can hear this easily. Vibrato is a "periodic pulsation of pitch, loudness or timbre." In effect, vibrato can be produced in more than one way through interaction of different elements of tone. Wind instruments can not produce a tremolo on a single tone. Any instrument can produce a tremolo using two tones. Pipe organ builders frequently use a third term, *tremulant*, to describe a vibrato which is produced by a less than complete tremolo. Mr. Keenan has described a means of building an electronic *vibrato.*

JAMES S. UPTON
Alma, Mich.
RE

15

In the Shop . . . With Jack

BY JACK DARR

ANTENNAS

TV ANTENNAS ARE LARGE STRUCtures composed of aluminum tubing, fastened on housetops to provide convenient roosts for birds. Far too many technicians think that this is true; antennas are strictly for the birds. This accounts for a lot of very short-range CB and communications troubles. They're not for the birds.

That sounds a little silly, but it is intended to bring up the real subject of this discussion—the importance of the proper antenna on CB and communications systems. CB receivers are quite sensitive, and communications receivers have amazing sensitivity, but the transmitters demand the *right* antenna before the transmitter can be heard much farther than the length of a football field.

Too many technicians are using antennas that are about as efficient as a straightened-out coat-hanger or an old bedspring. *All* transmitting antennas are very critical; in CB, even more so. You might not miss the loss in the 50–75-watt output of a police radio, but with the flea-power CB transmitters, you certainly will!

The purpose of the transmitting antenna is to radiate the rf power from the final stage into the surrounding air (or ether; take your choice). Even a very small error in measurement, mistuning, or mismatching can reduce the power output to nearly zero. Fringe benefits: A properly tuned antenna gives the receiver maximum sensitivity, too. Any technician can install a CB antenna and tune it up; there is no FCC regulation which prohibits this.

A transmitting antenna is a *tuned circuit*. (A straight piece of wire?) Yes, indeed. That's because it's just long enough—and no longer—to be resonant at a certain frequency. Each antenna has, at its working frequency, a certain *characteristic impedance*. Most of this impedance consists of what's called *antenna resistance*. It's the resultant of the current and voltage at the antenna terminals. The same amount of current flows that you'd have if there were an actual 50-ohm (or whatever) resistor at that point.

A transmitting antenna is the only "single-ended" circuit in electronics! Current flows up the antenna and vanishes! Sort of an electronic Indian Rope Trick. It does this because most (we hope!) of the energy which flows up the antenna is *radiated*. It leaves the antenna in the form of fields of electrical energy. These travel in all directions, away from the antenna at the speed of light.

From working with tuned transformers, you know that a *load* circuit must be resonant if it is to take the most power from the source. So, to get maximum signal output (radiated energy) from our transmitting antenna, it, too must be tuned. To tune a straight piece of wire, we cut it to the exact wavelength (or some fraction) of the frequency we are using. We can do this (practically) only if the length is inside reasonable limits. A quarter-wave antenna at broadcast frequencies is very efficient, but a bit unhandy for a receiver. At 1,000 kHz, it would be 250 feet long! Up in the Citizens band, we're down to only 109 inches; a long whip but still possible. At 150 MHz, we're down to about 20 inches, which is even better.

Why is an antenna "resonant?" Because we cut the wire to a wavelength (or half, or quarter, etc.) at the operating frequency. If we feed a current into it at radio frequencies, the first pulse of current travels down the wire, finds an infinite impedance (open circuit) at the far end and turns around and bounces back. When it gets back to the transmitter end, it finds another pulse of current waiting for it. Hitting the high resistance of the transmitter, it bounces back toward the other end again.

If our antenna is resonant, the pulse, when it arrives, will find current pulse #2 going in the same direction *at the same time*, and with the same polarity. So, they'll help each other, making a current pulse with much higher amplitude. If the antenna is not resonant, the two current pulses will partially *cancel* each other, so that we have a great deal less energy instead of twice as much. By adding, this process keeps up until we have so much energy bouncing back and forth on the antenna that some of it leaks off into space, forming the radiated field.

If you want a corny analogy, it's like a bunch of kids running back and forth from one end of a playground to the other. Every time they come to the school end, another class lets out and more kids join up. Pretty soon, there isn't room for all the galloping kids and some of them have to jump the fence! Let's call those the radiation kids—they've energetic—the induction kids are lazy, and stay where they are. The same thing happens in an antenna. The current builds up until there isn't room for all of it. The radiation componemt jumps off the antenna.

A more technical explanation is that an antenna has impedance. Current flowing in an impedance causes energy to appear in the surrounding space in the form of fields; when the current stops flowing these fields collapse, back into the wire, causing a flow of current in the opposite direction. When the current reaches a certain limit, these fields get so strong that some of them leave the vicinity of the wire, carrying energy away. That's where it goes!

Actually, there are two fields in the immediate vicinity of an antenna. The induction field is greater in magnitude, and different in phase, from the radiation field. But the induction field diminishes rapidly with distance, while the radiation field diminishes slowly. The induction field is useful in low-power headphone communication, but since it diminishes rapidly, it isn't good for much distance. The radiation field is the only one useful for distant communication.

Each field—induction and radiation—has two components—electric and magnetic. These components exist at right angles to each other.

The polarization of the radiation field depends on the direction of the antenna with respect to the earth. A vertical antenna radiates a vertically-polarized electric component of its radiation field. The receiving antenna extracts the most energy from the radiated field if it's oriented the same way as the transmitting antenna. If the two antennas are at right angles, we get the minimum of energy pickup.

So, how do we get maximum energy radiation from an antenna? Tune it. This means cutting it to the exact length. In free space, the formula for this is wavelength (feet) =

$$\frac{984}{f(\text{MHz})}$$

In actual antennas, we run into resistance, inductance, and the presence of nearby objects, all of which affect the formula. A more practical formula is wavelength (feet) =

$$\frac{936}{f(\text{MHz})}$$

Using this, a quarter-wave CB antenna works out to 109 inches. Because the whole band covers less than 1 MHz (26.965 to 27.255 MHz), we can use

(continued on page 22)

17

In the Shop . . . With Jack

(continued from page 17)

the same antenna for all channels. There's less than an inch of difference between Channels 1 and 23! It isn't *that* critical, anyway.

This is a lot of antenna for a moving vehicle. To make the antenna shorter, we can add inductance in series with it. By winding the antenna wire into a coil, we can take up a lot less space. This is called a *loading coil* and can be either at the top, bottom or center of the antenna, and do the same thing. It's handier, and more durable if we put it in a nice stout housing and make this a part of the base. The antenna is now a *base-loaded whip*.

Modern base-loaded whips are highly efficient and durable. The antenna rod itself can be a thin, flexible steel whip, so that it bends when hitting the inevitable low limb or garage roof. Theoretically, this class of antenna is not quite as efficient as a full-length whip, but in actual service, it delivers a lot of signal. The difference would be detectable only with very precise measuring instruments ideed.

There's one very simple and practical way to tune up an antenna; a field-strength meter! If you measure the actual rf radiated from an antenna, when you find a peak, you have got about all you're going to get out of *that* one! Incidentally, if it *won't* peak, this means that it isn't resonant, and you'd better find out *why*, or your antenna isn't going to work worth a darn.

A field-strength meter for antenna tuneup can be very simple: Put a short pickup rod, about 18 inches long, on a vom, with a diode in series with it. Then set the vom to a low dc current range, and you'll be able to read the radiated field strength from any transmitting antenna. To adjust the reading, move the meter closer to or farther from the antenna, or turn the vom to a higher or lower scale. [Also see *"Build a FET Field-Strength Meter,"* in our March 1968 issue.—*Editor*]

On a CB antenna, you'll get a good reading on an 0-1 mA or 0-50 μA scale, at about 8–10 feet from the whip itself. On cars, if the antenna is on the back and the transmitter in the front seat, set the pickup whip on the roof, or on the ground, and run a pair of long leads to the meter in the front seat. No loss, since this is now dc! Tune the transmitter for *maximum* meter reading, and the antenna is tuned up. If you can't find a peak, this means that the antenna is not resonant. Check the antenna tuning adjustments, whip length, base connections, and so on, and you'll find it. **R-E**

Now There Are 3 Heathkit® Color TV's

The NEW Deluxe Heathkit "227" Color TV

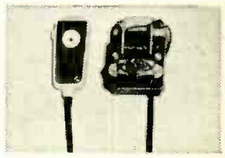
Kit GR-227
$419.95
(less cabinet)
$25 mo.

Exclusive Heathkit Self-Servicing Features. Like the famous Heathkit "295" and "180" color TV's, the new Heathkit "227" features a built-in dot generator plus full color photos and simple instructions so *you* can set-up, converge and maintain the best color pictures at all times. Add to this the detailed trouble-shooting charts in the manual, and you put an end to costly TV service calls for periodic picture convergence and minor repairs. No other brand of color TV has this money-saving self-servicing feature.

Advanced Features. Top quality American brand color tube . . . 227 sq. in. rectangular viewing area . . . 24,000 v. regulated picture power . . . improved phosphors for brilliant, livelier colors . . . new improved low voltage power supply with boosted B+ for best operation . . . automatic degaussing . . . exclusive Heath Magna-Shield to protect against stray magnetic fields and maintain color purity . . . ACC and AGC to reduce color fade and insure steady, flutter-free pictures under all conditions . . . preassembled & aligned IF with 3 stages instead of the usual 2 . . . preassembled & aligned 2-speed transistor UHF tuner . . . deluxe VHF turret tuner with "memory" fine tuning . . . 300 & 75 ohm VHF antenna inputs . . . two hi-fi sound outputs . . . 4" x 6" 8 ohm speaker . . . choice of installation — wall, custom or optional Heath factory assembled cabinets. Build in 25 hours.

Kit GR-227, (everything except cabinet) . . . $42 dn., as low as $25 mo. **$419.95**
GRA-227-1, Walnut cabinet . . . no money dn., $6 mo. **$59.95**
GRA-227-2, Mediterranean Oak cabinet (shown above), . . . no money dn., $10 mo. **$94.50**

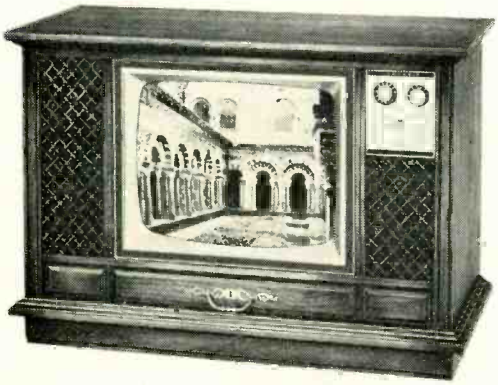
Kit GRA-27
$19.95



New Remote Control For Heathkit Color TV

Now change channels and turn your Heathkit color TV off and on from the comfort of your armchair with this new remote control kit. Use with Heathkit GR-227, GR-295 and GR-180 color TV's. Includes 20' cable.

Kit GR-295
$479.95
(less cabinet)
$42 mo.



Deluxe Heathkit "295" Color TV

Has same high performance features and built-in servicing facilities as new GR-227, except for 295 sq. in. viewing area (industry's largest picture) . . . 24,000 volt picture power . . . universal main control panel for versatile in-wall installation . . . and 6" x 9" speaker.

Kit GR-295, (everything except cabinet), 131 lbs. . . . $48 dn., $42 mo. **$479.95**
GRA-295-4, Mediterranean cabinet (shown above), 90 lbs. . . . no money dn., $11 mo. **$112.50**
Other cabinets from $62.95.

Kit GR-180
$349.95
(less cabinet & cart)
$30 mo.

Deluxe Heathkit "180" Color TV

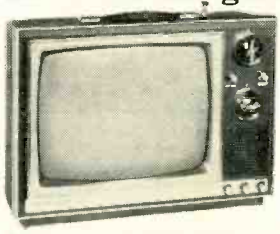
Same high performance features and exclusive self-servicing facilities as new GR-227 (above) except for 180 sq. in. viewing area.

Kit GR-180, (everything except cabinet), 102 lbs. . . . $35 dn., $30 mo. **$349.95**
GRA-180-5, table model cabinet & mobile cart (shown above), 57 lbs. . . . no money dn., $5 mo. **$39.95**
Other cabinets from $24.95

Deluxe 12" Transistor Portable B&W TV – First Kit With Integrated Circuit

Unusually sensitive performance. Plays anywhere . . . runs on household 117 v. AC, any 12 v. battery, or optional rechargeable battery pack ($39.95); receives all channels; new integrated sound circuit replaces 39 components; preassembled, prealigned tuners; high gain IF strip; Gated AGC for steady, jitter-free pictures; front-panel mounted speaker; assembles in only 10 hours. Rugged high impact plastic cabinet measures a compact 11½" H x 15¾" W x 9⅜" D. 27 lbs.

Kit GR-104
$119.95
$11 mo.



Kit GR-104, 27 lbs. . . . no money dn., $11 mo. **$119.95**

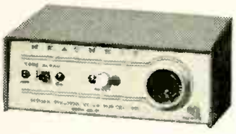
No Money Down On $25 to $300 Orders — Write For Credit Form

14 New Kits From Heath...

New! Heathkit Wireless Home Protection System for Your Family's Safety

GD-97
Utility Transmitter
for Universal Protection

GD-87
Wireless Smoke/Heat
Detector-Transmitter



GD-77 Wireless Receiver/Alarm
fail-safe, always alert

Applications Unlimited . . . Customize Your Own System. Here's reliable, low cost, 24-hour protection for your family and property. System warns of smoke, fire, intruders, freezing, thawing, cooling, rising or receding water, pressures . . . any change you want to be warned about. Uses unique new signaling method developed by Berkeley Scientific Labs.; exclusively licensed to Heath. Your house is already wired for this system, just plug the units into any AC outlet. "Load transmission" design (not a carrier type as in wireless intercoms) generates unusual signal that is practically unduplicable in other devices or random noise sources. Solid-state circuitry has built-in fail-safe capability to sound alarm if power fails, if power supply components in any unit fail, or if 50,000 hour bulb in smoke detector fails. Receiver/Alarm has 2800 Hz transistor alarm and receptacle for extra 117 VAC bell or buzzer to extend range, plus rechargeable battery (always kept charged) to sound alarm if power fails. Smoke-Heat Detector-Transmitter capability may be extended to other areas by adding extra heat sensors to its built-in sensor. Utility Transmitter accepts any type of switch or sensor for any purpose; examples: magnetic reed switches for doors and windows to warn of entry; step-on switches for door or driveway; micro switches with trip wire around yard; heat sensors; water pressure switches warn of pump failure; thermal switches warn of freezing in gardens, or thawing in freezers; two wires act as switch to warn of changing water levels in sump-pump wells, pools, etc. Units are small and unobtrusive in beige and brown non-reflecting velvet finish. Any number of units may be used in the system. All units feature circuit board construction; each unit takes only 3 hours to build. Operating cost similar to electric clocks. Invest in safety for your family now with this unique Heath system.

Kit GD-77, receiver/alarm, 4 lbs. **$39.95**
Kit GD-87, smoke/heat det.-trans., 5 lbs. **$49.95**
Kit GD-97, Utility trans., 4 lbs. **$34.95**
(numerous accessory switches available from Heath)

New! Heathkit 2-Channel, 200 Watt SSB Transceivers for CAP, MARS & 160 Meters

Kit HW-18-1
CAP model
with crystals
$119.95

Kit HW-18-2
MARS model
less crystals
$109.95

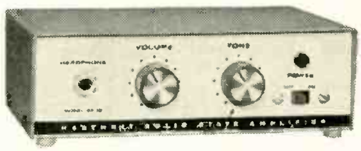
Assembled
HWW-18-1
CAP model
with crystals
$179.95

Kit HW-18-3
160 Meter model
less crystals
$109.95

Good News For CAP, MARS And 160 Meter Ops. This unique series of Heathkit SSB Transceivers was designed with your needs in mind. No more adaptations, no more conversions, no more make-shift rigs. These new transceivers are tailored for your needs with the sensitivity, selectivity, power output and operating convenience that make for effective communications at a fraction of previous costs.

Compare. 200 watts PEP SSB input. 25 watts input with carrier for compatibility with AM stations. Crystal filter sideband generation. 2 channels, switch-selected, crystal controlled. Fixed tuned for easy PTT operation. Transmit and receive freqs. locked together for true transceive operation. Clarifier control adjusts transceiver frequency ±250 Hz. Relayless transmit-receive switching. Local-Distance switch prevents receiver overload from strong local stations. Built-in speaker. PTT mic. & mobilemount included. Carrier & sideband suppression 45 dB. Sensitivity 1 uV. Selectivity 2.7 kHz. 50 ohm coax output. Accessory power supplies (Kit HP-13, mobile, $64.95; Kit HP-23, fixed station, $49.95).

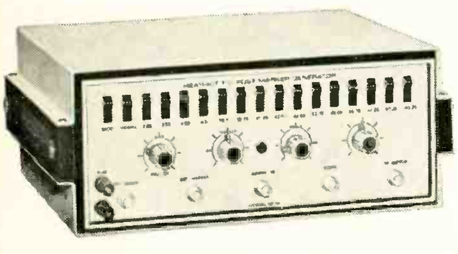
New! Heathkit Solid-State Utility Monophonic Amplifier



Kit
AA-18
$19.95

This amazing little amplifier accepts ceramic phono cartridges, AM tuners, FM tuners, tape recorders, etc., and delivers a solid 4 watts of music power from 20 Hz to over 100 kHz at a low 1.5% THD. Drives high efficiency speakers of 4 to 16 ohms. Ideal for small music system or testing amp. for service shops. Circuit board construction is easiest; just 5 short hookup wires and 6" cable. Single knob tone control. Headphone jack. Pilot lamp. Transformer operated, 120/240 VAC, 50-60 Hz.

New! Heathkit Crystal-Controlled Post Marker Generator



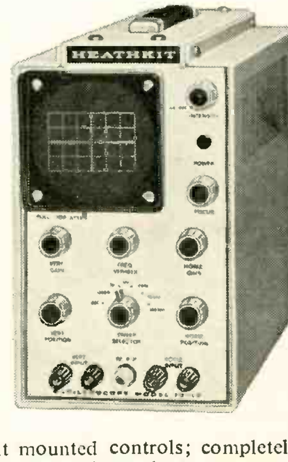
Kit IG-14
$99.95
$10 mo.

Fast, accurate color TV and FM alignment at the touch of a switch! 15 crystal-controlled marker frequencies. Select picture and sound IF's, color bandpass and trap freqs., 6 dB points, FM IF center freq. and 100 kHz points. Use up to six markers simultaneously. Birdie-type markers. Trace and marker amplitude controls permit using regular 'scope. 400 Hz modulator. Variable bias supply. Input and output connectors for use with any sweep generator. Also has external marker input. BNC connectors. Solid-state circuit uses 22 transistors, 4 diodes. Two circuit boards. Handsome new Heathkit instrument styling of beige and black in stackable design. Until now, an instrument of this capability cost hundreds of dollars more. Order your IG-14 now, it's the best investment in alignment facilities you can make.

Kit IG-14, 8 lbs., no money dn., $10 mo. **$99.95**

New! Low Cost Heathkit 5 MHz 3" Scope

Kit IO-17
$79.95

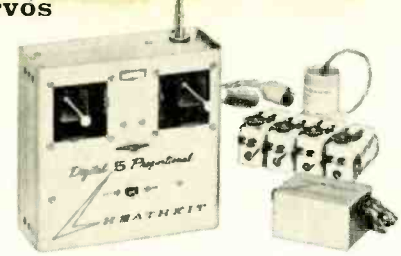


Here is the wideband response, extra sensitivity and utility you need, all at low cost. The Heathkit IO-17 features vertical response of 5 Hz to 5 MHz; 30 mv Peak-to-Peak sensitivity; vertical gain control with pull-out X50 attenuator; front panel 1 volt Peak-to-Peak reference voltage; horizontal sweep from internal generator, 60 Hz line, or external source; wide range automatic sync; plastic graticle with 4 major vertical divisions & 6 major horizontal; front mounted controls; completely nickel-alloy shielded 3" CRT; solid-state high & low voltage power supplies for 115/230 VAC, 50-60 Hz; Zener diode regulators minimize trace bounce from line voltage variations; new professional Heath instrument styling with removable cabinet shells; beige & black color; just 9½" H. x 5½" W. x 14½" L.; circuit board construction, shipping wt. 17 lbs.

See 300 More in FREE Catalog

New! Heathkit/Kraft 5-Channel Digital Proportional System with Variable Capacitor Servos

System Kit GD-47
$219.95
$21 mo.



This Heathkit version of the internationally famous Kraft system saves you over $200. The system includes solid-state transmitter with built-in charger and rechargeable battery, solid-state receiver, receiver rechargeable battery, four variable capacitor servos, and all cables. Servos feature sealed variable capacitor feedback to eliminate failure due to dirty contacts, vibration, etc.; three outputs: two linear shafts travel ⅝" in simultaneous opposite directions plus rotary wheel. Specify freq.: 26.995, 27.045, 27.145, 27.195 MHz.

System Kit GD-47, all of above, 5 lbs. **$219.95**
Kit GDA-47-1, transmitter, battery, cable, 3 lbs. **$86.50**
Kit GDA-47-2, receiver, 3 lbs. **$49.95**
GDA-47-3, receiver rechargeable battery, 1 lb. **$9.95**
Kit GDA-47-4, one servo only, 1 lb. **$21.50**

World's Most Advanced Stereo Receiver

Kit AR-15
$329.95
(less cabinet)
$28 mo.

Acclaimed by owners & experts for features like integrated circuits & crystal filters in IF amplifier; FET FM tuner; 150 watts music power; AM/FM and FM stereo; positive circuit protection; all-silicon transistors; "black magic" panel lighting; and more. Wrap-around walnut cabinet $19.95.

Kit AR-15 (less cab.), 34 lbs. . . . $33 dn., $28 mo. **$329.95**
Assembled ARW-15, (less cab.), 34 lbs. . . .$50 dn., $43 mo. **$499.50**

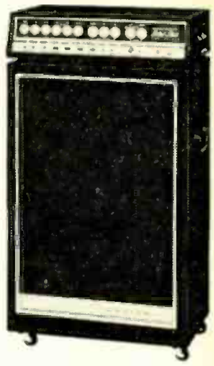
New! Solid-State Portable Volt-Ohm-Meter

So Handy, So Low Cost we call it "every man's" meter. Just right for homeowners, hobbyists, boatowners, CBer's, hams . . . it's even sophisticated enough for radio & TV servicing! Features 12 ranges . . . 4 AC & 4 DC volt ranges, 4 ohm ranges; 11 megohm input on DC, 1 megohm input on AC; 4½" 200 uA meter; battery power; rugged polypropylene case and more. Easy 3 or 4 hour kit assembly.

Kit IM-17
$19.95

What would you expect to pay for a Vox "Jaguar" Combo organ with a 180-watt 3-channel amp? $1000? $1250? $1500? More?

Kit TOS-1
Organ, Amplifier & Speaker Kits
(240 lbs.)
$598.00



Kit TOS-2
Organ Kit, Assembled Amplifier & Speaker (240 lbs.)
$698.00

You can get both for only $598 during this Special Heathkit Offer!

Now you can get this famous professional combo organ with a versatile high-power piggy-back amp. and matching speaker system for just a little more than you'd expect to pay for the "Jaguar" alone! The Heathkit/Vox "Jaguar" is solid-state; two outputs for mixed or separated bass and treble; reversible bass keys for full 49 key range or separate bass notes; bass volume control; vibrato tab; bass chord tab; four voice tabs (flute, bright, brass, mellow); keyboard range C_2 to C_6 in four octaves; factory assembled keyboard, organ case with cover, and stand with case. Also available separately; you'll still save $150 (order Kit TO-68, $349.95).

The Heathkit TA-17 Deluxe Super-Power Amplifier & Speaker has 180 watts peak power into one speaker (240 watts peak into a pair); 3-channels with 2 inputs each; "fuzz", brightness switch; bass boost; tremolo, reverb; complete controls for each channel; foot switch; 2 heavy duty 12" speakers plus horn driver. Also available separately kit or factory assembled (Kit Amplifier TA-17, $175; Assembled $275; Kit Speaker TA-17-1 $120; Assembled $150; Kit TAS-17-2, amp. & two speakers $395; Assembled TAW-17-2, amp. & two speakers $545).

New! Heathkit Guitar Headphone Amplifier

Kit TA-58
$9.95

Practice your electronic guitar playing in private! Plug this miniature amp. into output jack of guitar and use mono or stereo headphones (4 to 2 megohms). Solid-state circuit has tailored response, automatic on-off switching, powered by battery (not supplied). 2 lbs.

New! Heathkit Solid-State "Fuzz Booster" For Guitar Amplifiers

Kit TA-28
$17.95

"Fuzz" is what it's called, harmonic distortion is what it is, and you can add it to your guitar amp with this kit. Transistor circuit is contained in die cast footswitch housing and powered by internal battery (not supplied). Two controls adjust tone and intensity of "fuzz". Build it in one evening. 4 lbs.

NEW
FREE 1968 CATALOG!

Now with more kits, more color. Fully describes these along with over 300 kits for stereo/hi-fi, color TV, electronic organs, electric guitar & amplifier, amateur radio, marine, educational, CB, home & hobby. Mail coupon or write Heath Company, Benton Harbor, Michigan 49022.

HEATHKIT

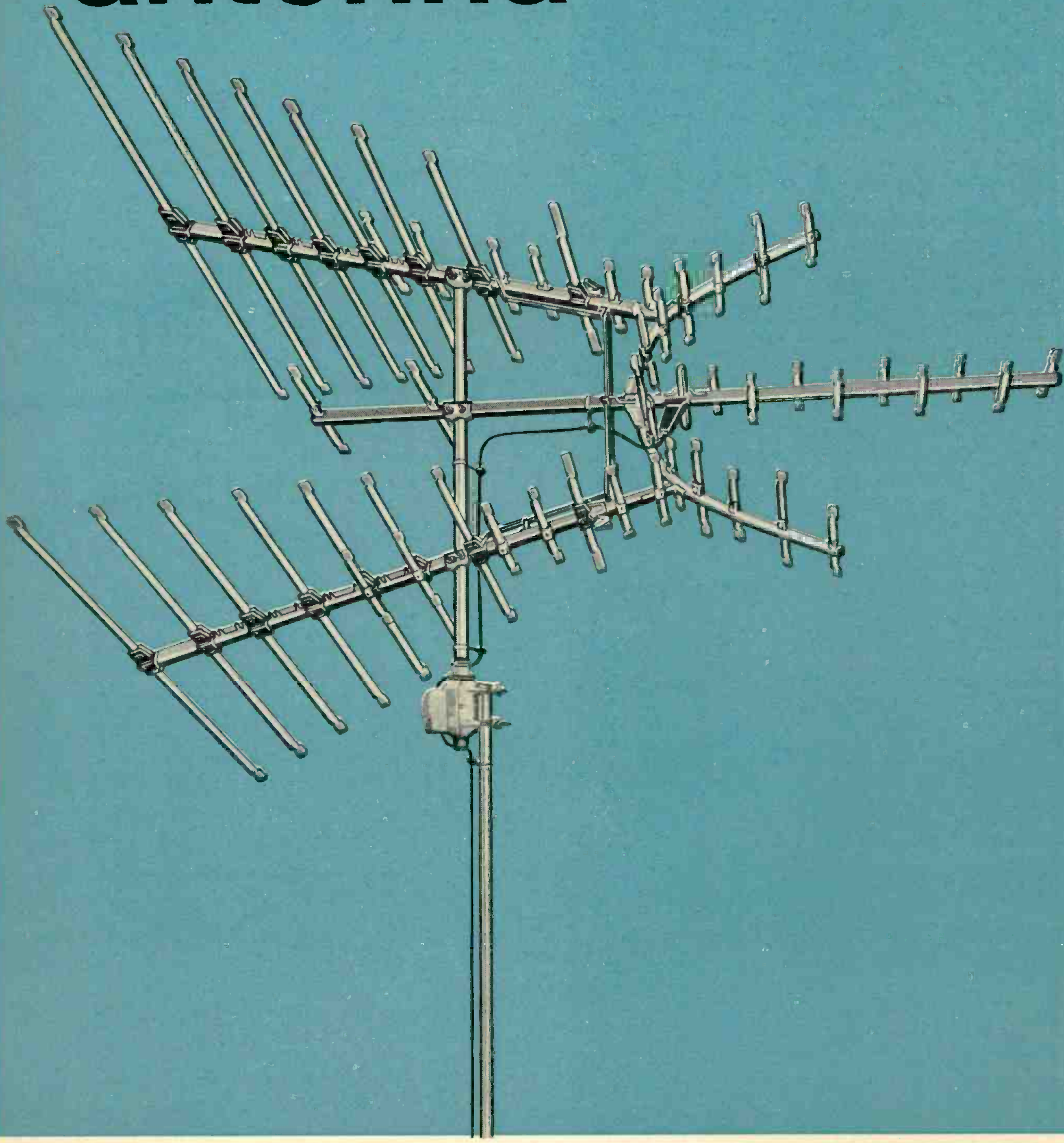
HEATH COMPANY, Dept. 20-5
Benton Harbor, Michigan 49022
In Canada, Daystrom Ltd.

☐ Enclosed is $__________, including shipping.
Please send model (s)__________
☐ Please send FREE Heathkit Catalog.
☐ Please send Credit Application.

Name__________
Address__________
City__________ State__________ Zip__________

Prices & specifications subject to change without notice. CL-326

introducing the hundred dollar antenna



plus a not so short story about why Winegard's new SC-1000 is worth every penny...why it's the most powerful 82-channel antenna ever created for civilian use...and how it can change your antenna business.

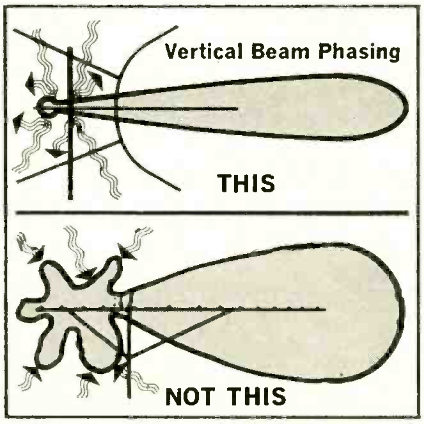
Every once in a while a new antenna comes along that's more than just "new" and "different looking" and "bigger" and "better" and "more powerful". Once in a while, maybe once in a lifetime, an antenna is created that makes all the "usual claims" and then supports every one of the claims with *performance.* That's our hundred dollar antenna. The SC-1000. The top of our Super Colortron line. The top of any antenna line ever created.

This VHF-UHF-FM super fringe antenna has undergone exhaustive testing and tuning refinements—and proved that it delivers performance worthy of its name, and it's price. Take, for example, an installation in Houston—41-feet above ground, equipped with rotor and 75 ohm downlead (no preamplifier.) The owner* writes that with the SC-1000 he is now receiving superior reception on stations ranging from 60 miles away (Bryan, Texas) to 200 miles away (Alexandria, La. and Lafayette, La.) Now that's what we call results. And it's why the SC-1000 is already being called "the long distance antenna." Because it pulls in the farthest away, toughest channels—and always better than ever before.

Yes, feature for feature and dollar for dollar (even a hundred dollars) there has never been an antenna like the SC-1000. Let's take a look at the features.

*Name supplied upon request.

Exclusive New Compact "Wedge" Design . . . Plus New Vertical Beam Phasing On Each VHF Channel. Vertical Beam Phasing on all VHF channels means there is no signal pickup from above or below the antenna. It means interference from such sources as airplanes, cars and diathermy machines are shut out. And it means that ghost signals are highly rejected. And that's not all. The VHF capture area is doubled and power gain over a conventional single bay is doubled. The vertical beam is flattened and elongated and spurious vertical lobes are eliminated. All that, and the SC-1000, with its unique "Wedge" design, is still vastly shorter and more mechanically stable than any other configurations would have to be to come close to the gain of the SC-1000.

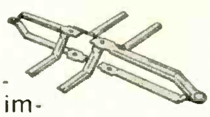


New "Constant Focus" UHF Screen. Concentrates all signal on Tetrapole collector element, provides as much signal capture area as an 8-foot parabolic, and at a fraction of a parabolic's size and weight.

New "Interlaced UHF Resonant Reflectors". Form a high density magnetic screen with all current fields in phase and working together for a new high in parabolic reflector efficiency.

Exclusive Patented* VHF Director System. Absorbs VHF signal and focuses it onto the collector elements. Helps give the SC-1000 pinpoint directivity to knock-out ghosts, smear and snow. *U.S. Patent No. 2700105, Canada No. 511984.

New "Tetrapole" UHF Collector Element. Has larger signal absorption area than standard UHF dipole. Maintains constant 300 ohm impedance and allows *no loss* coupling between the VHF and UHF operations.



Exclusive "Impedance Correlators". Provide perfect 300 ohm VHF impedance match and produce more signal gathering power per inch of antenna—and also contribute to making the SC-1000 extremely compact.

Exclusive Ellipsoidal Boom. Strongest boom ever used on a tv antenna. All elements of antenna are special aluminum alloy 40% stronger than used on most antennas.

Long Distance FM & FM Stereo Reception Bonus. Comparable to the results you get with a 10 element FM yagi.

Genuine Gold Anodized Finish. The only permanent gold finish on any antenna. Sunfast. Protects against corrosion and fading. Lasts years longer.

Exclusive Built-In Cartridge Housing. Integral part of the antenna keeps downlead connection weathertight. Accepts Winegard's solid state cartridge preamplifiers, color spectrum filter, etc. A truly great Winegard innovation.

Exclusive Winegard Gold Bond Performance Guarantee, Plus A New 2-Year Replacement Warranty.

The SC-1000 Will Change Your Entire Antenna Business. We created the SC-1000 simply because there was a glaring need for a modern 82-channel super powerful, super fringe antenna. And performance figures show that it has far surpassed even our most optimistic goals. So whenever you want to get the last ounce of clean, brilliant reception from a new color set—whenever you have a tough reception problem, install the new Winegard SC-1000. You'll have the most satisfied customers in town. And you'll have the best antenna profits in town!

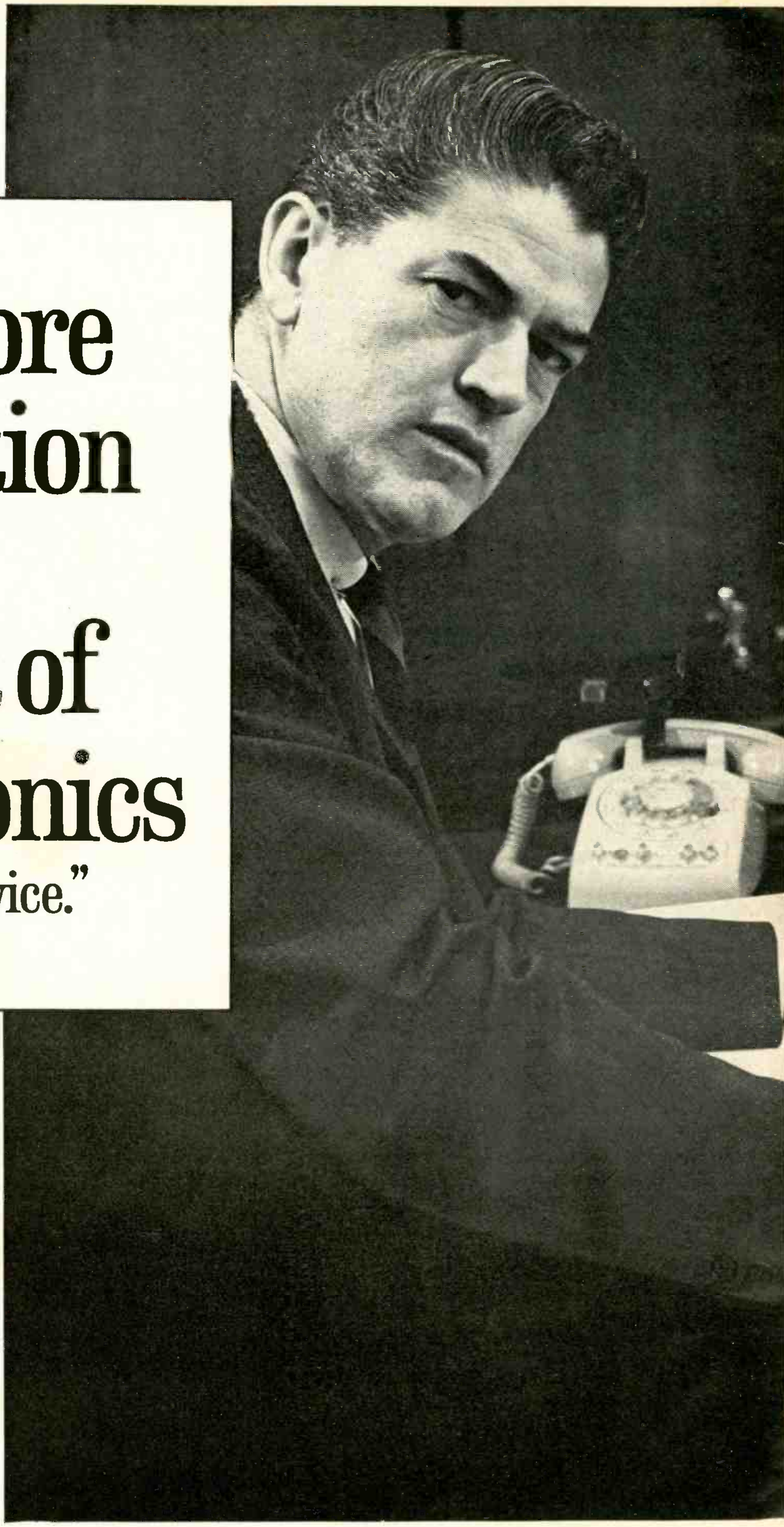
Find Out For Yourself. We want you to see for yourself that "the hundred dollar antenna" is everything we say it is, and more. So try one first chance you get. Ask your Winegard distributor for details now. And write for Fact-Finder #261.

Winegard
ANTENNA SYSTEMS

WINEGARD COMPANY • 3000 Kirkwood Street • Burlington, Iowa 52601

"Get more education or get out of electronics

...that's my advice."



Ask any man who really knows the electronics industry.

Opportunities are few for men without advanced technical education. If you stay on that level, you'll never make much money. And you'll be among the first to go in a layoff.

But, if you supplement your experience with more education in electronics, you can become a specialist. You'll enjoy good income and excellent security. You won't have to worry about automation or advances in technology putting you out of a job.

How can you get the additional education you must have to protect your future—and the future of those who depend on you? Going back to school isn't easy for a man with a job and family obligations.

CREI Home Study Programs offer you a practical way to get more education without going back to school. You study at home, at your own pace, on your own schedule. And you study with the assurance that what you learn can be applied on the job immediately to make you worth more money to your employer.

You're eligible for a CREI Program if you work in electronics and have a high school education. Our FREE book gives complete information. Airmail postpaid card for your copy. If card is detached, use coupon below or write: CREI, Dept. 1405G, 3224 Sixteenth Street, N.W., Washington, D.C. 20010.

Founded 1927

CREI

Accredited Member of the National Home Study Council

CREI, Home Study Division
McGraw-Hill Book Company
Dept. 1405G, 3224 Sixteenth Street, N.W.
Washington, D.C. 20010

Please send me FREE book describing CREI Programs. I am employed in electronics and have a high school education.

NAME__________ AGE_____

ADDRESS__________

CITY______ STATE______ ZIP CODE____

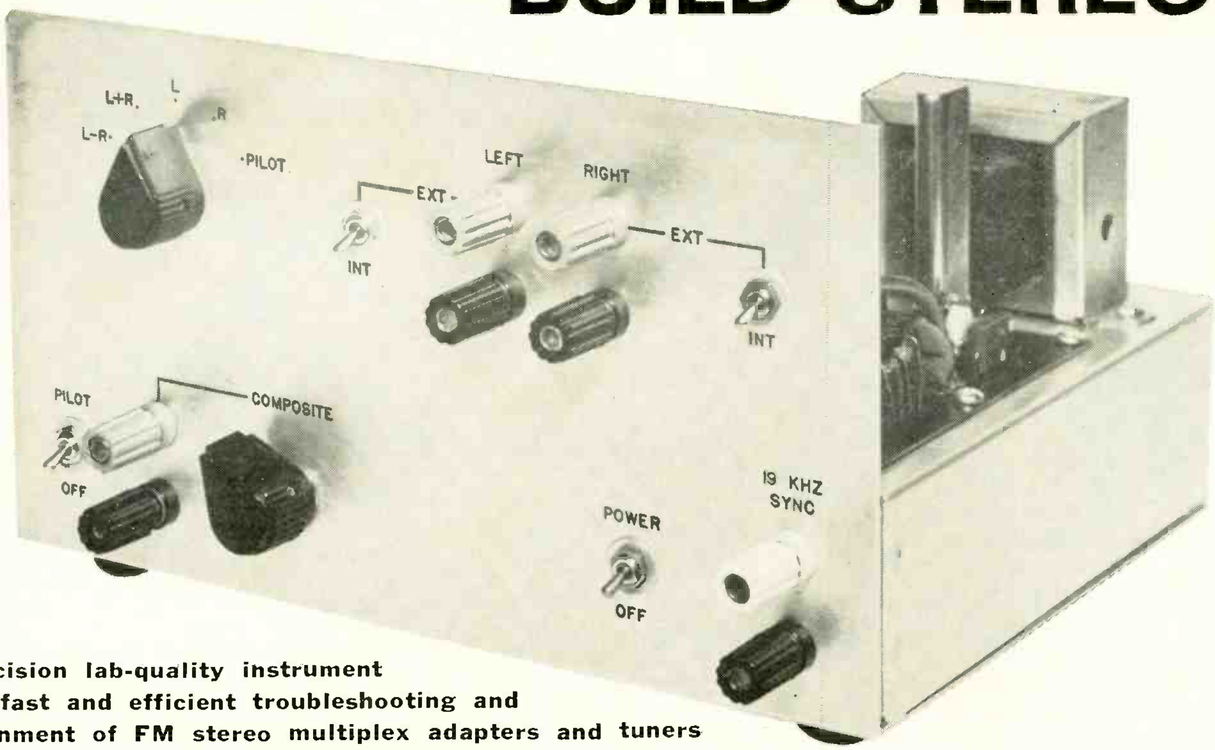
EMPLOYED BY__________

TYPE OF PRESENT WORK________ ☐ G.I. BILL

I am interested in ☐ Electronic Engineering Technology
☐ Space Electronics ☐ Nuclear Engineering Technology
☐ Industrial Electronics for Automation
☐ Computer Systems Technology

APPROVED FOR TRAINING UNDER NEW G.I. BILL

BUILD STEREO



Precision lab-quality instrument for fast and efficient troubleshooting and alignment of FM stereo multiplex adapters and tuners

FM MULTIPLEX GENERATOR

By KENNETH F. BUEGEL

THIS STEREO MULTIPLEX GENERATOR was designed and built to overcome the shortcomings and disadvantages of an earlier model that I had used for 4 years. It features audio preamplifiers with built-in pre-emphasis, greater channel separation, simpler alignment —only one tuned circuit and five other adjustments requiring less than 10 minutes to make. Overall performance is improved by the novel circuit used to develop the required signals.

Channel separation is 40 dB at 50 Hz and 50 dB at 500 Hz and above. The total of all hum, noise and residual carrier components is down 52 dB from reference output. Construction cost for this solid-state generator is about $55. A printed-circuit board is available to simplify and speed construction.

How it works

The schematic is shown in Fig. 1. Transistor Q1 is a 76-kHz oscillator, while Q2 serves as a buffer and pulse driver to IC1. Diode D1, at the input of IC1, clamps the negative level of Q2's output pulses. Integrated circuit IC1 is an inverting gate which squares up the drive pulses and feeds them to IC2, a J-K flip-flop wired as a divide-by-2 counter. The oscillator frequency is 76 kHz, IC1 triggers on every *positive* pulse, and IC2 changes *state* on each pulse.

A complete square-wave transition from low to high, and back to low again, requires two 76-kHz input pulses; thus we have formed a perfect 38-kHz square wave. Both halves are exactly equal in their periods since IC1 always changes state at the same point on each input pulse.

One output of IC2 goes from ground to a positive level as the other output changes from positive to ground level. These changes are within 0.03 μsec of each other. Each output drives a high-speed transistor (Q3 and Q4) to provide 15-volt switching signals to the audio gates (D2–D5). The time required to drive the gate from full off to full on is less than 0.01 μsec; so gate-diode matching is not critical. By way of contrast, a 20-volt p-p sine wave would require 0.4 μsec to switch the gate.

One output of IC2 (terminal 7) also drives a variable one-shot (delay) multivibrator, IC3. This in turn feeds the delayed 38-kHz pulses to another divide-by-2 counter, IC4. An output of IC4 furnishes 19-kHz base-drive pulses to Q5. A 19-kHz ringing coil, T1, in the collector of Q5 transforms these pulses into a sine-wave signal.

Phase adjustment

Tuning T1 will introduce a phase delay of the 19-kHz pilot signal. The adjustment of pulse width by R11 allows correct matching of the phase of this pilot signal with the 38-kHz switching signals. (FCC stereo transmission standards require both signals to cross zero in the positive direction together. This defines left-channel transmission on the positive half of the 38-kHz signal.)

Transistor Q6 is connected as a phase-shift audio oscillator. R23 adjusts the output when internal modulation is used. Left and right preamplifiers (Q7–Q8 and Q9–Q10) are identical, with Q11 included in the right channel to provide an inverted signal. Transistors Q7 and Q9 operate at very low gain. Small bypass capacitors (0.0047 μF) across the relatively large emitter resistors (47000 ohms) provide the desired pre-emphasis.

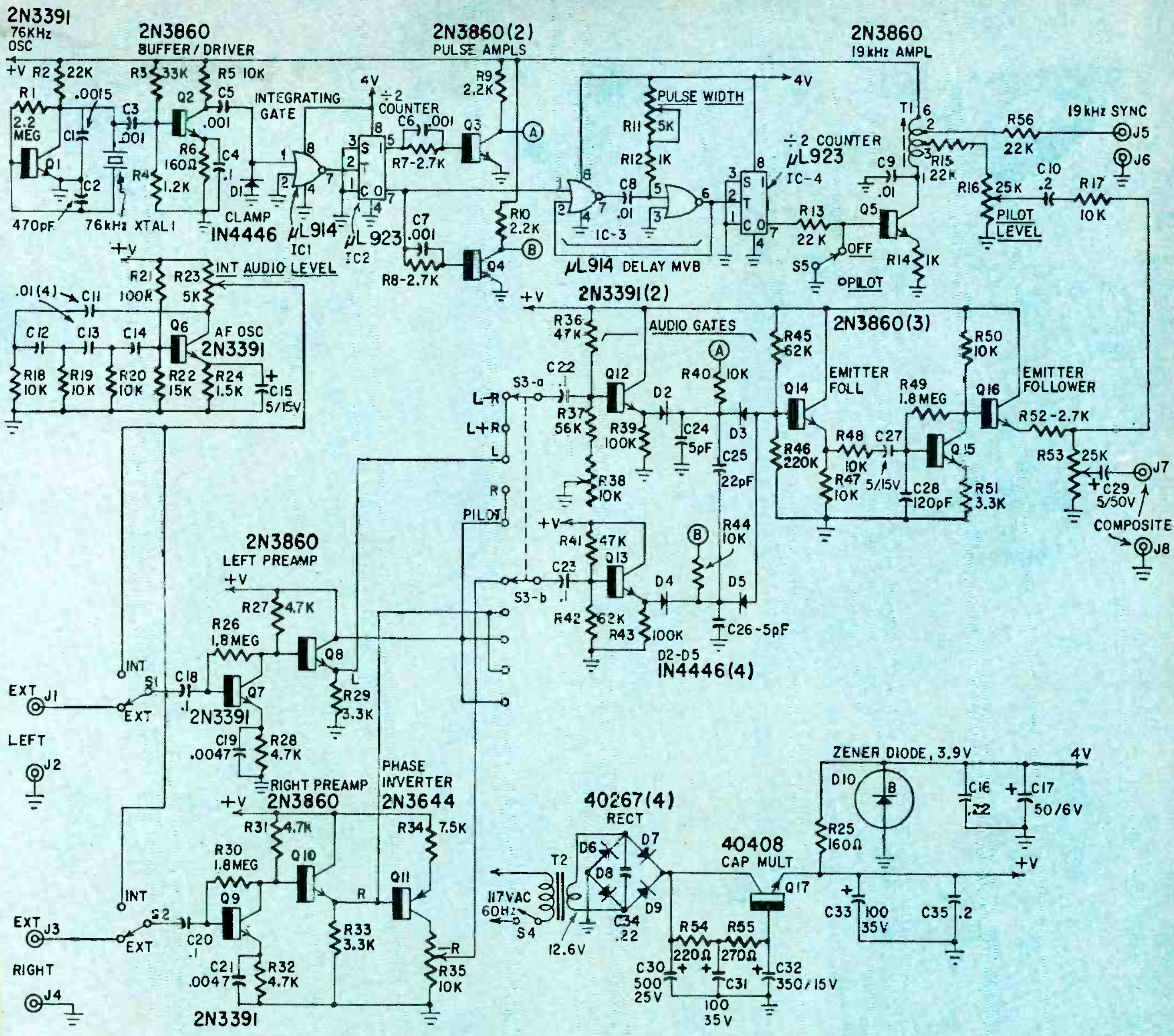
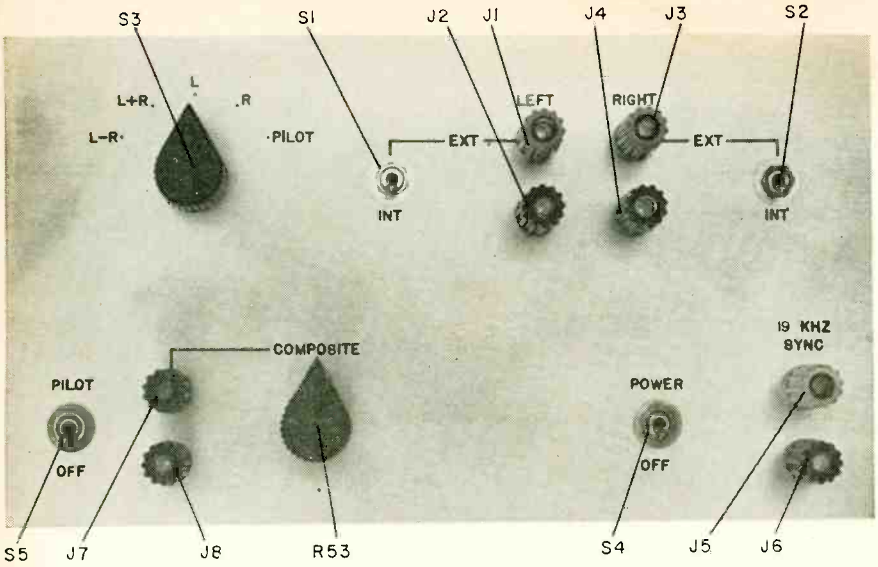


Fig. 1—Stereo MPX generator uses a novel count-down circuit for the 38- and 19-kHz signals to insure good separation.

PARTS LIST

C1—0.0015-µF mica or polystyrene capacitor
C2—470-pF mica capacitor
C3, C5, C6, C7—0.001µF miniature extended foil/film capacitor (Sprague type 192P Pacer or equal)
C4, C18, C20, C22, C23—0.1-µF, 20-V disc ceramic capacitor
C8, C9—0.01-µF polystyrene capacitor (Mallory type SX or equal)
C10, C35—0.2-µF, 10-V disc ceramic capacitor
C11, C12, C13, C14—0.01-µF disc ceramic capacitor
C15, C27, C29—5-µF, 15-V electrolytic capacitor
C16, C34—0.22-µF Mylar capacitor
C17—50-µF, 6-V electrolytic capacitor
C19, C21—0.0047-µF extended-foil/film capacitor (Sprague type 192P Pacer or equal)
C24, C26—5pF disc ceramic capacitor
C25—22-pF disc ceramic capacitor
C28—120-pF mica capacitor
C30—500-µF, 25-V tubular electrolytic capacitor
C31, C33—100-µF, 35-V electrolytic capacitor
C32—350 µF, 15-V electrolytic capacitor
D1, D2, D3, D4, D5—1N4446 silicon diode (G-E)
D6, D7, D8, D9—40267 silicon diode (RCA)
D10—3.9-V, 10%, 1-W Zener diode, 1N4730 or equal
Q1, Q6, Q7, Q9, Q12, Q13, Q15—2N3391 transistor (G-E)
Q2, Q3, Q4, Q5, Q8, Q10, Q14, Q16—2N3860 transistor (G-E)
Q11—2N3644 transistor (Fairchild)
Q17—40408 transistor (RCA)
IC1, IC3—µL914 (dual 2-input gate integrated circuit (Fairchild)
IC2, IC4—µL923 J-K flip-flop integrated circuit (Fairchild)
R1—2.2-megohm resistor
R2, R13, R15, R56—22,000-ohm resistor
R3—33,000-ohm resistor
R4—1200-ohm, 5% resistor
R5, R17, R18, R19, R20, R40, R44, R47, R48, R50—10,000-ohm resistor
R6—150-ohm resistor
R7, R8—2700-ohm, 5% resistor
R9, R10—2200-ohm resistor
R11—5000-ohm, ¼-watt linear potentiometer, horizontal PC mount (Mallory MTC53L4 or equal)
R12, R14—1000-ohm resistor
R16, R53—25,000-ohm linear potentiometer
R21, R39, R43—100,000 ohm resistor
R22—15,000-ohm resistor
R23—5000-ohm linear potentiometer
R24—1500-ohm resistor
R25—160-ohm, 5% resistor
R26, R30, R49—1.8-megohm resistor
R27, R28, R31, R32—4700 ohm, 5% resistor
R29, R33, R51—3300-ohm resistor
R34—7500-ohm, 5% resistor
R35, R38—10,000-ohm, ¼-watt linear potentiometer, horizontal PC mount (Mallory MTC14L4 or equal)
R36, R41—47,000-ohm, 5% resistor
R37—56,000-ohm, 5% resistor
R42, R45—62,000, 5% resistor
R46—220,000-ohm resistor
R52—2700-ohm, 5% resistor
R54—220-ohm resistor
R55—270-ohm resistor
All resistors ½-watt, 10% unless otherwise noted
S1, S2, s.p.d.t. toggle switch
S3—2-pole, 5-position rotary switch
S4, S5—s.p.s.t. toggle switch
T1—19-kHz oscillator transformer J. W. Miller type 1354-PC or equal)
T2—Filament transformer, 12.6-V, 600 mA or more
J1, J2, J3, J4, J5, J6, J7, J8—6-way binding post
XTAL-1—76-kHz, 0.01% crystal (International Crystal Mfg. Co. type GP-13, $19.95 plus postage. Order from manufacturer at 10 North Lee St., Oklahoma City, Okla. 73102. Allow three weeks for delivery).
Misc—7"x9"x2" aluminum chassis, crystal socket, knobs, hardware.
Note—Etched and drilled glass epoxy PC board No. MG-1 available for $7.25 postpaid from Transitex Co., P.O. Box 98205, Des Moines, Wash. 98016. If you have difficulty locating Fairchild Semiconductors, you can order them from Transitex. Set includes IC1, IC2, IC3, IC4 and Q11 for $5.70 postpaid.



Front panel of the FM stereo generator is made from a 5" x 9" sheet of aluminum. Controls are laid out for convenience and ease of operation. A 19-kHz sync signal is rarely used in stereo alignment so jacks J5 and J6 may be omitted.

Switch S3 selects the required combination of L, R and −R signals to form the desired composite output signal. The switching gates formed by Q12, Q13, Q14 and diodes D2 through D4 operate in this way:

When point B is switched to +V, D4 and D5 are reverse-biased and present an impedance of many megohms between the emitter of Q13 and the base of Q14. At the same time point A is at ground potential, effectively connecting the emitter of Q12 to the base of Q14 through the low "on" resistance of D2 and D3. Either Q12 or Q13 is connected to Q14, except for the 0.01-μsec switching interval mentioned earlier.

Any difference between the emitter voltages of Q12 and Q13 will appear at the output as an undesirable 38-kHz carrier component. Potentiometer R38 is used to equalize the emitter voltages.

Transistor Q15 is a low-gain stage connected to output emitter follower Q16. C28 and R48 in the base circuit of Q15 provide the only filtering used in this generator. Potentiometer R16 sets the level of pilot signal added to the left and right components appearing at the junction of R52 and R53. A level greater than 5 volts p-p is available at the composite output jacks, J7–J8.

The 40408 transistor, Q17, is used as a capacitance multiplier in the power supply. Adequate filtering of the base current to Q17 keeps ripple content low. Power for the integrated circuits is regulated by Zener diode D10.

Construction

A 7" x 9" x 2" aluminum chassis was used to build the unit shown in the photographs. After determining the location of front-panel controls the cutout should be made to mount the circuit board. The board listed in the parts list has a ¼" edge with holes for 6-32 hardware. All power supply components are grouped along the back edge of the chassis. Although small switches and pots were used because they were on hand, ample space exists for larger controls. You may wish to omit the 19-kHz SYNC jacks since they are rarely used in any alignment procedures.

After completion apply power and check the two supply voltages. The emitter voltage of Q17 should be about 15 volts, depending on line input voltage. The voltage read across D10 may be anywhere within the range of 3.5 to 4.3 volts.

Alignment

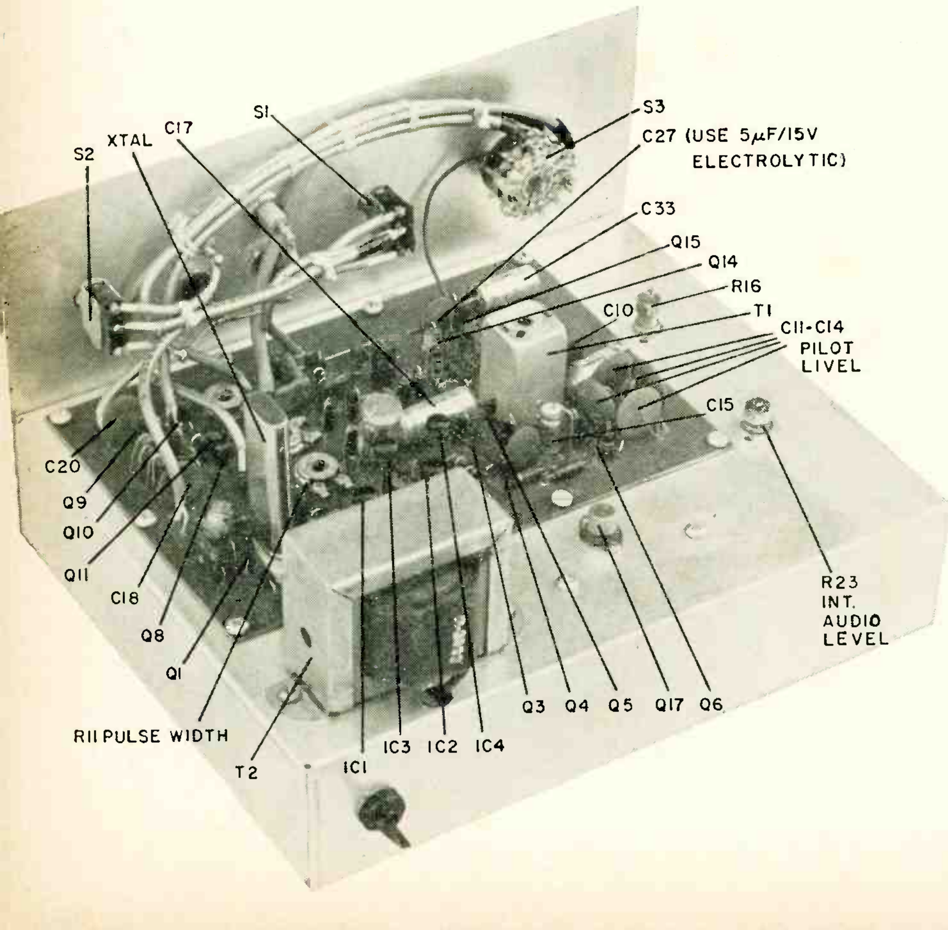
The only essential equipment required is an audio generator and an oscilloscope with a bandwidth of at least 500 kHz.

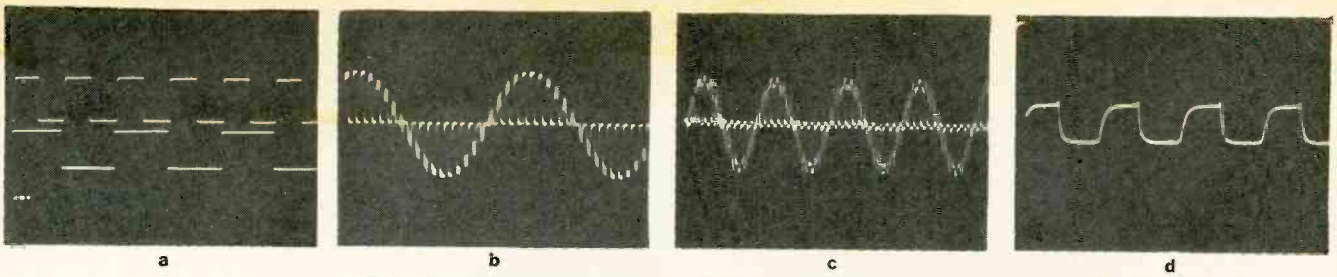
1. With the scope, check for a 38-kHz square wave of 15 volts p-p at both points A and B. Connect the scope to J7 with R53 set for maximum output. Set S3 to PILOT. Set R16 (PILOT LEVEL) to maximum. Set S5 to PILOT. Adjust R11 (PULSE WIDTH) until a 19-kHz pilot signal appears at the output. Tune T1 for maximum pilot amplitude. R11 will be further adjusted in Step 6.

2. Set S5 to OFF. Set S3 to PILOT. Adjust R38 for minimum output (maximum 38-kHz carrier suppression). See Figs. 1-d and 1-e.

3. Set S3 to L + R. Set S1 and S2 to EXT. Apply a 1-volt rms 1-kHz signal

All active circuits are on the PC board; power-supply components are on chassis.





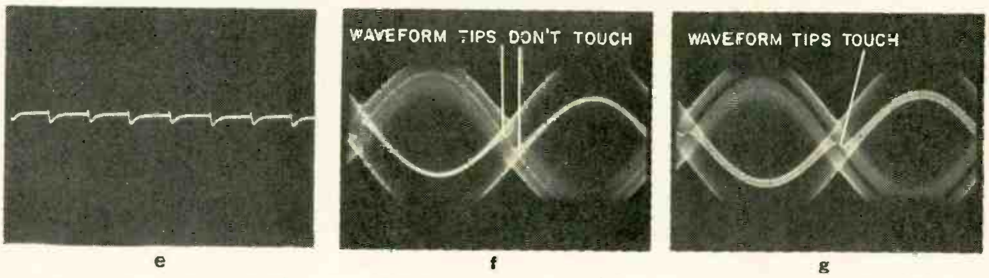


*Fig. 2-*a*—Top trace is 19-kHz output of IC4; bottom is 38-kHz output of IC2. Text explains the reason for timing delay.* b*—A 2-kHz left (or right) only signal from internal generator without 19-kHz pilot. Perfectly straight baseline indicates good separation.* c*—Same as* b *with 19-kHz pilot added. Pilot amplitude is 10% of total.* d*—Pattern indicating incorrect adjustment of R38 in Step 2 of alignment procedure.* e*—Correct adjustment of R38.* f*—Misadjustment of R11 causes incorrect phase relationship between 19-kHz pilot and 38-kHz switching signals.* g*—Pattern when R11 is adjusted.*

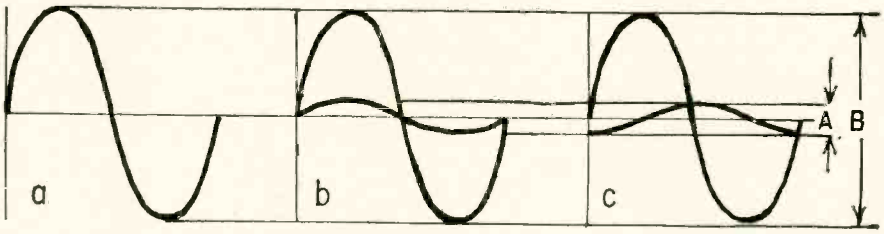
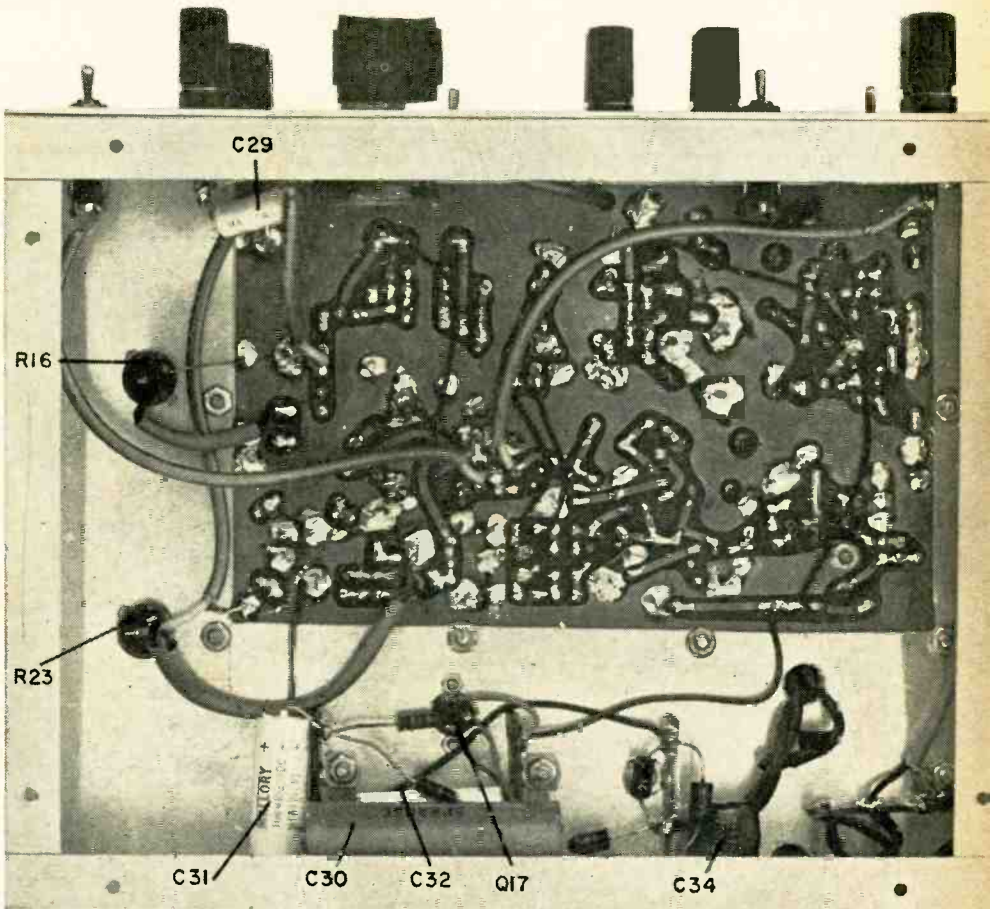


Fig. 3—When measuring separation, make sure that the scope itself does not cause phase shift. Pattern a *(L or R only) indicates excellent separation;* b *and* c *show amplitude and phase distortion, respectively. Separation = 20 $\log_{10}$ B/A dB.*

PC board reduces wiring. Shielded cable is used for runs between board and controls.



to J3 *only*. Note the height of the scope trace. Now set S3 to L − R and adjust R35 for the same trace height.

4. Leave the scope vertical gain in exactly the same position. Set S1 and S2 to INT. Set S3 to L + R. Adjust R23 for the same trace height as in Step 3.

5. Leave the scope vertical gain control in the same position. Set S3 and S5 to PILOT. Adjust PILOT LEVEL until the 19-kHz pilot level is 10% of the trace height noted in Step 4.

6. The last adjustment is setting the phase relationship between the 19-kHz pilot and the 38-kHz switching signals. Set S1 and S2 to EXT. Apply a 0.2-volt rms 100-Hz signal to *both* J1 and J3. Set S3 to L − R. Set S5 to PILOT. You will probably have a scope pattern which closely resembles Fig. 2-f. This photo shows incorrect phase relationship. Adjust R11 until the tips of the brighter center portions of the pattern are opposite each other as shown in Fig. 2-g.

Separation measurement

Alignment is now complete. There are no interacting adjustments but you may wish to recheck.

Separation measurements are made as shown in Fig. 3. Connected to a good FM signal generator with wide-band modulation capabilities, this unit makes an excellent stereo demonstrator. **R-E**

HOW TO SIGNAL-TRACE

Old time troubleshooting technique revived

By MATTHEW MANDL

WITH INTEGRATED CIRCUITS, SOLdered-in transistors, and modular construction in solid-state TV receivers, signal-tracing procedures for localizing a defective stage are even more valuable than for tube receivers. In the latter, when we suspect a stage or two of contributing to the trouble symptoms, it is an easy matter to substitute new tubes or test the old ones. If this doesn't cure the trouble, not much time is lost and we can look elsewhere.

Basic signal tracing

Three instruments are needed for effective signal tracing: An rf signal generator (with internal audio modulation), an oscilloscope and an electronic (vacuum-tube or transistor) voltmeter. There are four basic methods for signal-tracing rf and audio stages:

1. Apply a signal to the input of a stage and observe the output waveform of that stage. If an amplified output signal is obtained, the generator is applied to the input of another suspected stage and the output from it again checked. The procedure is repeated for any stage to be checked. The basic setup is shown in Fig. 1-a. This method is used for random checking of single stages.

2. Connect the signal generator to the input of the first stage of an amplifier chain and check the output of that stage with the scope. If no signal is obtained the defective stage has been isolated. If a normal signal is observed, move the scope to the output of the second stage and recheck. In this method only the scope is moved to successive stages until no signal output is obtained. The procedures are shown in Fig. 1-b.

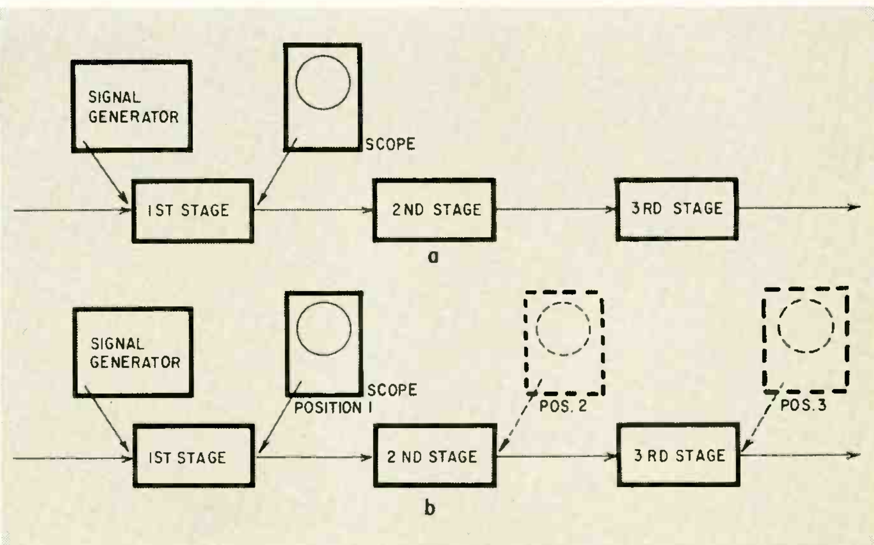
3. The third method is the opposite of the second. The scope is connected to the output of the last stage as in Fig. 2-a. Now the signal is applied to the input of this stage and, if an output signal is obtained, the generator is moved to the input of the second stage to see if the signal gets through this circuit also. Again, only one instrument lead needs to be shifted.

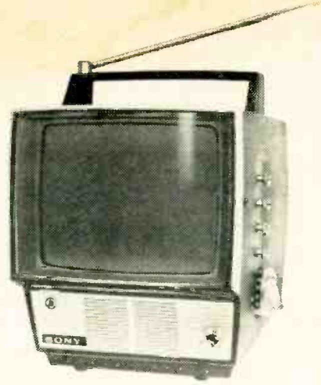
4. The fourth method is to take advantage of the broadcast signal and thus dispense with the signal generator. The scope is moved from stage to stage until no signal output is observed. This is shown in Fig. 2-b.

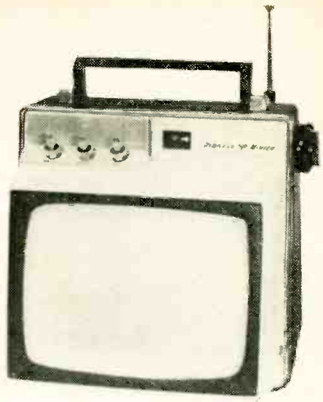
Practical factors

Don't apply too high a signal to transistor circuits. Start with a low-level signal output and increase it gradually. It is good practice to turn off the set before connecting the signal-generator or scope probes. If you do

Fig. 1—Two basic signal-tracing methods. In method a, *the generator and scope are both moved together from stage to stage; in* b, *the output of the signal generator feeds the first stage and the oscilloscope is moved from stage to stage. Regardless of method used, don't jump from circuit to circuit in a random manner.*







TRANSISTOR TV

to speed transistor TV servicing

connect the scope probe while the set is on, make sure you do not short out the collector-to-base terminals of a transistor. Also be careful not to short out voltages to ground, even momentarily. This procedure prevents surge currents which could damage transistors. The scope probe must be a pinpoint type for safe and accurate use in crowded circuit component areas.

If you are signal-tracing video i.f. stages use a diode-type scope probe to detect the video signal at points ahead of the detector or use a low-capacitance probe and connect the scope to the output of the video detector. The test signal can then be applied to the inputs of the various i.f. stages, moving toward the tuner, until the defective stage has been found.

Localize the trouble

Remembering the basic rules for localizing trouble saves signal-tracing various sections unnecessarily. If both sound and picture are absent, signal-trace the stages from tuner to sound takeoff point. If sound is present but no picture, check the stages between the sound takeoff point and the picture tube. If a picture is present but no sound, check the stages between the sound takeoff point and the speaker. If sound is present but the picture *screen* is dark (no raster), check the high-voltage supply. If the picture is weak, remove the antenna lead-in and apply a modulated rf signal to the input terminals. If the signal appears at the detector and the CRT in good order check out the antenna system.

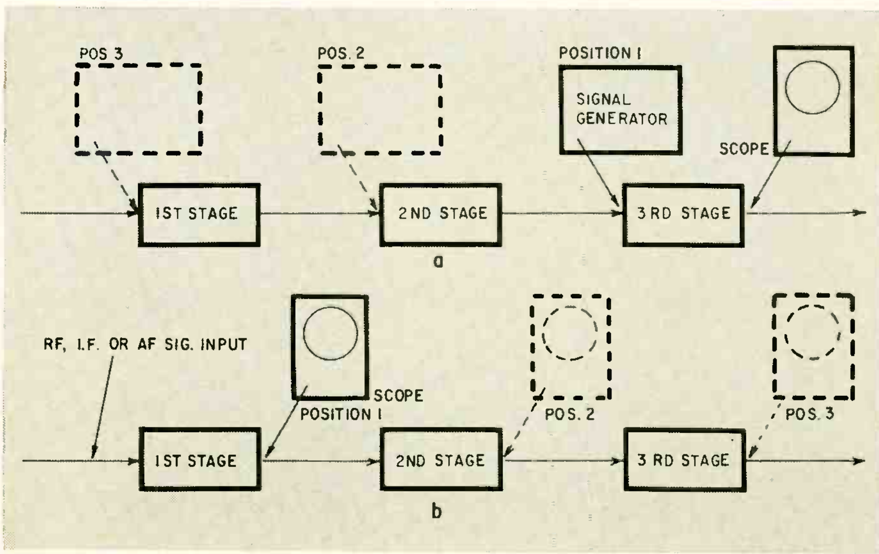
The generator and scope leads can be connected to the various sections of solid-state circuits with less loading effect than encountered in tube circuits, because transistor impedances are generally lower than those of equivalent tubes. In some circuits the lower signal amplitudes of transistor stages may require you to crank up the vertical gain on the scope a little, but sufficient signal amplitude will be available for signal tracing.

Typical setup

Make sure a common ground exists between the signal generator, the scope and the receiver. A typical setup for checking the last video i.f. stage and the detector is shown in Fig. 3. This circuitry is in the Sylvania A06-1 chassis, and the sound takeoff is from the collector of the video amplifier. Hence, any defective stages prior to sound takeoff will affect both picture and sound. The signal generator is applied to the coupling capacitor to the last video i.f. stage, as shown. The signal generator is set to the intermediate

(continued on page 66)

Fig. 2—Two more signal-tracing methods. In a, oscilloscope is across the output of the circuit while the signal generator is moved from stage to stage until the signal disappears to pinpoint the defective stage. In b, *the scope follows the signal from the input through successive stages until the signal is lost.*



Installing An Intercom/Music System In An Existing Home

It can be done without a visible trace of wire

By GARY WAYNE

A RECENT LOOK AT THE HOME INTERcom business revealed what appears to be a lopsided and limited marketing philosophy. Most, if not all, sales efforts are being directed at the new-home market. Of course it is much easier to run wires before the walls are up and finished, but with a little ingenuity, the barrier of a finished wall or even a ceiling can be circumvented without a visible mark or wire.

One major manufacturer of intercoms said it just wasn't interested in the existing homes market. Whether the manufacturers think it can't be done, or that it requires special equipment or know-how, or that it costs more than the job is worth could not be determined. Another company thought wiring an existing house could be done, but with all sorts of complications and difficulties. Still another company said, "We'd like to see you do it."

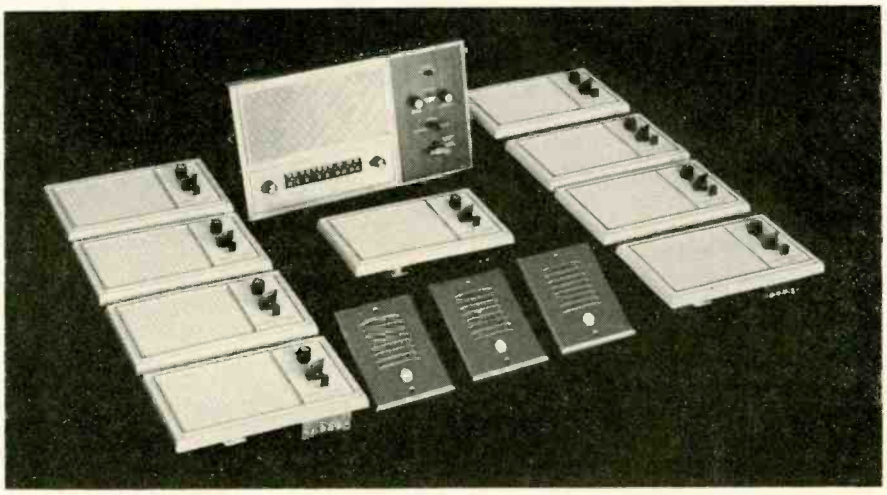
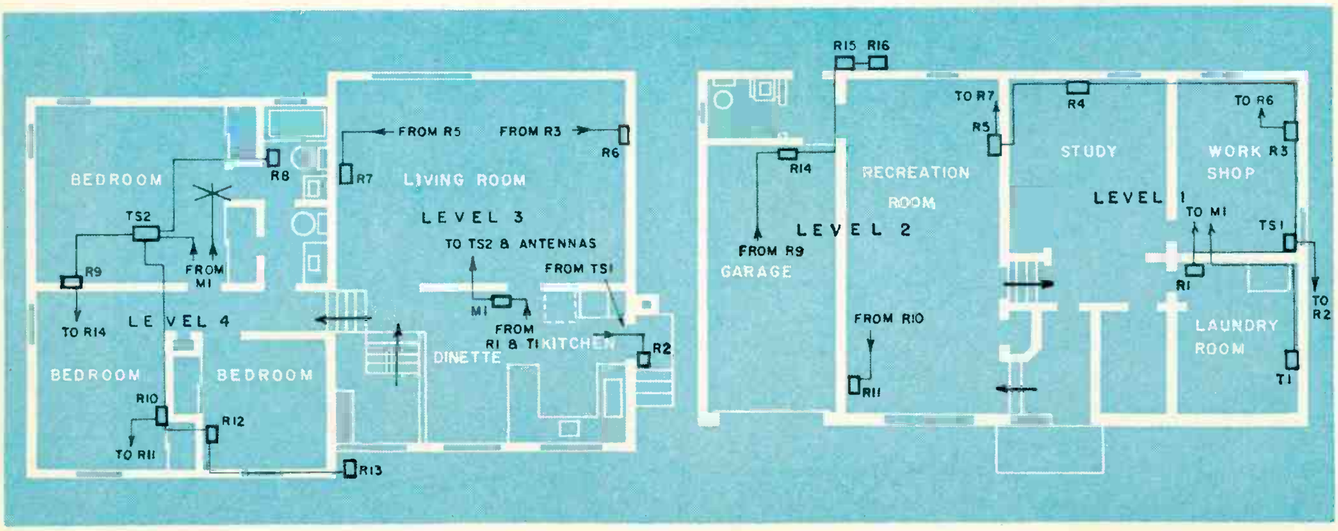


Fig. 2—Combination intercom and AM/FM radio system is easy to install. Two remotes were made portable to expand system to 16 positions without overloading.

If it weren't for the fact that telephone installers routinely solve home wiring problems, the negative attitude of some intercom pros would have killed the idea of installing an intercom system in an existing home. This attitude is unfortunate, because at any given time there are more existing homes than there are homes under construction. Besides it doesn't make sense to have to build a new house just to get an intercom system.

Intercom systems are plentiful and they come in all sizes. You can buy anything from a simple two-station wireless job to a complex of a dozen or

Fig. 1—Layout system to determine cable run and location of stations. To get to level 2 from level 1 in this home it is easier to go up through level 3 into the attic, then across to terminal strip TS2 and down through level 4, than to follow a direct path.



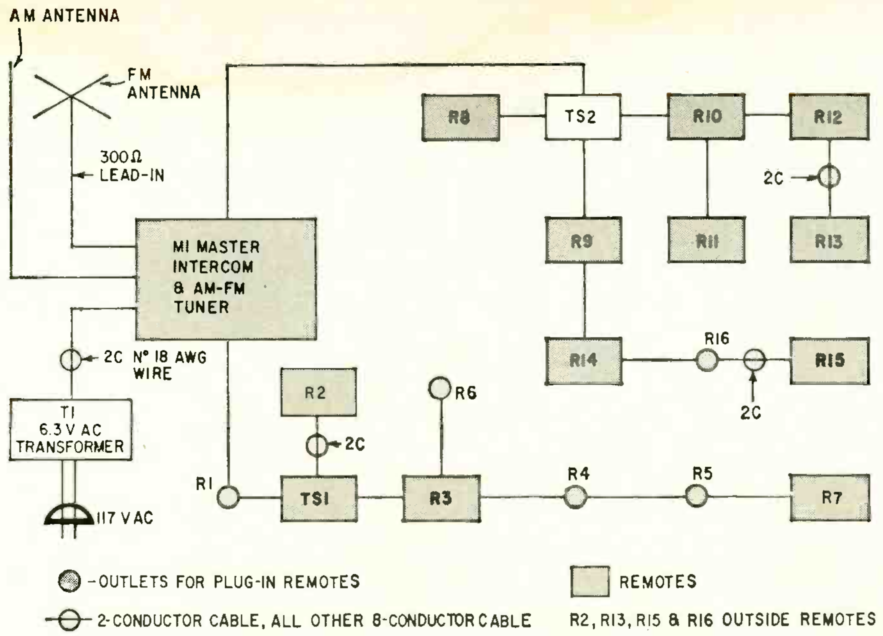


Fig. 3—Wiring is as simple as it can be . . . any unit can be wired to any unit. Outdoor remotes can be hooked up with 2-conductor cable to the nearest indoor remote or master. Stations R1, R4, R5 and R16 are octal outlets to accept the portable remotes.

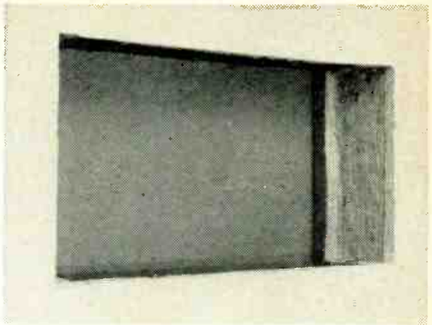


Fig. 5—Because of a double-stud reinforced doorway, the opening cut in the wall shown in Fig. 4 required chiseling a ¾" notch into each of the bordering studs.

more stations with a built-in music system and provision for indoor and outdoor units and with features which allow a person being called to answer a call without touching the intercom.

Some systems permit more than one two-way conversation to take place at a time, such as those employing a number of master stations. Other systems employ a single master station specifically designed for ease of operation and installation. There are systems employing a single remote amplifier, but with remote stations resembling master units equipped with switching ability for initiating selective and private calls.

Determine your needs. Do you want to listen and talk to visitors at your front door without the need for them to push a button? Do you wish to use your intercom as a baby sitter, or to monitor sounds in some remote part of the house? Do you wish to maintain privacy at one or more stations? Do you like to have your intercom pipe your favorite radio program throughout the house? Then you will need a wired system.

Prepare a sketch of the house and mark the desired location of each station, as shown in Fig. 1. Because of the four levels in this particular split-level house it is easier to show all the rooms in two separate drawings. More or less drawings can be used.

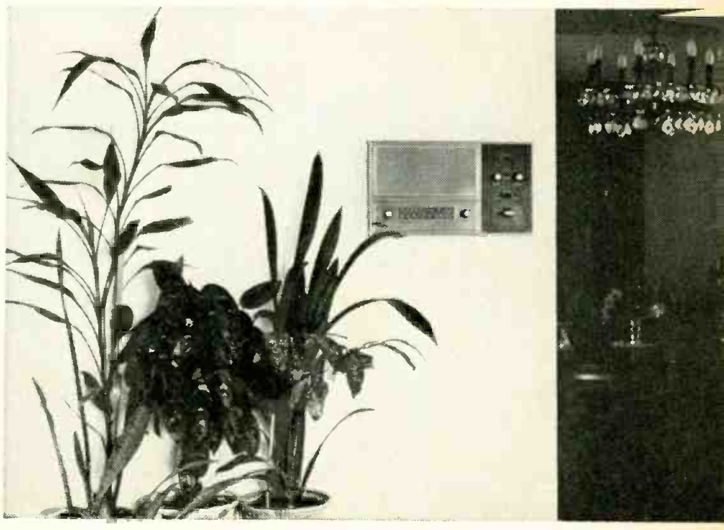
For security and convenience it is desirable to have each of the three outside doors in this house equipped with an outdoor remote unit. The second and third levels of the house called for six remote units: one in each of the three bedrooms, one in the bathroom and two in the large combination living and dining room area. Since the focal point of this particular home is the kitchen and dinette, that is the logical place to locate the master unit.

In the lower portion of the house it appeared logical to install one unit in the garage, two in the very large recreation room, one each in the study, workshop and laundry. All together the need was for a master station, three outdoor remotes and 12 indoor remotes, for a total of 16 positions. Perhaps this many stations reflect the height of laziness but, without too much effort, justification for several more positions could have been made for the inside of the house and for the outside areas, particularly in the vicinity of the patio.

Encouragement to go ahead with this project came from the Bogen Communications Division of Lear Siegler, Inc. They also happened to have a very suitable system for the home. The system features a master station which can ideally carry a dozen

Fig. 4—Mark off the area to be cut out as accurately as possible. Do not depend upon the panel escutcheons to hide sloppy work.

Fig. 6. Master station installed without horizontal supports. The back box (roughing frame) is screwed to studs on each side.



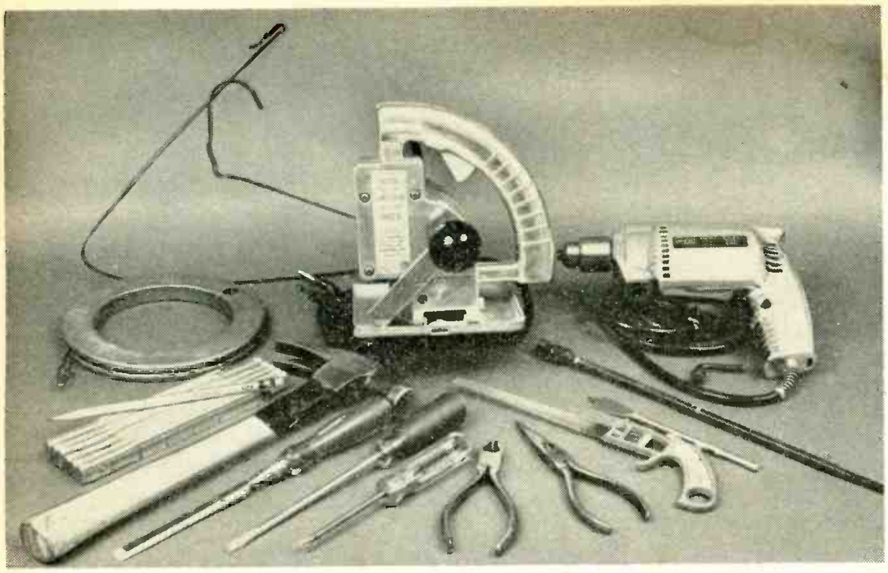


Fig. 7—Only a handful of tools are needed for the entire job. An electric drill and extension make it possible to get past the floors and ceilings over the wall spaces.

remote units without overloading, and a built-in AM and FM radio. (The master and remote units are shown in Fig. 2.) Other features satisfied all requirements except the total number of stations needed . . . the three additional stations could have been added, but another exciting idea popped up which was instantly incorporated into the overall plan.

To wit, instead of possibly overloading the system, two of the remote units would be made portable. They would be mounted in a small cabinet and equipped with a 10-foot cable and octal plug which could be plugged into any one of several strategically located outlets. In this way it would be possible to wire up the other bathrooms, install several outdoor outlets and even run some additional cable for future installation of more outlets. Stations R1, R4, R5, and R16 were assigned outlets for the plug-in portable units.

One big advantage this intercom system has is a parallel wiring configuration which requires only eight conductors (four twisted pairs) for the entire circuit, regardless of the number of units. It is a very simple wiring arrangement (shown in Fig. 3). No special wiring sequence of stations is required. All units are in parallel . . . it isn't necessary to run a separate line back to the master station from each remote. Any unit, even the outdoor remotes, can be connected to any indoor remote. Only two conductors are required for the outdoor remotes.

Optional push-buttons on the outdoor remotes for bell or chime operation also require a two-wire cable or ordinary bell wire. The only other wires needed are for the AM and FM antennas.

Because the intercom is solid-state and requires only 6.3 volts at 60 Hz ac (a stepdown transformer is used to drop the line voltage) low-tension wiring is used and there need be no fear of running wire in violation of the electric code in most if not all areas.

Before making a single purchase, even after you have determined your needs, lay your system out on paper. The more time you spend on the layout, the less time you will spend on actual installation. Study the house and try to visualize how easy or difficult it will be to run the wires, which walls are more accessible, etc.

Is it easier to work from the basement up into the wall space, or is it easier to work from the attic down into the wall space? Will it be necessary to run wire through the wall to the outside, then around part of the house and then through the wall to go inside again? Or is it easier to conceal the wire behind molding or under baseboard heaters. Will you have to really do it the hard way and notch out pieces of walls or ceilings because the run is across the beams? Finally, will you have to take advantage of several of these techniques to complete the job? Where possible run wires parallel with studs and beams and take advantage of the hollow spaces that exist in walls and ceilings.

Be prepared to modify your plan and to select alternate locations for the intercom station within a room just in case you run into an insurmountable obstacle. You must be careful not to disturb existing plumbing and electrical wiring. You must also avoid cutting or drilling into studs and beams that support the weight of the house.

When estimating the amount of wire needed, measure both the horizontal and vertical distances, add at least an extra foot at each station or junction, and then increase your estimate by about 10%. It is better to have some wire left over than to run short.

Not all installations are as large or as complex as this one appears to be. Yet, except for a couple of problems which showed up at the front and back doors and in the garage, the job was fairly easy.

The site for the master unit was se-

Fig. 8—Intercom is powered by a single 6.3-volt transformer (black face). Other units serve door chimes and sprinklers.

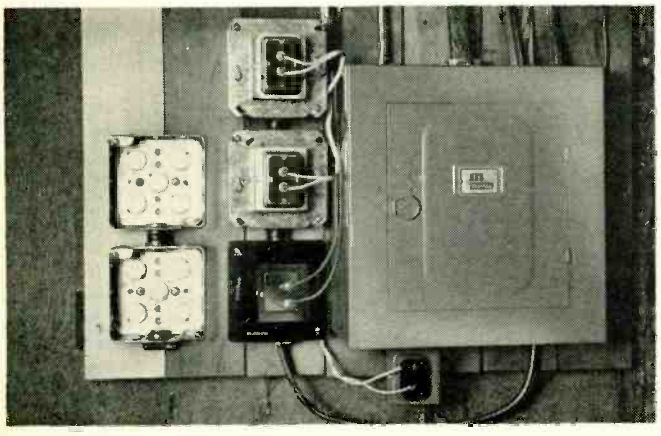
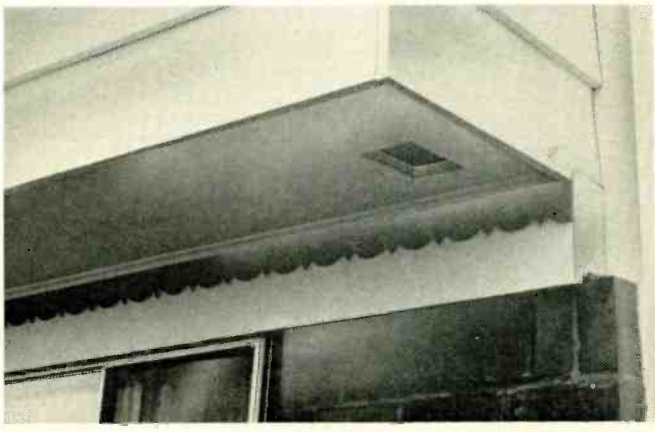
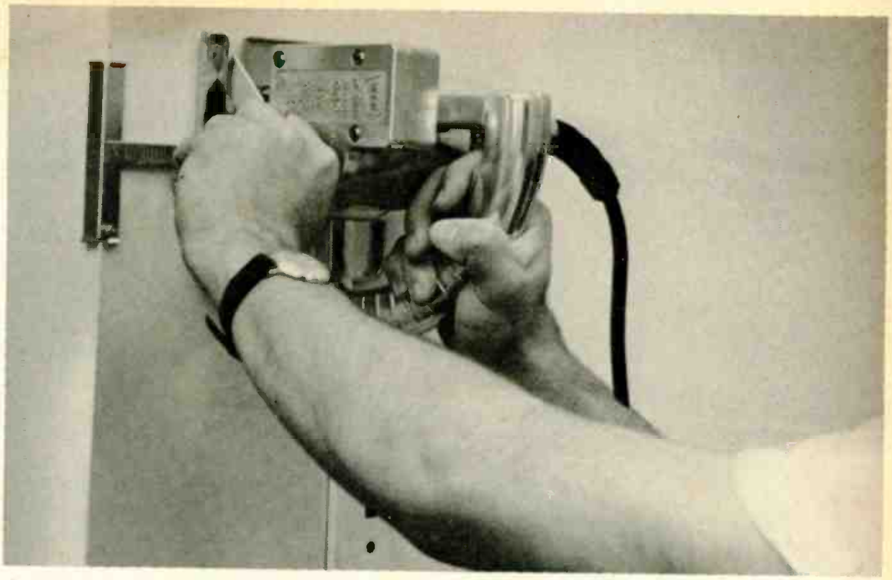


Fig. 9—More than adequate gain and sensitivity permitted locating the front door unit under the overhang, away from rain.



lected and carefully marked off as shown in Fig. 4. *Normal* spacing between studs is 16" from center to center, or about 14½" actual space. This is also the amount of space needed to accommodate the metal frame (back box) which holds the master station in place. Shades of trouble to come . . . when the wall was opened, only 13" of space between studs was found. The studs were installed 16" on center, but the right side, because it framed an opening in the wall, was double-studded.

To recoup the lost 1½", a hammer and wood chisel were put to work to notch out ¾" on either side as shown in Fig. 5. While it is more work to notch out both studs, it is better than completely severing one of the studs. The back box fitted snugly into the opening and was later screwed to the studs on both sides. Fig. 6 shows the master station in place.



Opening the wall is a cinch. Most walls will give way to a sharp knife or small saw, but you can't beat the speed and convenience of a power tool when properly used.

However, before securing the back box and installing the station it is necessary to get at least some of the wires in place. The plan was to drop a line from the master station to the basement level and also to run a line up into the attic and across to the bedroom area. The line in the attic would then go down through the walls into the bathroom and three bedrooms and continue going down into the garage and recreation rooms. Somehow (by osmosis) the front- and back-door outdoor units would be wired up.

A horizontal wooden member (fire stop) about 1' below the opening in the wall blocked the path to the floor. A ⅝" high-speed wood cutting bit in a ⅜" drill as shown in Fig. 7, cleared the way. The same pistol-shaped drill was used to drill a hole through the floor into the wall opening, from the basement up. This can be quite tricky and is excellent for those who want to live dangerously. A couple of inches out of the way in one direction would have chewed a hole in the wall-to-wall carpeting; an equal error in the opposite direction would have taken care of the not inexpensive vinyl floor covering in the kitchen/dinette area.

Careful measuring paid off, the holes in the fire stop and flooring were not too much out of line. A 10-penny nail was tied to the end of a length of kite cord and dropped through the hole in the fire stop. A wire coat hanger, dressed for the occasion (cut, straightened and hooked at one end), was used as a fish hook through the hole in the floor from the basement side. It took only two passes to snag the cord and pull it through. The cord was shuttled back and forth to transport the eight-conductor cable and the two-conductor 6.3-volt ac line.

Installation of the 6.3-volt transformer requires a 117-volt line and a gem box. Unless you are a licensed electrician do not go into the fuse (or circuit-breaker) box; instead, run an extension cord and plug to a nearby existing outlet. However, for a professional type installation the transformer can take its place alongside the fuse box, as shown in Fig. 8. The other transformers shown are for a sprinkler system and the door chimes.

Only one more task to do before the master station could be hooked up and secured in place: The eight-conductor cable FM antenna transmission line and a single conductor wire which served as an AM antenna had to be run up into the attic. A 12" drill extension and a long arm made the grade without difficulty. Fortunately, the electric drill fitted into the wall space, with room to spare. Once the cable was in place in the attic it was connected to a centrally located barrier terminal strip (TS2 in Fig. 3) and then branched out to the bathroom (R8) and two of the bedrooms (R9 and R10). From station R10 the cable ran to the other bedroom (R-12), to the front door (R13) and down to R11 in the recreation room.

Several problems developed at the

(*continued on page 80*)

Fig. 10—Back box for the door remote unit is screwed to the two wooden cross braces installed in the overhang opening.

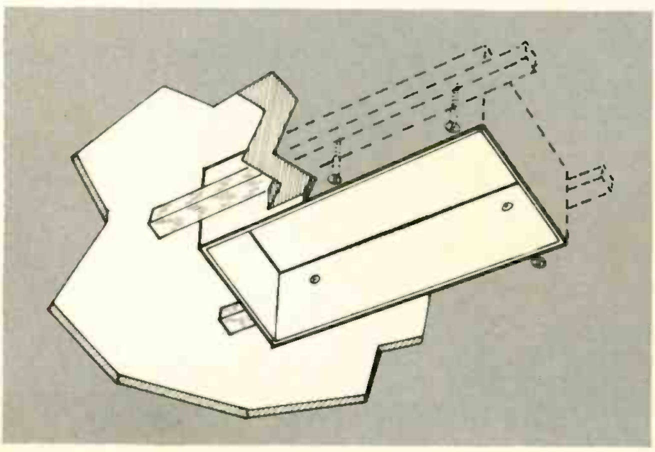
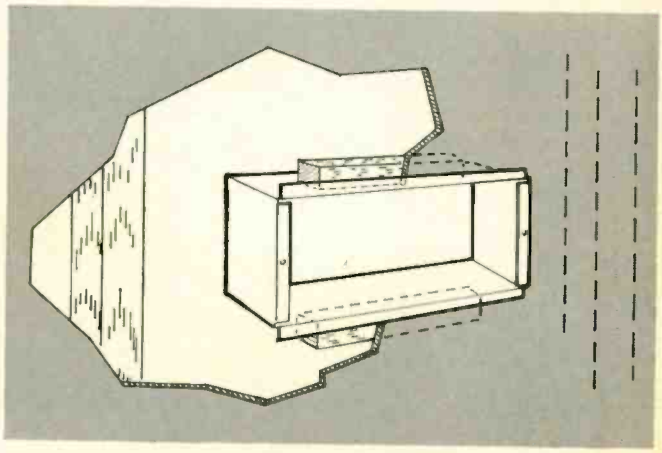


Fig. 11—Wall sandwich used to support indoor remote back boxes. Only 2 woodscrews hold each wooden brace on the box.



GET STARTED IN

By LEN BUCKWALTER

IF YOU'VE SUCCESSFULLY WIRED EXtension speakers to an amplifier you may be a short step away from the world of commercial sound. It's a burgeoning field that presents the installer with unending possibilities. One day you'll install a three-speaker system in a small retail shop. The next job could require a network of 30 speakers in a multilevel department store. And nearly any system includes electronic hardware rarely found in home-entertainment equipment. It includes special transformers and amplifier outputs, L-pads and horns.

Yet the basic aim of commercial sound rarely changes: To distribute audio with little loss, and with flexible control, over floor space. Reaching that objective often begins in the planning stage.

Surveying the job

The first step in any sound installation is a survey, to get the information needed to choose equipment. You'll want to quiz the customer about areas to be covered, where microphones would prove useful, and whether background music will play through the system. Many retailers want several mikes for paging or special announcements from various points in a store. Some clients wish to reduce sound in one room independently of level in the main area. Outdoor coverage in a parking lot may be desirable. This is the data you'll need to establish the number of inputs, control points and approximate speaker locations.

The survey should also provide a technical road map. Walk around the premises and draw a rough sketch, or floor plan. Show details such as mike points and speaker-mounting possibilities (see Fig. 1). This kind of attention to detail saves a lot of back-and-forth travel on installation day.

Where to locate the amplifier? Store managers usually want absolute control over the amplifier and want it located in an office (or enclosure). The problem is that many stores have precious few inches to spare and you'll have to install a new shelf to be used for the equipment.

Other considerations worth noting are how wiring may be routed over the premises. Will you need a special drill bit to make a hole in a floor or wall? Estimate the number of feet needed for wiring runs. After you've extracted as much detail as possible during the survey, you're prepared for the next phase, done at the shop or home.

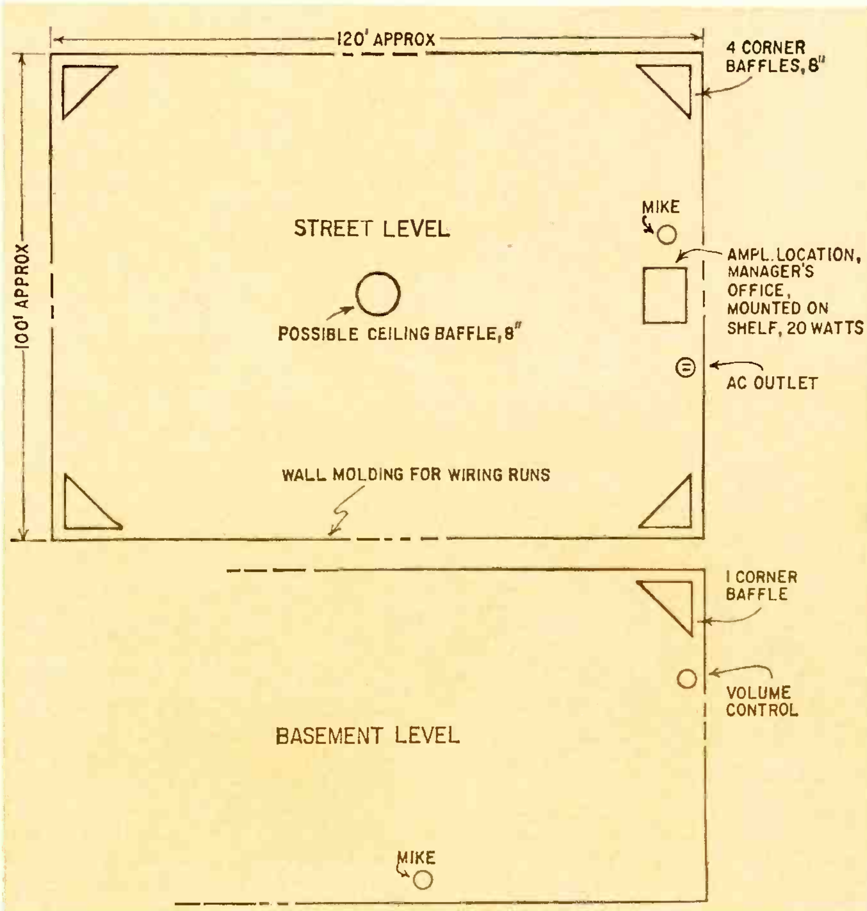
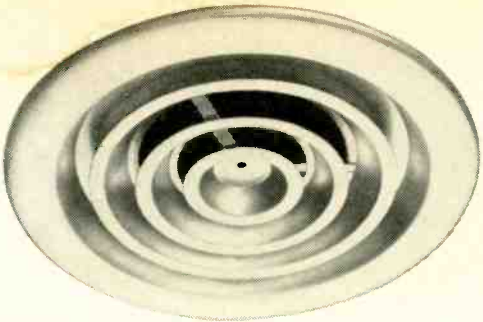


Fig. 1—Before doing anything else, survey the site and make a sketch of the proposed speaker and microphone layout. Discuss this carefully with client.



Sound ideas for a sound future . . . follow the profit path from survey to installation

COMMERCIAL SOUND

Armed with rough sketches, you can start to classify the system and work out a suitable wiring arrangement. An installation will usually be in one of two speaker-wiring categories. A small system can be wired at voice-coil impedance (similar to wiring extension speakers in the home); a large system will usually employ live transformers. The first is inexpensive but sometimes inefficient; the second costly but more efficient.

The typical retail store, beauty salon or small industrial shop needs only a small sound system. Dimensions are usually less than 2000 square feet in such an establishment, with wall lengths generally under 30 by 60 feet. Ample coverage should be provided by three or four speakers.

Since a variety of factors affects acoustic conditions—noise level, ceiling height and room coverings—we can't give precise formulas for speaker location and amplifier power. But experience suggests that nearly all of these cases can be covered by an amplifier rated at 15 to 20 watts.

Speaker selection

In speaker placement, the most important requirement is smooth dispersion of sound. It's possible to use few speakers and run them at high audio output for full coverage. But this annoys people close to a speaker, especially when the system is piping background music throughout the day. The preferable solution is more speakers operated at lower levels. One successful approach has been to use an approximate spacing between speakers of 15 to 20 feet. When speakers are positioned near very high ceilings, spacing may be greater; dispersion improves at greater distance and each speaker may operate at a higher level.

Where an area tends to approach a square layout it's often a good idea to begin with speakers at the four corners. Walls that meet at right angles aid in smooth and wide distribution of sound. Any "holes" in coverage may then be filled in with mid-wall or room-center speakers. An exception occurs in the case of outdoor coverage, where extremely high mounting points (a pole or side of a building) permit a few units to cover a wide area.

A versatile indoor speaker is an 8-inch paper-cone type. It's small enough to mount conveniently in many locations, but large enough to reproduce background music effectively. What's more, it's inexpensive. The more costly 12-inch speaker might be a better choice where a speaker is located far from the ear of the listener and speaker blasting won't be a problem. Unless there's a reason for using a wide-range or hi-fi speaker, a standard replacement type proves a good performer for indoor PA work.

Many baffles are available for mounting your speakers. The V-shaped corner baffle, however, is especially valuable since it provides wide-angle dispersion. A recessed baffle, which mounts flush with the ceiling, offers the neatest installation. But chances are you'll get the opportunity to use it only when the location is under construction. After the premises are completed, you might no longer have access for wiring runs above the ceiling or between floors.

Another specialized group of PA speakers are for outdoor work. They're enclosed in weatherproof housings and take on designations like driver, trumpet and horn. As a group, outdoor speakers are remarkably efficient and cover long distances on relatively low audio power. This capability is partly due to the narrowing of sound over a restricted arc, and partly due to high efficiency at the expense of wide frequency response. In choosing an outdoor type, check to see if its directionality affords coverage of the desired area. Otherwise, these speakers are handled in the same manner as their indoor counterparts.

Running speaker lines

Once you've decided on speaker types, the next consideration is getting power distributed equally. In most small systems, wiring may be done at voice-coil impedances. Speakers are connected directly to the amplifier, but in a variety of wiring combinations that preserve impedance match, and thus avoid excessive power loss.

Proper matching also causes the same power to appear at various speakers tied into the system. This approach, however, has limitations. It is based on short speaker lines wired with substantial conductors, typically No. 18 wire (ordinary zip cord). A rule of thumb is that lines up to about 50 feet will perform reasonably well at voice-coil impedances (3.2, 8 and 16 ohms). Much beyond that span, the line itself consumes too much power; you get progressively less audio in speakers strung along the line.

In a system using only three or four speakers, some power loss can be tolerated by simply running the amplifier at high volume. Since speakers close to the amplifier will tend to blast, they can be individually reduced by one of the volume-control tech-

Shown at the top of these two pages are typical pieces of commercial sound equipment you might use: Electro-Voice 619 dynamic microphone, Lafayette PA-645 amplifier, Soundolier 66 ceiling baffle and Electro-Voice 844-A horn-type speaker.

niques mentioned later.

This lossy solution assumes you have ample reserve power and can suffer line losses which become increasingly pronounced as the impedance of the line is lowered. It's a tactic that should be reserved for installing the small system.

Speaker connections

As shown in Fig. 2, the simple series connection can provide an impedance match at voice-coil impedances in a small installation. The three 3.2-ohm speakers are shown in series,

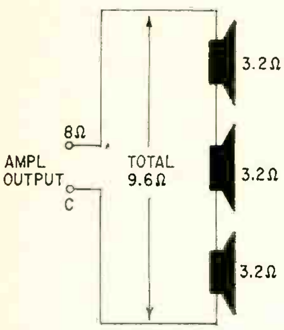


Fig. 2—In a series connection, the sum of the loudspeaker impedances should match the amplifier's output impedance.

which adds impedances to a total of 9.6 ohms. The line, connected to the amplifier's 8-ohm tap, yields a reasonably good match and equal speaker power (ignoring power lost in the line). Similarly, five speakers in series would match the amplifier's 16-ohm tap satisfactorily.

A disadvantage often pointed out for the series connection is that if one speaker voice coil blows, the complete system is inoperative. But that is a rare event. A purist might also point out that if any speaker in a series lineup goes through its acoustic resonance point, it could generate a small ripple of distortion to the remaining units. This is a criticism more aptly applied to a hi-fi installation, where ultimate quality is the goal.

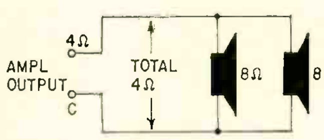


Fig. 3—A parallel circuit. Divide the impedance of one speaker by the number of speakers to get amplifier impedance.

Another technique for the small system is the parallel connection. As illustrated in Fig. 3, speakers are tapped across the line, where impedances divide like parallel resistors. And as for parallel resistors, the total number of ohms is simply the impedance of one speaker divided by the number in parallel. (This calculation works only if all speakers have the same voice-coil impedance.) Thus in our two-speaker example—8 ohms each—the total of 4 ohms provides a perfect match to the amplifier.

The pitfall of the parallel connection is that impedances fall rapidly to below that of the amplifier's lowest tap as speakers are added. Further, we've shown 8-ohm speakers, but there's a good chance you'll be using 3.2-ohm types, which further aggravates the problem. The answer is often a combination approach.

By placing branches of speakers in series to build up impedance, then adding branches in parallel to bring down impedance, you gain additional flexibility. An example is shown in Fig. 4. Note that two 8-ohm units in series build a 16-ohm branch. This is repeated for another set of two speakers. Then, by wiring each branch in parallel, the total is reduced to 8, thus matching amplifier output. A similar arrangement could be worked out for 3.2-ohm speakers.

In laying out any of these systems, attempt to get some physical symmetry in the wiring, so lines will run in nearly equal lengths to different sets of speakers. Doing so tends to equalize line loss. You will have less of a chore in coping with unequal sound level through the system.

Controlling volume

The master volume control for any system is the gain control on the main amplifier. Its setting determines the overall audio level throughout the installation. But to obtain either system balance or control points at individual speakers, additional controls may sometimes be necessary in the speaker lines.

It should be apparent that changing volume at any one speaker must leave a series or parallel matching arrangement unaffected. Individual speaker volume is best controlled with an L-pad, shown in Fig. 5-a. The L-pad is a dual wirewound rheostat that maintains constant line impedance regardless of volume level setting. Although the speaker sees a change in impedance with a change in volume, this effect is not detrimental.

Selecting an L-pad is merely a matter of choosing one to match speaker impedance and power fed to it. Pads are made in several resistances to match nearly any voice coil you're apt to encounter. A typical L-pad for PA work is rated at 4 watts of continuous audio, 15 watts peak.

It's also possible to control more than one speaker simultaneously with a single L-pad. In Fig. 4, the two top speakers (8 ohms each) are series-connected for a total of 16 ohms. A 16-ohm pad could be inserted in the line feeding only those speakers. This might prove effective if you wish to control a group of speakers simultaneously in a room away from the main listening area.

An L-pad can only *reduce* audio power to a speaker. It cannot boost a weakened signal that has traveled

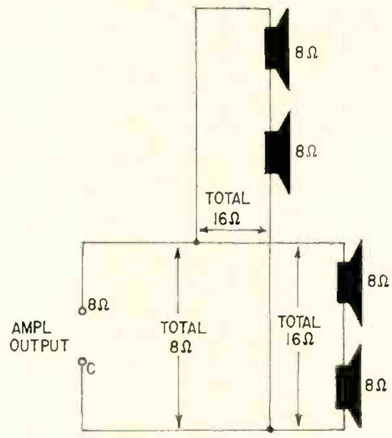


Fig. 4—Series-parallel connection of four speakers to a single amplifier tap uses two branches to match properly.

over a long line to a remote group of speakers. Overcoming the loss by raising amplifier volume may cause near speakers to blast. Thus, basic balance of the system might require pads in additional speakers.

Large systems

So great is the power distribution problem in long wiring runs that installers seldom use the voice-coil techniques just described. As wire lengths run into hundreds of feet, even heavy wire sizes will be the cause of considerable power loss.

A second problem is just as critical: When speakers grow in number it becomes increasingly difficult to combine them in series and parallel arrangements. Fortunately, a relatively simple solution exists.

Constant-voltage line

The 117-volt ac line in your home is part of a constant-voltage line. You can easily plug in any electrical appliance rated at 117 Vac with little regard to the power it consumes (so long as it doesn't blow the fuse). A 75-

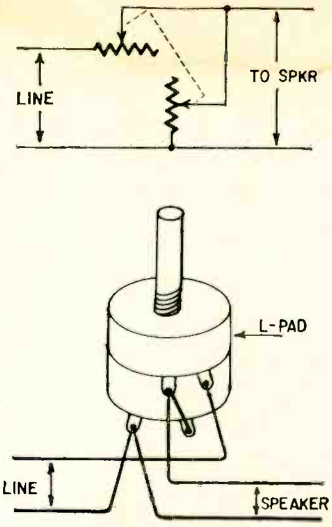


Fig. 5—To control the volume of an individual speaker, an L-pad keeps line impedance constant and doesn't affect the volume on other speakers.

watt lamp, a 300-watt TV receiver and a 50-watt soldering iron simply draw their rated current (and thus power) from a common line.

The same principle is employed by the larger PA amplifiers. In addition to the usual 4-, 8- and 16-ohm

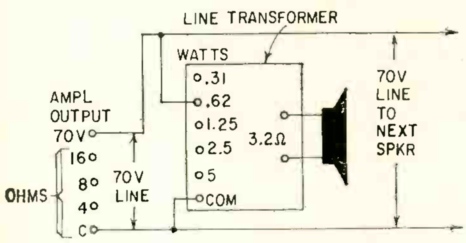


Fig. 6—The line-to-speaker transformer in a 70-volt system is tapped to feed more or less power to the speaker. Each speaker is fed from a separate line-matching transformer.

outputs, one tap is designated 70 volts. ("70 volts" means that when the amplifier is driven to full rated output —say 50 watts—a potential of 70 volts will exist across the line.) Now any variety of speaker sizes, shapes and power levels can be "plugged into" the line. Speakers may be added to the line at a future time—or removed —without affecting other speakers along the line.

This additional tap for 70 volts vastly increases flexibility in installation and eliminates any calculations. It slashes power losses in lines, too, since the higher voltage and impedance levels reduce line loss. Of course, you can't exceed the output capability

Five points to remember:

1. Survey the premises first, making a floor plan and estimating speaker and microphone need and placement.
2. The amplifier should usually be centrally located.
3. It's usually better to use more speakers at lower volume, than fewer speakers at higher volume.
4. Use constant-voltage speaker lines in large systems where cable runs are long
5. Different locations may need different speaker output levels; use line-transformer taps or L-pads.

of the amplifier. With 10 speakers being driven by a 50-watt amplifier, total power consumed by the speakers cannot be more than 50 watts.

Further, the 70-volt line requires the addition of transformers to match the line down to speaker voice-coil impedance. But the process, as you'll see, also provides a handy method of controlling balance and volume at each speaker.

Using the 70-volt line is simplicity itself, as shown in Fig. 6. A line, or constant-voltage, transformer is usually mounted within the speaker baffle. Note that one side of the transformer has a series of taps marked in various wattage levels. You merely select the desired wattage for the speaker—in this case 0.62 watt—and connect the line between that tap and common. This procedure is repeated for each speaker in the system. If the transformer is feeding, say, a large outdoor horn. the installer might pick the 5-watt tap to produce ample power.

Another useful feature is that after the system is installed, it's easily possible to balance it. If a particular speaker produces excessive sound, the tap is merely dropped down one position and speaker power is reduced by one-half.

A speaker connected to a 5-watt tap will take 5 watts from the line only when the amplifier is driven to full rated output. If one speaker is connected to a 5-watt tap and another to a 10-watt tap, the first will draw half

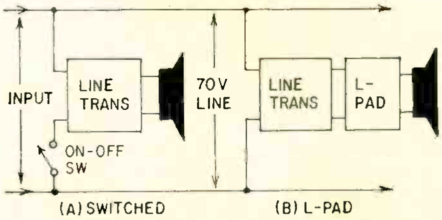


Fig. 7—Two ways to control volume of a single speaker in a 70-volt system: Switch (left) simply turns speaker on and off, while L-pad (right) allows continuous control of sound volume.

as much power as the second.

There are various tactics for controlling volume in individual speakers on a constant-voltage line. It may be as simple as shown in Fig. 7-a, where a switch in one leg to the transformer removes that component from the circuit. This method provides only on–off operation for the speaker. To obtain continuous volume control, an L-pad rated at the speaker's voice-coil impedance is wired after the transformer, as shown in Fig. 7-b.

Another possibility is shown in Fig. 8. This method will not produce smooth, continuous changes in volume since it operates in stepped fashion.

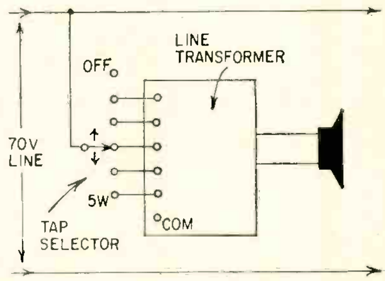


Fig. 8—Another way to control volume of a single speaker in a 70-volt system.

The selector switch is turned to the desired tap. Note that the first position is off, then volume grows increasingly stronger as the switch moves down the taps. Although power doubles at each step, there is only a slightly audible change to the listener. Tap-changing transformers of this type are unlike L-pads in that they do not waste power when the speaker is adjusted to low levels.

While loudspeakers and amplifiers aren't the only components in a sound system, getting them installed takes care of most of the work. It's relatively easy to add microphones, turntables, tape decks and AM and FM tuners, as needed. The main thing is to cover the desired area with sufficient intelligible sound. **R-E**

BIG BOOM IN SOUND

High-power amplifiers, close-talking microphones, beefed-up speakers and earth shattering sounds

By JACK DARR

THERE'S A NEW BOOM IN THE SOUND business, and I do mean BOOM! It's in the sound equipment used by musical groups playing all that new pop, rock and Western music. A typical group may have only four guitars, but they get as much power as a 100-piece marching band—more, in fact.

Electronics retailers report that a very large percentage of sales in the last year or two have been in this kind of equipment. Well-informed sources seriously estimate that this branch of the business can go as high as $500,000,000! It's been growing rapidly for the last few years, and is still growing.

The customers for this equipment are young. They have their own ideas about what they want, and how they want to use it. A lot of these ideas are completely foreign to some sound men (present company included) and, in fact, violate long-established laws of acoustics, second-installation practices, and so on. However, they do have one point in their favor—they work!

To get in on the boom, the first thing is throw away the book, get your foot out of the rut and get with it. The sound problems you'll find won't be easy, if you try to use "conventional" equipment; however, to meet the tremendous demand, manufacturers have come up with specialized equipment that *will* work under these conditions, and work very nicely, thank you!

The first thing these musicians want is power and lots of it. They figure that they came to be heard, and they want to make sure they are. It's hard for an old-timer like me to comprehend, but many groups use individual amplifiers big enough to cover a good-sized football stadium! "Guitar amplifiers" with 50, 60 and even 100 watts are common. Indoors! (There goes an old belief!)

There is always one vocalist, and in many groups, all the members sing. To be heard above the instruments, separate vocal amplifiers are used, with powers up to 100 watts again. Photo on opposite page shows a typical amplifier system, with 100 watts output. This one will accept two microphones. Mixers can be used to provide as many as eight mikes at the same time.

Instrument amplifiers run all the way from the little 5-watt "practice" amplifiers up to the 100-watt and even 200-watt sizes. The most common construction seems to be what is called a "piggyback": The amplifier sits on top of the speaker enclosure, with its control panel slanted, for easier access, like the unit of Fig. 1.

Speaker enclosures are small, considering the tremendous sound power they must handle. Two of the most popular types are the "laydown" and the sound column.

Cone speakers, by the way, are always used in today's music. The old trumpet–driver combination is a more efficient speaker, but lacks the strong, solid bass these musicians want—so they're out.

Microphones and speaker placement

Stand by to throw another old idea overboard—that mikes must always be *behind* the loudspeakers. Not any more! Young musicians believe, quite logically, that *they* should be seen as well as heard! So, the musicians and the mikes are out in front and the speakers are in back, as you can see in the action shot of the "Cryan' Shames" (left). Putting mikes in front of speakers brings up some difficulties, *if* conventional equipment is used. You can see another big difference here too. Notice how close the singer at left is to his mike! The old idea of "never nearer than 12 inches" is gone. These are specially designed mikes, as we'll see in just a minute. They have to be, to work in front of the speakers delivering such high sound power.

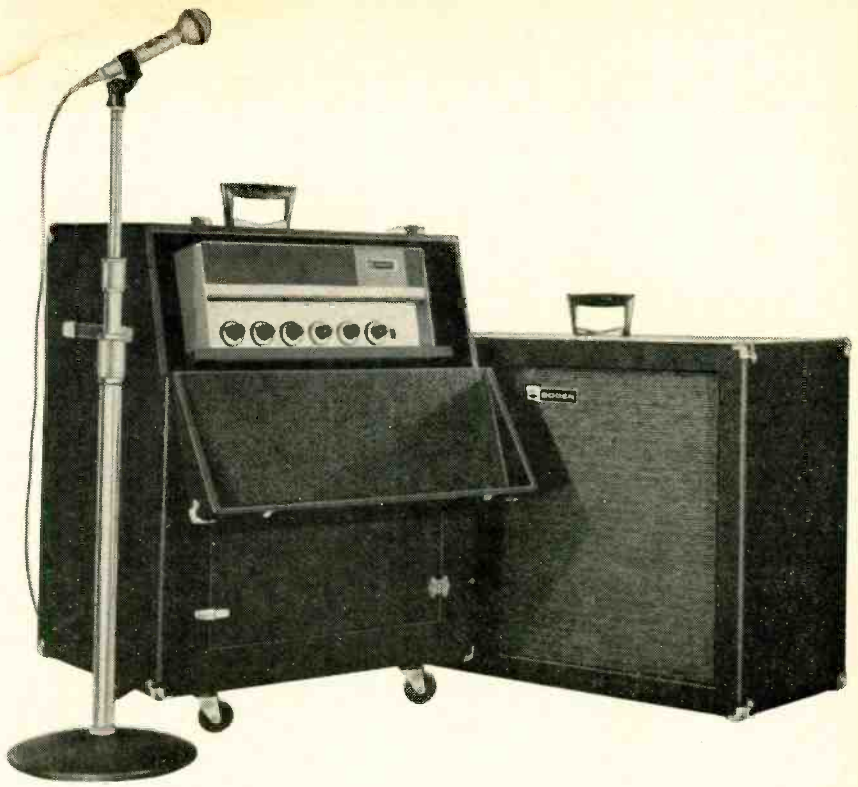
Now let's take a look at some of the details—the changes and redesigns that manufacturers had to make in their products to do this kind of work.

Amplifiers

All the parts in a system are equally important, but let's start on familiar ground. We've had high-powered amplifiers for a long time. The latest versions, tube or transistor, are much more compact than the older ones.

A typical musical group might use three guitars: lead, rhythm and bass. A string bass may be added. All will be "electric guitars" (I know this ought to be "electronic," but it isn't.) In some cases, each instrument will have its own amplifier. In others, a medium-power amplifier (50 watts!) may be used, with multiple inputs, tone controls, reverb and other special effects.

To get up into the really high powers, the big boomers like those shown on page 49 can be used. Fig. 2 is a partial schematic of a 200-watt booster consisting of two 100-watt amplifiers in parallel. Each has a 7247 amplifier phase inverter and four 8417's in push-pull parallel. If you want to approach the mildly ridiculous, five 100-watt



A typical vocal amplifier system, the Bogen Swinger 100, puts out 100 watts of power. This model will accept two microphones. Mixers permit use of 8 mikes.

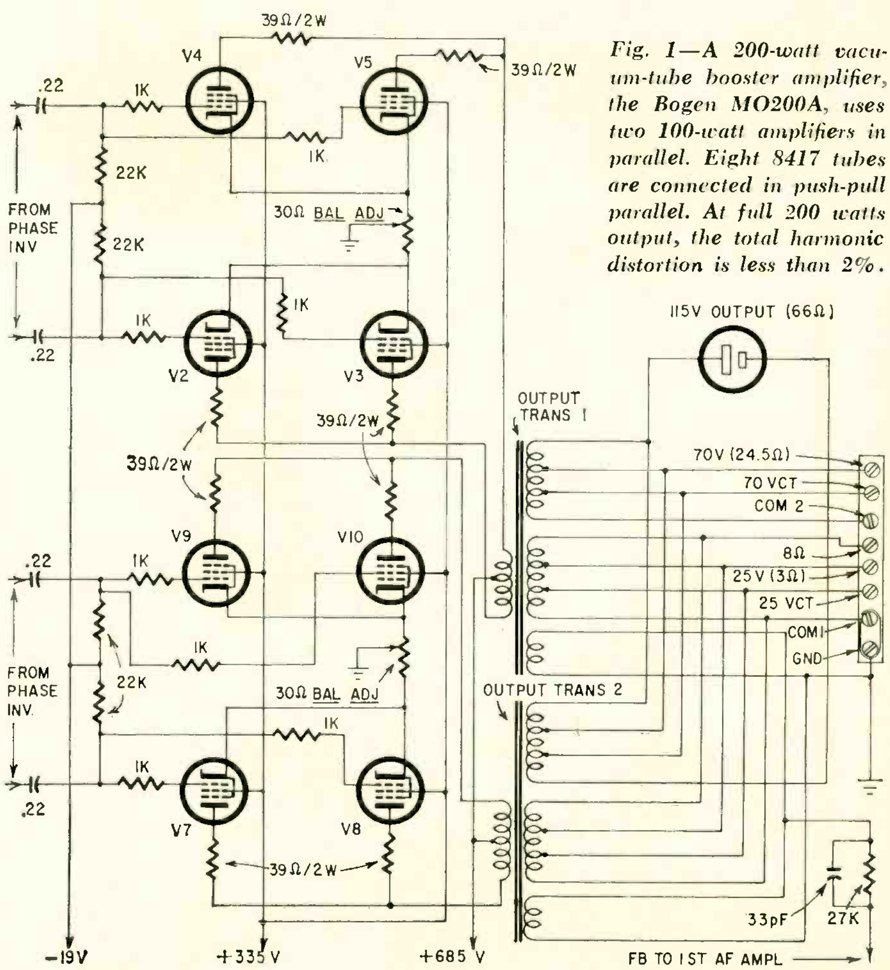


Fig. 1—A 200-watt vacuum-tube booster amplifier, the Bogen MO200A, uses two 100-watt amplifiers in parallel. Eight 8417 tubes are connected in push-pull parallel. At full 200 watts output, the total harmonic distortion is less than 2%.

boosters can be driven by a single preamp, for a total of 500 *watts* output!

External mixers can be used with instruments, mikes or a combination of each. The mixer shown on p. 50 has five inputs, each with its own gain control, and a master gain control. Mixers like these can be paralleled to give any number of inputs needed. Another version of this instrument is also shown; this has four inputs and built-in reverberation. You can adjust reverb on the front panel, by a remote switch mounted on one of the guitars, or a hands-free, foot-operated switch. Reverb or echo is often used to simulate the sound of a large hall or to create special effects.

Peter Noonan ("Herman" of Herman's Hermits) in action with close-talking microphone technique. Specially designed microphones can be held ½ inch from vocalist without producing distortion.

Bass amplifiers

Extra-heavy low-frequency response is needed for bass guitars or string basses. This demands high power in the amplifiers themselves, since, even in a normal composite musical tone, practically all the *power* is in the lower frequencies. (It takes more "work" to move speaker cones back and forth over large excursions at very low frequencies.)

The amplifiers are designed with heavy bass-boost circuits, and very large cone speakers are used. Electro-Voice makes one with a *30-inch* diameter! With a high-powered amplifier, this can be a real "window-breaker"!

Reliability

These amplifiers had to be redesigned for "hard work." Even in a home hi-fi amplifier with a 100-watt rating, the average power output is only about 1–2 watts! The rest is saved for occasional music peaks. However, in go-go clubs, the amplifiers may be running at 75–80% of full output power for hours at a time. They are also subjected to extremely high transient voltages; stringed instruments normally have a very sharp "attack" or initial rise time, and this can put terrific voltage surges through the system. Components must be rated to carry them, or you'll have component failures at regular intervals!

Microphones

"Microphones must always be behind the speakers." That's what we *used* to say. Look at these photos of performers in action! The mikes are all along the front of the stage! But how do we get away from feedback?

Simple. Specially designed close-talking mikes are used, and the singers work very close to them—photo left shows Peter Noonan ("Herman" of Herman's Hermits) in action. He is actually working about ½ inch from the microphone.

Sound waves are very much like radio waves. Each wavefront is basically hemispherical; it loses power tremendously as it travels away from the source, because of the spreading action. The actual sound power at a distance of ½ inch from the singer's lips is much, much higher than at say 24 inches (see Fig. 2). This "proximity boost" is a normal characteristic of all microphones, and is deliberately emphasized in these special models. The boost in level may be 50–60 dB or even more.

These mikes are relatively insensitive to sounds coming from more than about 3 feet away, but quite sensitive to nearby sound at a high level. Comes out with exactly the effect we must have for this kind of work.

Practically all such mikes are dynamics. Even crystals proved too delicate for this kind of rough service. Special shockproof construction makes them rugged and long-lasting.

Mikes are often hand-held for convenience and to give the performer more freedom to move around. Most of them are provided with a "quick-disconnect" mounting from the stand. A plastic C-shaped clip holds the mike tightly, but it may be slipped forward and out very easily.

Proximity effect

Beside volume gain, we get another bonus from the close-talking technique. Older mikes, such as ribbons, suffered from "pop" (explosive "B" and "P" breath sounds) and wind noises; they also accented sibilants ("S" and "C" sounds) These new dynamics are designed to eliminate this effect by special baffling inside the case. (I call this "whodunit" technique —a baffling case.)

A phenomenon which was regarded as evil in older mikes, especially ribbons, was called "proximity effect." If the performer got too close to the mike, there was an increase in bass response. Could be as much as 15 dB around 100–200 Hz. This was an undesirable feature which was eliminated or avoided.

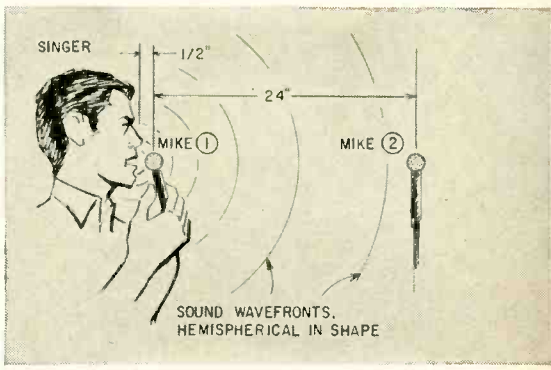


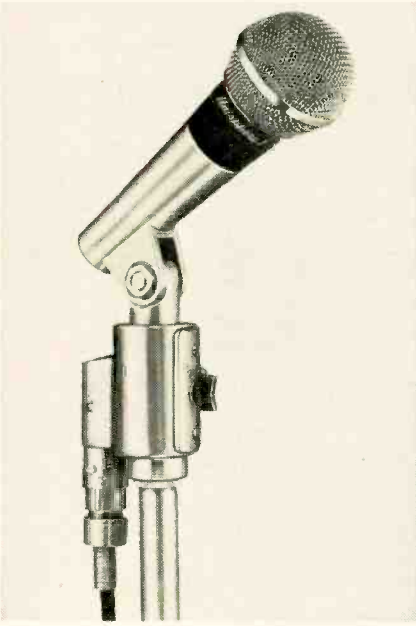
Fig. 2—Sound waves act somewhat like radio waves. Their intensity at a given point decrease exponentially as the wave travels away from the source. Therefore, the sound intensity at mike #1 is very much greater than that at the location of mike #2. Special mikes use this "boost."

Now, though, bass boost is being deliberately designed back into microphones. Most modern pop singers today are young. They haven't had years of voice training to develop a tremendous pair of lungs, like the old opera singers. Their voices tend to be somewhat thin. But when they work very close to mikes, the built-in bass boost makes them sound full and rich, and this, of course, is just what they want.

As a final hint, microphone cables must be very strong and durable for

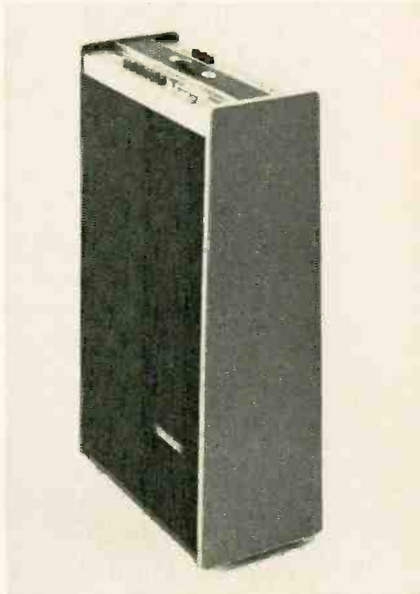
MICROPHONES

Today's vocal mikes use windscreens to avoid breath popping. Quick mounts aid active singers. Top to bottom are Shure PE566, Turner 700, Sonotone DM70.



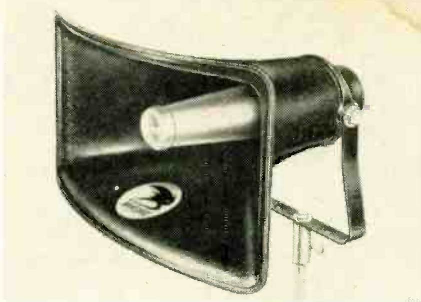
AMPLIFIERS

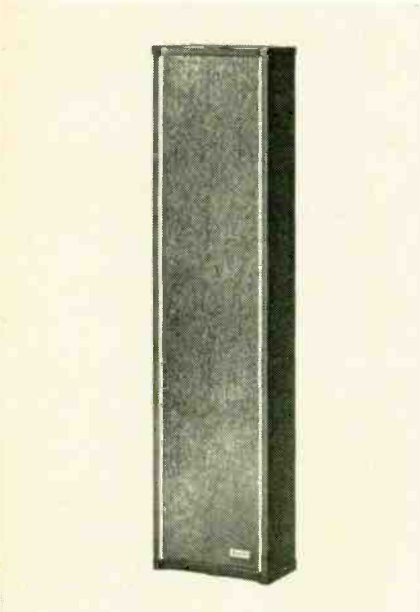
Amplifiers are powerful: Bogen M120 (120 watts, PA); Lafayette (80 watts, bass instrument); Lectrolab/Allied (75 watts, bass instrument); Guild Quantam (200 watts, bass instrument); Baldwin Exterminator E-1 (250 watts, instrument); Hilgen Swing-away Guitarist 5063 (75 watts, guitar); Ampeg Olympian (230 watts, bass instrument).

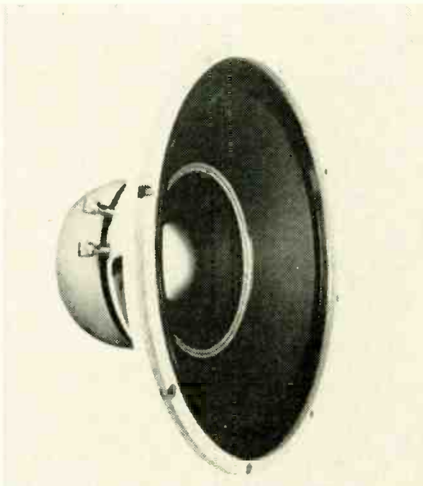


SPEAKERS

To handle the bursts of power delivered by today's powerful amplifiers, speakers are made more rugged. Shown are Atlas Sound CJ-125 Banshee (top right), for vocal amplifiers; Jensen HFC-84 column system; and the Altec Lansing 420A Biflex.

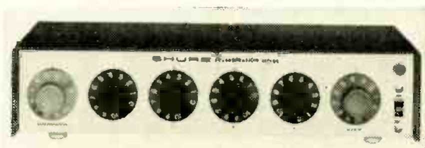


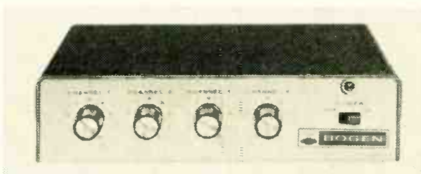




ACCESSORIES

Vocal groups can add mikes with a mixer. [Shure PE7ORM (right) and Bogen MX6A-T (lower right) mixers.] Guitarists like "fuzz" because it adds character to the sound they produce. (The foot-controlled Lectrolab/Allied Fuzz Box below.)





this kind of work. Mike plugs must be tightly soldered, and for goodness' sake do *not* forget to fasten the "strain-relief" fitting to the cord when replacing plugs! Mike cables are pulled, tugged and hauled all over the stage during a performance, and the connections must not come loose.

Speakers

Now we come to the final part—speakers. These probably demanded a more complete "re-engineering" than any of the rest. As we said, there were high-power amplifiers and suitable mikes, but we did not have *cone* speakers that would handle this much power. The familiar outdoor-type trumpet-driver combination would, of course, but this is out. The boys want cone speakers, mainly for their much better bass response.

Since even the best cone speakers were rated at about 30 watts maximum, a complete overhaul was necessary. In the early days, some odd things happened. One salesman sold a group a 100-watt amplifier, with four "heavy-duty" cone speakers. In a little while, they were back—all four speakers literally blown to ribbons!

Speaker engineers started ordering large pots of black coffee. They had to develop reliable test methods which would help them build speakers to handle this kind of power. Jensen, Electro-Voice and others worked out "torture tests" to see if projected designs, materials and methods could take it.

They tried high-level music, white noise, and so on, and eventually settled for a "warbled" sine-wave tone at a very-high-power level. In the first tests with this method, *every one* of their best speakers failed at a warbled-tone level of about 50 watts! When they got through, however, they had speakers which could take a *100-watt* warble tone all day and like it! Many of them are guaranteed for life.

However, getting to this point was far from easy. I asked one leading speaker design engineer, "What did you have the most trouble with?" He said wryly: "*Everything!*" This is true—literally everything on the speaker had to be rebuilt from the ground up. They still look the same on the outside, but on the inside—wow!

The first thing to go was the voice coil. You know what a voice coil used to look like: about 20 turns of fine wire on a thin paper form. Imagine dissipating 100 watts of power in something like that! So the first thing that happened was the voice coils melted.

Bigger wire solved that problem. Then another one came up. The terrific heat actually melted the enamel off the wire. High-temperature enamel cured that, whereupon more trouble arose. The heat softened the cement that held the coil to the bobbin, and the voice coil pulled off entirely. A "thermosetting" cement, which got harder instead of softer as the heat increased, cured that one.

The bobbins themselves were made of paper. This simply charred and disintegrated. Going to a Fiberglas bobbin, with a special high-temperature plastic binder, fixed that one.

Then, special cements had to be developed, to hold the voice-coil form to the cone itself. What my engineer friend, with a grin, called "library-paste joints" couldn't take it. Inevitably, epoxy cement was chosen, and the joint reinforced to take the strain.

There was one more important thing, before they left this area—the leads which connect the voice coil to the terminal board on the frame. As all old technicians know, broken leads here accounted for a great many cases of "open voice-coil" complaints; it was seldom the voice coil itself. Here, with the long throw of the cone and the terrific vibration, ordinary wires simply disintegrated in a very short time.

Long hours of work, and many tests, produced special wires, similar to the fabric-cored leads used in smaller speakers but vastly different in strength and flexibility. A special method of fastening these to the terminal lugs on the cone had to be worked out. Now, the connecting leads are made with a very special "set" to them.

This is a necessity, so that they

(*continued on page 69*)

FEEDBACK QUIRKS

Feedback theory and practice are sometimes out of phase. Find out why from these case histories. By NORMAN H. CROWHURST

The theory of feedback seems so simple. You look at the problem and the theory tells you that you can't miss on this one. But somewhere something that you don't figure in theory sneaks in and gives you a puzzling time finding out what went wrong. Let's take some examples from situations I've encountered.

Two-way transfer. In the first one that comes to mind, feedback was not used to correct defects, like distortion or response deviation, but to contribute to the desired performance: the feedback crossover filter. According to the theory, it's a matter of fitting rolloffs to a stage of amplification, either high-pass or low-pass, and then applying overall feedback to sharpen the turnover.

Two RC combinations (Fig. 1), each producing a response as shown in curve A will, when combined, produce a response B, without feedback. This is the sharpest knee that two RC networks can produce without feedback. The object is to use the right amount of feedback—in this case it should be 6 dB—to sharpen the turnover to the shape of curve C. In theory, the sharpening reduces the relative loss at the 90°, 6-dB/octave point from 6 dB to 3 dB, and at the same time shifts it by a frequency ratio of 1.414 (according to whether it is high- or low-pass).

To play the design safe, I figured out the turnover points from a reactance chart, then checked the value of feedback resistor that would reduce gain in midband by 6 dB. Finally I checked the response with this resistor in circuit, but returned to ground instead of the feedback point (Fig. 2). As expected, the combined response was that of curve B (Fig. 1).

Now I connected the feedback, but instead of producing curve C (Fig. 1) the curve didn't go on down as it should (curve DC, Fig. 3). The sharpening part was fine, but somehow the feedback spoiled the total amount of separation available. How?

Until then, I hadn't realized that the signal doesn't know which way feedback theory expects it to flow through a resistor. According to the theory, signal flows only from right to left through the feedback resistor (Fig. 1-a), which it will do while the signal is bigger at the output than the input. But when gain falls off due to the RC action, so the signal at the input is bigger than that at the output, the flow will be from left to right, which theory doesn't consider.

The simple fact was that signal was "leaking" through the feedback resistor.

A variation of this occurred when I designed a similar filter around a transistor instead of a tube. Following the same procedure, I ran into trouble. First, although I used carefully chosen RC combinations to produce 3 dB loss at the same frequency, when I put them both in, one in the base and one in the collector circuit, the total loss at this

(continued on page 86)

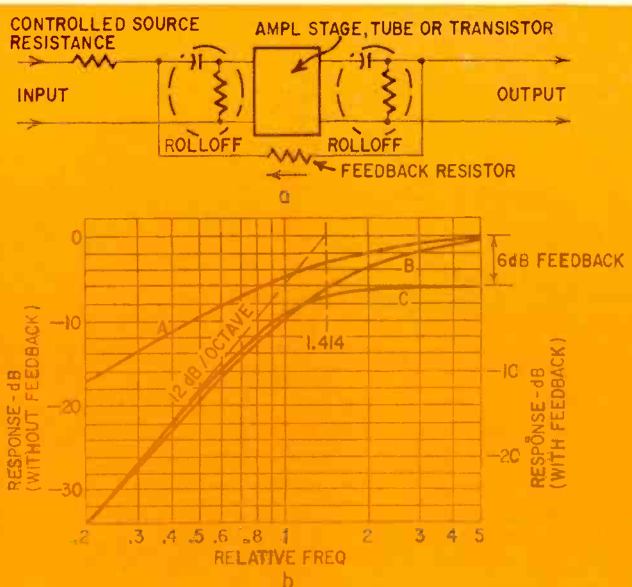


Fig. 1—Each RC network generates a rolloff as shown in curve A. Responses combined produce the rolloff curve shown at B. A 6 dB feedback sharpens response to produce the curve at C. On frequency scale, 1 represents the final crossover frequency.

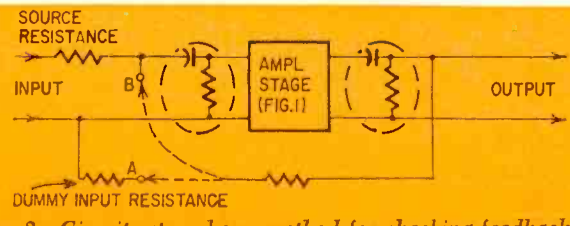


Fig. 2—Circuit setup shows method for checking feedback response. Feedback resistor is switched between points A and B.

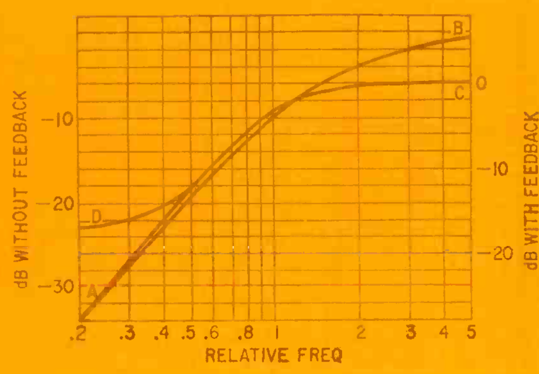
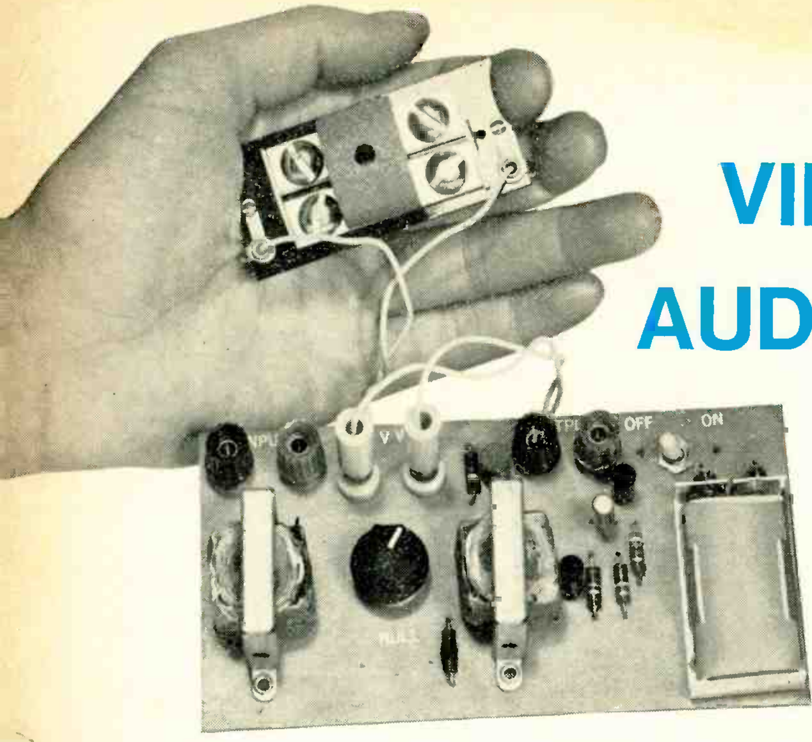


Fig. 3—Signal leakage through feedback resistor produces curve DC instead of AC. Curve AB results without feedback.



VIBRATING-WIRE AUDIO FILTER AND OSCILLATOR

Novel amplifier circuit has an exceptionally narrow bandpass of only 1 or 2 Hz.

By JOHN C. RANKIN

IF A STRAIGHT PIECE OF WIRE IS PLACED in a magnetic field and an audio-frequency voltage is applied to it, the wire will vibrate and act as a very narrow bandpass filter.

Wire filter

Figure 1 shows a 2-inch length of No. 38 wire in a field supplied by a 2-oz magnet. The wire resonates near 1000 Hz and behaves like a high-Q LC circuit.

Most 1000-Hz circuits consisting of inductance and capacitance have low values of Q—between 5 and 10—due to the high resistance of the large amount of wire required. Resistance and capacitance are often used in parallel-T circuits for better results. Although the curve of such circuits indicate good selectivity, close examination will nevertheless show that they rarely have a Q greater than 15. Sometimes regeneration is applied to both these circuits to improve selectivity, and at maximum selectivity the Q may reach 90 in a circuit bordering on instability. The selectivity of any of these circuits may be classed as poor and leaves a lot to be desired.

The vibrating wire in Fig. 1 has a Q of over 600 near 1000 Hz. It can be one of the most selective audio amplifiers available for such uses as telemetry, communications (CW) or wave analyzers.

The short vibrating wire is a low-impedance device. I used the bridge circuit of Fig. 2 as a bandpass amplifier.

The bridge is balanced by feeding in any frequency except the resonant one of the wire, then adjusting R2 for a null. When a signal of about 1000 Hz is applied, the wire vibrates, its impedance changes and the bridge is no longer balanced; so the 1000-Hz signal is passed.

Transformers T1 and T2 can be any type of speaker transformer used in tube or transistor radios and connected so that T1 steps down and T2 steps up. The transistor amplifier makes up for losses in the balancing network; gain from input to output is about 4.

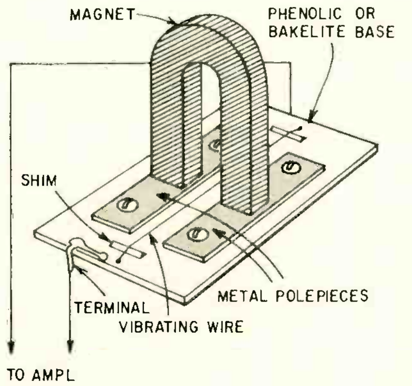


Fig. 1—Position of pole pieces and magnet is not critical, but the wire must be taut and not touch the pole pieces.

If the input is too high, the wire will vibrate excessively and will possibly touch the pole pieces. Under high input conditions, the vibrating wire will act as a frequency doubler and a 500-Hz signal will produce a 1000-Hz signal at the output terminals. If signal level is kept reasonably low, however, the device remains linear. Good operating conditions seem to be about 50 mV in and 200 mV out.

Strong input signals can move the wire to the electrical center of the pole pieces, which may not be the position in which the wire was originally placed. This change in position alters the strain on the wire, varying the original frequency. You can avoid this by sealing the wire at both ends so that it cannot be moved at the end supports.

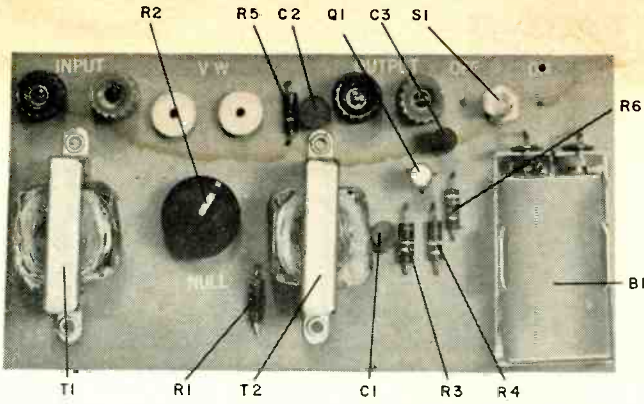
Wire oscillator

The vibrating wire can also be used as an oscillator. The circuit of Fig. 3 oscillates at around 1000 Hz and is a bit unusual; there are no capacitors in the oscillator circuit, only in the power supply.

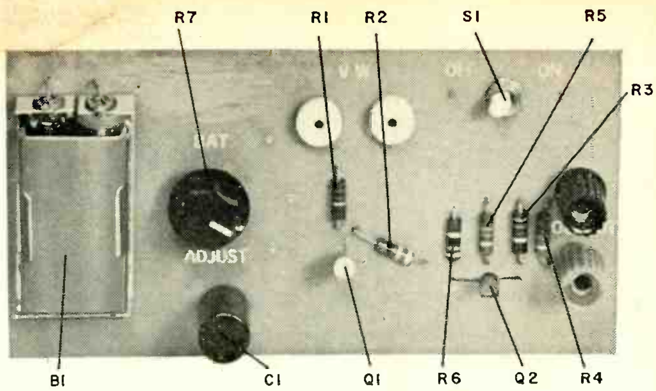
Variable resistor R7 is adjusted for lowest output distortion when used with two types of wire to be described later. Distortion is 8% at 400 mV out and 3% at 100 mV. These figures probably could be improved, however, by using true complementary transistors and changing resistor values. Both transistors are high-gain types and should not be changed unless similar gain units are available. I constructed several of these oscillators; all performed well.

Vibrating-wire construction

The assembly consists of a General Company 2-oz magnet placed on 2" x ½" iron mending plates made by National Manufacturing Company of Sterling, Ill. Both items are available in hardware stores. The mending plates are mounted with ¼" bolts on a 3" x



Vibrating wire in a bridge gives this amplifier an exceptionally narrow bandpass, making it ideal for remote control work.



A prototype vibrating-wire sinewave oscillator. Its circuit is unique in that no L, C or R elements are used for tuning.

½" piece of 1/16" plastic. I spaced the plates about 1/16" apart. The wire is stretched taut in the center of the gap and soldered to a 2-56 screw mounted at each end of the plastic. Run the wire through a hole at each end of the plastic before soldering it to the screws; then shim the plastic rod (.025" diameter) at each wire end. You can cut the thin plastic rod from a plastic whisk brush.

As the heart of the device, the wire must be prepared carefully. Originally, I used No. 38 enameled copper wire; the enamel was removed with fine sandpaper. Then I noticed the resonant frequency changed in time, because the copper did not retain its original tautness. A 6" length was then stretched to 7" before installation—with improved results. At this stage I noticed something unusual: only half the length of wire had stretched—which meant the wire had two diameters—and the output of the amplifier had two adjacent peaks similar to two overcoupled coils.

My best results were obtained with a special nickel alloy wire. An assembly using this wire was subjected to heat and cold and proved very satisfactory. When it was frozen for 1 hour and immediately checked, the original frequency of 1000 Hz had changed to 960 Hz—only a 4% change. Since wire contracts with cold, the frequency should have increased; the lower frequency may have been due to moisture on the wire causing a change in its mass. Nevertheless, within 10 minutes the resonant frequency returned to 1000 Hz, although the unit was still very cold.

Nickel alloy wire is easy to handle and solders easily; it is available in 24" lengths. For those who may wish to try it, it is called Nickel Alloy 180 with 0.004" diameter. You can order it from the manufacturer, California Fine Wire Co., 390 Manhatten St., Grover City, Calif. 93433. Cost is $1, including postage in the USA.

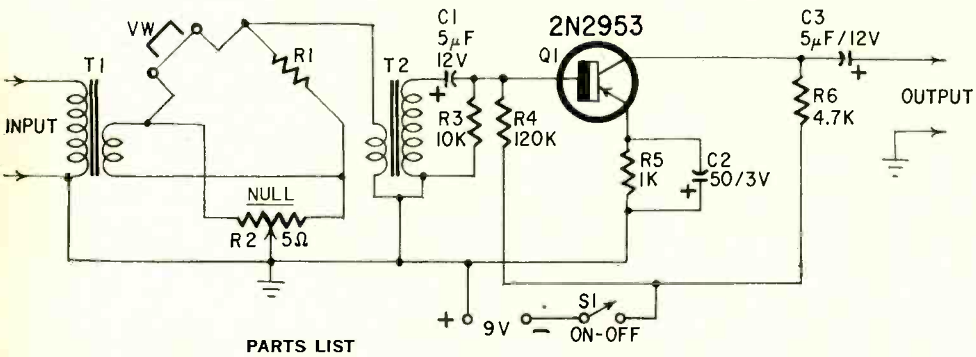


Fig. 2—Resonant frequency of vibrating wire (VW) sets passband of this amplifier.

PARTS LIST

Bandpass Amplifier
C1, C3—5-μF, 12-volt capacitor
C2—50-μF, 3-volt capacitor
R1—See text
R2—5-ohm linear potentiometer
R3—10,000-ohm, ½-watt resistor
R4—120,000-ohm, ½-watt resistor
R5—1,000-ohm, ½-watt resistor
R6—4,700-ohm, ½-watt resistor
T1, T2—Speaker transformer (see text)
S1—S.p.s.t. switch
Q1—Audio pnp transistor, RCA 2N2953 or similar
VW—Vibrating wire (see text)

Sinewave Oscillator
C1—200-μF, 6-volt capacitor
R1—1,200-ohm, ½-watt resistor
R2—10,000-ohm, ½-watt resistor
R3—5,600-ohm, ½-watt resistor
R4—1,000-ohm, ½-watt resistor
R5—1,800-ohm, ½-watt resistor
R6—47-ohm, ½-watt resistor
R7—10,000-ohm linear potentiometer
Q1—Audio pnp transistor, RCA 2N2953 or similar
Q2—Audio npn transistor, GE 2N2925 or similar
S1—S.p.s.t. switch
VW—Vibrating wire (see text)

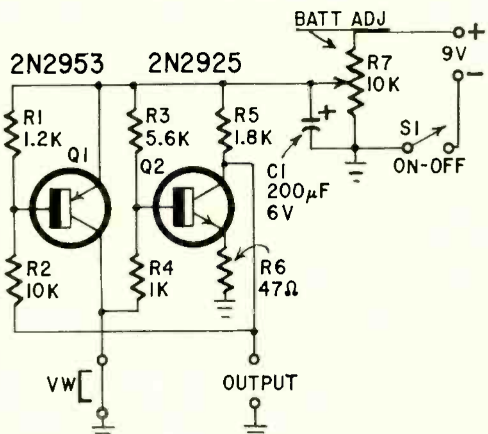


Fig. 3—Unique sinewave oscillator uses a simple vibrating wire as tuning device.

Adjustment and operation

The value of resistor R1 in Fig. 2 depends on the type of wire used as the vibrator; if you use copper, R1 should be a piece of wire identical to that used as the vibrator. Nickel alloy has a resistance about 15 times greater than copper, so with nickel wire, you should use a 30-inch length of No. 38 copper wire, or a carbon resistor of 1 or 2 ohms, for R1. You will find the correct value when R2 nulls at about mid-range.

Resonant frequency of the vibrating wire is varied, by changing the tension on the wire with a screw and threaded bushing. I made a unit that had a frequency variation of 750 Hz to 1500 Hz. You can use larger magnets, but oscillator output may be square waves, due to overdriving. In this case, it would be necessary to increase the value of R6 to possibly 150 ohms. An increase in magnet size means an increase in impedance of the vibrating wire, and in the amplifier this would mean an increase in output voltage.

To test a vibrating-wire amplifier you need a good audio generator. Q is over 600, and I made this Q measurement by the 3-dB method; this means the bandwidth was 1.6 Hz at 1000 Hz. Obviously, most audio generators cannot read this accurately. To make the

(continued on page 89)

Operational Amplifier Basics

Progress—from computers to household devices By THOMAS H. LYNCH*

THE OPERATIONAL AMPLIFIER (OP amp) has recently become one of the most versatile tools in electronics. It had its expensive beginnings in analog computers, but inexpensive semiconductors have brought the cost of op amps down considerably. Now they can be used wherever analog (time-varying) signals are processed—for example, in audio amplifiers, oscillators, voltmeters and power supplies. They can easily take the place of a large assortment of individual transistors, resistors and capacitors in many applications.

Probably the op amps' primary advantage is the simplicity with which circuit performance may be predicted. The passive components used to connect the operational amplifier almost entirely determine circuit performance.

Basic characteristics

The versatility of an op amp arises from its unusual set of specifications:

1. It amplifies dc as well as ac signals.
2. Its gain (A) at dc is ideally infinite.
3. Its input impedance (Z_{in}) is ideally infinite.

The reasons for these specifications will become clear as we proceed.

An operational amplifier is basically a very-high-gain direct-coupled amplifier that uses external feedback for control of response characteristics. It was originally designed as a device to perform mathematical functions—integration, differentiation, addition and subtraction. Since its inception, however, the op amp has found wide usage in such things as signal amplification and wave shaping, servo and process controls, analog instrument and system design and impedance transformation.

Op amps are versatile and useful because external negative feedback controls response characteristics. If an op-amp circuit provides enough gain, the closed-loop amplifier characteristics become a function of only the feedback components. Hence the circuit designer's ingenuity in choosing and using feedback parts is the only limiting factor.

A common arrangement for op amps is a direct-coupled cascade of two balanced differential-amplifier stages, with the second stage driven push-pull by the first.

In most cases the op amp has two inputs, one inverting and one non-inverting (Fig. 1). This characteristic means that if a positive signal is applied to the (−) input, the output will swing negative. Similarly, with a positive input connected only to the (+) input, the output will swing positive. We can further see that if the same signal voltage is applied at the same time to the (+) and (−) inputs, the output will not change—it will stay zero (Fig. 2). This is because (ideally):

$$e_{in}(-A) + e_{in}(A) = e_{out} = 0$$

This rule will (ideally) hold for any value of e_{in}, (+) or (−). (A measure of this specification is called common mode rejection—a ratio of the change in the output for a given common change in the input.)

Thus far, we can see that the approximate output of the op amp is given by:

$$e_{out} = A(e_1 - e_2)$$

where:

A is the gain, typically very large,
e_1 signal voltage at the (+) input,
e_2 signal voltage at the (−) input.

*Bunker-Ramo Corp.

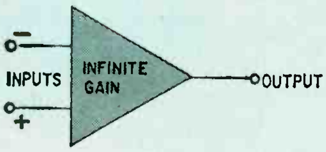


Fig. 1

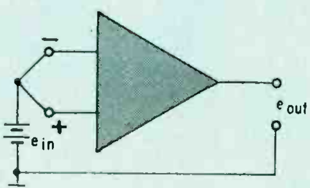


Fig. 2

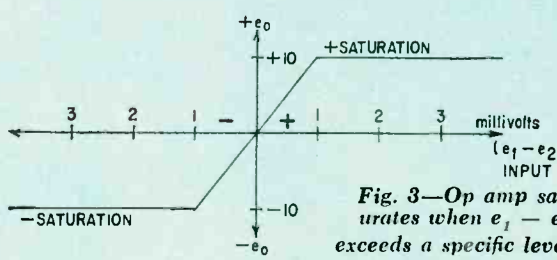


Fig. 3—Op amp saturates when $e_1 - e_2$ exceeds a specific level

Fig. 3

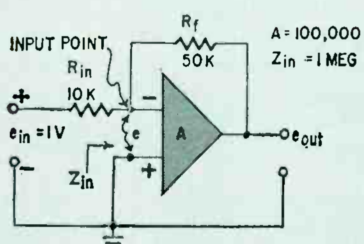


Fig. 4

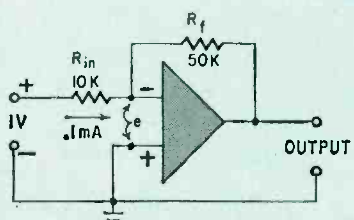


Fig. 5

Operational amplifiers are generally characterized by exceptionally high gain, extremely wide bandwidth and two inputs. These and the following basic circuits show how external components can be added to control gain, frequency response and impedance.

At this point you might notice that if gain (A) is large—say 10,000—the output voltage will be rather large for very small input voltage differences. For example, if ($e_1 - e_2$) was as small as +0.005 volt the output would be +50 volts. Since all amplifiers are capable only of a certain maximum output (say ±10 volts in this case), clearly for input differences in excess of 1 mV the output voltage will not increase beyond 10 volts (Fig. 3).

What practical use is there for an amplifier that saturates with only a 1-mV input signal? If we connect an op amp as shown in Fig. 4, what will the output voltage be?

First note that the amplifier gain is very large, and R_f is connected from the (−) input to the output. Negative feedback results, forcing e to be a very small value, regardless of the output voltage. For example, if $e_{out} = 5$ volts, e would only be $e_{out}/A = 5/100{,}000 = 0.00005$ volt.

Second, remember that the input impedance is large ($Z_{in} = 1$ megohm). This means that very little current will go into the (−) input:

$i(-) = 0.05$ mV/1 megohm for a 5-volt output
$= 0.05$ nA (nanoampere)

The negative input terminal is thus a "virtual ground"—i.e., the voltage drop is approximately zero (as a ground point) but little current flows into it (as an insulator).

Since e_{in} is much greater than e, a current will flow through R_{in} equal to 1 volt/10,000 ohms, or 0.1 mA (see Fig. 5). Kirchhoff's laws state that currents flowing into a circuit point must equal the currents flowing out of that node point. Thus, if (ideally) no current flows from the node into the (−) input of the op amp, the 0.1 = mA current must flow out of the node through the 50,000-ohm resistor R_f. If a current of 0.1 mA flows through 50,000 ohms, it must have a voltage drop of E = (0.1 mA) × (50,000 ohms) = 5 volts. Since E = e_{out}, e_{out} must clearly be equal to −5 volts. (Fig. 6).

This then is a simple amplifier with gain equal to:

$$A_v = R_f/R_i = -5$$

An important conclusion is that the gain is essentially dependent only on the external feedback resistors.

Put it to work

To begin with, Figs. 7 through 10 shows several basic amplifier connections. There are a few considerations to make when using the inverting amplifier of Fig. 7.

First, source impedance R_s of signal source e_{in} must be added to the amplifier's nominal input impedance to get the actual value of R_i; this value is needed to determine amplifier gain accurately. Because of this, the inverting amplifier usually is used only with a low signal impedance, such as the output of an amplifier like this one.

Second, since the output of this amplifier must drive both the load and R_f in parallel, their combined impedance should be greater than the minimum value for the particular amplifier being used—usually 2,000 ohms or greater. R is added to make the resistances seen by both the (+) and (−) inputs identical. This improves the temperature-drift characteristics of the amplifier. If R_{in} is small (10,000 ohms or less) R can usually be eliminated.

A noninverting follower is shown in Fig. 8. Since all the output is fed directly back to the input, the gain will be +1. Also, the input impedance will be very high (usually 50 megohms or greater). This is useful when the previous stage must not be loaded down—as in a tuned circuit, a voltmeter input, or a ceramic microphone.

The gain follower (Fig. 9) has feedback to the (−) input reduced so that the amplifier has a positive gain. The input impedance will be very high also:

$$Z_{in} \simeq \underbrace{A\left(\frac{R_i}{R_f}\right)}_{\text{loop gain}} \underbrace{(Z_{in})}_{\text{diff. input Z}}$$

When the loop gain is high, this can be 50 megohms or more. It is significant to note that the overall closed-loop gain does not depend upon the source impedance.

The previous circuit can be modified for ac applications, as shown in Fig. 10. When the closed-loop gain is 100 or more, the input impedance will be 10 megohms or greater. At the signal frequencies, X_{ci} is so small it may be neglected. The circuit then looks similar to Fig. 9, except that R has been added. This resistor is "bootstrapped" since the voltages at both ends are almost identical. This means that a signal voltage at the input (the top of R) will cause a similar in-phase voltage at the bottom of R because of the feedback divider $R_i/(R_i + R_f)$. Almost no signal current flows through R, and therefore its value is effectively increased to 10 megohms or more.

The other applications on page 58 are a small sample of the wide variety of circuit functions that can be easily accomplished with an op amp. Because of the frequency response of most op amps, these applications are usually limited to frequencies less than a few hundred kilohertz. More applications along with discussions of problem areas can be found in the reference material.

Tables I and II list a wide selection of integrated and discrete operational amplifiers priced at $20 or less

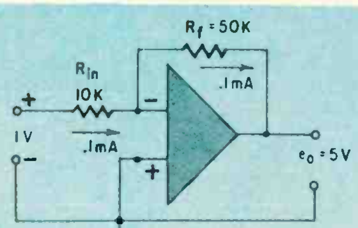


Fig. 6

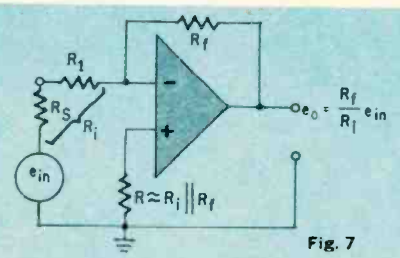


Fig. 7

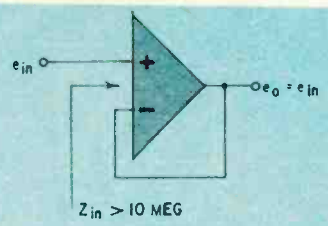


Fig. 8

Of particular interest are the circuits on these pages illustrating some of the basic concepts used in adapting the op amp to specific types of circuits.

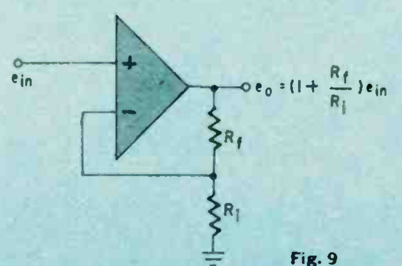


Fig. 9

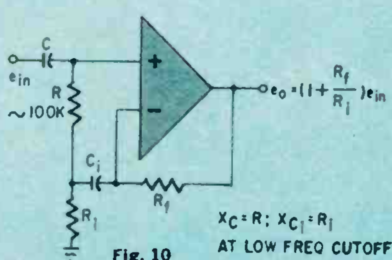


Fig. 10

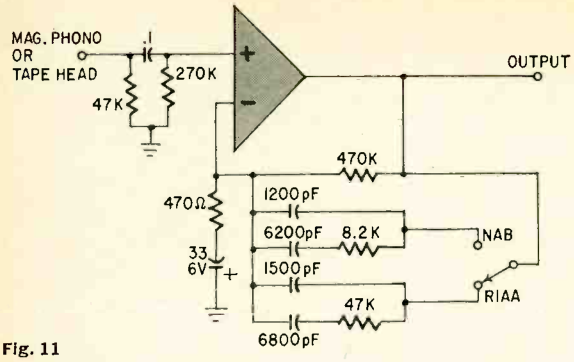


Fig. 11

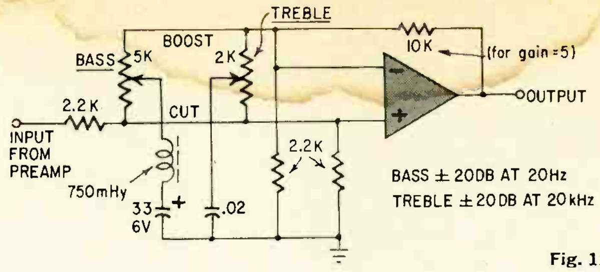


Fig. 12

Figs. 11, 12 and 13 are hi-fi preamp, tone control, and 20-watt amplifier. Figs. 14, 15, 16, 17 and 18 are integrator, sample-and hold, inverting adder, adder and subtractor and voltage comparator circuits, respectively, for use in computer service.

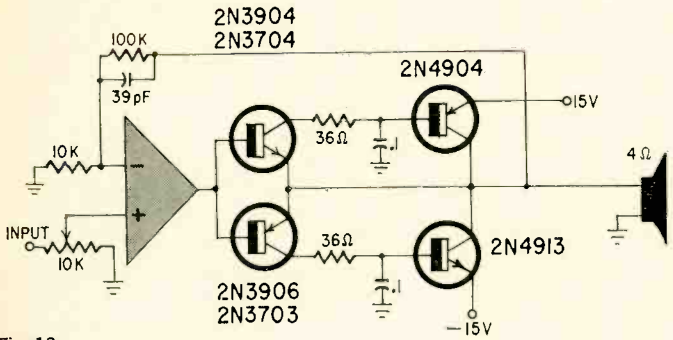


Fig. 13

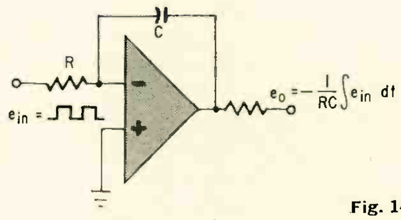


Fig. 14

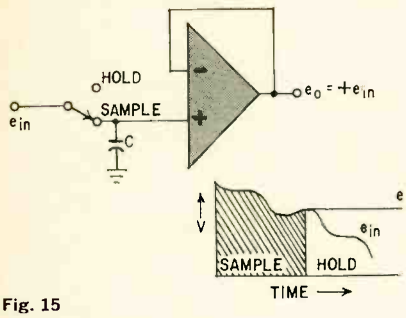


Fig. 15

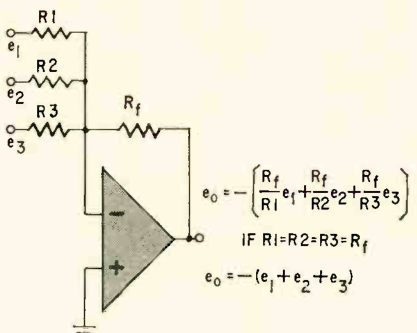


Fig. 16

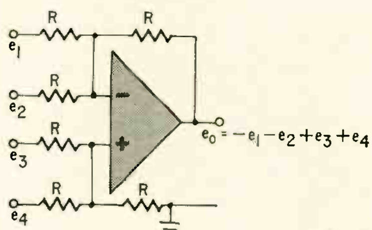


Fig. 17

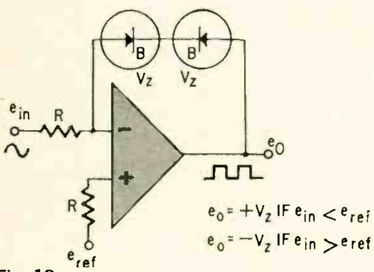


Fig. 18

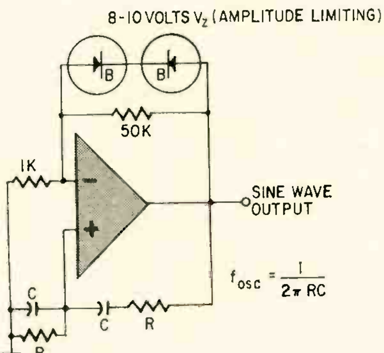


Fig. 19

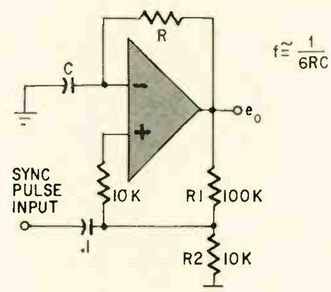


Fig. 20

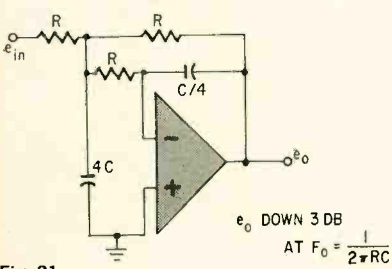


Fig. 21

Fig. 19—Zëner diodes limit amplitude in this Wien-bridge oscillator. Fig. 20—Square-wave multivibrator. Simplified formula is $f_{osc} \cong \frac{1}{6RC}$. *Figs. 21 and 22 are low-pass and twin-T bandpass filters. Fig. 23 is the "ideal" diode and Fig. 24 is a high-impedance low-voltage voltmeter.*

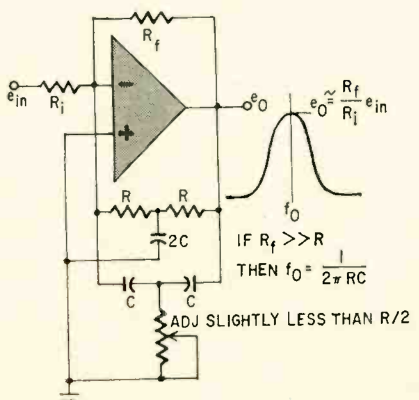


Fig. 22

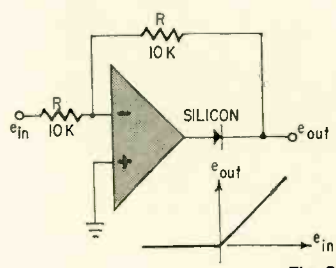


Fig. 23

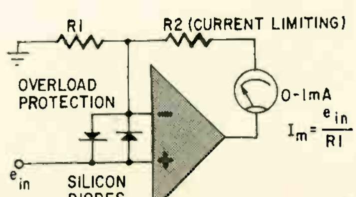


Fig. 24

Table I

IC OPERATIONAL AMPLIFIERS

Manufacturer	Type	Z_{in} diff. (typ) ohms	A_{vol} (typ)	Drift $\mu V/^{\circ}C$ (typ)	Pwr Sup volts	Price (each) $
Amelco	709BE	400K	45K	3	±15	15.00
	806CE	1meg	60K	10	±12	20.20
	809CE	200K	40K	10	±15	6.50
	809CJ	200K	40K	10	±15	6.50
Burr Brown	3056/01	300K	65K	5	±15	18.00
	3057/01	200K	50K	10	±15	12.00
Fairchild	μA702C	32K	3.4K	3	+12 −6	4.50
Semi-conductor	μA709C	250K	45K	3	±15	7.50
GE	PA223	2.5meg	7K	10	±12	5.85
Motorola	MC1430G	15K	5K	5	±6	8.25
	MC1431G	600K	3.5K	10	±6	8.85
	MC1433G	600K	60K	10	±15	9.75
NSC Micro-circuits	LH201[1]	400K	150K	10	±15	17.00
	LM201	400K	150K	6	±5 to ±15	13.10
Philbrick/Nexus Research	T52[2]	200K	40K	20	±15	7.95
	S52[3]	200K	40K	20	±15	7.95
RCA	CA3008[4]	14K	1K	4	±6	10.30
	CA3008A[4]	20K	1K	4	±6	10.90
	CA3010[4]	14K	1K	4	±6	6.60
	CA3010A[4]	20K	1K	4	±6	9.50
	CA3015[4]	7.8K	3.2K	4	±12	8.25
	CA3015A[4]	10K	3.2K	4	±12	10.30
	CA3016[4]	7.8K	3.2K	4	±12	10.50
	CA3016A[4]	10K	3.2K	4	±12	11.60
	CA3029	14K	1K	4	±6	4.13
	CA3029A	20K	1K	4	±6	6.20
	CA3030	7.8K	3.2K	4	±12	7.20
	CA3030A	10K	3.2K	4	±12	7.45
	CA3037[4]	14K	1K	4	±6	6.60
	CA3037[4]	20K	1K	4	±6	9.50
	CA3038[4]	7.8K	3.2K	4	±12	8.25
	CA3038A[4]	10K	3.2K	4	±12	10.30
	CA3031/702A[4]	25K	3.2K	4	+12, −6	8.25
	CA3032/702C	20K	3.2K	4	+12, −6	6.60
	CA3033[4]	1.5M	31.6K	6.6	±12	8.15
	CA3033A[4]	1.0M	63.3K	6.6	±18	11.45
Signetics	NE515K	2.3K	3.2K	5	±6, −3	9.00
Texas Instruments	SN724L	1meg	1.2K	25	±5	12.10
	SN72702L	32K	3.4K	5	±12, −6	13.00
	SN72709L	250K	45K	10	±15	9.35
Union Carbide	UC709	3meg	50K	6	±18	15.00
	UC4000C	3meg	50K	5	±15	19.50
	UC4001C	3meg	50K	10	±15	11.10
	UC4002C	3meg	50K	20	±15	8.50
	UC4002[4]	3meg	50K	20	±15	17.00

[1] Internally frequency compensated
[2] TO-5 case
[3] Dual in-line package
[4] Mil. temp. range −55°C to +125°C

in single quantities. For the sake of brevity, only the more important parameters are listed.

The integrated circuits are packaged in multi-pin TO-5 cans or flat packs. The package type has some effect on price, the TO-5 usually being cheaper by a couple of dollars. Many other factors are included in the final price and each particular amplifier has its virtue. (For example, the NSC type LM201 provides the highest gain for its moderate cost.)

More information on each type can be obtained directly from the manufacturer, who will provide a list of distributors. Manufacturers' addresses are listed at the end of this article.

Discrete op amps are easier to use, as they have been frequency-compensated for a 20 dB/decade rolloff (which insures unconditional stability). Most of these discrete op amps are generally more rugged electrically than the intgerated ones—a point to consider for experimentation. This is because of the larger transistors and resistors used in construction. The output of most of these op amps will supply a standard 2.2 mA at ±10 volts.

The most common size is 1⅛" square and ⅝" high with the input/output and power pins on the bottom. This is a common industry-accepted size. An exception is Fairchild's ADO-49C; it is a μA709C with frequency-compensation components in a small, round epoxy package. The manufacturers of these op amps should likewise be consulted for further information.

Where to get more information

A listing of useful material on op amps is included under "References" on page 84. Much of this can be obtained at little or no cost by writing to the manufacturers (see page 85 for addresses). References marked (*) are especially useful. Also included is a glossary of op-amp terminology. **R-E**

Table II

Discrete/Hybrid Operational Amplifiers

Manufacturer	Type	Z_{in} diff. (typ) ohms	A_{vol} (typ)	Drift $\mu V/^{\circ}C$ (typ)	Price (each) $
Analog Devices	111	150K	30K	10	$13.00
	105A	1meg	60K	10	16.00
Burr Brown	3009/15C	500K	32K	10	20.00
	3077/12C	300K	100K	10	15.00
Data Device Corp.	D-5	220K	100K	10	17.00
	D-6	300K	20K	10	16.00
Fairchild Controls	ADO-44	300K	10K	20	9.75
	ADO-45	300K	100K	10	15.00
	ADO-49C	250K	40K	5	18.00
K and M	KM23	200K	100K	5	16.50
Philbrick/Nexus Research	SQ-10A	300K	100K	12	14.00
	SD-5	300K	20K	25	11.00
Zeltex	PF55AU	220K	40K	10	15.00
	PF85AU	330K	150K	6	18.00
	116D	200K	20K	25	19.00
	ZEL-1	1meg	500K	25	12.50

All units require ±15 volt power supply.

BUILD A

Once it's on, it stays on,

By TOMMY N. TYLER

EVER HAVE ONE OF THOSE DAYS WHEN things just seem to pile up on you, and to top it off the boss asks you to get out a rush job before quitting time? Here's just what the doctor ordered for moments like this—a genuine Panic Button to vent your frustrations. Press the button and you start a wailing siren which slowly cycles up and down in pitch—just like a police siren. It lets everyone within earshot know that an official "panic" is underway. If you're in the mood to build a conversation piece which you can leave lying around on desk, work bench, or service counter for a thousand laughs, look no further. The Panic Button can be built for about $13 worth of parts. Warning—be prepared for an avalanche of requests from friends and relatives to make them one too!

In Fig. 1—a block diagram of the unit—you will see a free-running multivibrator with approximately a 6-second period. It varies the pitch of the panic-button siren up and down by controlling the frequency of the second multivibrator. The square-wave output (Fig. 2-a) of the slow generator is passed through an RC integrating circuit which converts the square wave to a near triangular wave (Fig. 2-b). This sawtooth waveform is coupled to the fast multivibrator to vary its frequency (Fig. 2-c). The variable frequency output is then amplified to drive the speaker.

You'll see the complete circuit in Fig. 3. Transistors Q1 and Q2 generate the 6-second square wave to integrator circuit R6–C4. Q3 is an emitter-follower buffer amplifier, which prevents loading the integrator. The output of Q3 varies the "off" time of transistor

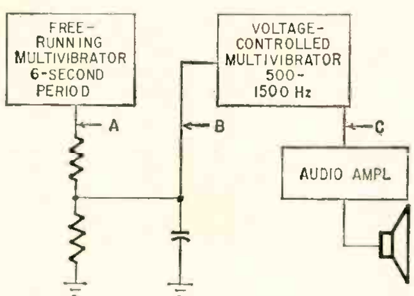


Fig. 1—Block diagram of the Panic Button. Free-running multivibrator changes the frequency of the voltage-controlled multivibrator to produce a siren-like sound.

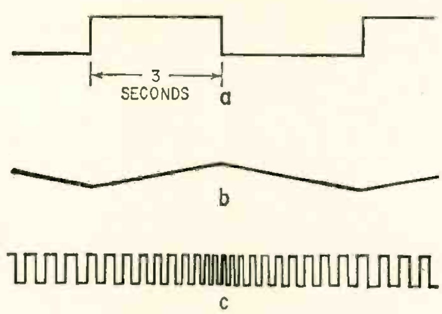


Fig. 2—Waveforms at points in Fig. 1: (a) Output of the free-running multivibrator; (b) past the integrator; (c) the output of the voltage-controlled oscillator.

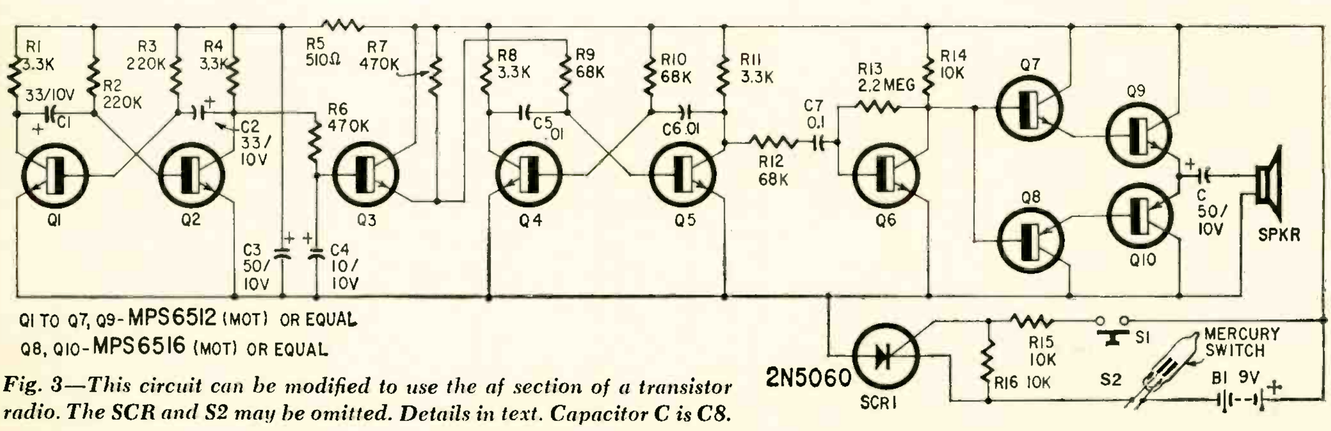
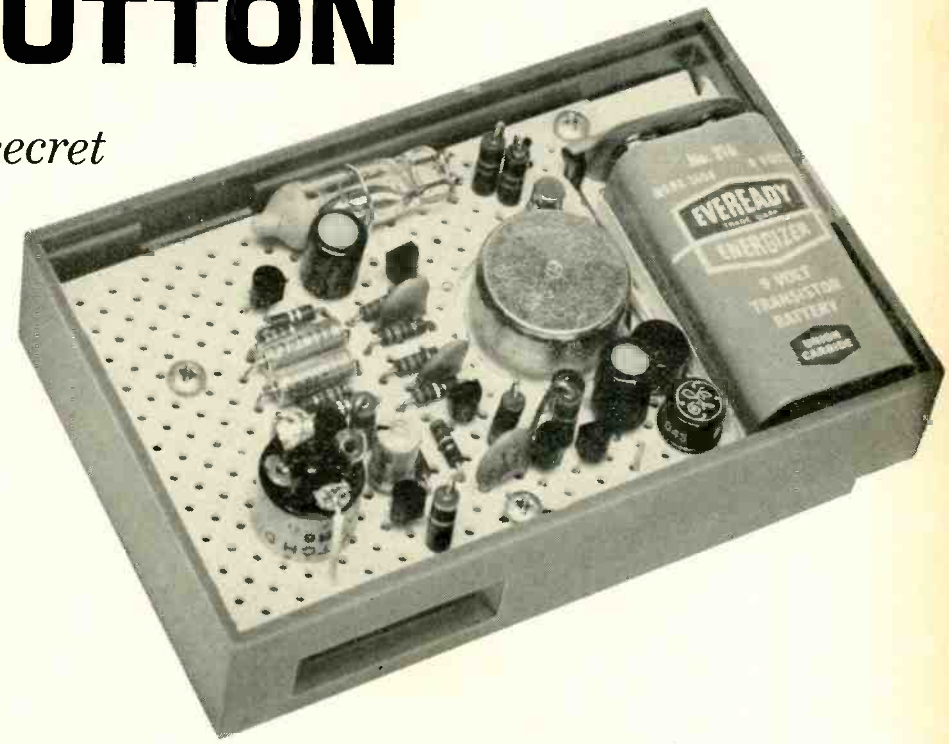


Fig. 3—This circuit can be modified to use the af section of a transistor radio. The SCR and S2 may be omitted. Details in text. Capacitor C is C8.

PANIC BUTTON

unless you know the secret



Q4 in the fast multivibrator by modifying the charging current to C5. The resulting variable-frequency output is tapped off the collector of Q5 and drives the audio amplifier.

Resistor R5 and capacitor C3 decouple the low-frequency multivibrator from the rest of the circuit, to prevent false triggering.

You may wish to make several interrelated circuit modifications, which will provide just the right pitch or frequency range and rate of cycling up and down. The cycling rate can be modified by changing the values of C1 and C2, or R2 and R3, in the slow multivibrator. Using 100,000 ohms for R2 and R3 speeds the siren action a bit, though it also increases the overall pitch. Don't try to increase R2 and R3 too much unless you have transistors with fairly high beta.

After this period has been adjusted to your satisfaction, take a look at the output of the integrator. Too short a time constant here will cause the siren pitch to level off at the top and bottom of each cycle, rather than rise and fall smoothly. Too long a time constant will limit the peak amplitude of the triangular wave and may not provide an adequate up-and-down range of pitch variation.

After you've adjusted the integrator to get a decent triangular wave, some adjustment of the nominal period of the fast multivibrator and the amount of drive from Q3 may be necessary as a final tuneup. Changing the values of R9 and R10, or C5 and C6, will have the greatest effect on setting the average pitch or "register" of the siren. I suggest you stick to the neighborhood of 1 kHz for a realistic, penetrating sound. Reducing the value of R9 will increase the up-and-down range of siren sweep, and vice versa.

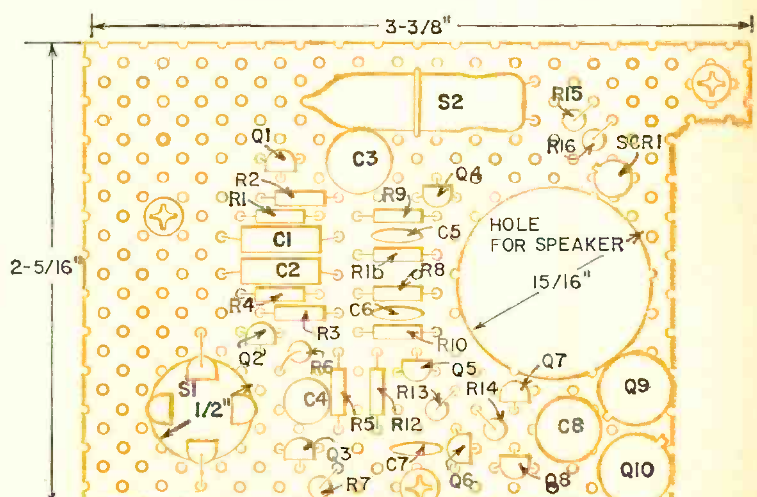
Since one half of the period of the fast multivibrator is fixed, the output is actually a pulse of constant width

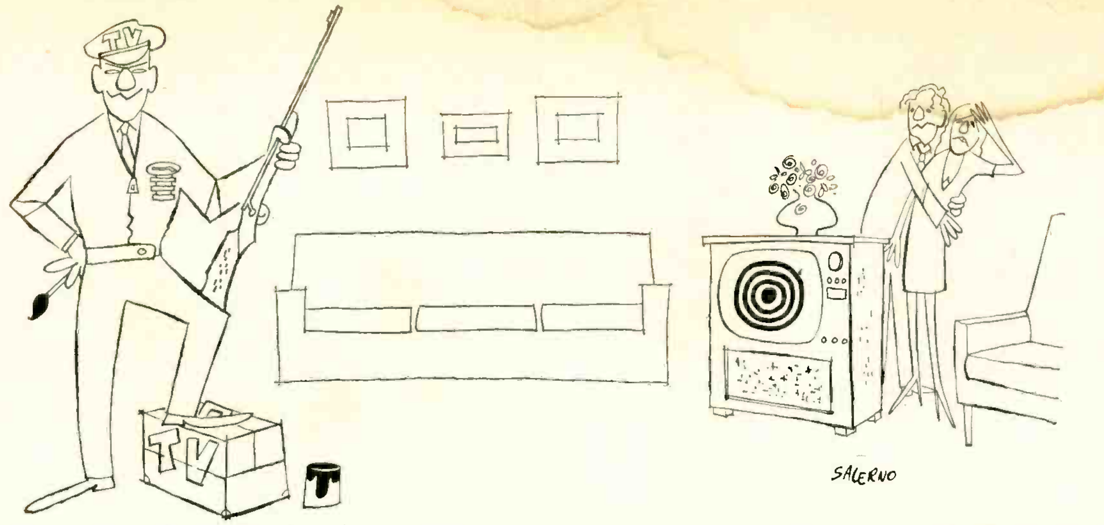
(continued on page 83)

Parts List

B1—9-volt transistor radio battery
C1, C2—33μF, 10-volt electrolytic capacitor
C3, C8—50μF, 10-volt electrolytic capacitor
C4—10μF ceramic or tubular capacitor
C5, C6—0.01μF disc ceramic capacitor
C7—0.1-μF ceramic or tubular capacitor
Q1, Q2, Q3, Q4, Q5, Q6, Q7, Q9—Silicon npn small-signal transistors (Motorola MPS-6512 or similar)
Q8, Q10—Silicon pnp small-signal transistors (Motorola MPS6516 or similar)
R1, R4, R8, R11—3300-ohm resistors
R2, R3—220,000-ohm resistors
R5—510-ohm resistor
R6, R7—470,000-ohm resistors
R9, R10, R12—68,000-ohm resistors
R13—2.2 megohm resistor
All resistors ½ watt
R14, R15, R16—10,000 ohm resistors
SCR1—Silicon controlled rectifier, 25 volts, 0.6 amps (2N5060, GE C6U or similar)
S1—Momentary pushbutton switch, s.p.s.t., normally closed
S2—Mercury switch, s.p.s.t., normally closed
SPKR—Speaker, 50- to 100-ohm voice coil, ¼ watt (Quam 22Ao6Z100 or similar)
MISC—Metal box; battery connector (Cinch-Jones 5D or similar)

Fig. 4—Exact layout of parts on the perforated board, shown full size. All wiring is point - to - point done on the other side of the board. S2 is mounted with a piece of hookup wire to board. Note that exact size of board will depend on the size of the transistor radio (if any) that you use.





TV Service Puzzle — For SHARPSHOOTERS Only

If you can solve this, you're a good tough-dog man

By WILLIAM DARRAGH

IN TV WORK, "NORMAL TROUBLES" are caused by parts failures. Capacitors short, resistors change value, coils open, and tubes go dead. Our diagnostic methods and thinking must be set up to locate these. Yet, if we run across a completely abnormal case —something that could never happen under normal circumstances, we can run it down using standard methods.

If you're a sharp diagnostician, you can tell what happened in this puzzler; all the clues are given. Strange as it seems, we do run into things like this at too-regular intervals, and we have to deal with them. So, if you like really hard puzzles, here's one. The alleged "expert" who worked on it for two days fell flat on his face at several points, misinterpreting a perfectly plain reaction. See if you can do better than yours truly.

The set was a G-E KC color chassis, 2nd version. The circuit breaker (CB101) and one of the silicon rectifiers (CR204) used in the full-wave bridge were replaced first. Fig. 1 shows the power-supply circuit.

When it was turned on, the plate of the 6CG3 damper tube got red hot. No high voltage or raster, of course. There was a suspicion that lightning had hit the set, causing the original damage. The "expert" was called in.

The "stock" tests were made: New 6CG3 damper, high-voltage regulator and rectifier tubes were substituted. All parts in the secondary circuit were checked for shorts—boost circuits, yoke, etc. All possible "boost loads" were cleared.

After too long a time, the cathode current of the 6JS6 horizontal output tube was measured. It read far too high, about 300 mA. This was the reason for the damper overheating. The 6JS6 plate current flows through that tube.

The 6JS6 screen-grid voltage was low, about 40 volts. So was the grid; all measurements were taken with a vom. Also, the horizontal-discharge tube plate voltage was almost gone—about 40 volts instead of the normal 115 under load.

Voltage measurements to the source showed that the 270-volt line was down to only 40 volts. The filter output, at 400 volts, was OK. The 250-ohm dropping resistor, R103, was very hot, as exploratory tests with a digital wattmeter showed. Sucking the blister raised on the digital probe (the "expert's" left forefinger—not the right kind of digit!), this was investigated.

An ohmmeter reading from the 270-volt line to chassis showed around 5,000 ohms. A bit low. Could be due to reading through the bridge rectifier, so the prods were reversed. Same thing.

Since a 50-μF electrolytic (C131

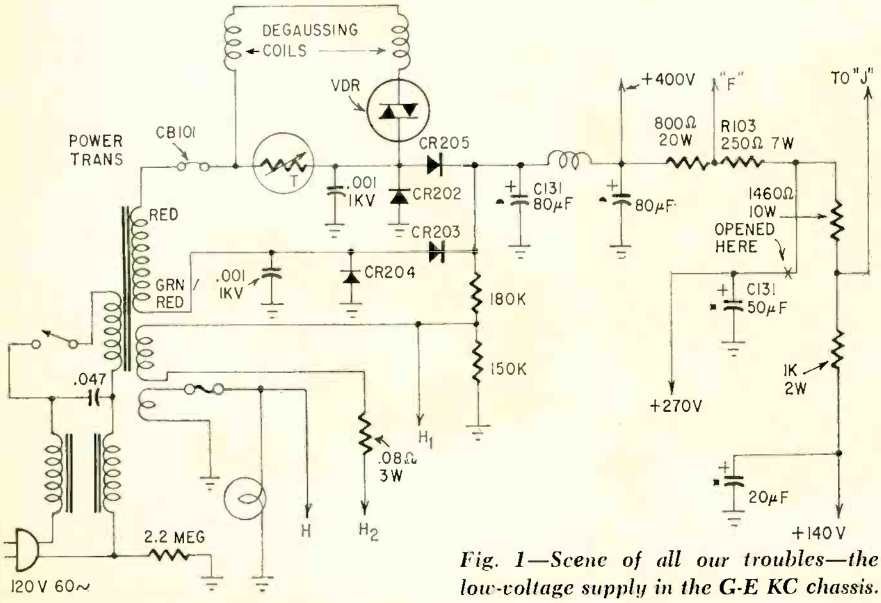


Fig. 1—Scene of all our troubles—the low-voltage supply in the G-E KC chassis.

with square marker) was connected directly to the 270-volt line, this was unhooked. The set was turned on, dc voltage jumped back up to about 200, and a small portion of a raster was seen; about a quarter of the screen was lit, with the rest blacked out by a large hum bar. Hum was also very loud in the sound.

Touching the 270-volt lead to the capacitor terminal caused the original symptoms to come back. Ah, ha—bad capacitor! (*1) An ohmmeter check showed that it had quite a high resistance, so a high-voltage breakdown was assumed, and a new capacitor ordered. (The "*" indicates one of the mistakes; see the footnotes in the answer.)

The new capacitor arrived and was duly installed. Lo and behold, the same symptoms! Hot damper, hot resistor (not checked with digital wattmeter), the works. The new capacitor's connections were checked out; fine. The old capacitor was checked on the capacitor checker; no leakage, plenty of capacitance. Hmm.

Now, the expert did what he should have done quite a while back—got out the scope. Still thinking of some kind of oddball leakage between elements of a multiple electrolytic or something, he checked the B+ supply circuits for ripple. Filter output (+400 volts) about 2.0 volts p-p; fine. Rest of B+ taps normal, except the +270 volts. This showed a sawtooth ripple of about 100 volts p-p, with the 50-μF electrolytic still connected across it. This ripple showed up as soon as the set was turned on. (*2)

Disconnecting the 50-μF electrolytic made this ripple go over 200 volts, offscreen on the scope, at any rate. Scope was set up for a maximum of about 150 volts p-p.

After the power was turned off, ohmmeter tests from the 270-volt line still showed the same—about 5,000 ohms to ground. The 270-volt line loads were completely disconnected from the source, at the point indicated in Fig. 1. This left no normal dc voltage supply to this point; only the various loads on the PC board were connected to the 270-volt line.

Now the ohmmeter showed about 2,000 ohms from the (floating) 270-volt point to chassis. Unintentional reversal of the ohmmeter leads showed a very high dc resistance to ground—almost 50,000 ohms. (*3)

After the power was turned back on, with the 270-volt point still disconnected, the ripple was very high. This showed up on all the 270-volt points on the PC board, part of which is shown in Fig. 2. After turning the

(*continued on page 82*)

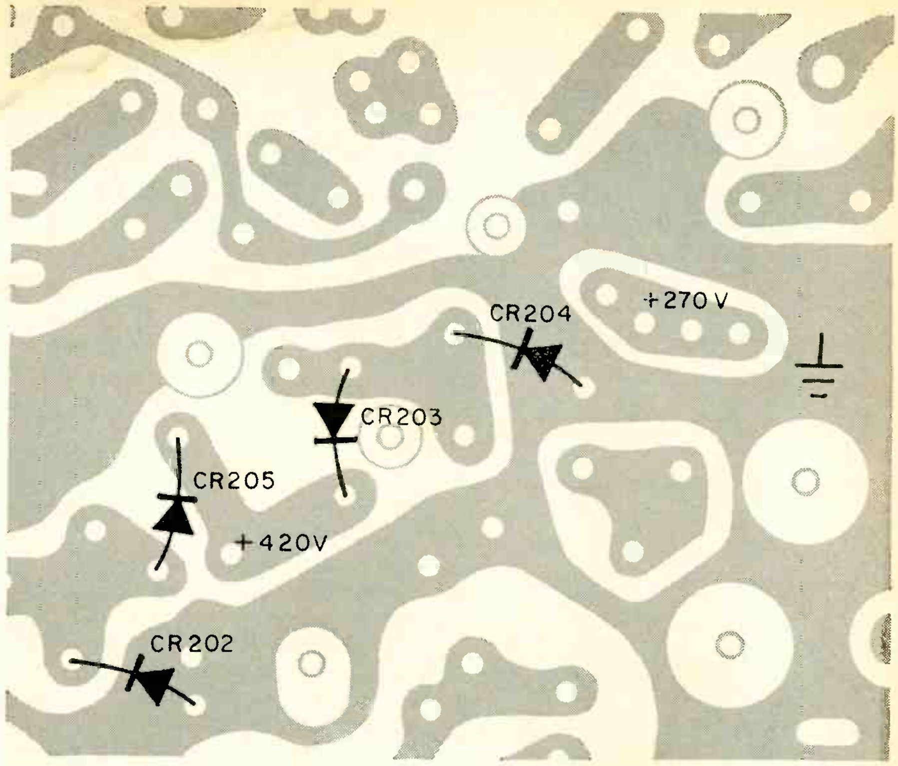


Fig. 2—The pertinent section of the PC board in the G-E KC television chassis. Note the location of the silicon rectifier diodes near the center of the board.

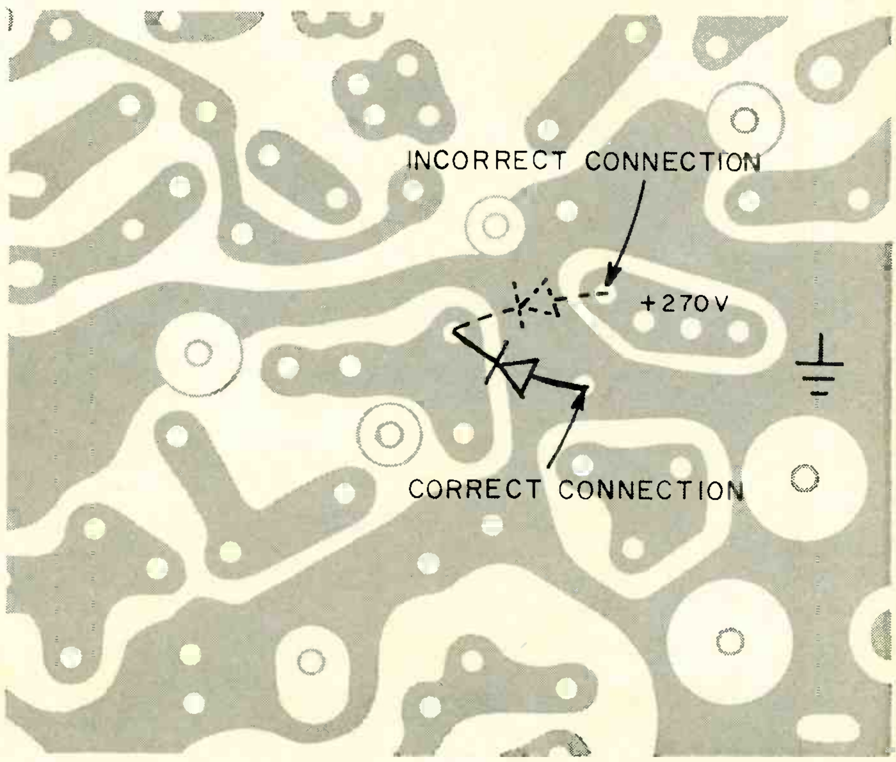


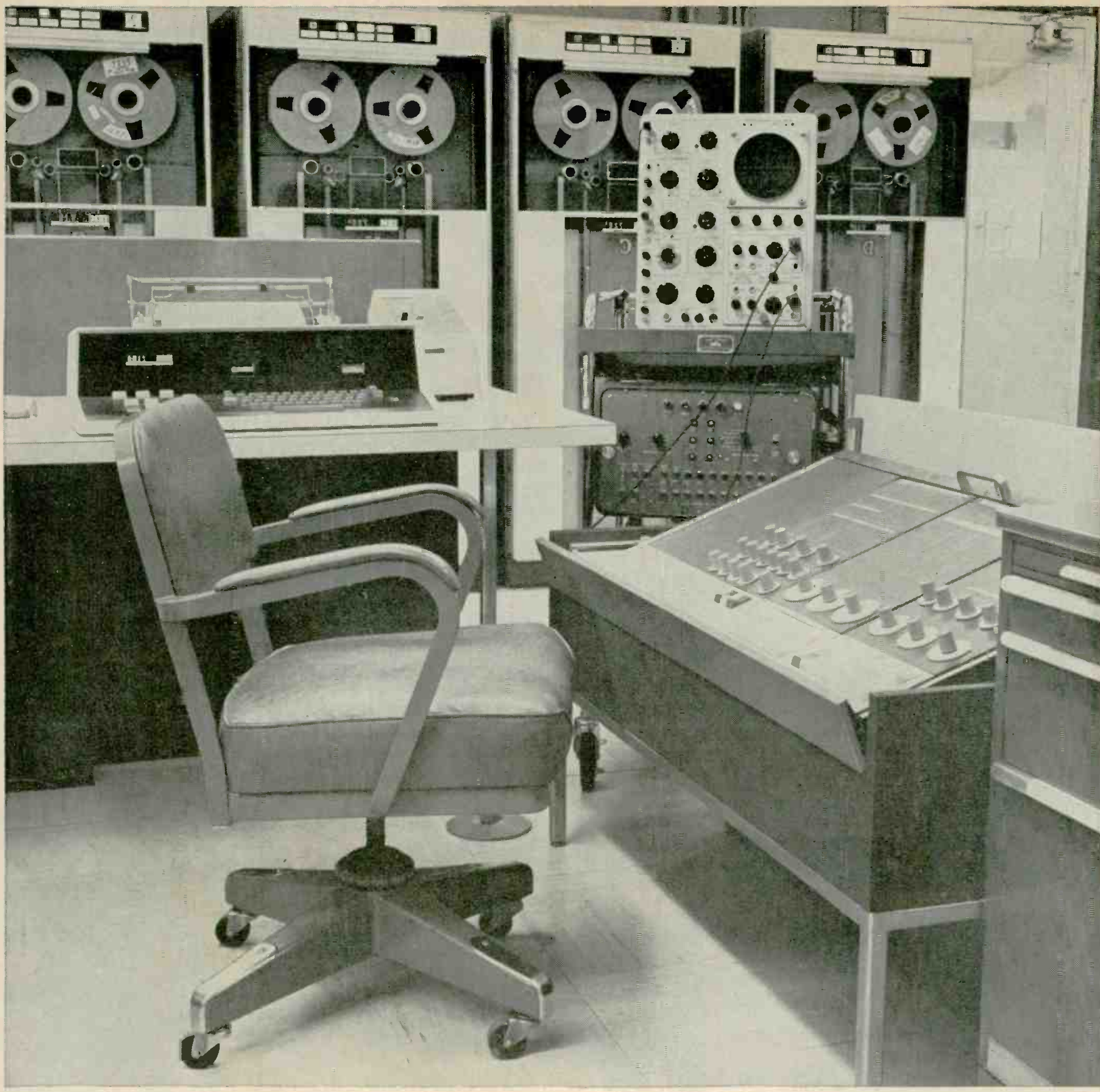
Fig. 3—The villin unmasked. The anode end of rectifier diode CR204 was accidentally connected to a 4-terminal point on the 270-volt line as shown by the dashed lines. The distance between the correct and incorrect connections was 1/8 inch.

**1: This is very small evidence on which to make flat statements about the quality of a capacitor! A real expert should have tested it for leakage and capacitance, on a capacitor checker. This would have avoided the wait for a new capacitor, and the expense. Always use more than one test!*

**2: This ripple is definitely not due to something in one of the tubes, since they didn't have time to warm up. This symptom showed up instantly, which meant that it was caused by something in the power supply itself.*

Putting the capacitor back dropped the dc voltage and ripple, which should have told us that the capacitor was good.

**3: This is the kind of ohmmeter reaction you get from only one thing: a rectifier! Unlikely as it seems at this point, this test told us that there was a rectifier in the circuit somewhere, and it certainly had no business there (see the schematic).*



This important job (and its big salary) is reserved for a qualified electronics technician. It can be you!

It's a fact. There are *many thousands* of jobs like this available *right now* for skilled electronics technicians. What's more, these men are going to be in even *greater* demand in the years ahead. But how about you? Where do you fit into the picture? Your opportunity will never be greater...so act *now* to take advantage of it. The first step? Learn electronics fundamentals...develop a practical understanding of transistors, troubleshooting techniques, pulse circuitry, micro-electronics, computers and many other exciting new developments in this booming field. Prepare yourself now for a job with a bright future ...unlimited opportunity...lasting security...prestige... and a steadily-increasing salary.

Thousands of ambitious men are using Cleveland Institute of Electronics Training Programs as a stepping stone to the good jobs in Electronics. Why not join them? You will learn at home, in your spare time, and tuition is remarkably low. Read the important information on the facing page. Then fill out the postage-free reply card and drop it in the mail today. Without obligation we'll send you all the details. But act now...and get *your* high-paying job just that much sooner.

How You Can Succeed In Electronics

. . . Select Your Future From Five Career Programs

The "right" course for your career

Cleveland Institute offers not one, but five different and up-to-date Electronics Home Study Programs. Look them over. Pick the one that is "right" for you. Then mark your selection on the reply card and send it to us. In a few days you will have complete details . . . without obligation.

1. Electronics Technology

A comprehensive program covering Automation, Communications, Computers, Industrial Controls, Television, Transistors, and preparation for a 1st Class FCC License.

2. First Class FCC License

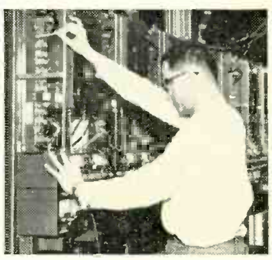
If you want a 1st Class FCC ticket *quickly*, this streamlined program will do the trick and enable you to maintain and service all types of transmitting equipment.

3. Broadcast Engineering

Here's an excellent studio engineering program which will get you a 1st Class FCC License and teach you all about Program Transmission and Broadcast Transmitters.

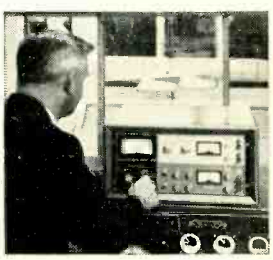
4. Electronic Communications

Mobile Radio, Microwave, and 2nd Class FCC preparation are just a few of the topics covered in this "compact" program . . . Carrier Telephony too, if you so desire.



5. Industrial Electronics & Automation

This exciting program includes many important subjects such as Computers, Electronic Heating and Welding, Industrial Controls, Servomechanisms, and Solid State Devices.



An FCC License . . . or your money back!

In addition to providing you with comprehensive training in the area indicated, programs 1, 2, 3, and 4 will prepare you for a Commercial FCC License. In fact, we're so certain of their effectiveness, we make this *exclusive* offer:

> The training programs described will prepare you for the FCC License specified. Should you fail to pass the FCC examination after completing the course, we will refund *all* tuition payments. You get an FCC License . . . or your money back!

CIE's AUTO-PROGRAMMED™ lessons help you learn faster and easier

Cleveland Institute uses the new programmed learning approach. Our AUTO-PROGRAMMED™ lessons present facts and concepts in small, easy-to-understand bits . . . reinforce them with clear explanations and examples. Students learn more thoroughly and faster through this modern, simplified method. You, too, will absorb . . . retain . . . advance *at your own pace.*

Lifetime job placement service for every CIE graduate . . . at no extra cost

Once enrolled with CIE, you will get a bi-monthly listing of the many high-paying interesting jobs available with top companies throughout the country. Many Cleveland Institute students and graduates hold such jobs with leading companies like these: American Airlines, American Telephone and Telegraph, General Electric, General Telephone and Electronics, IBM, Motorola, North American Aviation, New York Central Railroad, Raytheon, RCA and Westinghouse.

CIE lessons are always up-to-date

Only CIE offers new, up-to-the-minute lessons in all of these subjects: Logical Troubleshooting, Laser Theory and Application, Microminiaturization, Single Sideband Techniques, Pulse Theory and Application, Boolean Algebra.

Full accreditation . . . your assurance of competence and integrity

Cleveland Institute of Electronics is accredited by the Accrediting Commission of the National Home Study Council. You can be assured of competent electronics training by a staff of skilled electronics instructors.

ENROLL UNDER NEW G.I. BILL. All CIE courses are available under the new G.I. Bill. If you served on active duty since January 31, 1955, or are in service now, check box on reply card for G.I. Bill Information.

CIE Cleveland Institute of Electronics

1776 E. 17th St., Dept. RE-48, Cleveland, Ohio 44114

Circle 28 on reader's service card

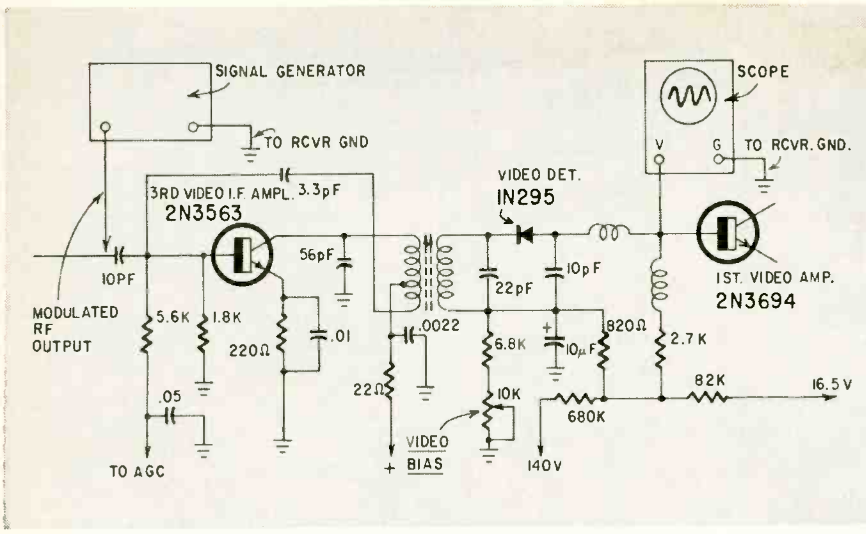


Fig. 3—Signal-tracing the last i.f. and detector in the Sylvania AO6-1 chassis. Take care that the signal generator's output does not overload the i.f. circuit.

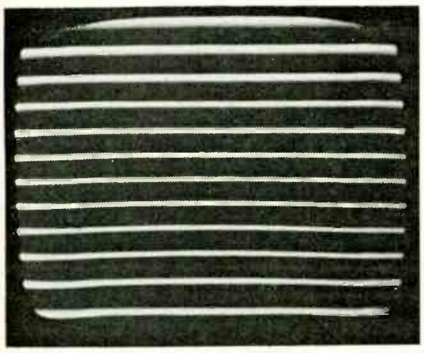


Fig. 4—Black horizontal bars appear when modulated rf or i.f. signal is fed to TV receiver. Variations in width of bars indicates a need for linearity adjustments.

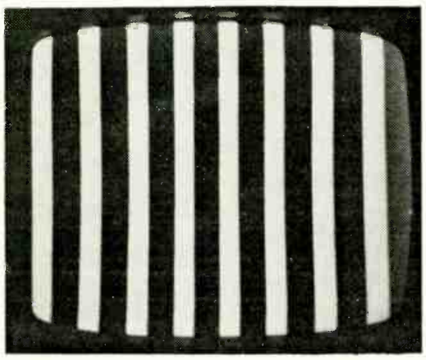
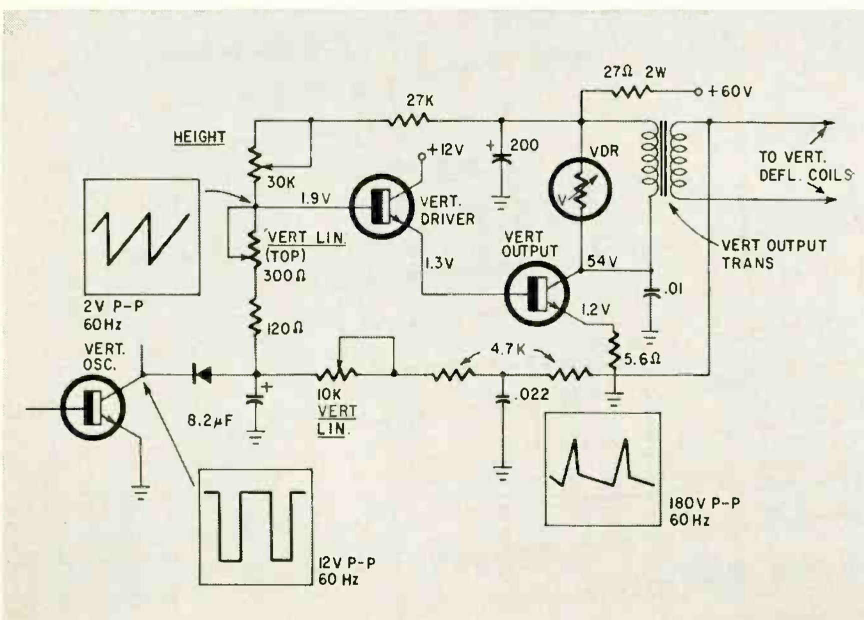


Fig. 5—Vertical bars appear when the modulating frequency is multiple of 15,750 Hz—the horizontal frequency. Waveshape determines the bars' sharpness.

Fig. 6—The vertical driver and output circuit in a Westinghouse set. This model has output transformer; many others use direct coupling from output to yoke.



SIGNAL-TRACE TRANSISTOR TV

(continued from page 37)

frequency and modulated with an audio signal. The video detector demodulates the i.f. signal and the resultant audio sine wave appears on the scope as shown, if the i.f. amplifier and detector are functioning properly.

The demodulated audio signal is applied to the video amplifier base input so that bars will appear on the TV screen if the video amplifiers and the picture tube are all right. The bars will be vertical if the audio signal is a multiple of 15,750 Hz, and horizontal if it is a multiple of 60 Hz. Most signal generators use a modulating signal of 360–600 Hz, so the bars will be as in Fig. 4. Bar width depends on the type signal used (sine wave, square wave, etc.).

Thus, you would not need an rf signal generator to signal-trace through video or audio amplifiers. If you have a variable audio-generator frequency, you can also check vertical and horizontal linearity if the generator goes up to 200 kHz or so. To produce about 10 vertical white and 10 vertical black bars means the picture tube control must be cutoff and released 10 times during the 15,750-Hz, or 15.75-kHz, sweep. The resulting pattern is as shown in Fig. 5. Uneven width of either the vertical or horizontal bars indicates differences in linearity during the scan.

Sweep circuits

TV vertical and horizontal sweep systems generate their own signals, so we need only a scope to trace the signal through to the sweep output stages. If sweep synchronization is poor and can't be corrected with the hold controls, use a scope to determine if a sync signal of proper shape and amplitude is available at the sweep oscillator input.

Manufacturers' schematics usually show scope patterns at various sections of the sync and deflection circuits. Typical sweep patterns and peak-to-peak voltages for a solid-state vertical system are shown in Fig. 6 (Westinghouse V-2483-1 chassis).

Scope patterns should appear as shown in the diagram. Fig. 7 shows the pattern obtained at the base of the vertical driver. When we compare this with the corresponding waveform in Fig. 6 the curvature on the leading edge of the sawtooth indicates that the vertical linearity requires adjustment.

As you check stages nearer the sweep output section you will have to turn down the vertical gain on the scope to keep the pattern within the

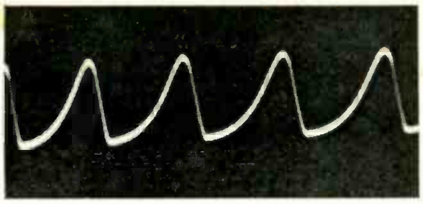


Fig. 7—Curvature in the leading edge of the sweep waveform at the driver base (Fig. 6) indicates poor linearity.

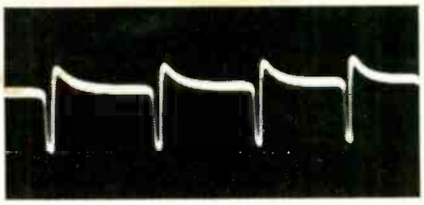


Fig. 9—Horizontal oscillator output waveform. Vertical lines on scope may appear dimmer and thinner than horizontal lines.

scope screen. This is necessary because of the increased signal amplitude. Note that the base input of the vertical driver shows only a 2-volt p-p signal, while the collector of the vertical output transistor shows 180 volts p-p!

Typical scope patterns for the horizontal sweep system are shown in Fig. 8. Note the wide voltage difference between the pattern at the base of the horizontal driver and that at the emitter of the horizontal output transistor. If pattern drawings instead of photos are shown on the manufacturer's schematic, you will have to consider the differences between them and a true scope pattern.

When signal-tracing sweep systems start waveform observation at the oscillator and proceed through the driver and output stages to localize the defective stage. If, for instance, a signal is observed at the output of the driver but not at the output stage in Fig. 8, the driver transformer may be defective or the output transistor burned out.

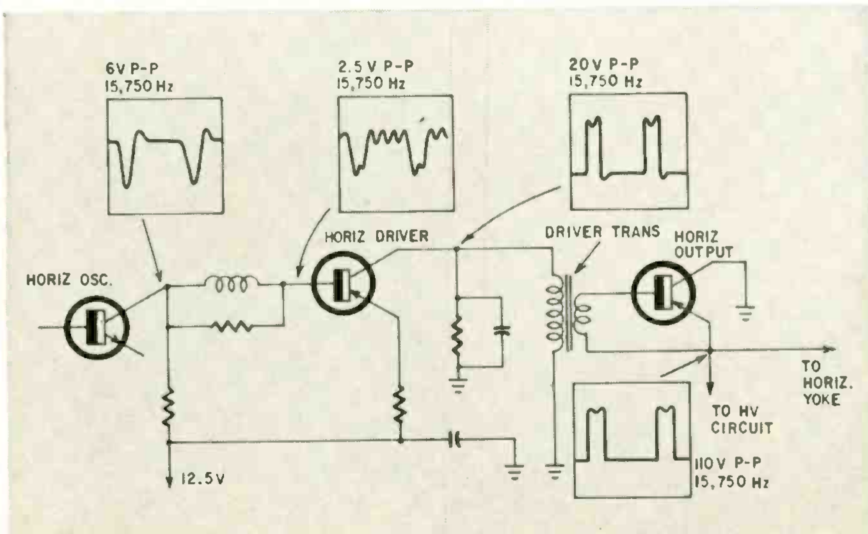
In signal tracing your main concern will be the presence or absence of a signal. If you are checking pattern shapes for linearity, however, waveshape is important. Even if you adjust the scope's vertical and horizontal gain controls to get an approximation of the pattern shown, the waveshape trace on the scope usually will show thicker lines for the horizontal portion of the trace, than for the vertical portion. This is normal because the scope's beam usually has to move faster vertically than it does horizontally. The faster the beam moves the less it excites the phosphors on the face of the tube. See Fig. 9.

Using an electronic voltmeter

The vacuum-tube or transistor voltmeter can replace the scope in some applications, though the scope is much to be preferred for the observance of waveform and measurement of peak-to-peak voltages. The voltmeter could, for instance, be applied to the video-detector output for sensing the presence of a demodulated signal. Similarly, it can be one of its ac ranges and used to detect the presence of an audio signal in the audio amplifier stages by isolating the dc with a series capacitor.

The vtvm (or tvm) can be advantageously used, however, to check for agc voltages at each video i.f. stage (signal tracing the agc voltage generated by the agc detector). Similarly, the voltmeter is useful for signal-tracing the dc voltages from the low-voltage rectifier through the supply and to the various circuits. **R-E**

Fig. 8—Horizontal sweep patterns in the Motorola TS-460 transistor TV chassis.



TRANSISTOR TV SERVICING PRECAUTIONS

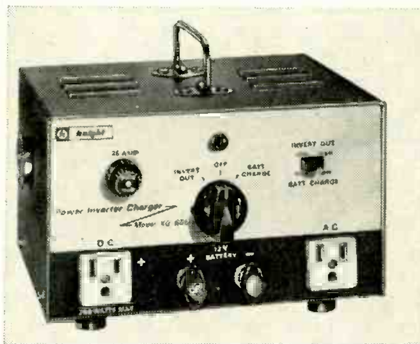
1. Use a low-capacitance probe (10–15 pF) on the scope.
2. Make sure that alligator clips or test prods do not accidentally touch any point in the circuit except the correct test point. Shorts and arcs can destroy several transistors at once. Always turn off the set before connecting or disconnecting test leads.
3. Do not use an ac-operated vtvm or scope to measure resistance or voltage or to check waveforms *between* any two elements in a transistor. Hum voltage and leakage currents may be high enough to damage transistors. When using ac-operated test instrument *always* ground them to the TV chassis.
4. Check soldering irons and guns for ac leakage. Leakage currents can ruin transistors.
5. When using a signal generator for signal tracing, be aware that its low output impedance can change bias conditions on transistors and upset circuit operation. Consult the service notes for the set to find appropriate signal-injection points. When in doubt, use an isolating resistor of 10,000–20,000 ohms in series with the generator's hot lead.
6. The temptation to use a vom for resistance and continuity measurements is strong, so be careful! The open-circuit voltage on the test leads may exceed the voltage ratings of transistors and low-voltage electrolytic capacitors. Know your ohmmeter before using it for solid-state equipment tests.
7. Do not short the CRT anode lead to ground to check for high voltage. Transient voltages can ruin transistors and the short-circuit current can burn out the flyback.
8. Be careful, when checking deflection oscillators and drivers. Accidentally shorting or interrupting either can destroy the output transistor.
9. Do not apply excessive heat to transistor circuit when checking intermittents. Heat can cause thermal runaway, and drive transistors to destruction.
10. Always use a line-isolation transformer on hot-chassis (transformerless) TV chassis.
11. Always use exact replacements—especially transformers, transistors and inductors.

EQUIPMENT REPORT

Knight-Kit Solid-State Power Inverter/Charger Model KG-666

Circle 33 on reader's service card

NEW TWO-IN-ONE COMBINATION KIT makes it possible to go from 12 volts dc to 110 to 130 volts ac at a nominal 60 Hz and, vice versa, to go from 117 volts ac 60 Hz to 12 volts dc. In addition it can provide 110 to 130 volts dc output from either a 117-volt ac input, or a 12-volt dc input. It can operate ac and dc appliances including, radios, TV sets, 2-way radios, power tools, lights, electric shavers and test equipment, from a 12-volt battery.



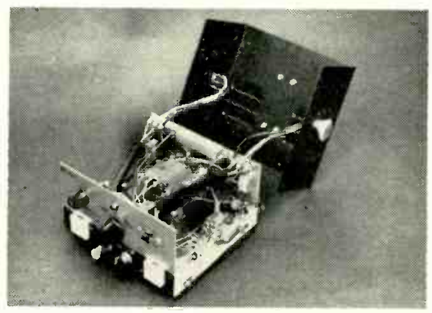
It can also be used to charge 12-volt batteries. The (6-ampere) charging rate reduces itself as the battery becomes charged and is self-regulating. Either a high or a low charging rate can be selected.

You can use the inverter/charger in cars, boats, trailers and in the home, as well as in the lab on a test bench.

A substantial heavy-duty affair in spite of its compact size, the kit can be easily and quickly assembled. Quality components are used throughout. The circuits are well protected with both a fuse and a circuit breaker. The circuit breaker goes to work when the battery is too low and the charging rate is too high. It is a simple matter to switch in the lower charging rate and push the reset button. Once the battery takes on enough of a charge, the higher rate can be selected.

The KG-666 model shown here is rated at 200 watts continuous power. A lower-power-rated unit (KG-662 at 125 watts, continuous) is essentially the same except for a smaller power transformer. Four power transistors are used in the 666 and two are in the 662. You can connect more than one appliance . . . only precaution is not to exceed the power rating. Forget about using 1000-watt frypans, toasters and electric irons. A 400-watt inverter usually tips the scales at $100 to $150 and kilowatt jobs are scarce.

Certain appliances, particularly those with small universal motors such as are used in portable tools (drills, saws, sanders, etc.), will operate more efficiently from the dc outlet than from the ac outlet on the unit. In like manner an electric shaver may give you a closer, faster clipping when plugged into the dc instead of the ac outlet.



However, you do have to watch out for certain types of high-inductive loads and certain loads which require a high starting current. Synchronous motor loads such as clocks and other constant-speed devices that depend upon exact frequency for accurate operation will work, but with some compromise in timing accuracy. Use of the High/Low switch may help.

A construction book with clear, easy-to-follow instructions, and a separate operator's manual which tells how to use and hook up the unit come with the kit. Chalk up a meritorious star for having all the diodes mounted on a card and each diode unmistakably identified. Give the unit another star for its double-barreled usefulness and its excellence.—*Wally Marshall* **R-E**

Specifications KG-666
- Square-wave output, 55-65 Hz at 200 watts continuous power.
- Self regulating Hi-Low 6-amp tapering charge for 12 V. batteries, with resettable circuit breaker.
- Dc output supplies full starting torque for universal motor loads (power tools, etc.)
- Capacitive and diode-despiking network to protect the 4 power transistors
- 2-position output-load optimizing switch
- Pilot light, 25 amp. fuse and 2 amp. circuit breaker
- Color-coded battery terminals
- Compact size—4¾" x 8" x 8¼"
- Two or more units may be stacked to provide added power in dc mode
- Price KG-666 Kit $44.95 (KG-662 Kit $34.95)
- Sold by Allied Radio Corporation, 100 N. Western, Chicago, Illinois 60680

BIG BOOM IN SOUND
(continued from page 50)

will never bend at right angles to the terminal lugs, which causes quick breakage (see Fig. 3). All flexing must take place near the middle of the lead, on the longest possible radius. The mass of these leads, and their stiffness, must be very carefully controlled, to avoid the chance of a resonance developing which would cause fast breakage.

Finally, the problem of suspension of the cone, at the center and the outer edge—this, according to the engineers, probably caused more trouble than any other single thing. The great amount of cone travel needed actually tore the cone loose all the way around the edge, and broke the voice-coil assembly loose from the "spider" at the pole piece.

Beefing up the center suspension was a real headache, but it was finally solved. The difficulties of working out a suspension that would give full cone travel without restriction, yet be strong enough to take the strain, wasn't easy.

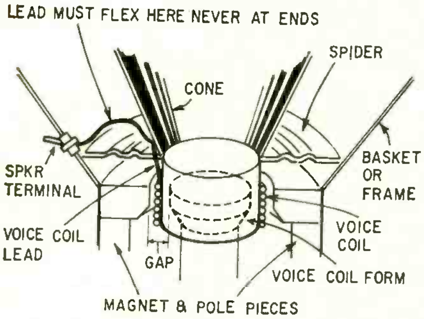


Fig. 3—Even the connecting leads from voice coil to frame had to be beefed up to handle the high power.

Several methods are now used, all having been *very* thoroughly tested.

The outer or rim suspension was even more bothersome, if that's possible. In many cases, the original thin paper cone simply tore apart, all the way around. The use of a special long-fiber paper, specially processed, was the answer. The paper has to be heavy enough to withstand the strain, stiff enough to give good high-frequency reproduction, yet flexible enough to make into an "annulus" (ring) at the outer edge, to provide for the necessary movement!

Unlikely as it sounds, all these requirements were finally met. A rubber-like coating on the paper at the rim gave enough reinforcement to let the cone be flexible at that point, yet strong enough to hold under repeated flexings. This allowed free movement of the voice coil, but enough strength to keep the cone from trying to jump out of the basket when the speaker is running at high power.

This brings up one very important point for the technician when he finds speaker trouble in one of these systems. Ordinary "replacement speakers" simply will not do. You *must* use an exact duplicate of the original. If the voice coil has opened or the cone has torn, send it back to the factory for a reconing job. If one of these high-power speakers is replaced with a "hi-fi" or even a PA-type unit, chances are it will be back very soon, all in pieces!

Conclusion

Amplifying today's musicians is big business, not only in audio power but in money. These groups have the money, and they're willing to spend it to get the sound and the effects they want. No matter how much their ideas conflict with your old-fashioned ones about how sound systems oughta be used, don't argue! They know what they want, and they're going to get it. Quite frankly, it's none of your darn business! *They* can make it work, and that's the main point.

This kind of equipment used to be sold entirely through radio–TV parts distributors. They were the only ones who had it. Now it has gone almost entirely to "music stores" and "guitar centers" which specialize in it. The growth of these establishments has been simply phenomenal in the last 2 to 3 years. You can sell it yourself, if you want, the equipment is readily available.

If you're interested in servicing this kind of equipment, it can be a very good deal. That is, *if* you can do the work, and do it the way it must be done. Few music stores have full service departments; so this can be a lucreative field if you can get all the service and repair work.

Service data are easily available from the makers of the equipment. Most of these are US companies, by the way; there does not seem to be a great deal of import competition, except for small and comparatively rare brand-name items. An article in the November 1966 issue of RADIO-ELECTRONICS ("Keeping Big Amplifiers POWerful," William Darragh, p. 96) gave a lot of good ideas on testing and repairing high-power audio amplifiers.

Using the right test methods, test equipment and the very best grade of replacement parts you can get, can make this into a really remunerative department of your business. **R-E**

69

Service Clinic

By JACK DARR

> **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. S., New York 10003.**

New Flyback, No Agc

I replaced the flyback in a Motorola WTS/534. Now, when the set warms up, the sound and picture go off. I've got a raster, but nothing on it!—E.E., Fort Worth, Tex.

Sounds like agc trouble. Check the polarity of the keying pulse on the agc tube. Quite often, in flyback replacement, especially if a "universal" or non-factory replacement is used, we get into this trouble. If the keying pulse has the wrong polarity, the keyer tube can't conduct; so, no agc.

Also, in this circuit, the agc path goes *through* a small secondary winding on the flyback. Check the circuit wiring. If the agc plate lead is on the wrong tap, you'll kill the agc by putting incorrect voltage on it, and get this "white-out."

Projector Amp Hums

I have a Bell & Howell sound movie projector with a bad hum in the shop. This isn't power-supply hum, for I can kill it by turning the volume control down. Do you know what this could be, and where can I get a diagram of this amplifier?—C. F., Wilbur, Ore.

It has always been very difficult to get any service information on these projector amplifiers, and I don't suppose it's any easier now! However, I think we can find the trouble by process of elimination.

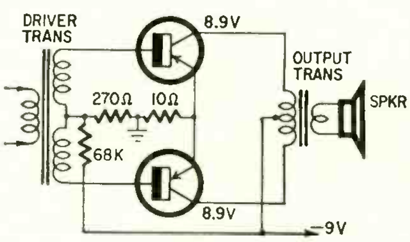
This could be heater–cathode leakage in the preamplifier tube, or some ac ripple in the exciter-lamp oscillator supply. They use an ultrasonic oscillator to supply the exciter lamp voltage, to get away from 60-Hz hum. The oscillator tube is one of the three 6V6 tubes on the chassis. The oscillator transformer is underneath, a small cylindrical coil. Check all three tubes for heater-cathode leakage.

You can also follow the circuit from the volume control on up through the preamplifier to the photocell. Try shunting each plate, grid, etc., with a 0.5-μf capacitor; this will tell you at what point the hum is getting in. By the way, don't let the amplifier sit on your bench with the photocell under a fluorescent light! If you do, it will pick up a 60-Hz hum from these lights! This is normal. Cover the cell with a light-tight box or shield while trying to locate the hum source.

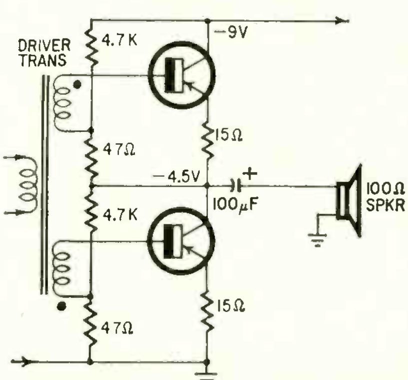
Collector Voltages in Output Stages

I keep getting confused by the voltages in push-pull output stages in transistor radios! Most of them check low, but each collector has the same voltage. I ran into one the other day with 9 volts on one collector, 4.5 volts on the other, and the emitter voltages all fouled up, too. The darn thing worked, though! What's going on here?—N.J., Yuma, Ariz.

You've run into one of the major differences between tube and transistor



a



b

circuits. Your first circuit was a conventional push-pull, as in part *a* of the diagram here. However, the second one is evidently an *output-transformerless* (OTL) circuit, as in *b*.

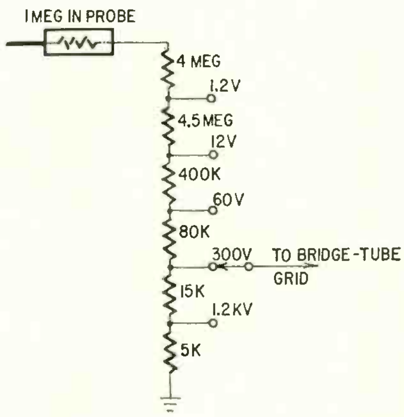
Notice in *b* that the battery voltage is applied directly to the collector of the "top" transistor; this transistor is then in effect "stacked" with the lower one. Its emitter goes to the collector of the lower unit, instead of to ground as in *a*. (However, you can see that the base and emitter bias resistors are still there, to set and stabilize operating bias.)

This works exactly like a stacked-B+ circuit in TV sets with tubes, as far as dc is concerned. The speaker, though, is fed audio signals alternately from each transistor (on alternate half cycles of signal) through the big electrolytic capacitor. Incidentally, there should never be *any* dc across the speaker in this type of circuit!

Vtvm Calibration Check

My vtvm is way off on the dc volts scales. If I put a 45-volt battery on the 300-volt scale, the meter says 225 volts! Can you tell which resistor is off, or what's the matter?—E. W., Anaheim, Calif.

The input of a vtvm is just a big fat voltage divider. See diagram. The total of the resistors is the input resistance of the instrument. A selector switch connects the grid of the bridge tube to whatever tap you need for a certain full-scale voltage reading. The full-scale voltage applied to the tube grid is always the same. For instance, in the diagram of the input circuit of a Simpson 303 vtvm,



you can see that the total resistance is 10 meg. For full-scale reading on the 1.2-volt scale, you'd have 0.6 volt applied to the bridge-tube grid. The grid is connected to the exact center: 5 megohms on either side. With 1.2 volts across the whole divider, divide the *applied* voltage by ½, and get 0.6 volt.

The values of the other resistors are chosen so that when full-scale voltage for each range is applied to the divider, we still get 0.6 volt on the tube grid! On the 300-volt scale, for example, we have only 20,000 ohms to ground and 9.8 meg in series, so we still get the same voltage on the grid itself.

You probably have a burned-out resistor in the divider. From the symptoms, it sounds as if one of the resistors *below* the 300-volt tap has gone way *up* in value. You get far too much voltage on the tube grid, and therefore a false high-voltage reading.

To check, measure the total resistance of the divider from probe tip to ground. Check this against the service manual. Then check the resistance of all individual resistors in the divider. Most of the resistors used here will be color-coded, especially the bigger ones. If the resistor should be burned up so that you can't read the coding, and no value is given in the schematic, you can figure the value from the values of the other resistors and the scale markings.

For In the Shop . . . With Jack see page 16

RADIO-ELECTRONICS READER'S SERVICE

Here's how you can get manufacturers' literature fast:

1. Tear out the post card on the facing page. Clearly print or type your name and address.

   Include zip code! Manufacturers will not guarantee to fill your requests unless your zip code is on the reader service card!

2. Circle the number on the card that corresponds to the number appearing at the bottom of the **New Products, New Literature** or **Equipment Report** in which you are interested.
   For literature on products **advertised** in this issue, circle the number on the card that corresponds to the number appearing at the bottom of the advertisement in which you are interested. Use the convenient index below to locate quickly a particular advertisement.

3. Mail the card to us (no postage required in U.S.A.)

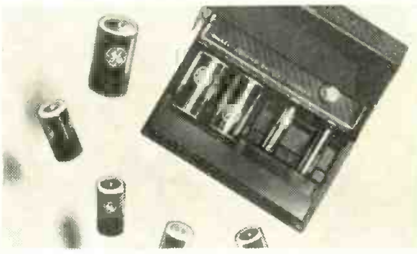
Advertisements in this issue offering free literature (see the advertisement for products being advertised):

AEROVOX CORPORATION (Pg. 4)	Circle 9
ALLIED RADIO CORPORATION (Pg. 92)	Circle 128
ARCTURUS ELECTRONICS CORPORATION (Pg. 94)	Circle 133
ARROW FASTENER COMPANY, INC. (Pg. 83)	Circle 116
ARTISAN ORGANS (Pg. 93)	Circle 130
B & K (Division of Dynascan Corporation) (Pg. 77)	Circle 108
BARKER PRODUCTS COMPANY (Subsidiary of Component Manufacturing Service, Inc.) (Pg. 79)	Circle 110
BURNSTEIN-APPLEBEE COMPANY (Pg. 86)	Circle 122
BROOKS RADIO AND TV CORPORATION (Pgs. 90-91)	Circle 126
CARINGELLA ELECTRONICS, INC. (Pg. 84)	Circle 118
CLEVELAND INSTITUTE OF ELECTRONICS (Pg. 12)	Circle 14
CLEVELAND INSTITUTE OF ELECTRONICS (Pg. 62-65)	Circle 28
CONAR (Division of National Radio Institute) (Pg. 22)	Circle 22
COOK'S INSTITUTE OF ELECTRONICS ENGINEERING (Pg. 90)	Circle 127
CORNELL ELECTRONICS COMPANY (Pg. 96)	Circle 138
DATAK CORPORATION, THE (Pg. 83)	Circle 115
DELTA PRODUCTS, INC. (Pg. 6)	Circle 10
DELTA PRODUCTS, INC. (Pg. 84)	Circle 117
EDMUND SCIENTIFIC COMPANY (Pg. 95)	Circle 135
EICO ELECTRONIC INSTRUMENT COMPANY, INC. (Cover III)	Circle 150
ELECTRONIC CHEMICAL CORPORATION (Pg. 93)	Circle 131
ELECTRO-VOICE, INC. (Pg. 69)	Circle 30
ELPA MARKETING (Pg. 12)	Circle 13
GAVIN INSTRUMENTS, INC. (Subsidiary of Advance Ross Corporation) (Cover II)	Circle 7
GC ELECTRONICS COMPANY (Pg. 76)	Circle 107
GC ELECTRONICS COMPANY (Pg. 85)	Circle 120
GRANTHAM SCHOOL OF ELECTRONICS (Pg. 1)	Circle 8
HEALD COLLEGES (Pg. 93)	Circle 132
HEATH COMPANY (Pgs. 23-25)	Circle 25
INDIANA HOME STUDY INSTITUTE, THE (Pg. 89)	Circle 124
INTERNATIONAL CRYSTAL MFG. COMPANY (Pg. 98)	Circle 149
JENSEN MANUFACTURING (Division of The Muter Company (Pg. 16)	Circle 19
E. F. JOHNSON COMPANY (Pg. 78)	Circle 109
KENZAC (Pg. 94)	Circle 134
LAFAYETTE RADIO ELECTRONICS (Pg. 88)	Circle 123
MOSLEY ELECTRONICS, INC. (Pg. 86)	Circle 121
MUSIC ASSOCIATED (Pg. 22)	Circle 23
OLSON ELECTRONICS, INC. (Pg. 90)	Circle 125
PERMOFLUX CORPORATION (Pg. 84)	Circle 119
POLY PAKS (Pg. 97)	Circle 139
QUAM-NICHOLS COMPANY (Pg. 68)	Circle 29
QUIETROLE COMPANY (Pg. 83)	Circle 114
RCA ELECTRONIC COMPONENTS AND DEVICES (Test Equipment Division) (Pg. 15)	Circle 18
RCA ELECTRONIC COMPONENTS AND DEVICES (Test Equipment Division) (Pg. 17)	Circle 20
RYE INDUSTRIES, INC. (Pg. 82)	Circle 113
SAMS & COMPANY, HERBERT (Marketing Division of Tompkins Radio Products) (Pg. 80)	Circle 111
SCHOBER ORGAN CORPORATION, INC. (Pg. 14)	Circle 17
SCOTT, INC., H. H. (Pg. 14)	Circle 100
SOLID STATE SALES (Pg. 95)	Circle 136
SPRAGUE PRODUCTS COMPANY (Pg. 81)	Circle 112
SUPEREX ELECTRONICS (Pg. 70)	Circle 31
SYLVANIA (Subsidiary of General Telephone & Electronics) (Pg. 13)	Circle 15
TAB BOOKS (Pg. 7)	Circle 11
VACO PRODUCTS COMPANY (Pg. 75)	Circle 106
WARREN ELECTRONIC COMPONENTS (Pg. 96)	Circle 137
WINEGARD COMPANY (Pgs. 26-27)	Circle 26
ZENITH (Pg. 71)	Circle 32

NEW PRODUCTS

More information on new products is available free from the manufacturers of items identified by a Reader's Service number. Turn to the Reader's Service Card facing page 72 and circle the numbers of the new products on which you would like further information. Detach and mail the postage-paid card.

RECHARGEABLE BATTERY SYSTEM, *Perma-Cell.* Combines the rechargeable G-E nickel-cadmium batteries and an automatic charger. Batteries can be re-



charged 1000 times or more and come in types D, C and AA sizes. Charger operates off 117 volts ac and can charge any two or four of the battery types or any pair or combination simultaneously. Loading of the charger is simple and fast. A red indicator light glows when batteries are properly placed. D-batteries are $3.95 a pair, C-batteries are $3.15 a pair and AA are $3.49 a pair. Charger is $9.95—**General Electric Co.**

Circle 46 on reader's service card

RADAR DETECTOR. Miniature microwave receiver clips to car sun visor to alert driver of approach to a controlled radar speed zone well in advance of critical clocked area. Operates on 2 penlight batteries, has up to 2-mile range and is completely transistorized. Device picks

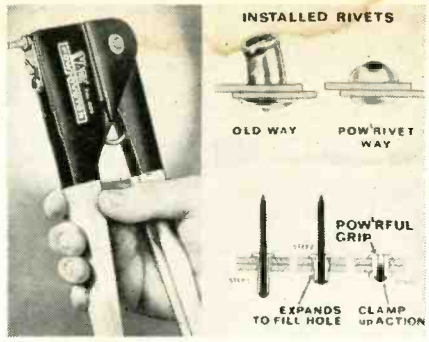
up radar signal from police vehicle and emits a steady beep to warn driver to slow down to posted speed before he reaches the zone where his speed is clocked. Legal in 48 states. $44.95—**Solar Electronics**

Circle 47 on reader's service card

TUNER CLEANER, *Super 100.* Cleans the delicate wafer contacts and connections of tuners and coats them with a protective lubricant, guarding against dust, dirt and cutting particles contained in grime. Can be used on color and black-and-white TV tuners. Also restores quiet operation of potentiometer type controls for receivers. Available in pressurized can with an extension needle for spraying into hard-to-reach tuners and controls. Will not affect plastic fittings, nylon shafts and plastic channel-strip holders.—**Injectorall Electronics Corp.**

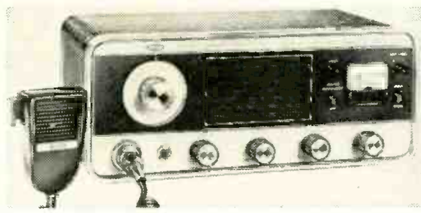
Circle 48 on reader's service card

75



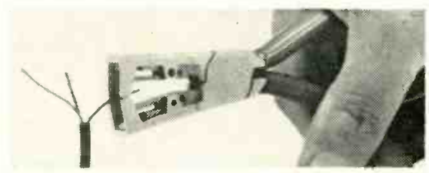
HAND RIVETER, *Pow'Riveter.* Rivet expands to its own head diameter for use in wide-tolerance holes. Clamp-up action assures a snug fit, eliminating the possibility of loose assembly. Low profile guarantees a finished appearance on both sides of the riveted material. Sealed stem provides a waterproof and dustproof fastening of the riveted material. Four sizes of rivets replace 11 sizes of ordinary blind rivets. Riveter's 4-way head accommodates any size blind rivet as well as special rivets; the other two heads are for $\frac{5}{32}$" and $\frac{3}{16}$". Riveter plus supply of assorted rivets is $4.95—**VACO Products Co.**

Circle 49 on reader's service card



CB 2-WAY RADIO, *Model A-2567.* Solid-state power supplies are built-in for both 12-V dc mobile and 115 V ac base use. Receives all 23 channels. Sensitivity: 0.5 mV or better for 10 dB signal-to-noise ratio; selectivity: ±3 kHz for 6 dB; audio output: 2.5 watts; power input: 5 watts; modulation: 100%. Features switchable Range Expander, illuminated 3-scale meter and dual-conversion superhet receiver. Supplied with all crystals, ac and dc power cords, push-to-talk mike and universal mobile mounting clips. $179.95—**Allied Radio Corp.**

Circle 50 on reader's service card

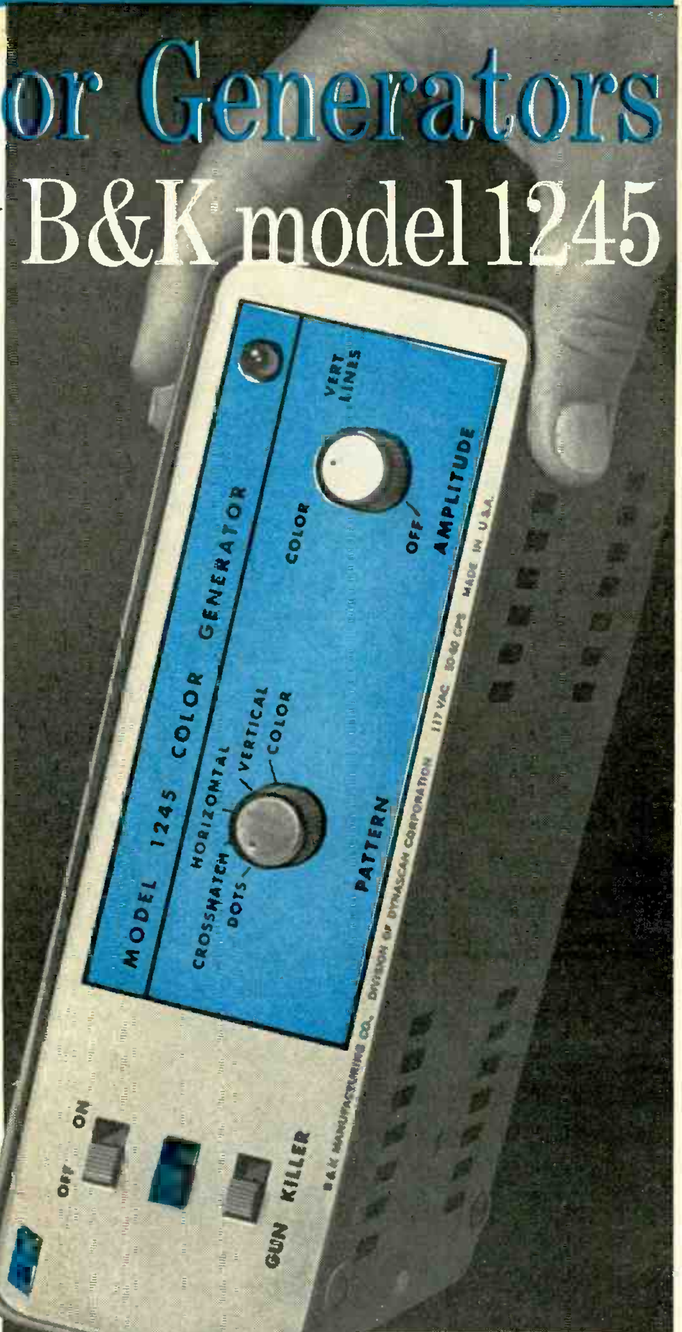


WIRE STRIPPER. Self-adjusting wire stripper accommodates AWG Nos. 8 to 24 wire sizes. Hand stripper has 11 narrow cutting blades in each jaw. Each blade floats in its own spring mounting so that blades close around the wire in a circle as the handle is squeezed. Cutting tension is provided entirely by spring action in blades, not by amount of squeeze . . . the wire is stripped cleanly without nicking the conductor. Plastic cushion grips make the stripper easy and comfortable to use.—**Telvac Instrument Co.** R-E

Circle 51 on reader's service card

Compare Color Generators

look at the rest...
and you'll buy the best, new B&K model 1245



The all solid-state B&K Model 1245 Color Generator duplicates the waveforms transmitted by a color TV station.

Adherence to these waveforms makes it easy to converge the color tube, check sync and make other raster adjustments . . . and the color generator with station quality signal will be able to sync next year's sets. Generators with compromise waveforms do not give you this obsolescence protection.

Here are oscilloscope photographs from the outputs of two typical competitive color generators, one transistorized and one tube type, and the B&K Model 1245. The detailed analysis with each photograph shows a few of the reasons why you'll save time and effort with B&K.

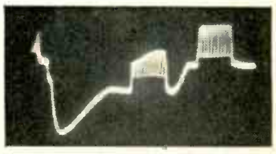
COLOR | **CROSSHATCH**

STANDARD STATION SIGNAL

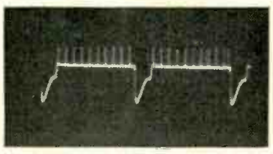
One horizontal sync pulse with its color burst.

Two lines showing horizontal sync pulse with black and white tv signal,

B&K MODEL 1245

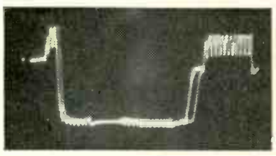


Good duplication of station signal including back porch. If the set won't sync, the set is defective.

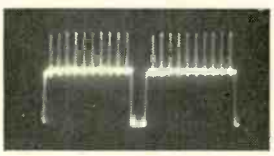


Well defined back porch on horizontal sync pulse permits accurately setting color killer and almost eliminates need to adjust brightness and contrast.

TRANSISTORIZED GENERATOR A



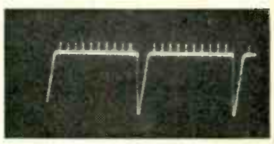
No back porch causes unstable color sync. Burst amplitude compression may permit sync on wrong color bar.



Square wave horizontal sync pulse with no back porch and poor dc coupling forces adjustments of brightness, contrast & fine tuning to obtain usable pattern.

GENERATOR B

No back porch; color information on top of sync-pulse makes sync difficult on some sets.



Complete absence of any back porch necessitates readjustment of brightness, contrast and fine tuning to obtain a usable pattern.

For the first time, with the no-compromise waveforms from the B&K Model 1245, it is possible to accurately set the color killer threshold control with a color generator.

The miniature size and convenience of the Model 1245 match its performance. It provides crystal-controlled keyed rainbow color bar display, and dot, crosshatch, horizontal line and vertical line patterns as well as gun killer controls that will work with any picture tube. Size only 2⅞ x 8½ x 8⅞". Net 134^{95}.

See your B&K Distributor for a demonstration or write for Catalog AP22.

B&K

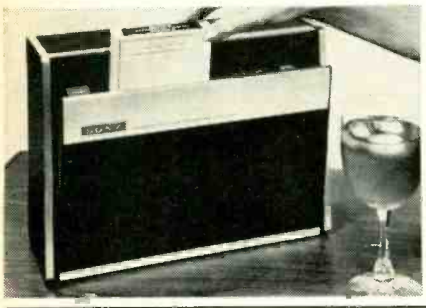
A DIVISION OF DYNASCAN CORPORATION
1801 W. Belle Plaine, Chicago, Illinois 60613
WHERE ELECTRONIC INNOVATION IS A WAY OF LIFE

Export: Empire Exporters, Inc., 123 Grand Street, New York, N.Y. 10013

Circle 108 on reader's service card

NEW AUDIO EQUIPMENT

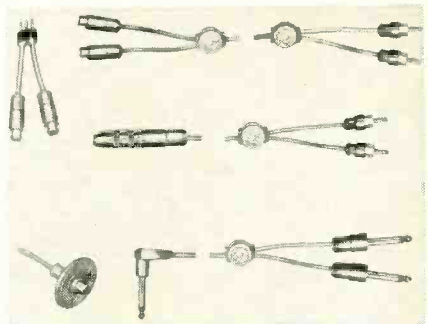
CARTRIDGE TAPE RECORDER, *TC-8.* Records from home tape recorder,



phono or FM multiplex. Plugs into recording outputs of any stereo system or line outputs of any stereo tape recorder. Cartridge-alignment indicator lights if cartridge is inserted improperly and unit won't operate until it is properly reinserted. Features automatic recording control which makes recording-level decisions automatically. Unit will accommodate the Sony or other conventional 8-track cartridges.—**Superscope, Inc.**

Circle 52 on reader's service card

AUDIO ACCESSORIES. Molded adapters and cable assemblies feature solder connections and internal cable clamps to support the cable and eliminate strain. Accessories include: stereo adapter that connects 2 single-conductor phono-jack



outputs to one 3-pin-in-line plug; speaker enclosure phono jack with a 24" cable and mounting screws; adapter cable with a d-conductor right-angle phone plug on an 11" 2-conductor shielded cable; 4-foot stereo adapter cable with 2 standard molded phono plugs; and a 3-foot stereo extension cable with 2 straight molded phono plugs wired to 2 phono jacks.—**Switchcraft, Inc.**

Circle 53 on reader's service card

STEREO COMPACT MUSIC SYSTEM, *Model SC-2020.* Offers a balanced combination of convenient features and precise, distortion-free performance in a compact control center with two powerful speakers. Both speakers and control center are securely housed in handcrafted oiled walnut cabinets. Features solid-state components, microcircuits and modular

construction. Will play monaural and stereo records and receive AM and FM broadcasts. User need only unpack unit and plug it in. Power output: 30 watts, IHF at 8 ohms. Frequency response: ±1.5 dB 20–30,000 Hz at 1 watt; harmonic distortion: less than 1%. Square-wave rise time: better than 5 microseconds. FM sensitivity: 2.9 mV, IHF; image rejection: better than 40 dB; separation: 30 dB; AM sensitivity: 50 mV. $329.00—**Harman-Kardon** R-E

Circle 54 on reader's 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's Service Card facing page 72 and circle the numbers of the items you want. Then detach and mail the card. No postage required!

1968 CATALOG. Contains 32 pages of electronic kits and factory assembled instruments in the fields of Citizens Band, amateur radio, stereo/hi fi, test instruments and kits for beginners. Prices of beginners kits range from $2.50 to $9.95. Fully illustrated and includes a listing of authorized EICO dealers.—**EICO Electric Instrument Co., Inc.**

Circle 55 on reader's service card

STEREO EQUIPMENT. Colorful new 12-page catalog describes the latest in stereo high-fidelity components and compact music systems from Bogen. Includes amplifiers, bookshelf speaker systems and Stereo-8 tape-cartridge players. Also lists turntables, receivers and tuners.—**Bogen Communications Div., Lear Siegler, Inc.**

Circle 56 on reader's service card

1968 SPRING CATALOG, No. 683, 132 pages. Includes *Lafayette's* top-rated equipment plus that of many other major manufacturers. Host of values in garden tools and accessories, power tools for the home workshop and marine equipment. Also has a complete selection of hi-fi components, Citizens-band 2-way radio, tape recorders, ham gear, radios, and much more.—**Lafayette Radio Electronics**

Circle 57 on reader's service card

STRIP-CHART RECORDERS. 20-page catalog gives details of 50 models of miniature strip-chart recorders, all featuring the RUSTRAK dry writing process. Includes information on chart paper, drive-motor specifications, accessories, optional features, dimensions, weights and ordering information.—**Rustrak Instrument Div., Gulton Industries, Inc.**

Circle 58 on reader's service card

SOLDERING EQUIPMENT. This 24-page catalog covers accessories, service parts, representative tips, and soldering irons—a total of over 450 items. Includes tip-temperature control systems, small solder pots, safety stands, tip cleaners, etc. Price sheets are included.—**American Electrical Heater Co.**

Circle 59 on reader's service card

1968 DC POWER SUPPLIES. 88-page catalog and handbook combines a textlike discussion on dc power supplies and a selection guide and condensed listing to make it easy to select the supply which best meets your needs. Handbook portion discusses technical details and applications of dc power supplies and includes circuit principles, operating features, performance measurements and special applications.—Hewlett-Packard Co.

Circle 60 on reader's service card

PLASTIC TUBE SEALER. Bulletin describes Models C-3H, (hand-grip) and C-3W (wall-mounted) tube sealers. Tells how instrument operates and illustrates uses. Lists special features and prices for both models.—Harwil Company

Circle 61 on reader's service card

PA AMPLIFIERS. Catalog details the new Bogen line of Challenger CHS solid-state public amplifiers. Charts and photographs describe four new CHS models—CHS-100, 50, 35, and 20, listing technical data and prices. One page is devoted to a listing of accessories.—Bogen Communications Div., Lear Siegler, Inc.

Circle 62 on reader's service card

CORRECTION

Mosley Electronics, Inc. (New Literature January, February 1968) catalogs list manufacturers' representatives and their territories, not dealers. Mosley manufactures TV/FM antenna accessories and audio accessories and does not make TV/FM antennas.

INSTALLING INTERCOMS

(continued from page 41)

front door. Either a hole had to be cut in a brick wall to hold the outdoor station or it could be installed on the bottom part of the overhang which was about 3′ away from the door and about 6′ above the stoop level. Because sensitivity of the remote unit is more than adequate for this distance and the overhang provides a good shelter from rain, a 3¾″ by ½″ opening in line with the corner of the bedroom above was cut in the overhang (Fig. 9). A sabre saw on the outside and a ⅝″ drill from the inside of the bedroom prepared this site. A two-conductor cable from the door unit to station R12 is now concealed by the baseboard heater.

The back box for the outdoor remote at first posed a problem in that it was to be mounted in the overhang section in front of the house. The underpart of the overhang was ¼″ thick plywood backed with a sheet of ¾″ composition insulation material which was of little value for holding the

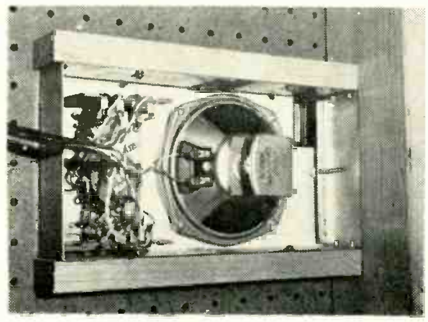


Fig. 12—Rear view of the remote unit in the workshop. Here again, the wall (pegboard) is sandwiched between 2 wood braces and the flange on the back box. Unfinished side of wall made this photograph possible. This is not a dummy.

outdoor remote unit. There were no supporting braces of any kind close to the opening, and the back box for the outdoor remote is flangeless. Solving this problem was only a matter of screwing a piece of wood on each side of the opening and then securing the box in place, as shown in Fig. 10.

Connections from stations R10 to R11 and R12 were made without a hitch. A line was dropped through the wall from stations R10 to R11.

Installation of stations R14, R15 and R16 was not too difficult, but they did require more time than the others. A ⅛″ pilot hole was drilled through the floor under the baseboard molding directly below station R9. The drill was angled to make a hole in the ceiling in the garage below, directly in line with the wall space above. A 5⁄8″ drill placed in the pilot hole in the ceiling, worked its way straight up into the wall space as desired. The molding was put back in place to cover the pilot hole in the floor. After some "notching" and "fishing" and a few more notches, the cable was in place in the garage and rear-entrance way ceiling. While the rear-door remote unit needs only a two-conductor cable, the eight-conductor cable was run to it and an octal outlet in a weatherproof enclosure which was installed nearby.

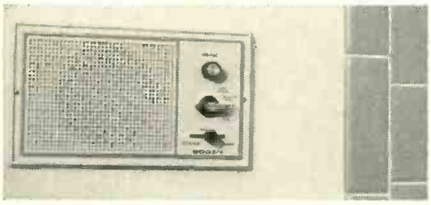


Fig. 13—Finished bathroom installation can accompany a wet baritone with background music . . . that's plush living.

Stations R1, R3 and R4 in the basement were wired by running eight-conductor cable along the ceiling between the beams and the space provided by furring strips which support an acoustic tile ceiling. Station R5 hookup was a cinch . . . it didn't even require an extra hole for the cable. However, the outdoor remote at station R2 called for some fisherman's luck but nothing like the amount of work for the back door.

Installation of the back boxes for the remote units without the aid of cross braces between the studs was desired. To install cross braces from stud to stud, without cutting a hole larger than the back box would have required some fairly fancy carpentry work and expertise. Instead a piece of 3⁄4″ furring strip about 2″ wide and 9½″ long was screwed to the top and bottom of the back box to sandwich the wall between the wood and the flange on the box, as shown in Fig. 11. It is a simple matter to press the flange against the outside of the wall and the wood against the inside of the wall with one hand while you secure the box and the wood in position with a couple of wood screws.

See Fig 12 for a rear view of this type of installation. Only two screws are needed for each piece of wood. Mounting strength and stability is more than adequate. Figure 13 shows a completed installation in the bathroom . . . nothing like music to shower by.

A little Spackle and paint for the half dozen small notches in the garage and rear-entrance way ceiling, finished the job. There is nary a trace of wire or a notch showing. **R-E**

TV Service Puzzle—For SHARPSHOOTERS Only

(continued from page 61)

power off and using the ohmmeter, the "expert" found no reading at all (open circuit) from the 270-volt line to the primary of the power transformer. (*4)

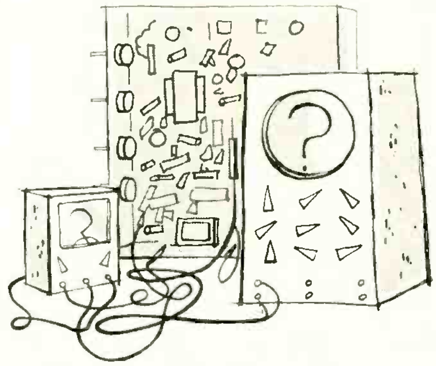
Checking from the 270-volt line to the secondary of the power transformer, there was a 2,000-ohm reading to the red-green wire, and a very high resistance, almost 50,000 ohms, with the prods reversed. (*5)

There you are. Those are the clues. Remember that this is not in any way a "normal" fault; it cannot be accounted for by a part failure. However, there *is* a logical explanation, and you have all the clues needed to find it, illogical though it sounds.

Let's repeat the clues, for luck:

1. There are no bad parts in the set.
2. There is no dc short on the 270-volt line or in the supply.
3. There is a 100-volt p-p sawtooth ripple on the 270-volt line, even when it is disconnected from the source.
4. An ohmmeter connected between the 270-volt points and the secondary of the power transformer shows a typical "rectifier-type" reversible reading at these points.

There you are; go get 'em.



The answer

When shorted rectifier CR204 was replaced, it was soldered to the PC board (see Fig. 3). In this chassis, the rectifiers are small silicon units, located on the PC board, under a cross-brace and quite a bit of wiring. The rectifier was replaced with the right polarity, in case you thought of that. *But*: instead of connecting its anode (negative) end to ground, as it should have been, it was accidentally connected to the four-terminal "blob" which was one of the junctions of the 270-volt line!

So, this rectifier, when it conducted, fed a very large ripple (half-wave rectified) voltage *into* the 270-volt dc line! This ripple, which went right through the big electrolytic capacitor as if it were ac, overloaded the dropping resistor, and dropped the dc voltage at that point, causing all of the other symptoms!

This was an almost "natural" mistake.

The PC board, where the rectifiers are mounted, is very crowded, and the correct point is only ⅛ inch from the place where it was connected! This is one of those things that any of us could do at any time, which is the moral of this story! Now, let's look at the actual diagnosis, and see where the old "expert" fell flat down.

**4: There is obviously a high ac voltage getting into the 270-volt line, from the very high ripple. This means a short circuit from the ac source (the power transformer) to the 270-volt line. This accounts for the behavior of the big electrolytic capacitor when it is connected and disconnected.*

**5: The "short" between +270 volts and the transformer secondary* must *be through a rectifier (primary was cleared, remember,). The ohmmeter readings definitely confirm this.*

A careful, point-by-point examination of the PC board, and especially the area around CR-204 (lowest reading to the red-green wire of the secondary, where CR204 is normally connected, remember?), finally disclosed the real trouble! It could happen to you! **R-E**

BUILD A PANIC BUTTON

(continued from page 59)

whose repetition rate varies. If you change the frequency considerably from that provided by the component values given in the schematic you may want to make the value of C5 different from C6 so that the average output is approximately a square wave.

Transistors Q6, Q7, Q8, Q9 and Q10 provide a surprising amount of volume from the speaker. Adjust the value of R13 to bias the collector of Q6 at 4 to 5 volts.

Total battery drain of the circuit shown is from 20 to 30 mA.

An SCR is used to turn on the alarm, and a mercury switch to turn it off, by turning the case upside down. This was done partly for novelty, but mainly to permit use of a momentary pushbutton. If you have an alternate action, push-on/push-off switch, you can save the cost of the mercury switch and SCR.

Construction details

The Panic Button can be inexpensively built by cannibalizing a transistor radio, available for as low as about $3.50 at discount stores. Some of the components, particularly the miniature electrolytics, can be salvaged from the radio. Use the snap-on battery contacts, battery and speaker, too. In fact, you can use the entire audio amplifier portion of the radio. Simply connect Q4–Q5 output (right side of C7 in Fig. 3) to the top of the volume control in the radio, and the common line to the bottom.

My version was constructed on a piece of perforated board with 0.2" staggered centers. Fig. 4 shows the board (full size) with dimensions and parts placement.

I used a Jade-brand imported transistor radio, with a tuning dial hole in the case front. The switch I used for S1 exactly fit this hole (see photo). Depending on the radio you use, you can probably find a pushbutton that will do, although you may have to make a hole in the front of the case.

As an alternative to the mercury switch, mount a set of very light relay or lever switch contacts on the board. A sharp blow to the case should then open the contacts momentarily—which is all that's required to turn off the SCR, and the Panic Button. Should you decide at any time that you would like to get more volume, connect the output of the siren to a hi-fi set or another more powerful amplifier. **R-E**

Operational Amplifier Basics

(continued from page 57)

OP-AMP GLOSSARY

Common-mode gain—Ratio of output voltage over input voltage applied to (+) and (−) terminal in parallel.

Common-mode rejection ratio (CMRR)—Ratio of an op amp's open-loop gain to its common-mode gain.

Differential-input voltage range—Range of voltages that may be applied between input terminals without forcing the op amp to operate outside its specifications.

Differential Input Impedance (Z_{in} diff)—Impedance measured between (+) and (−) input terminals.

Drift, input voltage—Change in output voltage divided by open-loop gain, as a function of temperature or time.

Input voltage offset—Dc potential required at the differential input to produce an output voltage of zero.

Input bias current—Input current required by (+) and (−) inputs for normal operation.

Input offset current—Difference between (+) and (−) input bias currents.

Offset—Measure of unbalance between halves of a symmetrical circuit.

Open-loop bandwidth—Without feedback, frequency at which amplifier gain falls 3 dB below its low-frequency value.

Open-loop voltage gain (A_{vol})—Differential gain of an op amp with no external feedback.

Slew rate—Maximum rate at which output voltage can change with time; usually given in volts per microsecond.

REFERENCES

*Applications Manual for Computing Amplifiers for Modeling, Measuring, Manipulating and Much Else, By the Staff of Philbrick Researches Inc., 1966

*RCA Linear Integrated Circuit Fundamentals. Radio Corporation of America, 1966

RCA Application Notes ICAN—5290,5015

*Handbook of Operational Amplifier Applications. Burr-Brown Research Corp., 1963

Handbook of Operational Amplifier Active RC Networks. Burr-Brown Research Corp., 1966

*Fairchild Semiconductor Linear Integrated Circuits Application Handbook, by James N. Giles. Fairchild Semiconductor, 1967

Motorola Application Notes AN 275, 273, 248, 204, 258, 261. Motorola Semiconductor Products

Westinghouse Application Notes, File No. 91-508. Westinghouse Corp.

Union Carbide Application Notes, AN 4R, 6, 7. Union Carbide Electronics

*Operational Amplifier Application Manual, Parts 1, 2, 3. Analog Devices

Application of Op-Amps, Technical Bulletin No. 8. Amelco Semiconductor

Operational Amplifier Application Notes ZA 101, 102, 103. Zeltex Inc.

Some Op-Amp Manufacturers

Amelco Semiconductor
P.O. Box 1030
Mountain View, Cal. 94040

Analog Devices, Inc.
221 Fifth Street
Cambridge, Mass. 02142

Burr Brown Research Corp.
International Airport Industrial Park
Tucson, Ariz. 85706

Data Device Corp.
240 Old Country Road
Hicksville, N. Y. 11801

Fairchild Semiconductor
313 Fairchild Drive
Mountain View, Cal. 94040

Fairchild Controls
P.O. Box 1388
Mountain View, Cal. 94040

General Electric
Semiconductor Prods. Dept.
Electronics Park
Syracuse, N. Y.

K and M Electronics
102 Hobart Street
Hackensack, N. J. 07601

Motorola Semiconductor Prods. Inc.
Box 955
Phoenix, Ariz. 85001

NSC Microcircuits Div.
2950 San Ysidro Way
Santa Clara, Cal. 95051

Opamp Labs
172 S. Alta Vista Blvd.
Los Angeles, Cal. 90036

Philbrick/Nexus Research
Allied Drive at Rt. 128
Dedham, Mass. 02026

Radio Corp. of America
Electronic Components and Devices
Harrison, N. J. 07029

Signetics Corp.
811 E. Arques Ave.
Sunnyvale, Cal. 94086

Texas Instruments
P.O. Box 5474
Dallas, Tex. 75222

Union Carbide Corp.
Semiconductor Dept.
P.O. Box 1209
Mountain View, Cal. 94040

Zeltex, Inc.
1000 Chalomar Road
Concord, Cal. 94520

FEEDBACK QUIRKS

(continued from page 51)

frequency was not 6 dB but 8 dB.

Assuming I just hadn't allowed for some resistance value belonging to the transistor, I tried changing capacitor values in the hope of finding a combination that would produce 6 dB loss at the 90° phase point (which I checked by finding where the transfer ellipse passes through from a left-to-right to a right-to-left slope—(Fig. 4). Whatever I did, I couldn't get less than 8 dB loss at the 90° point.

So, I thought, just use more feedback. Consulting my chart, I found that a response due to two RC networks that yielded 8 dB loss at the 90° point can be sharpened to 3 dB, with a frequency shift of 1.778 (instead of 1.414) and using 10 dB feedback, rather than 6 dB.

Accordingly I changed my capacitors so the 8-dB 90° point needed to be shifted by a 1.778 ratio, checked resistor values to get just 10 dB feedback and finally connected the loop, as I had done with the tube circuit. But the response wasn't anything like I expected (Fig. 5).

I tried more feedback, thinking the turnover point would eventually get sharp enough. Then I'd change the C's again to get the frequency right. But with this particular circuit, I just couldn't sharpen the turnover enough to get the 90° phase 3 dB down with *any* amount of feedback. Why?

Eventually I realized that my first failure to get predicted performance—when 3 + 3 apparently made 8—should have clued me to what was happening. As well as reflecting effective resistances, which the books told me about, when transistor coupling circuits include reactances, they can reflect reactances as well (Fig. 6). That was why, both with and without feedback, the transistor caused the summation of the separate RC responses to be different from what one would expect from addition of the component parts.

As soon as both RC elements were connected, the transistor presented a reactive component as part of the load for the input circuit, and another as part of the source circuit for the output circuit. Both without and with feedback the combined response was not the summation of the parts put together (Fig. 7).

As with the earlier problem, realizing what the problem was proved to be more than half the battle. In this case, an extra transistor to provide isolation as an emitter follower solved it.

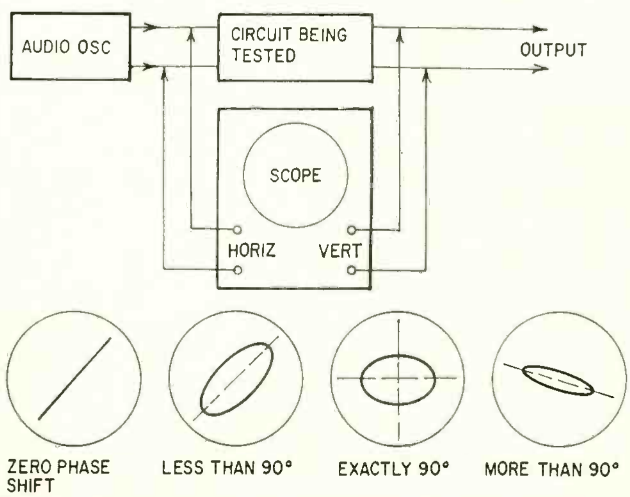


Fig. 4—Equipment setup for determining 90° phase shift point. Oscilloscope patterns readily show degree of phase shift.

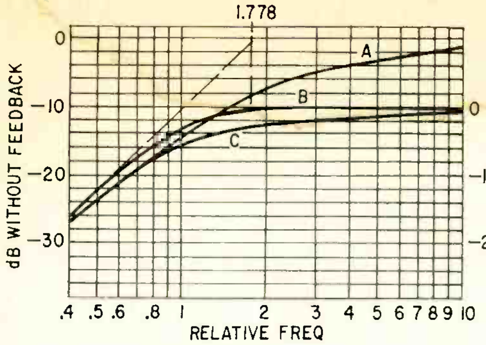
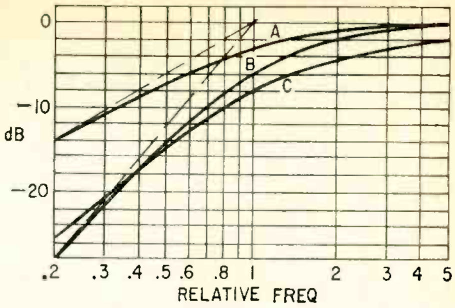


Fig. 5 (left)—Curve A shows response without feedback. Curve C is desired response and curve B is the response obtained.

Fig. 7—Transistor reactance prevents ideal combined response (B) from two A-curve circuits. The result is curve C.



Linear circuits. The next puzzler happens so often that everyone should know about it: If you don't know the answers, you should know the symptoms. The first time I spotted it I was called in to observe a comparison of two amplifiers: One was rated at 15 watts, but had no feedback. The other was rated at 50 watts, with lots of feedback.

Both were being used as guitar amplifiers. When the guitar was played softly, there was no doubt that the 50-watter sounded far cleaner. But when the player tried to get more sound, the 50-watter broke up, and actually seemed to give much less power than the 15-watter. A bench check had been run before I came along; the 15- and 50-watt ratings were real.

Since then the same kind of problem has come up many times. This is what happens: Feedback reduces amplifier distortion just as theory claims it will, *until clipping is approached*. It may be the output stage that clips, or it may be the driver stage, or it may be between the two of them; grid current of the output stage makes the driver stage clip. The effect is the same.

The important thing is that the front-end stages usually don't clip; they're still amplifying. When the drive/output stages clip, the output waveform flattens (Fig. 8). This is also the waveform that gets fed back. And a straight horizontal line is not a "waveform"—the signal has stopped getting through. So suddenly, from this point on, there is no feedback to partially cancel the input signal.

As a result, the amplifier starts getting the same input signal it would get if there weren't any feedback connection. If there's 20 dB of feedback, the input jumps to 10 times normal as soon as clipping starts. This just makes clipping that much worse—more sudden. So, while the feedback cuts distortion, as predicted, below the clipping point, as soon as clipping is reached, worse distortion is suddenly triggered.

Failure to predict this comes from the fact that the theory regards the amplifier as an essentially linear device. It's not quite linear, of course, otherwise we wouldn't need the feedback at all. But it's close to linear and the feedback just cleans up that little bit of nonlinearity. The fact is, an amplifier (when it clips) doesn't even approximate a linear device from that point on.

Complications. If that's all that happens you're lucky. Often, I've found, clipping can trigger even worse kinds of distortion. Not only is the clipping made much more sudden, and inescapable once the signal is too big, but it triggers an aftereffect (Fig. 9). Why does that happen?

Only the drive and output stages are working near their limits. Earlier stages have a bigger margin for linear amplification. And the input stages usually have most of all. They could probably handle 50 times the normal input signal. So when clipping starts, the combined input, formed by mixing the actual input with the feedback signal, steps up to many times its normal level, and is really spiky—just where the clipping is.

The input stages take this signal okay. But probably the last stage before the driver doesn't. It just rectifies this extra signal and biases itself beyond cutoff, from which it will only restore itself at a speed controlled by the bias-supply time constant (with the coupling capacitor).

So clipping triggers a cutoff condition at one stage. While this stage comes back into operation, the signal is distorted until the bias gets nearly normal. The effect

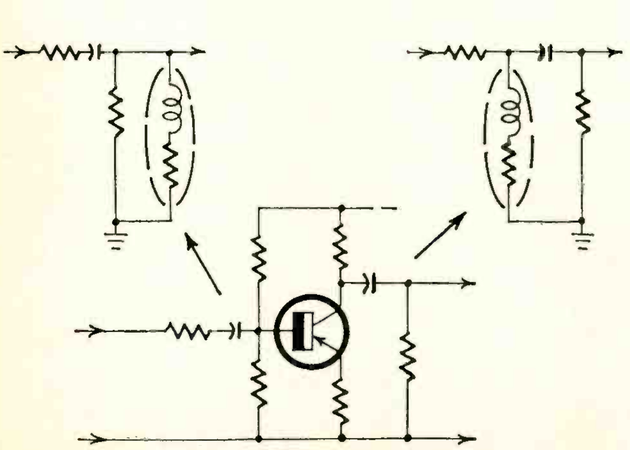


Fig. 6—Stray impedance (circled elements) at input and output of transistor cause the feedback discrepency in Fig. 5.

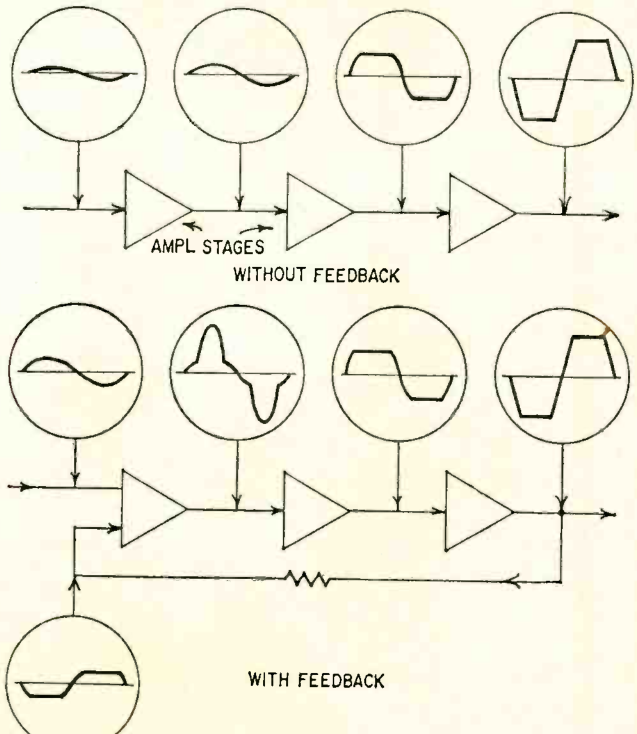


Fig. 8—Output clipping is exaggerated by feedback; flattened wave does not offset input wave.

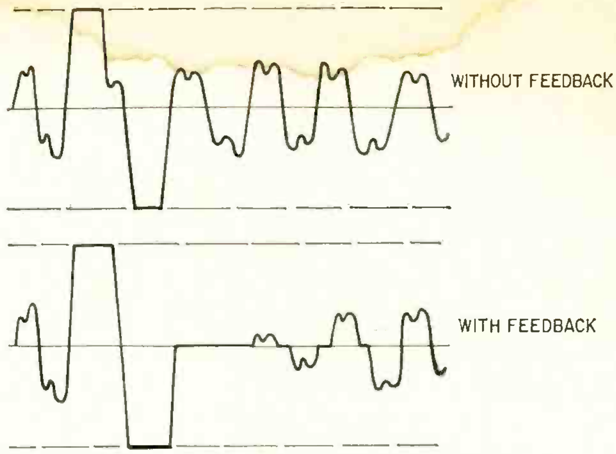


Fig. 9—Bottom curve shows long recovery time due to overbias. High signal level distortion can worsen with feedback.

makes distortion far more noticeable than it is with quick, sudden clipping.

This effect may not show up on a sine-wave test signal, because the steady signal will change the bias enough to reduce gain and thus stay just within clipping. But a musical signal often "hits" the amplifier with similar peak values without the steady buildup that a carefully controlled test signal is given, and the cutoff distortion occurs.

One more variety I'll mention in this category, then another that's closely related. In the first I was picking which side of a push-pull output to take feedback from to feed to an early stage cathode (or maybe it was an emitter). One way the amplifier screeched its head off as I made the connection; obviously that was the wrong side (Fig. 10).

So I connected the other side and it was stable—or seemed to be. Before trying the thing out full blast, I ran a response check at low level until I found the rolloff points, well below and above audible limits. This looked good. But then I started turning the volume up and next thing I knew, the amplifier was screeching as if I had the feedback connected to the wrong side of the output. Turning the signal off didn't stop it. Switching off and on again did.

What caused this? Every time the input signal reached a certain point, which wasn't full output, or even the beginning of clipping, this trouble started. After trying this and that, I eventually removed a high-gain stage that was ahead of the main feedback loop. Why should this cause feedback trouble? It wasn't even in the loop!

Careful checking showed that the high current swing in the output stage caused a minute voltage fluctuation in the B+ supply, which fed the plate circuit of the earlier stage. Reversing phasing didn't help, because the push-

(continued on page 91)

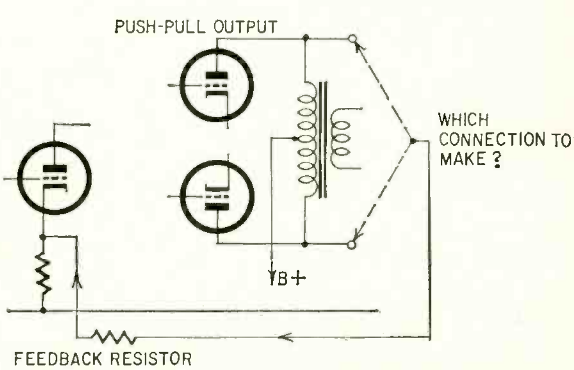


Fig. 10.—Alternate points for connecting feedback. In this case, one produced positive and the other negative feedback.

VIBRATING-WIRE AUDIO FILTER AND OSCILLATOR

continued from page 53

measurements I constructed a generator with a 180° dial covering 10 Hz to 1000 Hz. Allowing for pointer width and dial markings, it was debatable whether the bandwidth was 1 Hz or 1.6 Hz—which actually puts the Q between 600 and 1000.

Q is controlled by damping, and air causes damping of the vibrating wire—just as it does to a loudspeaker cone. Therefore, it's quite possible that even higher Q might be obtained by installing the wire in a vacuum.

The frequency of the wire may be changed by changing its length or diameter or both. There is no low-frequency limit; units may be constructed for 60 or 120 Hz. The practical high-frequency limit seems to be in the vicinity of 20 kHz.

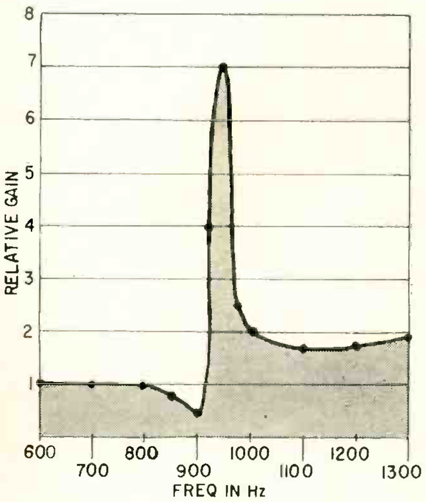
I chose a bridge circuit for the selective amplifier because it is simple and easy to get operating. A bridge is not necessary, though; a differential amplifier—integrated circuit or otherwise—might well prove more satisfactory.

Whichever way you try the vibrating wire, you'll find it quite different from the LC or RC circuits. **R-E**

HOW IT WORKS

Similar in principle to magnetostriction (mechanical) and tuning-fork filters, the vibrating wire fulfills the author's claims. I checked its performance with an audio generator and an oscilloscope. The wire must be stretched taut and must not touch the pole pieces. I had to shim up the prototype with a toothpick at each end. Increased stretching of the wire altered the resonant frequency slightly.

I also tried another dime-store magnet slightly different in size from



the author's. This change made little difference in operation, only changing resonant frequency slightly.

Using the bandpass amplifier, I found resonance sharp and Q high (see curve above). At resonance you can actually see the wire vibrating between the pole pieces!

The sinewave oscillator works well, too, though R7—BATT ADJUST—is touchy to set for minimum distortion in output waveform. Perhaps rather than a 10,000 ohm control, you should try a 2500-ohm pot and a 7500-ohm fixed resistor in series.

Toothpick shims seemed to work fine, and magnet size isn't critical. The pole pieces can be just plain pieces of iron. You can mount the whole assembly on an old-fashioned wooden breadboard. The project is nice and simple and it works.—*Thomas R. Haskett*

SCHOOL DIRECTORY

Circle 124 on reader's service card

NEW TUBES AND SEMICONDUCTORS

TWO NEW TUBES FOR COLOR TV

The 3CU3 (left in photo) and the 6LR6 are two new Sylvania tubes for the high-voltage and horizontal deflection circuits in color receivers.

The 3CU3 is a high-voltage rectifier using a new "posted filament" design for high reliability in instant-on operation. The new ruggedized filament is wound onto, but insulated from, a strong center post. The tube withstands momentary overloads that often destroy regular vacuum-tube and solid-state rectifiers.

The 6LR6 horizontal amplifier operates from 250–450-volt supplies. It has integral radiator fins for efficient heat dissipation. **R-E**

FEEDBACK QUIRKS

(continued from page 88)

pull stage swings current up (or down) twice per audio period—once for each half of the push-pull. If the current from one half of the push-pull was in the wrong phase to start instability, the other one was right!

Unintentional feedback. In a sense, that last example was an unintentional form of feedback, although it didn't show up (in this case at least) until the intentional form was connected, which made it puzzling. But the unintentional can still show independently.

Before the days of intentional feedback—which some of us can still remember if we think hard—there were two principal areas of feedback: subaudio, which was called motorboating, from the put-put sound it made, and ultrasonic, which was inaudible in itself, but would choke the amplifier up so that audio would break through in bursts, all distorted.

An annoying type, which has happened to me since we've had feedback amplifiers, included both. At first all I could tell was that some kind of pulsing was going on. There was little sound in the output, but the power transformer was groaning rhythmically. I put a scope on the output and found a pulsing rf oscillation (Fig. 11). I measured B+ and found the meter pointer kicking wildly in sympathy with the power transformer.

Putting a moderate-size capacitor from almost any grid to ground would stop the trouble, as well as reducing the response to higher audio frequencies. The rf oscillation bursts were going from output clear back to input. I checked the wiring to see whether any output leads had gotten too close to input leads, but no, it couldn't be that.

The only thing left was grounding, which appeared to be all in order, except for the fact that supply negative went to ground through the case of an electrolytic capacitor. I remembered the rule that a ground connection should be made only at the input end of an amplifier. So I lifted the electrolytic capacitor and fitted it with an insulated mounting, and grounded the negative line to chassis at the input jack only (Fig. 12).

Now all was well. What was happening? The rf oscillation was coupled via the chassis (which is all around everything) back to the input stage. It built up until the drive or output stage biased itself to cutoff, and then waited for that stage to start conducting again, when it started the oscillation all over again. Those things can still happen! **R-E**

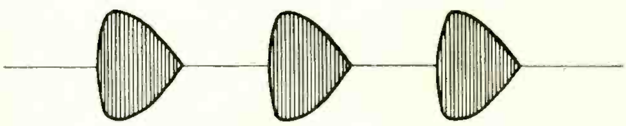


Fig. 11—Distortion produced by pulsing rf oscillations was cured by relocating negative supply ground near input stage.

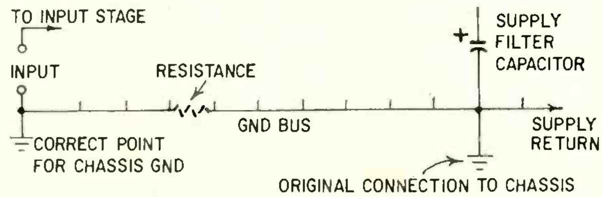
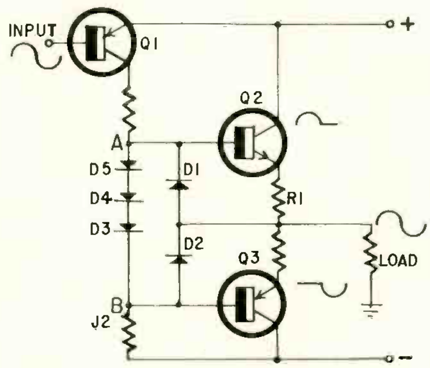


Fig. 12—Signal voltage drop along ground bus appears in series with input voltage in correct phase to generate feedback.

NOTEWORTHY CIRCUITS

AMPLIFIER PROTECTIVE CIRCUIT

In many solid-state push-pull amplifiers, a short circuit in the load or even a momentary short across the output terminals will destroy the output transistors. Too, if the circuit uses complementary transistors, oscillations can cause both of the output transistors to conduct simultaneously. This short-circuits the power supply and could destroy the amplifier.



The circuit shown, from *NASA Tech Brief*, limits current flow to a predetermined level and is designed so that excessive current flowing in one half of the push-pull amplifier turns off the other half.

A signal applied to the base of Q1 is amplified and appears at points A and B. (Disregard diodes D1 and D2 for a moment.) If Q2 and Q3 are operating in class AB or class B, the positive portion of the signal at A is amplified by Q2 (an npn transistor) and the negative portion of the signal at B is amplified by Q3 (pnp).

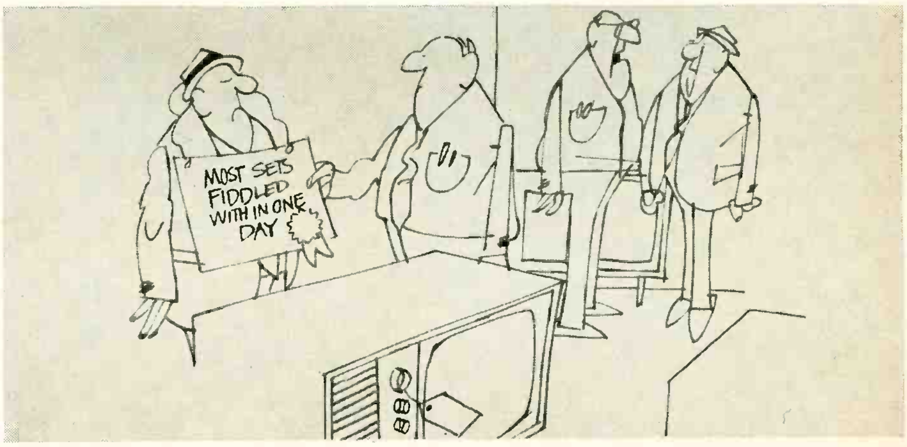
Similarly, the negative portion of the signal at A turns off Q2 and the positive portion at B turns off Q3. Thus, Q3 and Q4 conduct alternately to deliver a push-pull signal to the load.

Here is how the protective circuit works: Within the series circuit formed by R1, D2, D3, D4, D5 and the base-emitter circuit of Q2, all voltage drops (except that across R1) are determined by nonlinear elements (diodes). Also, the voltage drops across the emitter–base junction of Q2 and D2 are equal and can be disregarded. The remainder consists of equal and opposite voltage drops across D5, D4 and D3 and R1. Thus, the instantaneous voltage across R1 cannot be greater than the drop across the three diodes.

If the voltage drop across R1 tends to exceed the voltage across the diodes, this reduces the bias on Q2 and begins to turn it off. This means that if excess current through R1 causes the voltage drop across it to exceed the sum of the three diode voltages, the circuit starts current limiting. The limiting level is determined by the size of R1.

If Q2 tends to draw excess current, D2 turns on and the voltage drop across it—applied to the emitter–base junction of Q3—is of the polarity that turns off Q3. Conversely, if Q3 tends to draw excess current, the opposite action takes place in D1, causing Q2 to turn off. Thus, it is impossible for Q2 and Q3 to conduct simultaneously and short-circuit the power supply.

(Copies of the original bulletin—*NASA Tech Brief No. 67-10300*—are 15¢ each from Clearinghouse for Federal Scientific and Technical Information, Springfield, Va. 22151). **R-E**

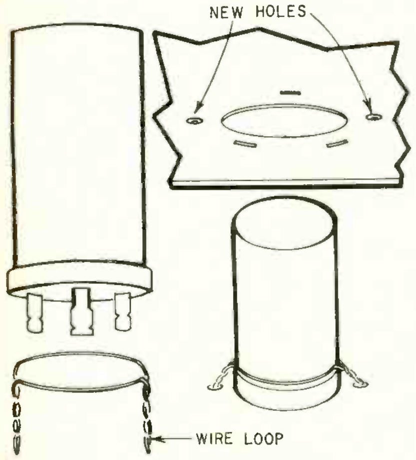


". . . We think certain customers deserve special recognition . . ."

TRY THIS ONE

ELECTROLYTIC MOUNTING KINK

Can-type electrolytic capacitors with broken mounting lugs can be held tightly in place with a simple wire mounting fixture. Loop a doubled piece of No. 18 tinned wire around the can.



Use pliers to twist both ends into pigtails, clamping the loop tight on the can. Bend the tails down and push them through two new mounting holes drilled in the chassis. Bend the pigtails flat against the chassis and solder in place.—*Peter Legon*

SILLY PUTTY IS HANDY TOOL

Bouncing putty, a silicone compound best known as a child's toy, makes a versatile helper around the shop. It is adhesive but not messy, doesn't dry out and has excellent high-temperature qualities, making it ideal as a third hand for soldering small parts. As an insulator, it can be used to temporarily protect the ends of cut wires carrying a voltage, or to give added insulation to coils. A blob of it, wrapped around the tip of a screwdriver, holds screws when starting them in those hard-to-reach places.

The putty is noncorrosive, too, making it handy to connect leads to mercury cells without soldering. This material, available in dime stores, has many other uses as well. Try it sometime.
—*Albert Koehler* **R-E**

SURVEY FINDS LITTLE TV RADIATION. Following a recent Public Health Service Survey of color TV sets in the Washington, D.C., area, health officials concluded the industry is capable of producing sets that operate "well within" established safety limits (not exceeding 0.5 mR/hr 5 cm from the receiver). Of 1124 sets tested, 268 had "detectable" radiation. Only 66 sets exceeded safety limits, and 16 of these were operating at 29,000 volts or more. Dr. William H. Stewart, Surgeon General for the Service, said the potential for biological damage was quite low. He recommended that sets be serviced only by authorized personnel. R-E

MARKET CENTER

ROTRON 100 CFM FANS

	Each
Sentinal—4 11/16 sq x 1½ D, 115 V, 60 cy. ..	$7 95
Sentinal—4 11/16 sq x 1½ D, 220 V, 60 cy. ..	9.95
Gold Seal—4 11/16 sq x 1½ D, 115 V, 60 cy. .	6.95

4 Pole Single Throw Contactor—115 V 60 cy 15 Amps MFG AH & H, ROWAN, etc. .... $9.95 each

All in fine condition. working, removed from equipment. Ship post paid anywhere Continental United States.

Leeds Radio, 57RE Warren St., N.Y.C., N.Y. 10007

RECHARGEABLE EVEREADY NI-CAD BATTERIES

9 v.d.c., 500 ma. hr. (7 dry button cells) size 2¾" long x 1⅝" dia., suitable for portable phonos, radios, test bench, labs. $15.00 value ...... $5.95 ea

One charger free with purchase of ten batteries.

Battery charger for the above or similar battery $3.95

Small DC Motor, Swiss precision made. operates on 3-4 v.d.c. suitable for models, battery phono, etc. $1.25

Same motor as above with gear chain, high torque. 4-5 rpm suitable for display, etc. $1.95

Sennheiser Model 407hn. directional. dynamic microphone (West German Mfg.) high and low impedance. excellent quality for voice and music. Limited quantity. $9.95

All merchandise is brand new and sold on a money back basis if not satisfied.

PEAK ELECTRONICS CO.
66 W. Broadway, New York, N.Y. 212-962-2370

"ARCTURUS" SALE

• Tube bargains, to name just a few:

#6146	$2.95	#5725/6AS6 79¢; 3 for	$2.00	#6AQ5	61¢
#6360..	3.50	#5842/417A......	2.50	#6BQ7	94¢
#6688..	3.50	#5847/404A......	2.50	#6CG7	59¢
#6939..	3.50	#1AX2 49¢; 5 for	2.00	#6J6...	49¢
#7025..	.59	#6K7.. 39¢; 3 for	1.00	#6T8...	88¢
#7788..	3.75	#12BN6 59¢; 3 for	1.49	#6U8...	78¢
#2D21..	.49	#25L6 59¢; 3 for	1.49	#12AU7	59¢

• Tube cartons: 6AU6 etc. size. $1.95 per 100. 6SN7 etc. size, $2.35 per 100. 5U4GB size, $2.75 per 100. 5U4G size, .03¢ each.

• Obsolete tubes: #UX200, $1.69; #80, $1.20; #10Y, 69¢

• 7 inch 90 degree TV bench test picture tube with adapter. No ion trap needed. Cat. #7BP7, $7.99.

• Silicon rectifier octal-based long-range replacement for 5U4, 5Y3, 5AS4, 5AW4, 5T4, 5V4, 5Z4. With diagram. Cat. # Rect 1, 99¢ each.

• Silicon rectifier replacement, octal based, for OZ4. Cat. # Rect 2, 99¢ each.

• 10 silicon rectifiers. 750 MA., 50 to 300 p.i.v. Cat. # 330F, 99¢ each.

• RCA-110 degree flyback transformer, latest type. Produces 10 KV. Includes schematic diagram application for any TV. Cat. # BR-1 $2.99.

• 5 transistor circuit boards containing up to 6 transistors. plus diodes, resistors, capacitors, etc. Cat. # TB10, 99¢

• Needles: values such as # AS22 sapphire, 39¢; diamond, 99¢

• Color yokes. 70 degree for all around color CRT's. Cat. # XRC70, $12.95. 90 degree for all rectangular 19 to 25 inch color CRT's, Cat. # XRC90, $12.95.

• Transistorized U.H.F. tuners used in 1965 to 1967 TV sets made by Admiral, RCA, Motorola, etc. Removable gearing may vary from one make to another. Need only 12 volts d.c. to function. No filament voltage needed. Easy replacement units. Cat. # U.H.F. 567, $4.95

• Flyback transformer in original carton. Made by Merit or Todd. Most with schematic drawing of unit. Please do not request specific type. Cat. # 506, 99¢ each.

• Kit of 30 tested germanium diodes. Cat. # 100, 99¢.

Send for our free catalog listing thousands of similar best buys in tubes, parts, kits, transistors, rectifiers, etc. Orders under $5.00, add 50¢ handling charge. Include 4% of dollar value of order for postage. Canadian postage $1.00 extra

ARCTURUS ELECTRONICS CORP.
502-22nd St., Union City, N.J. 07087 Dept. MRE
Phone: 201-UN 4-5568

Circle 133 on reader's service card

GENERAL

CONVERT ANY TELEVISION to sensitive Big-Screen Oscilloscope. Only minor changes required. No electronic experience necessary. Illustrated plans $2.00. **RELCO**-A25, Box 10563, Houston 18, Texas

FREE ELECTRONICS (new and surplus) Parts catalog. We repair multimeters. **BIGELOW ELECTRONICS**, Bluffton, Ohio 45817

BACK-ISSUES. Electronic, Scientific Magazines. **SEMCO**, Box 130, Roxboro, Quebec, Canada

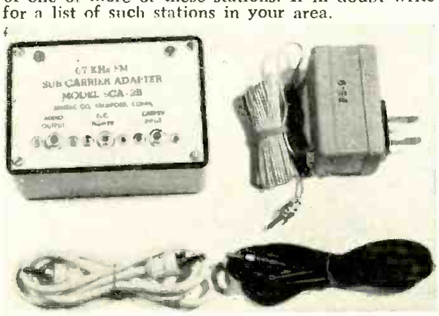
MONEY—SPARE TIME OPPORTUNITY—WE PAY CASH FOR NOTHING but your opinions, written from home, about samples of our clients' products. Nothing to sell, canvass or learn. NO SKILLS. NO EXPERIENCE. Just honesty. Details from: **RESEARCH** 669, Mineola, N. Y. 11501, Dept. LN-21

MAGNETS. All types. Specials-20 disc magnets, or 2 stick magnets, or 10 small bar magnets, or 8 assorted magnets, $1.00. **MARYLAND MAGNET COMPANY,** 5412-G Gist, Baltimore, Maryland 21215.

ACOUSTICS for the SOUND CONTRACTOR by Victor Brociner. Easy reading—breezy learning. Leads the way to profitable professionalism in the handling/installing of sound distribution/reinforcement systems. Fully illustrated. Hard cover edition $5.00 postpaid-cash or check with order. to **SOUND PUBLISHING CO.,** 150 E. 37th St., NYC 10016.

LIKE MUSIC WITHOUT COMMERCIALS?

The SCA-2B Sub-Carrier Adapter makes it possible for you to enjoy the background music transmitted on a 67KHz sub-carrier on many FM stations. (These programs cannot be heard on a FM set without an adapter) In the US there are approximately 400 FM stations authorized by the FCC to transmit the 67KHz programs. If you are within 50 miles of a city of 100,000 or more, it is probable that you are within the satisfactory reception range of one or more of these stations. If in doubt write for a list of such stations in your area.



Patent Pending

Sub-Carrier Adapter, Model SCA-2B with two 36" shielded cables. Price $39.95.
117 Volt AC Operated Power Supply, PS-9, Price $4.95.

SCA-2B FEATURES

SIZE: 4" x 2⅞" x 1⅝". • Simple plug-in connections to your FM tuner/amplifier. (If your FM tuner does not have a multiplex output jack, we supply hook-up information). • No installation adjustments • All silicon transistors • Operates from our PS-9 Power Supply or 6 to 12 volts D.C.

One Year Factory Guarantee

For Custom Installations: Completely Wired SCA-2 PC card (size: 2½" x 3" x ¾") with installation instructions for $34.95.

Write for Dealer Quantity Discounts.

Also available in a General Electric Model T1220B table radio. This is a 6 tube, 3 transistor, AM/FM radio with a four-inch speaker for $59.95.

Send order to **KENZAC Co.**
P.O. Box 66251, Houston, Texas 77006

Circle 134 on reader's service card

ADVERTISING INDEX

RADIO-ELECTRONICS does not assume responsibility for any errors which may appear in the index below.

WANTED

ELECTRONICS

AUDIO — HI-FI

 Circle 136 on reader's service card

Circle 137 on reader's service card

MARKET CENTER

TAPEMATES makes available to you ALL 4-TRACK STEREO TAPES—ALL LABELS—postpaid to your door—at tremendous savings. For free brochure write **TAPEMATES CLUB,** 5727 W. Jefferson Blvd., Los Angeles, Calif. 90016.

DISPOSAL—$80,000.00 hi-fidelity retail store inventory. New/used equipment; Ampex, Marantz, Fisher, others. Hewlett Packard test equipment. Free list—**MARCO ELECTRONICS,** Box 336 E, Winter Park, Fla., 32789

SPEAKER REPAIR. Hi-Fi, guitar, organ speakers reconed good as new at fraction of new speaker price. For details and Reconing Center in your area write **WALDOM ELECTRONICS, INC.** 9155-4, Dept, RE 4625 W. 53rd St., Chicago, Ill. 60632

Solid-State 50 Watt RMS Plug-in D.C. thru 25KC operational power AMPLIFIER KIT. Model 440K, $30.00 **OPAMP LABS.,** 172 So. Alta Vista Blvd., Los Angeles, California 90036

THE TAPE LIBRARY-Postage Paid rentals—CATALOG—SCOTCH TAPE—Discounted. Box 8146—DC 20024

INVENTIONS & PATENTS

MANUFACTURERS NEED NEW ITEMS! B. F. Goodrich, Black & Decker, South Bend Tackle and other million dollar corporations have authorized us to locate new products. For details regarding development, sale, licensing of your patented/unpatented invention, write: **THE RAYMOND LEE ORGANIZATION,** 230-U Park Avenue, New York City 10017

BUSINESS AIDS

1,000 Business Cards, "Raised Letters" $3.95 postpaid. Samples. **ROUTH,** 5717 Friendswood, Greensboro. N. C. 27409

TWO-WAY RADIO SERVICE INVOICE FORMS—Detailed. Free Sample Form No. 50 and Catalog. **OELRICH PUBLICATIONS,** 6554 W. Higgins, Chicago, Ill. 60656

Attention: TV Service Dealers. HIGHLY DETAILED TV SERVICE ORDER FORM STOPS PRICE COMPLAINTS BEFORE THEY START. FREE CATALOG AND SAMPLE NO. 206. **OELRICH PUBLICATIONS,** 6554 W. Higgins, Chicago, Ill. 60656

EDUCATION/ INSTRUCTION

LEARN TECHNICAL WRITING—at home. High paying prestige careers not requiring college. Growing demand, all industries for tech writers now. Low monthly tuition. Easy to understand. FREE career book, sample lesson. APPROVED FOR VETERANS. **AMERICAN TECHNICAL WRITING SCHOOLS,** Dept. REC-28, 5512 Hollywood Blvd., Hollywood, Calif. 90028

LEARN ELECTRONIC ORGAN SERVICING. New home study course covering all makes electronic organ including transistors. Experimental kits—schematics—trouble-shooting. Accredited NHSC-GI Approved. Write for free booklet. **NILES BRYANT SCHOOL,** 3631 Stockton Blvd., Dept. F, Sacramento 20, Calif.

HIGHLY EFFECTIVE HOME STUDY REVIEW for FCC commercial phone exams. Free literature. **COOK'S SCHOOL OF ELECTRONICS,** P.O. Box 36185, Houston, Texas 77036

FCC First Class License in six weeks—nation's highest success rate—approved for Veterans Training. Write **ELKINS INSTITUTE,** 2603E Inwood Road, Dallas, Texas 75235

WATCH REPAIRING. Learn to repair American and Swiss watches in spare time at home. Tuition $5 monthly. Diploma awarded. Free sample lesson. No obligation. **CHICAGO SCHOOL,** Dept. RER, Fox River Grove, Illinois 60021

B. SC. ENGINEERING MANAGEMENT—Correspondence Course Prospectus $1. **CANADIAN INSTITUTE OF SCIENCE & TECHNOLOGY,** 263 Adelaide St. W., Toronto.

GOVERNMENT SURPLUS

72 page illustrated Government Surplus Radio, Gadgeteers Catalog 25¢. **MESHNA,** Nahant, Mass. 01908

CLASSIFIED COMMECIAL RATE (for firms or individuals offering commercial products or services): 60¢ per word . . . minimum 10 words.
NON-COMMERCIAL RATE (for individuals who want to buy or sell personal items) 30¢ per word . . . no minimum.
Payment must accompany all ads except those placed by accredited advertising agencies. 10% discount on 12 consecutive insertions, if paid in advance. Misleading or objectionable ads not accepted. Copy for July issue must reach us before May 10th.
WORD COUNT: Include name and address. Name of city (Des Moines) or state (New York) counts as one word each. Zone or Zip Code numbers not counted. (We reserve the right to omit Zip Code if space does not permit.) Count each abbreviation, initial, single figure or group of figures or letters as a word. Symbols or groups such as 8-10, COD, AC, etc., count as one word. Hyphenated words count as two words. Minor over-wordage will be edited to match advance payment.

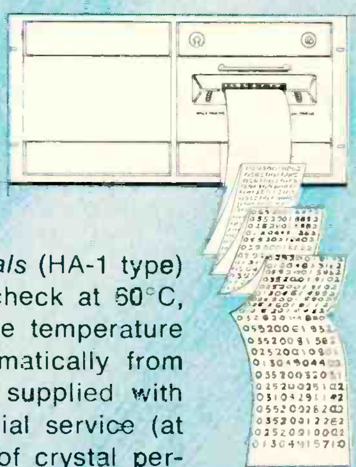
Circle 139 on reader's service card

NOW . . . AUTOMATIC

TEMPERATURE CERTIFICATION

FOR INTERNATIONAL

HIGH ACCURACY CRYSTALS



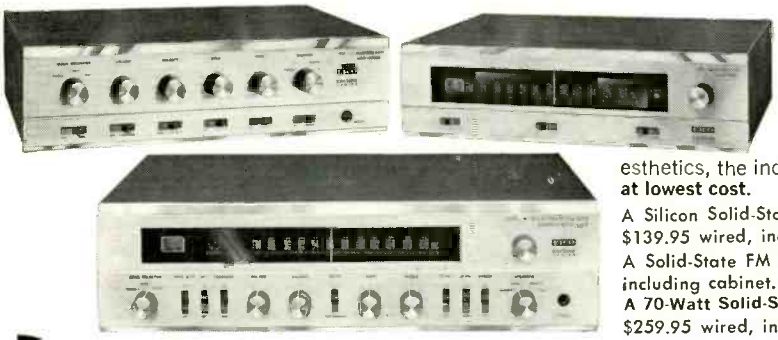
International High Accuracy Crystals (HA-1 type) receive a five-point temperature check at 60°C, 25°C, 0°C, –10°C and –30°C. The temperature vs frequency test, recorded automatically from an electronic readout printer, is supplied with each individual crystal. This special service (at no extra cost) is your assurance of crystal performance at tested temperatures. We will furnish additional temperature readings (on request) for a nominal charge. *Note: Our calibration service is available to customers desiring temperature run on other crystal types and oscillators.*

INTERNATIONAL CRYSTAL MFG. CO., INC.
10 N. LEE • OKLAHOMA CITY, OKLAHOMA 73102

Circle 149 on reader's service card

EICO Makes It Possible

Uncompromising engineering—for value does it!
You save up to 50% with Eico Kits and Wired Equipment.



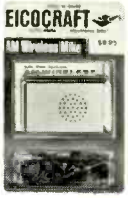
Cortina Stereo

Engineering excellence, 100% capability, striking esthetics, the industry's only **TOTAL PERFORMANCE STEREO at lowest cost.**

A Silicon Solid-State 70 Watt Stereo Amplifier for $99.95 kit, $139.95 wired, including cabinet. Cortina 3070.
A Solid-State FM Stereo Tuner for $99.95 kit, $139.95 wired, including cabinet. Cortina 3200.
A 70-Watt Solid-State FM Stereo Receiver for $169.95 $259.95 wired, including cabinet. Cortina 3570.

Eicocraft

The newest excitement in kits.
100% solid-state and *professional.*
Fun to build and use. Expandable, interconnectable. Great as "jiffy" projects and as introductions to electronics. No technical experience needed. Finest parts, pre-drilled etched printed circuit boards, step-by-step instructions.

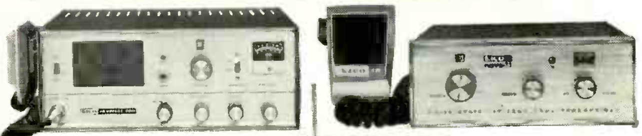


Electronic Siren $4.95, Burglar Alarm $6.95, Fire Alarm $6.95, Intercom $3.95, Audio Power Amplifier $4.95, Metronome $3.95, Tremolo $8.95, Light Flasher $3.95, Electronic "Mystifier" $4.95, Photo Cell Nite Lite $4.95, Power Supply $7.95, Code Oscillator $2.50, FM Wireless Mike $9.95, AM Wireless Mike $9.95, Electronic VOX $7.95, FM Radio $9.95, AM Radio $7.95, Electronic Bongos $7.95.

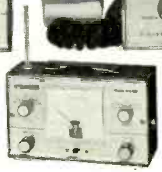
Citizen's Band

Two years ahead! Model 7923
All Solid-State 23-Channel 5W Transceiver. 4 exclusives: dual-crystal lattice filter for razor-sharp selectivity; efficient up-converter frequency synthesizer for advanced stability; precision series-mode fundamental crystals; Small: only 3"H, 8"W, 8¼"D. $189.95 wired only.

The best buy in tube-type CB—"Sentinel-Pro" 23-channel dual conversion 5W Transceiver $169.95 wired only.



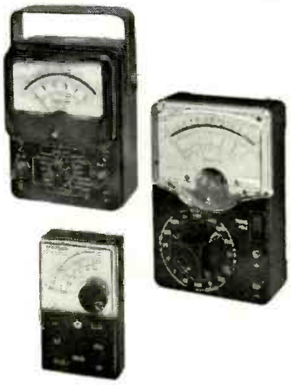
EICO Trans/Match (Model 715) is a professional test set designed for complete checking of ham and CB equipment. Kit $34.95; Wired $49.95.



Truvohm

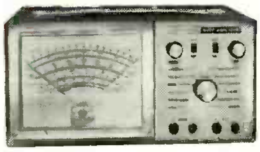
Professional Portable Multimeters by EICO.
The industry's *greatest* V-O-M values. Designed, made to Eico's high standards of professionalism. Each *complete* with batteries & test leads. Backed 100% by famous EICO warranty.

Model 100A4, 100,000Ω/V, $34.95.
Model 30A4, 30,000Ω/V, $19.95.
Model 30A3, 30,000Ω/V, $15.95.
Model 20A3, 20,000Ω/V, $12.95.
Model 4A3, 4000Ω/V, $9.95.
Model 1A1, 1000Ω/V, $5.95.



Automotive

EICO 888—Car/Boat Engine Analyzer.
For all 6V/12V systems; 4, 6, 8-cyl. engines.



Now you can keep your car or boat engine in tip-top shape with this solid-state, portable, self-powered universal engine analyzer. Completely tests your *total* ignition/electrical system.

Complete with a Tune-up & Trouble-shooting Manual. Model 888; $44.95 kit, $69.95 wired.

Test Equipment EICO®

100 best buys to choose from.

"The Professionals"
—laboratory precision at lowest cost.
Model 460 Wideband Direct-Coupled 5" Oscilloscope. DC-4.5mc for color and B&W TV service and lab use. Push-pull DC vertical amp., bal. or unbal. input. Automatic sync limiter and amp. $109.95 kit, $149.95 wired.

Model 232 Peak-to-Peak VTVM. A must for color or B&W TV and industrial use. 7 non-skip ranges on all 4 functions. With exclusive Uni-Probe.® $29.95 kit, $49.95 wired.

FREE 1968 CATALOG RE-5
EICO Electronic Instrument Co., Inc.
283 Malta Street, Brooklyn, N.Y. 11207
☐ Send me **FREE** catalog describing the full EICO line of 200 best buys, and name of nearest dealer.

Name__________
Address__________
City__________
State__________ Zip__________

Circle 150 on reader's service card

Customer satisfaction . . . and consequently your service reputation . . . can very often depend on the quality of the replacement parts you use. When it comes to replacement picture tubes, you can depend on an RCA HI-LITE for picture brightness and color fidelity at its finest. Install them and you literally "up-date" your customer's set with the same quality . . . the same tubes . . . that go into today's original equipment sets.

Enjoy the confidence of offering the finest. Rely on RCA picture tubes to protect your service reputation. They are designed to protect the biggest reputation in the Color TV industry.

RCA