Boost car gage accuracy in 20 minutes

60c ■ AUG. 1969

Radio-Electronics

In These Headphones—FM Stereo Receiver

(see page 43)

BUILD—

0-200 MHz frequency counter with IC's

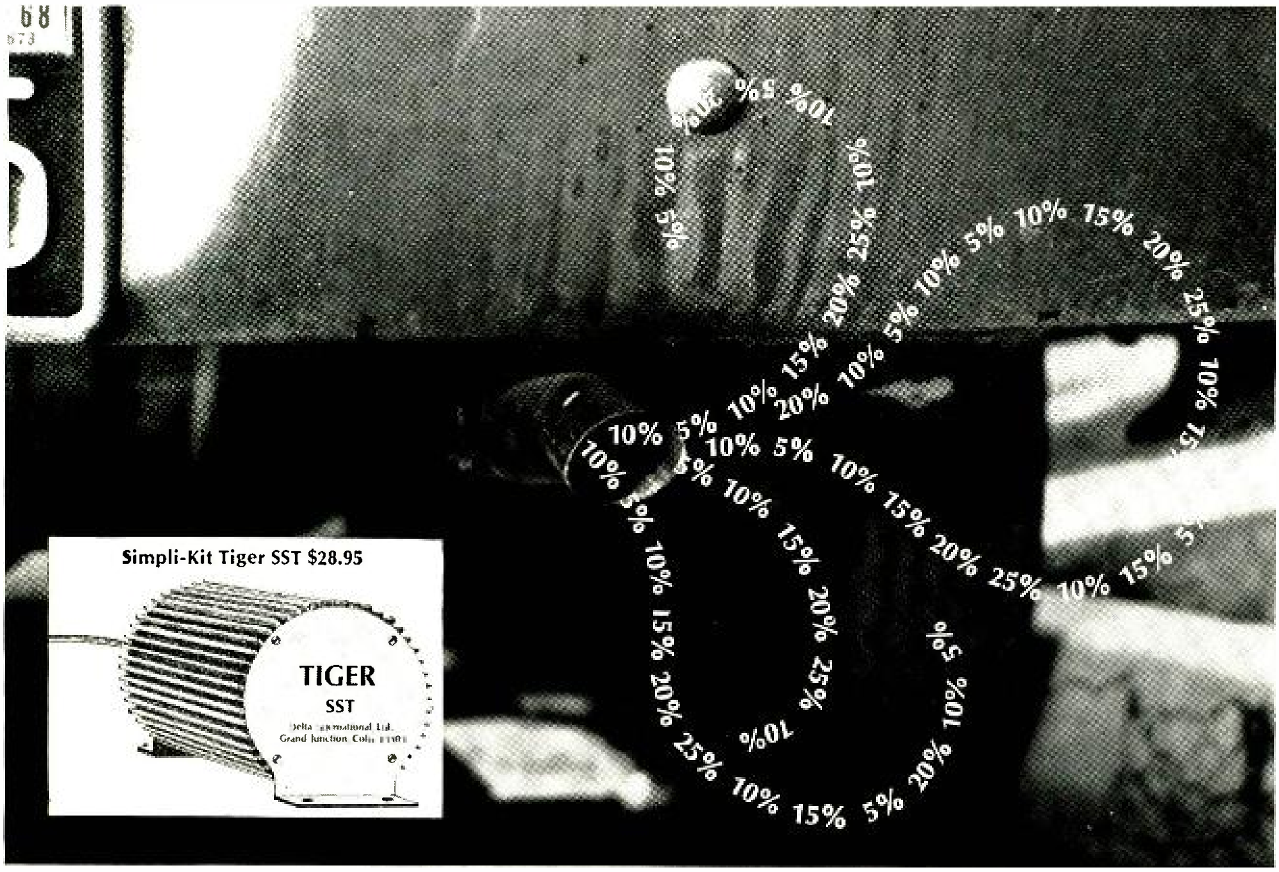
PROGRAMMED—

How to use triggered scopes

EXPERIMENT—

Digital readouts how they work

A GERNSBACK PUBLICATION



Capture that top 10% (at least) engine performance you're now blowing out the exhaust!

Announcing a new generation C. D. Ignition System—the Tiger SST.

Here, in a compact new unit, are all of the advantages of previous capacitive discharge systems that have been chalking up such impressive performance records the past several years—plus a good deal more. The dramatic results:

- gas mileage is increased up to 25%
- points and spark plugs last up to 5 times longer
- you go up to 5 times longer between tune-ups

The added performance your engine delivers with the Tiger SST is the fun part. You'll enjoy sharper acceleration to higher speeds—a smoother running engine at **all** speeds. And your engine will last longer.

Our new Tiger C. D. System is compatible with all domestic and foreign cars and trucks with 12 volt, negative ground systems. In Simpli-Kit form, the unit is easy to assemble and install in less than 60 minutes—no special skills or tools required. The unit is moisture proof and is not affected by underhood temperatures.

Order your Tiger SST today. It's the latest, most advanced C. D. System available. And, if you do an average amount of driving, it should pay for itself in less than two months. You'll be satisfied. Guaranteed. Money back.

Dealer/Distributor inquiries invited.

Special free offer!
Order now and receive a convenient to have, ruggedly built rechargeable flashlight **free.** It's a $4.95 value that can put an end to the annoyance of dead batteries. Your order must be received within 30 days from date of this publication.

Delta International, Ltd.
Box 1946C, Grand Junction, Colo. 81501

Enclosed is my check (or money order) for $________

Please send prepaid:

- ☐ **Simpli-Kit Tiger SST @ $28.95**
- ☐ Assembled Tiger SST unit @ $39.95

Make of car: __________ Year: ______

Name: __________

Address: __________

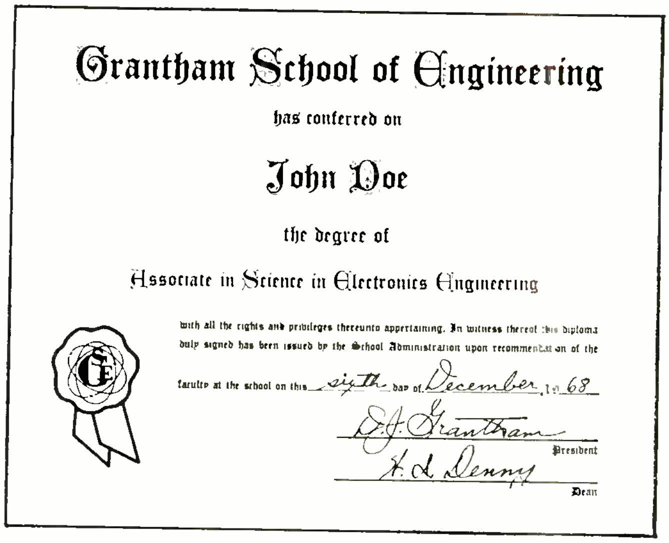
City/State: __________ Zip: ______

Circle 8 on reader service card

from Technician to ENGINEER

Advance beyond the technician level

Become an electronics engineer


Grantham School of Engineering
has conferred on
John Doe
the degree of
Associate in Science in Electronics Engineering
with all the rights and privileges thereunto appertaining. In witness thereof this diploma duly signed has been issued by the School Administration upon recommendation of the faculty at the school on this sixth day of December 19 68
E. J. Grantham President
H. L. Denny Dean

In the Grantham electronics engineering program, you can earn the Degree of *Associate in Science in Electronics Engineering* (the ASEE) mostly by home study – and can continue in resident classes to earn your BSEE. In this program you can acquire an extensive knowledge of engineering, for greater prestige and better pay.

In America's race to the moon and outer space, *more and more* engineers are needed. By becoming an electronics engineer, you can move into the forefront of technology and engineering, and be an important part of this exciting age. You can help make things happen and be properly rewarded for doing so.

The demand for engineers continues to increase; electronics engineers are needed in the space program and in many other military and domestic projects. In a recent survey conducted by the Engineering Manpower Commission of the Engineers Joint Council, it was found that engineering employment in the electrical and electronics industries is expected to increase by 40% in ten years. The need for engineers is increasing faster than the population as a whole. The survey report indicates that in the next decade, employers expect to need almost *twice as many* new engineering graduates as are likely to be available.

If you have the desire to be an engineer, the determination to stick to your objective, and a reasonably good aptitude for mathematics and technology, the Grantham educational program can produce the wanted results for you. But make no mistake about it, to become an electronics engineer requires work. You must be willing to do that work; otherwise you can never reach your objective, regardless of what course of instruction you may choose.

The Grantham *home study program* in electronics engineering consists of five "correspondence semesters" made up of a total of 370 lessons, followed by a two-week period of review and examination at the School. The prerequisite for enrollment in this program is high school graduation (or equivalent) and at least one year of experience as an electronics technician.

This *accredited* ASEE Degree program covers a review of basic electronic circuits and systems, applied engineering mathematics (including algebra, trigonometry, and calculus), classical and modern physics, technical writing, computer systems, electrical networks, and semiconductor circuit analysis and design. The ASEE Degree is awarded upon satisfactory completion of the 370 correspondence lessons and the final two-week residency at the School.

The Grantham educational program in electronics places heavy stress on fundamental concepts of logic and mathematics rather than on superficial manipulative skills. Since these fundamental ideas are largely unfamiliar to many electronics technicians, it is necessary to develop them in a systematic manner.

Accreditation and G.I. Bill Approval

Grantham School of Engineering is *accredited* by the Accrediting Commission of the National Home Study Council, *is approved* under the G.I. Bill, and *is authorized* under the laws of the State of California to grant academic degrees.

Grantham School of Engineering

Specializing in Electronics since 1951

ACCREDITED SCHOOL · NATIONAL HOME STUDY COUNCIL · NHSC

1505 N. Western Ave.
Hollywood, Calif. 90027

Telephone:
(213) 469-7878

Grantham School of Engineering RE-8-69
1505 N. Western Ave., Hollywood, Calif. 90027

Please mail your free Bulletin, which explains how the Grantham educational program can prepare me for my Associate in Science Degree in Electronics Engineering.

Name ______________________ Age ______

Address ______________________

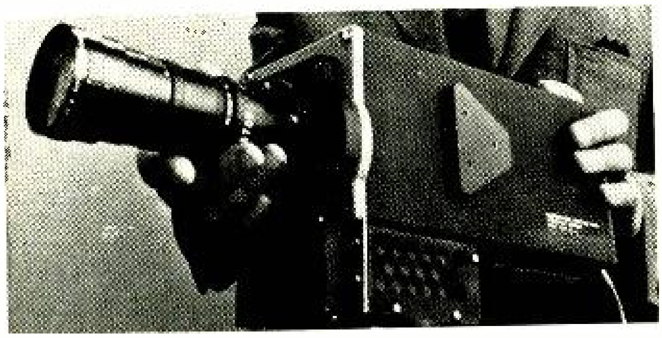
City ____________ State ______ Zip ______

Circle 9 on reader service card

NEW & TIMELY

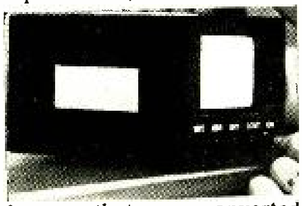
Volume 40 Number 8 RADIO-ELECTRONICS August 1969

APOLLO TV USES SEC TUBE



BALTIMORE—The 15-lb color TV camera used aboard Apollo flights 10 and 11 is almost identical to the unit being adjusted here by a Westinghouse project engineer. Also shown is the 2¾-inch b-w TV monitor used by the astronauts to see what scene was transmitted to earth.

The camera uses the field sequential system (New & Timely, July) in which a rotating color wheel passing in front of the CRT provides separate red, blue and green



images that are converted to a single color image on earth.

An important part to the color camera is a SEC (secondary electron conduction) CRT tube that can pick up dimly illuminated scenes invisible to ordinary vidicor TV cameras.

The camera is about 17 inches long, including the 12.5–75-mm zoom lens. The aperture stop range is f2.2 to f22, and focus range is 20 inches to infinity.

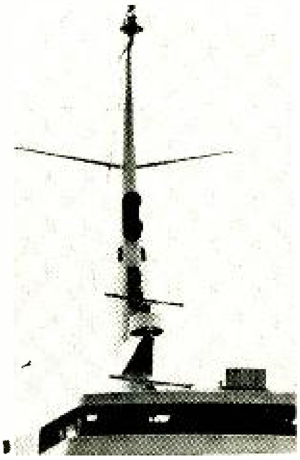
The color wheel just behind the lens spins at 600 rpm, and is divided into six sections. Conversion equipment on earth provides a 30-frame-per-second rate for the system.

VOICE PATTERNS DETECT POSSIBLE HEART ATTACKS

SAN FRANCISCO—Cardiologists at a medical center here have devised a technique for spotting potential victims of heart attacks by recording acoustic voice patterns.

Subjects were asked to read a brief statement designed to stir up their emotions while their voice was recorded on a converted electrocardiogram machine. Individuals with "explosive vocal intonations" showed an 84% correlation with a personality pattern in men suspected of being highly prone to heart attacks. The voice analysis technique is able to spot 75% of those who have already had heart trouble.

QUEEN ELIZABETH 2 GUIDED BY SATELLITE



NEW YORK—The Queen Elizabeth 2 arrived here May 7, guided on her first voyage to the U.S. by a satellite. A small antenna atop the foremast of the liner picks up signals from a Navy navigation satellite, pinpointing the location of the vessel within 1/10 mile. The shipboard communication system was installed by ITT and some of its British subsidiaries.

LOOKING AHEAD

By **DAVID LACHENBRUCH**
CONTRIBUTING EDITOR

1970 TV set preview

More small-screen color portables, particularly in the 11- and 12-inch size . . . more automatic color circuitry . . . the first electronically-tuned sets for the North American market . . . easier servicing. These appear to be some of the major trends in the 1970 television sets, for introduction to the public this fall.

Brightness derby resumes

Another trend is a new lap in the race for brighter color tubes. At press time there were several new entries, and more were expected. The most intriguing is RCA's "Hi-Lite Matrix" tube, to appear in five solid-state 23-inch receivers this fall, and later to be offered to other manufacturers (See New & Timely).

Other new bright color tubes in use in 1970 models: A General Electric tube using the new rare-earth gadolinium phosphor (Looking Ahead, May 1969), and a tube by Philco-Ford, said to be 35% brighter than previous tubes, thanks to a new phosphor application method.

Easier tuning

More automatic color circuits and various tuning aids are also features on some new sets. Credited with the first North American introduction of all-electronic varactor-diode color TV tuning is Electrohome of Canada, whose sets are also sold in the U.S. Electrohome's ingenious tuning device is featured in two top-of-the-line 23-inch sets. The tuning panel consists of a series of 18 pushbuttons—for the 12 vhf channels and any six uhf channels. The pushbutton panel may be removed from the receiver (it's connected by a flat cable) for use as a remote tuner.

The first varactor-tuned black-and-white set on the U.S. market probably will be a 19-inch Panasonic receiver. It, too, is pushbutton tuned, by means of two buttons which sequentially stop at preselected channels.

Easier uhf tuning is getting more attention in the new sets. Several remote-control sets now can be tuned to all

(*continued on page 4*)

BLACK MATRIX TUBE INTRODUCED BY RCA

HARRISON, N.J.—Color TV is brighter than ever with RCA's new Hi-Lite Matrix picture tube. According to RCA, the new large-screen color tubes are twice as bright as the company's current tubes and six times brighter than large-screen tubes made about 10 years ago.

Key to the boosted brightness is a newly developed phosphor-dot screening

(continued on page 4)

Radio-Electronics

August 1969 • Over 60 Years of Electronics Publishing

BUILD ONE OF THESE

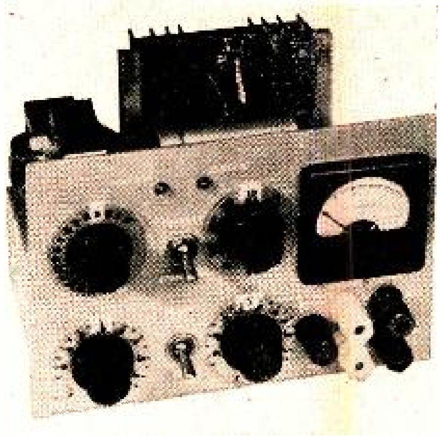
TELEVISION

AUDIO—HI-FI—STEREO

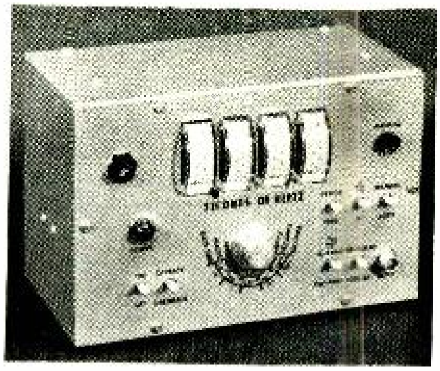
FOR THE EXPERIMENTER

GENERAL ELECTRONICS

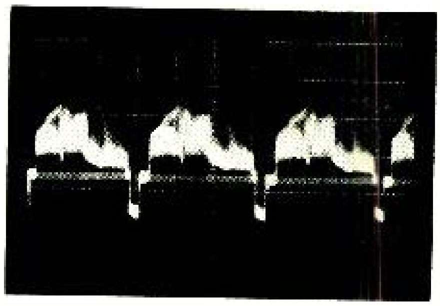
DEPARTMENTS



Lab-quality power supply is a must for the experimenter's bench. Precise regulation of voltage and current.
see page 49



IC Frequency Counter reads up to 200 MHz and can be calibrated to 0.05% accuracy.
see page 23



Trigger level controls for triggered scopes can be tricky. Where would you set the control to display this waveform?
see page 33

RADIO-ELECTRONICS, AUGUST 1969, Vol. 40, No. 8
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, 60¢.
POSTMASTER: Notices of undelivered copies (Form 3579) to Boulder, Colo. 80302.

Radio-Electronics is indexed in *Applied Science & Technology Index* (formerly *Industrial Arts Index*)

(continued from page 2)

process that deposits each one of the 1,267,650 red, green or blue phosphor dots within an opaque, black matrix.

The precision black matrix absorbs bright light shining on the face of the tube, and only a lightly tinted filter glass is used with the Matrix tube. This means the tube offers high picture contrast and clarity even in bright viewing conditions.

Coupled with the matrix screening process are new high-resolution electron guns that produce a focus spot smaller than do previous RCA guns.

The new tubes are electrically and mechanically interchangeable with the 25XP22. Limited quantities of the 23-inch diagonal tube are being made available to set manufacturers at $110 each.

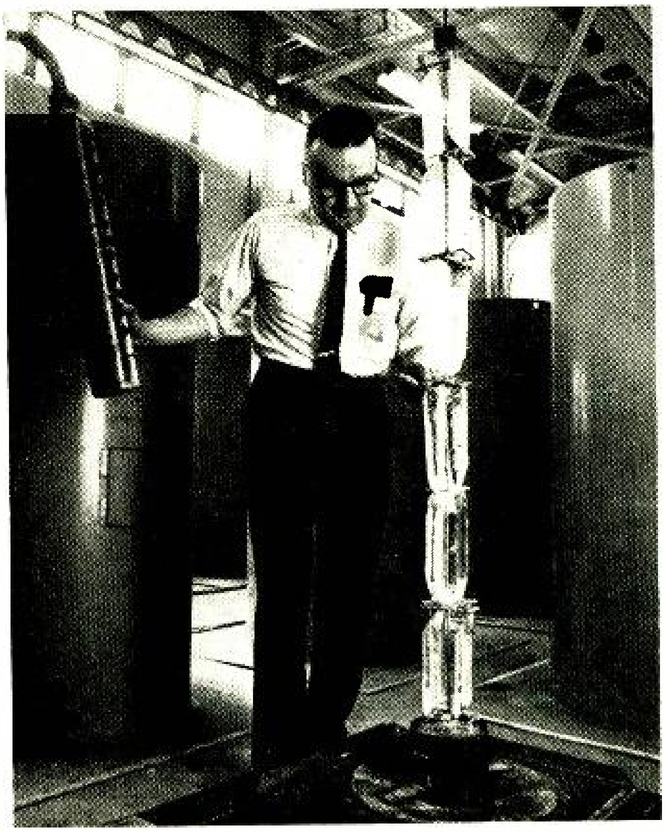
ANTENNA COMPLEX

A huge complex of antennas and transmitters is under construction in northern Wisconsin to link the US with its military forces throughout the world. Dubbed Project Sanguine by the Navy, the network could employ 250 powerful low-frequency transmitters tied to a 70 x 100-mile grid of antennas if completed in the 1970's.

Sanguine's top-priority coded messages would be beamed into the ionosphere and the earth's surface simultaneously. The ionosphere signal would encircle the earth, while the ground signal could penetrate the sea to reach submarines.

If approved by Congress, costs of the project could exceed $1 billion due to the expense of burying half the transmitters underground. Work on the first underground station may start next year.

R-FACE CRYSTALS GROWN



A rack of newly grown quartz crystals is removed from an autoclave where they have grown for 27 days at 750° F. A series of 27 of the 12-foot-long tanks is used at a Western Electric plant near Boston.

The new crystals are sliced into plates that can operate at 1 MHz. A different technique is used to produce the crystals, which results in an R-face (rhombohedral) structure. The R-face crystal can be used in communication applications to replace expensive natural crystals.

COMPUTER SYSTEMS PINPOINT COMPLAINTS TO POLICE AND HELP SHIPS AVOID NAVIGATIONAL SEA HAZARDS

Two new applications of computer technology will aid law enforcement and increase the safety of ships at sea.

In San Jose, Calif., a demonstration computer installed by Sylvania has been used to pinpoint instantly the location of telephone complaints to a police communication center and indicate the patrol unit assigned to that location.

The computer was programed with a number of geographic areas in the city and the patrols assigned to them. When a complaint address is received—whether by street, intersection or building—the location is typed into the computer while the caller is on the phone.

Within seconds, the computer verifies the address and indicates the "beat" number for the area. The system spots incorrect addresses given by callers and types out the right one. Most police departments now use a time-consuming index-card system for locating and verifying addresses.

Another computer system is being linked with ships to monitor onboard navigation equipment, unusual stresses and temperatures.

Ships subscribing to Satellite Navigation Corp.'s service are being equipped with computers and gauges that record all important instrument data. The on-board computer will be periodically interrogated by shore-based data acquisition centers via high-frequency radio or satellite signal. Each center will monitor up to 500 ships.

Operators at the centers, like air-traffic controllers, can then "steer" ships in congested areas or help them avoid storms. Computers at the centers will be programed with shipping routes, navigational hazards, tides, currents and updated weather data. Philco-Ford Corp. supplies gear for the system, which initially will be used along the North American coastline with direct ship-to-shore radio.

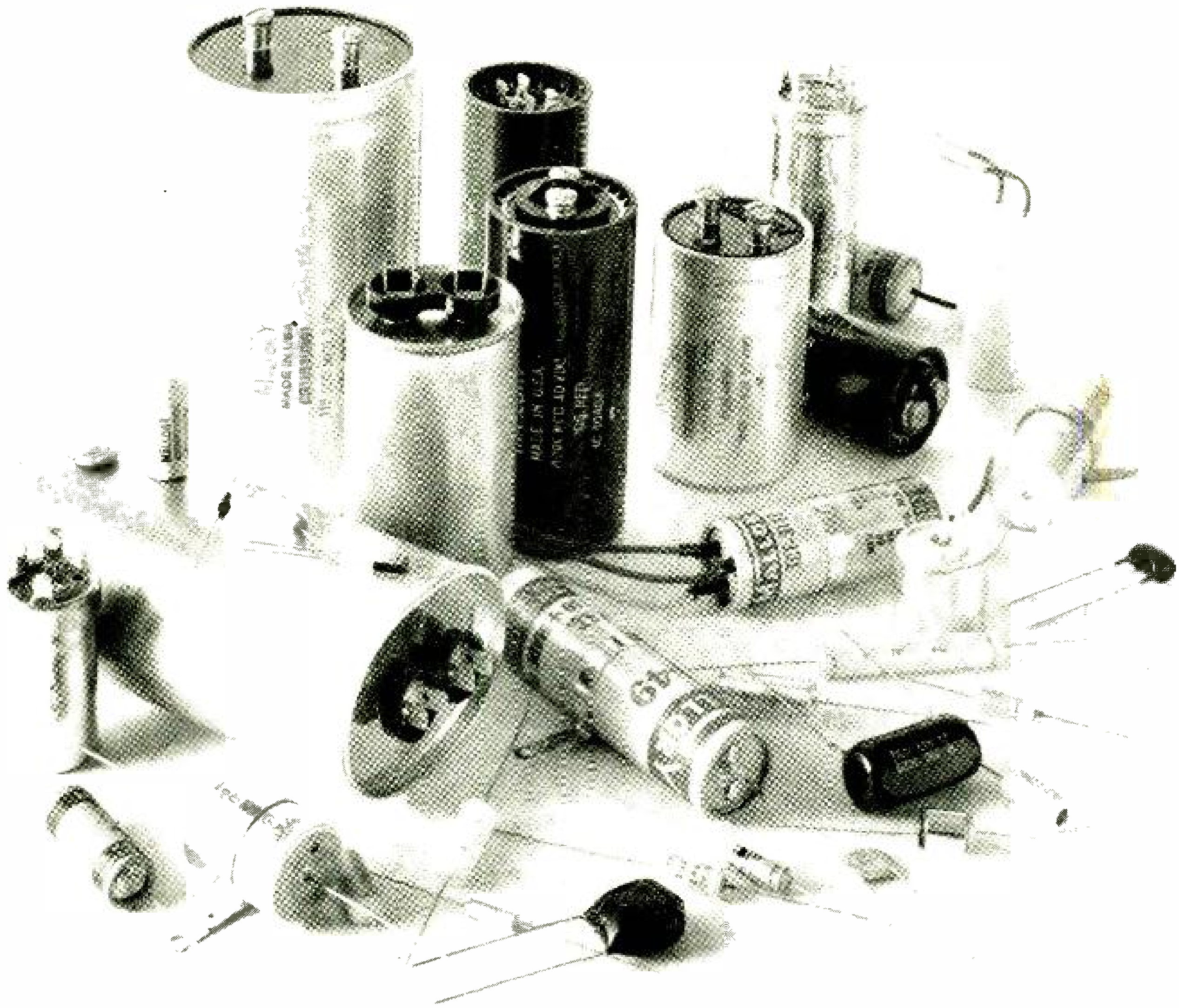
LOOKING AHEAD

(continued from page 2)

82 channels from chairside. Two of these use the signal-seeking method, employed for years in high-end car radios: the Magnavox system (introduced last year) and a new Sylvania version which can scan the uhf band in either direction with a single tuning button. (Touch it for a fraction of a second and it tunes toward the high end of the dial; hold it down a little longer and it scans downward.)

There will be at least two systems which require little, if any, adjustment of color and tint controls from program to program and channel to channel. Both of these operate by holding flesh tones to a pleasing level, despite changes in the incoming signal. Magnavox's "Total Automatic Color" was described last month. A Philco-Ford development, included in all of that company's 1970 color sets except its single 10-inch model, seems to use a similar principle. Called "Cosmetic Color," it involves modifications in the demodulation and matrixing circuits to convert certain pinkish, greenish and purplish tones to flesh colors.

(continued on page 12)



KEYBOARD THERAMIN

A keyboard version of the electronic theramin is being marketed by Scott Clavivox of Farmingdale, N.Y. The keyboard arrangement of the musical instrument solves the problem of playing the theramin in tune. The company anticipates use of the instrument on movie and TV sound stages, by rock groups and in electronic music studios.

TV AND 3-D PROJECTORS SHOWN

Two prototype devices for projecting three-dimensional movies and large-screen color TV were recently unveiled.

According to the developer of the color TV projection system, Advent Corp. (Cambridge, Mass.), a professional model of the device selling for under $5000 will be available within the year. The 3-D display system, using lasers and holographic film, is being studied by North American Philips for possible applications in entertainment—including 3-D TV.

Advent's color TV system can project a 4 x 6-foot display on a screen. Three 7-inch red, green and blue tubes provide a full-color image. A less expensive version of the system is being planned for the consumer market.

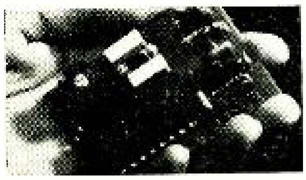
A laser–hologram projector recently demonstrated by Philips uses a 3-inch wide strip of film divided into holograms ½ inch apart. Unlike conventional movie projectors with shutters, the Philips machine moves the film continuously from frame to frame. When a laser beam passes through the holograms, the "information" is converted into and projected as a 3-D movie.

In addition to investigating TV applications for the system, Philips is perfecting a method of projecting images with ordinary light to eliminate the laser requirement.

30-WATT AMP WORKS WITHOUT A HEAT SINK

LONDON—An experimental 30-watt hi-fi power amplifier no larger than a cigarette pack was shown at a component electronics show recently. The small size is possible by using pulse width modulation (PWM) techniques that operate the power output transistors at efficiencies up to 95%, eliminating the need for heat sinks.

An audio input signal from a preamp (analog) is combined with a 2-MHz signal generated in a new PWM integrated circuit developed by Mullard Ltd. The audio signal, in the form of 2-MHz



digital pulses, can then be amplified to 4-amp peaks by fast-switching transistors. Because of the fast rise and fall times of the pulses, the output transistors convert only about 5% of the power supplied to heat. A low-frequency filter then removes the amplified audio, which is used to drive a loudspeaker.

With 30 dB of feedback, THD is 0.25%. Upper frequency response is limited to about 20 kHz.

Among other products introduced by Mullard were five IC's for TV, a variable-capacitance-diode TV tuner, and "push-through" picture tubes that can project beyond the front of the cabinet, exposing the entire CRT face.

BROADCASTERS AND CATV DRAFT TRANSMISSION PACT

WASHINGTON — CATV companies can provide subscribers with the three nearest networks and three independent stations if a draft proposal between the National Association of Broadcasters and the National Cable Television Association is okayed by Congress and the FCC. Acceptance of the proposal could provide most cities with a minimum of six channels. Under the arrangement, CATV would pay copyright fees on retransmitted programs, and also have a single channel for local broadcasting of sponsored entertainment.

(continued on page 12)

IN THIS ISSUE

Ever run out of gas when your dash gage read "¼"? It happens. But there's a simple conversion you can make that'll end the problem. Just a few solid-state components will do the job. Turn to page 38.

Radio-Electronics

HUGO GERNSBACK (1884-1967) founder

M. HARVEY GERNSBACK, *editor and publisher*

LARRY STECKLER, *managing editor*

Robert F. Scott, *W2PWG senior technical editor*

John R. Free, *associate editor*

Jack Darr, *service editor*

I. Queen, *editorial associate*

Matthew Mandl, *contributing editor*

David Lachenbruch, *contributing editor*

Carrie Ng, *editorial assistant*

Vincent P. Cicenia, *production manager*

Elizabeth Shincel, *production assistant*

G. Aliquo, *circulation manager*

Cover by Harry Schlack

RADIO-ELECTRONICS is published by Gernsback Publications, Inc.
200 Park Ave. South
New York, N.Y. 10003
(212) 777-6400

President: M. Harvey Gernsback
Vice President-Secretary: G. Aliquo

ADVERTISING REPRESENTATIVES

EAST
John J. Lamson, Eastern Sales Mgr.

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
RE 6534,5

SUBSCRIPTION SERVICE: Send all subscription orders and correspondence to RADIO-ELECTRONICS, Subscription Department, Boulder, Colo. 80302.

MOVING? For change of address, allow six weeks, furnishing both the old and new addresses and if possible attaching label from a recent issue below. Otherwise please print clearly your name and address exactly as it appears on your label.

ATTACH LABEL HERE

name (please print)

address

city state zip code

Mail to: RADIO-ELECTRONICS
SUBSCRIPTION DEPT., BOULDER, COLO. 80302

DELTA will tell you *everything!*—Complete Specs including schematics!

MARK TEN® SCR

CAPACITIVE DISCHARGE IGNITION SYSTEM

Now discover for yourself the dramatic improvement in performance of your car, camper, jeep, truck, boat — **any** vehicle! Delta's remarkable electronic achievement saves on gas, promotes better acceleration, gives **your** car that zip you've always wanted. Find out why even Detroit has finally come around. In five years of proven reliability, Delta's Mark Ten has set new records of ignition benefits. **No** re-wiring! Works on literally any type of gasoline engine.

- ▲ Dramatic Increase in Performance and in Fast Acceleration
- ▲ Promotes More Complete Combustion
- ▲ Points and Plugs Last 3 to 10 Times Longer
- ▲ Up to 20% Mileage Increase (saves gas)

KIT FORM $29.95 12V ONLY ASSEMBLED ONLY $44.95 ppd.

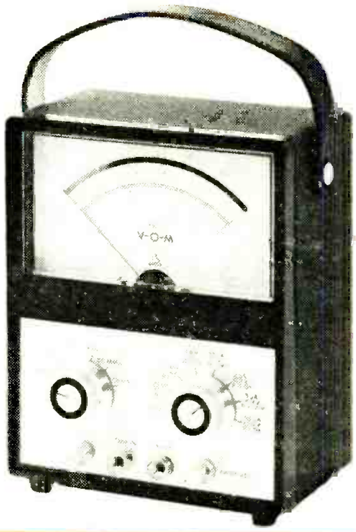
MODEL 3000 FET VOM

ONLY $74.95 ppd.

Delta now offers a compact, versatile, and extremely sensitive VOM which combines FETs and ICs for **extreme accuracy**. Compact (6½"W x 8"H x 3½"D), portable. Wt. 3¾ lbs.

IN KIT FORM: Feedback network with pre-selected components to eliminate all final calibration. **Ready to use when assembled!**

Only $59.95 ppd.



NEW DELTA FEATURES:

- ▲ Mirror scale 200 A D'Arsonval meter
- ▲ Integrated circuit (IC) operational amplifier for extreme accuracy
- ▲ FET input stage with current regulator
- ▲ Two stage transistor current regulator and Zener diode on OHMS for absolute stability and accuracy
- ▲ Voltage clippers for protection of input stage
- ▲ Fully temperature compensated for low low zero drift
- ▲ Ten turns ZERO and OHMS adjust potentiometers
- ▲ Epoxy glass circuit boards and metal case
- ▲ Enclosed switches
- ▲ Uses readily available type AA cells
- ▲ Uses standard test leads for maximum flexibility and ease of measurement
- ▲ 10 Megohms input impedance

COMPUTACH

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

- ▲ 0-8000 RPM range
- ▲ Perfect linearity — zero paralax
- ▲ Adjustable set pointer
- ▲ Wide angle needle sweep
- ▲ Translucent illuminated dial
- ▲ Chrome plated die-cast housing
- ▲ All-angle ball & socket mounting
- ▲ Use it with ANY ignition system
- ▲ Meter: 3⅛" dia. X 3⅜" deep
- ▲ Calibration kit included, no test eqpt. needed.

*An exclusive computer-tachometer for precise RPM measurement in easy-to-build Kit form!

$29.95 ppd.

KIT FORM ONLY

DELTA: Please send me literature immediately.
I am enclosing $________ for items checked.
☐ Mark Ten SCR (☐ Kit ☐ Assembled)
☐ Model 3000 FET VOM (☐ Kit ☐ Assembled)
☐ Computach (Kit only)
Please ship immediately.
Name________
Address________
City/State________ Zip____
*My car is (Model)________ (Year)____

Write today for complete literature packet

DP 9-8

DELTA PRODUCTS, INC.

P.O. BOX 1147 • GRAND JUNCTION, COLORADO 81501

Circle 11 on reader service card

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.

New & Timely

(continued from page 6)

STRONGEST MAGNET MADE

The latest claim to the strongest permanent magnet is being made by Raytheon. Using a blend of cobalt and the rare-earth element samarium, Dr. Dilip K. Das developed a material said to be four times as strong as most alnicos and twice as strong as platinum–cobalt magnets.

Initially, the magnets will be used in the company's microwave tubes, where they can replace up to four times their weight in previously used magnets.

The new material's energy product runs between 16 and 20 MGOe (million gauss-oersteds) compared to 3 for ferrites, 5 for common alnicos and 10 for platinum–cobalt. These merit figures include a magnetic substance's residual magnetism after a magnetizing field is removed, and its ability to resist demagnetization in an opposite-polarity field.

Dr. Das, framed by a metallurgical press, inspects a sample of the new magnet.

(continued on page 14)

LOOKING AHEAD

(continued from page 4)

Anti-X-ray devices

They probably won't be mentioned in set manufacturers' sales literature, but they'll be there—fail-safe gadgets to hold any radiation emission below detectable levels. Many have been phased into color sets before the model changeover. These systems include: (1) Use of precision components and elimination of the high-voltage adjustment so that voltage can't inadvertently be turned up beyond specifications. (2) Circuits which reduce or turn off high voltage if the shunt regulator tube is open or shorted. (3) Elimination of the shunt regulator by various methods, including use of a new h-v regulator diode. (4) Solid-state ac input voltage regulators. (5) Increased shielding at all critical points.

Less service, easier service

Service complaints and service problems are very much on the minds of set makers this year. Some are going the solid-state route in an attempt to increase reliability. Others, while increasing the solid-state content of color sets, say they will continue to use tubes in sockets where they have proved more reliable than solid-state components. A trend is developing toward easy removal of circuit boards or sections of circuits. Motorola's modular Quasar approach may be emulated by some new "sectional" chassis. Plug-in transistors are finding wider use.

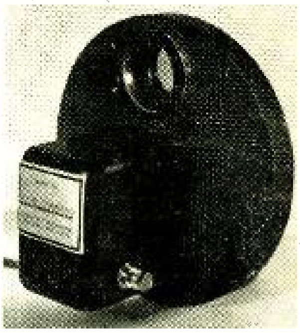
Quality-control programs are beginning to pay off, manufacturers say. Sylvania states that its "Gibraltar" color chassis, introduced a year ago, has proved 50% more reliable than its predecessor. Easy-servicing accessibility is another feature being enhanced this year. Sylvania's larger-screen b-w sets have a chassis that slides out on tracks, like a filing-cabinet drawer; the backs of G.E. color sets may be removed by disengaging three connectors.

(continued on page 14)

New & Timely

(continued from page 12)

OPTICAL DEVICE PRODUCES COLOR EFFECT



An optical device installed on the lens of b-w TV cameras enables scenes to be viewed in color on b-w monitors, according to Color-Tel Corp. (Sherman Oaks, Calif.), which is selling its Color Translator for $1500. The kit utilizes the subjective color effect and requires no electronic modification. Scenes are reproduced in flashing colors on any monitor, and a $150 compensating filter for 8-inch monitors increases color brilliancy. **R-E**

LOOKING AHEAD

(continued from page 12)

Warranties with labor

With the pressure on from both Washington and the consumer, TV receiver firms are trying to make warranties more understandable and more meaningful. Most are searching for formulas to include labor as well as parts without endangering relations with independent service technicians. Some began 90-day service-inclusive warranties last year or earlier. The remainder may well come along before the year is over, as meaningful warranties become a more important selling tool.

Joining the ranks of those offering 90-day labor in warranties included in the price of a color set are Philco-Ford and Sylvania, and quite probably others. Both of these companies have previously left this matter up to their individual dealers. Philco will compensate service dealers on a per-job, fixed-rate basis. Sylvania leaves compensation up to the dealer, but says allowance for warranty repairs are included in their margins on the sets.

RCA has been experimenting for more than a year with compulsory 90-day labor warranties in certain regions—first in Indianapolis, later adding most of the West Coast area. RCA officials say the program uses independent technicians as well as RCA Service Co. at the discretion of the dealer. Technicians are compensated on the basis of their actual charges, not according to any fixed-fee schedule.

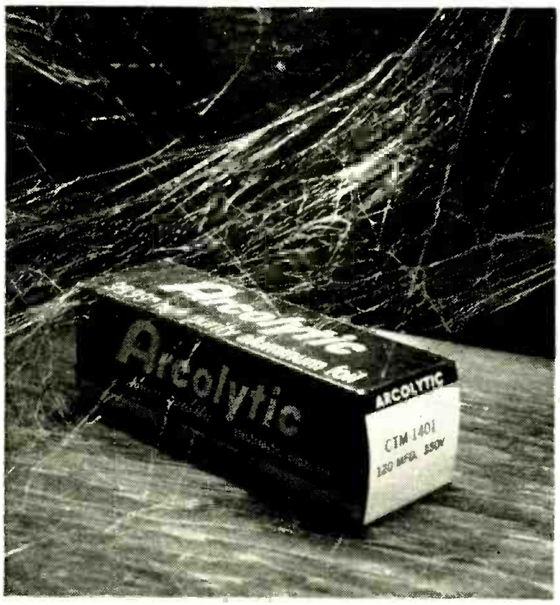
Radio trade-ins

The growing policy of over-the-counter replacement of faulty radios and other portable electronic items may lead to a new business: reconditioning and resale of trade-ins. G.E., Channel Master and others have long had a policy of 30-day warranty replacement of radios. Magnavox has now instituted a 90-day period.

Philco-Ford, in announcing 30-day replacement of all radios, plus some portable phonographs and tape recorders, suggests that it has figured out what to do with exchanged products. Philco is planning to promote the setting-up of 15 independent "rebuilding centers," to repair and rebox the trade-ins and resell them through regular channels, clearly labeled as "rebuilt," at reduced prices. **R-E**

IT'LL STILL LAST 50% LONGER IN THE SET.

BECAUSE IT'S AN ARCOLYTIC ELECTROLYTIC.



Don't sweat it if you find an Arcolytic that's been collecting dust.

Because Arcolytics have twice the shelf life. And 50% longer life in the set than ordinary electrolytics.

Reason is, they're wound with 99.99% pure aluminum foil, the only grade used in computer quality capacitors. Extra foil purity also reduces D.C. anode current leakage by half.

Arcolytics are available in more than 2,000 exact replacement values, to satisfy all radio, TV, and quality commercial equipment requirements.

Types in distributor stock include: twist mounts, printed circuit twist mounts, tubulars, miniature tubulars, and a high capacitance low voltage series.

(Ask your distributor for the new Arcolytic TV Capacitor Replacement Guide. Or write directly to Loral Distributor Products for your free copy.)

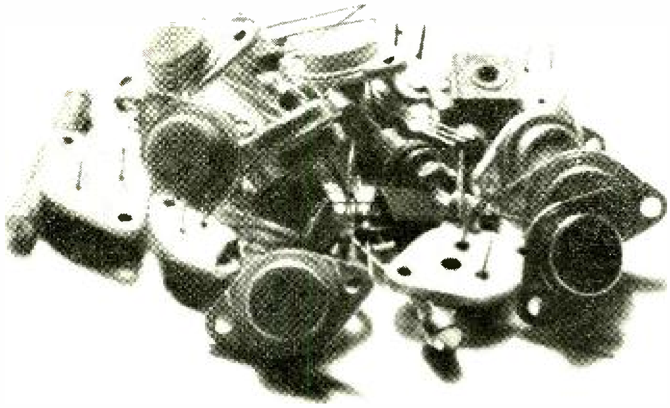
Arcolytic capacitors are available from distributors all across the country. So nobody has to settle for second best.

ARCOLYTIC

from Loral Distributor Products
A Division of Loral Corporation
Pond Hill Industrial Park, Great Neck, N. Y. 11022

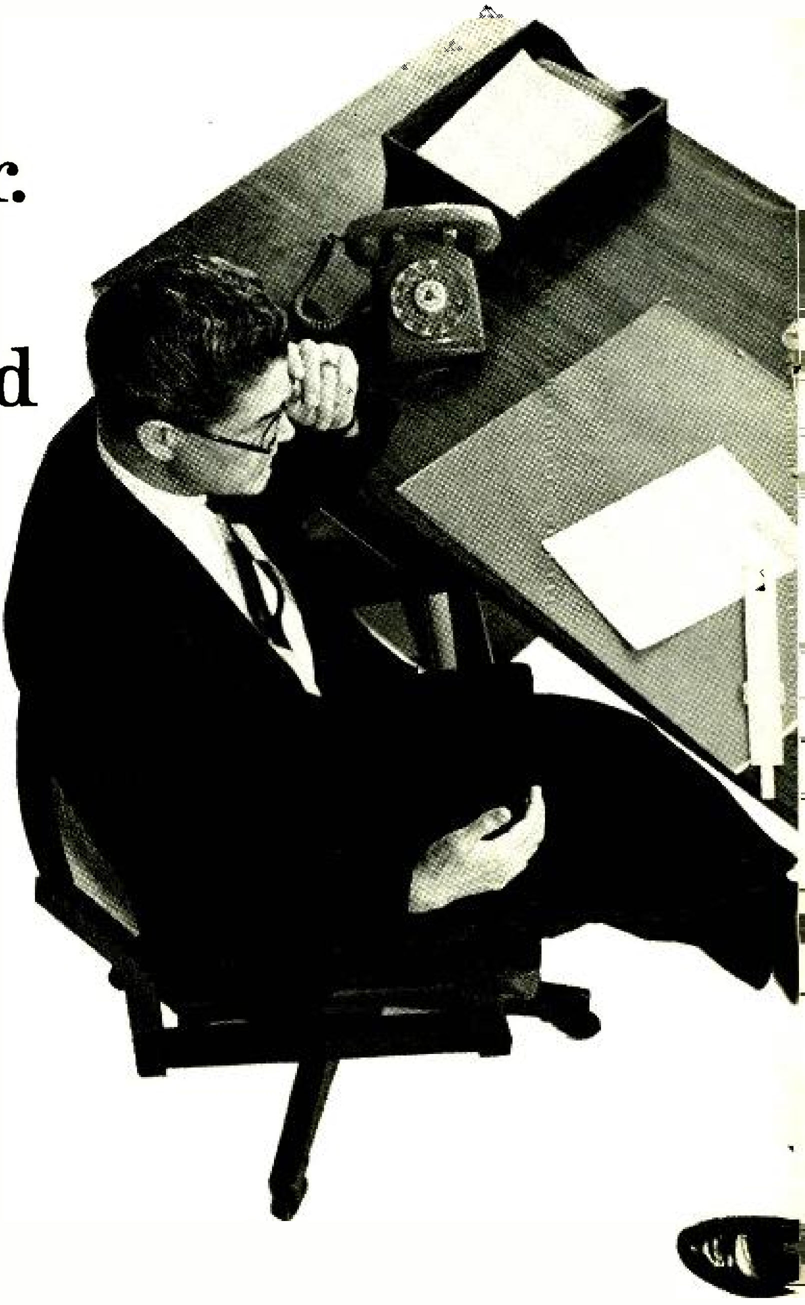
Circle 16 on reader service card

This is 30,000 solid state replacement parts.



Circle 17 on reader service card

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



Could they be talking about you?

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

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

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

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

Correspondence

BANJO PLUNKERS UNITE

I noticed you've invited comment from those who've built the guitar amplifier from the article in the November 1968 issue.

Being an old banjo plunker instead of guitar player, I figured the amplifier would not stand up to the more abrupt transient peaks of the banjo. Instead of the minimum power supply specified, I put in a larger ac transformer, feeding about 40 volts at 1 amp into the rectifier.

I also used a 10-inch, 30-watt speaker. The amplifier, with these changes, works perfectly.

To stand up under use with Fuzz-Tone input and Wah-Wah foot pedal, I found it necessary to use three diodes in series, instead of the single diode shown for bias control. I also added an audio choke and an extra 500 μF of capacitance to the rectifier filtering system to bring the noise level down.

Instead of the fabric covering specified, I finished the box in varnished natural wood with gold trim and hardware—to match the banjo. The pickup method used for banjo is the old De Armond magnetic, which was put out for acoustic wood guitars about 35 years ago.

LENT A. WILLIAMSON
Albuquerque, N. M.

WE'VE GOT ONE

We noticed in the January, 1969, issue of RADIO-ELECTRONICS that Mr. Carl Hartman of East Lansing, Michigan, wrote to you concerning a small amplifier that could be used as an amplifier monitor for headphone or small speakers and be driven by a tape recorder. You might be interested in knowing that Shure manufactures such an item, and it is called the SA-1 Solo-Phone Headphone Amplifier. This unit has two inputs, one with a completely flat response for tuner or tape, and the second for an RIAA magnetic phono cartridge equalized input. **R-E**

N. A. HESSLINK, JR.
Shure Brothers Inc.
Evanston, Ill.

BUILD

DIGITAL RTL FREQUENCY COUNTER

Count signal frequency with 4-digit accuracy

by **BOB BOTOS**

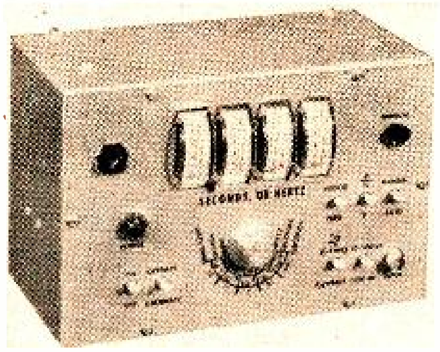
NOW YOU CAN BUILD AN IC FREQUENCY counter for less than $200. This unit counts random or periodic waveforms from 10 Hz to 20 MHz. The 4-digit readout is accurate to 0.1% using ac line-frequency calibration. An external calibration feature permits 0.05% accuracy.

For readout indicators the counter uses four $10 decade counting units (DCU's) described in RADIO-ELECTRONICS November 1968. Features of the counter compare to commercial frequency counters that cost a great deal more.

A block diagram of the counter is shown in Fig. 1. In the FREQUENCY mode, the incoming signal is either amplified or limited. It is then formed by the pulse shaper to function with the RTL IC's. The resulting pulse train, whose frequency depends on the incoming frequency, is one of the inputs to the count gate.

The 1-MHz oscillator signal is divided, according to the frequency multiplier switch position, and routed through the period selector to the second input of the count gate. This turns the count gate on for a specific "gate time." The output of the count gate is a burst of pulses directly proportional in number to the input frequency. These pulses are then counted by the decade counting units (DCU's), each of which contains a binary counter decimal (BCD) decade counter and a BCD-to-decimal converter and produces one readout digit. The count is retained in the readout until the counter is reset by the operator.

To reset a "high" or logical one is applied to all direct-clear inputs of the flip-flops and decade counters. In the MANUAL reset mode, this is done by a momentary pushbutton switch. In the AUTOMATIC reset mode, and in all but the number 5 multiplier switch position, the output of the decade divider located seventh removed from the oscillator does the resetting. This particular output goes high during the 8th and 9th seconds from zero time (that time immediately following the previous reset cycle).



Once this high signal is applied to the direct-clear inputs, the devices are reset. Therefore, they are effectively reset at the beginning of the 8th second. In the number 5 multiplier switch position, since the gate time is 10 sec, we must take the auto reset signal at the output of the 8th decade divider and reset occurs right at the 40-sec point.

Since each direct clear high must be held for a minimum of 100 nsec, a one-shot multivibrator is used to insure each device is reset. The signal triggers the one-shot, which holds the reset signal high for approximately 5 μsec. The 5-μsec value is arbitrary, but other propagation delays due to stray line capacitances and inductances, etc., throughout the counter were also considered. The output of the one-shot is buffered to provide enough drive for all direct-clear inputs.

Operation in the PERIOD mode is essentially the same with one major exception: the incoming signal is routed through the period selector and used as the gate time of the count gate, whereas the oscillator signal is used as the events counted.

A self-contained calibration feature is obtained by counting the frequency or period of the 60-Hz line voltage. (In larger cities the frequency accuracy of the 60-Hz power line is normally within ±0.05 Hz, or 0.083%) This "line calibration" guarantees ±0.1% accuracy, which will verify the counter is at least functioning to the indicated accuracy. For more accurate calibration an external calibration signal is recommended.

The counter preamp of Fig. 2 (upper left) uses a MC1552G IC video amplifier. Two input amplitude ranges are provided: 50–300 mV rms and greater than 300 mV rms. The 3 dB down points of the preamp circuit only, in the unattenuated position as shown, are 4 Hz and 42 MHz for small signal applications. Input impedance of the unit is typically 10,000 ohms.

Since the RTL IC's are guaranteed only to 4 MHz. a DTL decade counter (MC838P) is used to extend the frequency range to 20 MHz. The V_{cc} of +5 volts for the decade counter is obtained from the +6-volt supply by placing a silicon diode in the line.

To attain the high frequencies specified. be extremely careful when assembling the preamp. Shielding between input and output circuitry is important. I built the preamp into a separate chassis box. A double-clad PC board was used, and input and output components are located on different sides of the board.

As mentioned earlier. the pulse shaper conditions the incoming signal to meet input requirements of the J-K flip-flops. Fall time of a flip-flop's clock-pulse input must be within a 10–100-narosec range. (This is *not* applicable to the MC778P.) This fall time is accomplished by using one-half of a hex inverter, connected as a schmitt trigger (Fig. 2). The output of the pulse shaper is diode-coupled to a buffer which provides an adequate drive capability. Diode rather than capacitive coupling is used because a large capacitance value would be required at lower counter frequencies.

In the oscillator circuit, two gates are connected in a cross-coupled configuration, which is essentially a free-running multivibrator whose square-wave output frequency is locked by the crystal. The resistors serve as biasing elements, in addition to being a part of the circuit time constants. With the crystal placed as shown, however, R5 and C8 determine the period. Since R5 also establishes the bias of the input gate, and must be fixed for a given V_{cc}, C8 and the crystal, of course, would be changed if another frequency is desired. Typical values of C8 for other frequencies are 430 pF for 500 kHz and 0.001 μF for 100 kHz.

The trimmer capacitor permits exact adjustment of the frequency, which is stable to within ±0.01% from +15°C to +55°C, without a crystal oven.

One-shot multivibrator

The one-shot multivibrator circuit maintains the reset pulse for 5 μsec to insure complete reset. Fig. 3 illustrates the one-shot configuration of two RTL NOR gates and only one resistor and capacitor. In a quiescent condition prior to an input pulse, a steady current flows through R, applying a high voltage level or logic "1" to B1. This results in a logic "0" at B3, which is fed back to input A2. Since both A inputs are at a logical "0" at this time, A3 is at a logical "1" level. No charge is stored in C.

If a positive-going pulse (logic "0" to logic "1") is now applied to input A1, A3 goes low and C begins to charge. The high initial charging current through R drops the voltage at B2 to a logic "0" which, together with the permanent "0" at B2, switches output B3 to a logic "1". This "1" is fed back to input A2 and maintains A3 at a low level until C charges to the point where B1 reaches the logic "1" threshold level. Then output B3 is switched to a "0", completing the generation of the monopulse. The "0" at B3 is fed back to A2 and the one-shot returns to its original state.

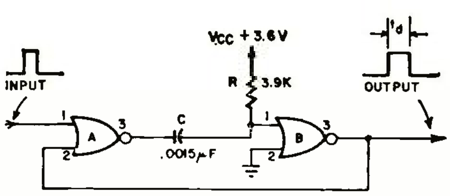


Fig. 3

The minimum pulse width of the trigger input is governed by the propagation delays of the gates used, and is approximately equal to the sum of the individual propagation delays. Using the MC724P, which typically has delays of 12 nanosec, the minimum trigger width would be 24 nanosec. The minimum trigger pulse amplitude is of course V_{BOT}, or 1.8 volts peak. V_{BOT} is the high-value voltage applied to an input of an RTL device to insure saturation of the driven transistor.

The output pulse width, t_d, is determined by the relationship $t_d \approx 0.69\ RC$. A pulse width of 225 msec is obtained, using R = 4300 ohms and C = 75 μf. The recommended maximum value of R is determined by:

$$R_{max} = \frac{V_{cc} - V_{on}}{I_{in}}$$

For the MC724P,

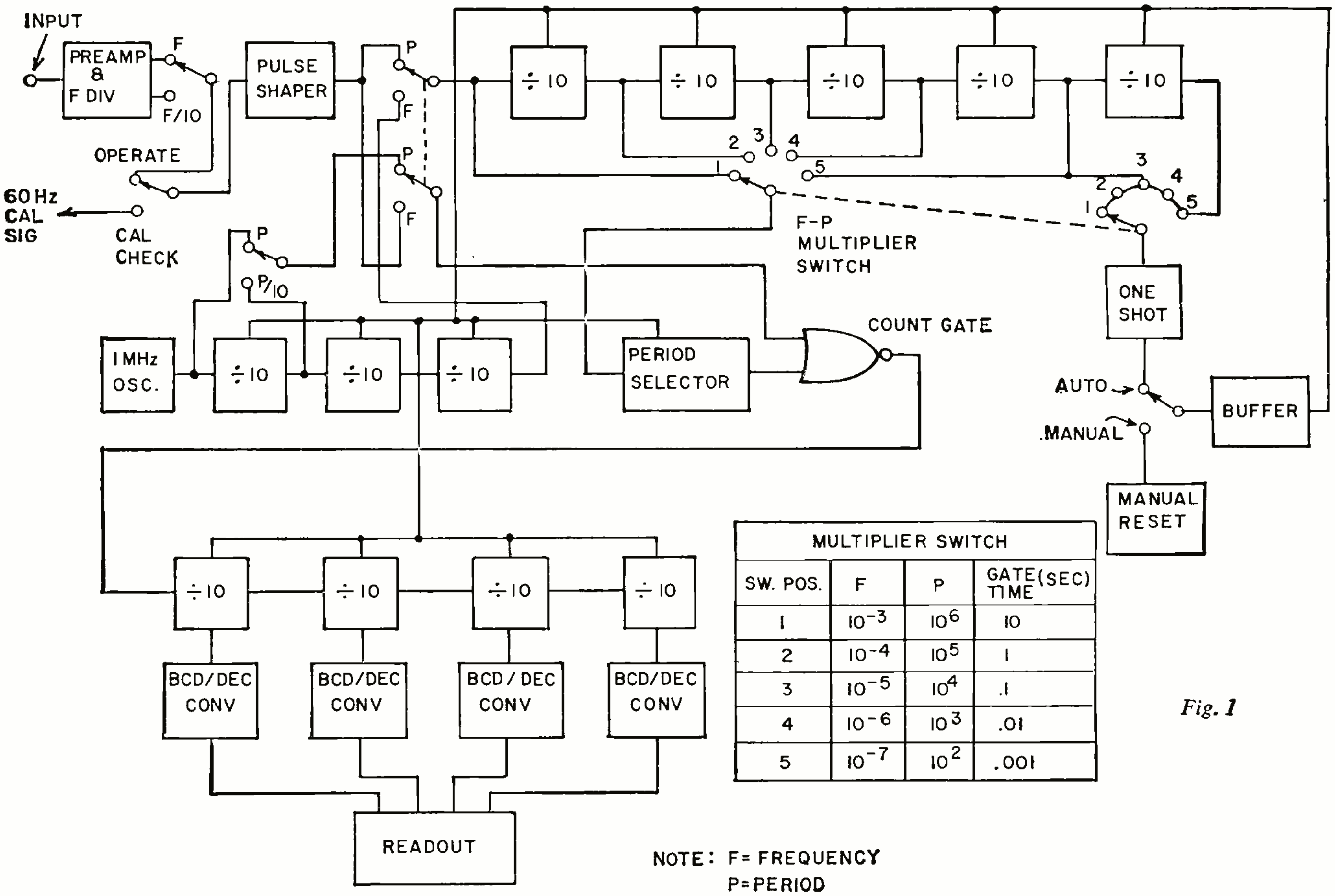
$$R_{max} = \frac{(3.6 - (0.865)}{0.5 \times 10^{-3}}$$

$$= 5400 \text{ ohms}$$

This is necessary because in the quiescent state sufficient current (I_{in}) must be supplied to gate B to insure its "on" condition.

An analysis of the one-shot output pulse shows an exponential decay to about the 1-volt level, which then falls quite rapidly to the zero-volt level. This is due to the exponential voltage rise at B1 as capacitor C charges. Once gate B starts to switch, the feedback loop provides regeneration and causes the change to be completed abruptly. The output level at which the abrupt change begins is a function of the input threshold voltage which varies from device to device.

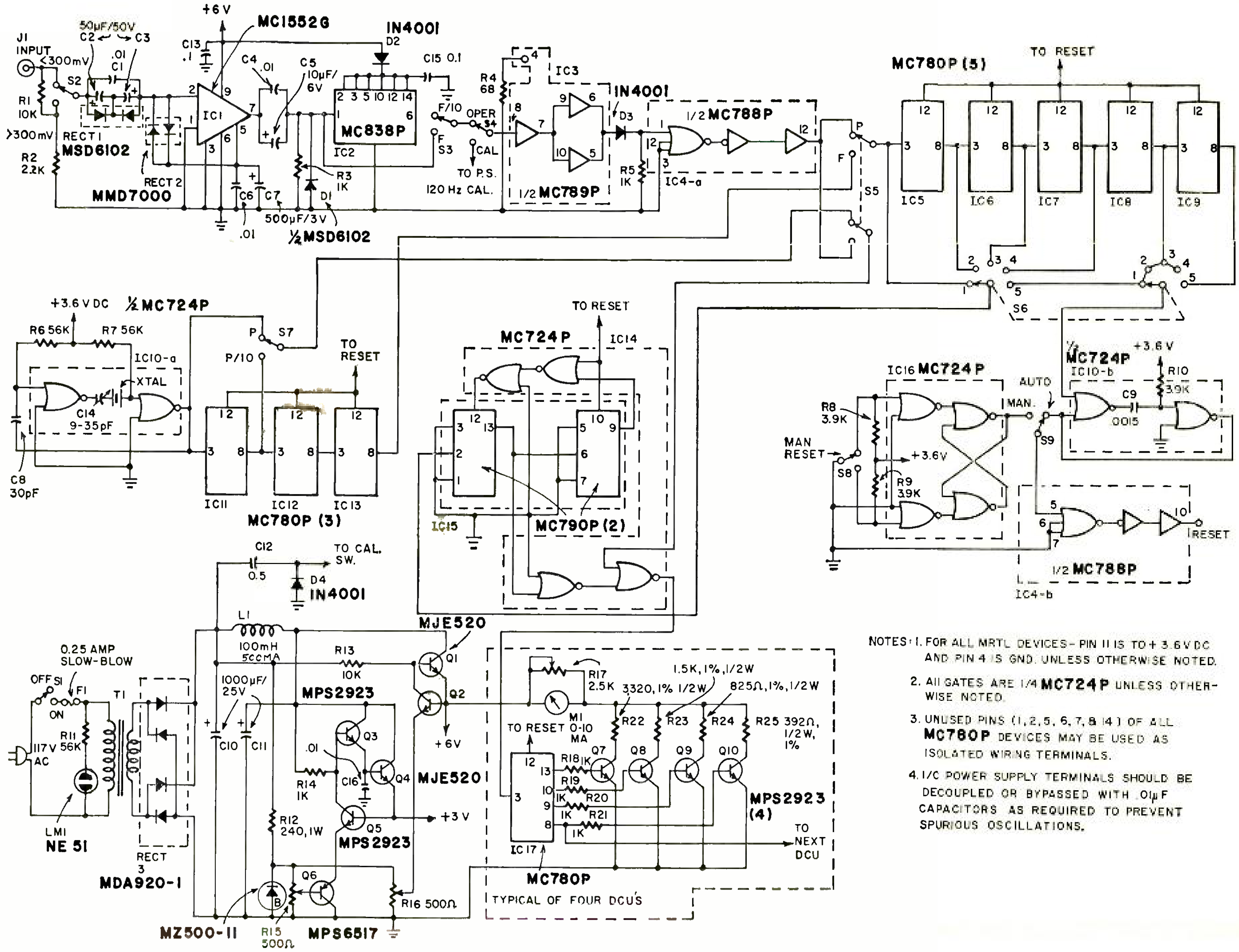
A question that arises concerning a one-shot multivibrator is, Will its output pulse drive a flip-flop directly? The RTL devices in this counter that require an input clock pulse fall time in the 10–100-nanosec range and fall times for one-shot output pulse widths less than 5 μsec meets this requirement. However, while an output pulse width of 225 msec operates a flip-flop to a good confidence level, the buffer conditioning of the one-shot output signal insures the resetting of the necessary flip-flops.



MULTIPLIER SWITCH

SW. POS.	F	P	GATE TIME (SEC)
1	10^{-3}	10^{6}	10
2	10^{-4}	10^{5}	1
3	10^{-5}	10^{4}	.1
4	10^{-6}	10^{3}	.01
5	10^{-7}	10^{2}	.001

Fig. 1



NOTES: 1. FOR ALL MRTL DEVICES – PIN 11 IS TO +3.6V DC AND PIN 4 IS GND. UNLESS OTHERWISE NOTED.

2. All GATES ARE 1/4 **MC724P** UNLESS OTHERWISE NOTED.

3. UNUSED PINS (1, 2, 5, 6, 7, & 14) OF ALL **MC780P** DEVICES MAY BE USED AS ISOLATED WIRING TERMINALS.

4. I/C POWER SUPPLY TERMINALS SHOULD BE DECOUPLED OR BYPASSED WITH .01μF CAPACITORS AS REQUIRED TO PREVENT SPURIOUS OSCILLATIONS.

Fig. 2—Schematic. This is not a simple project and careful, patient work in building it is a must.

In this counter a decade counting unit (DCU) is a device which contains a divide-by-10 counter, a BCD-to-decimal decoder and a numerical readout.

As shown in Fig. 2, the divide-by-10 function is accomplished by using the Motorola MC780P decade counter. The output of the MC780P is a 1, 2, 4, 8 binary-coded decimal representation.

The most inexpensive way of performing the decoding and readout function is by using the current summing technique. Here, the outputs of the MC780P control the on–off condition of transistors. The collector resistors are binary weighted, which results in binary-weighted currents. The collector currents are brought to a summing junction and, since the total current can be in only one of 10 discrete states, they are readily displayed on a current meter with a zero-through-9 scale. An accumulative error of even ±0.25 mA still allows clear readings. For best results, however, 1% precision resistors are recommended for the current weighting. Carbon-film precisions can be purchased at around 50 cents each.

It might be noted that the values of the collector resistors are not exact binary multiples. This is due to two factors: Standard resistors are not made in the sizes needed, and allowance must be made for a variation in the voltage drop across various meters. The resistor values chosen provide more than 10 mA to the meter. This allows shunting the movement to compensate for meter variations.

The power supply (Fig. 2) is a series-regulated, emitter-referenced, dual-output voltage circuit. The voltages are individually adjustable. The range of the nominal 6-volt section is 1–6 volts, with ±1% regulation to 100 mA. The range of the nominal 3.6-volt section is 1.5–6 volts, with ±2% regulation to 500 mA at the 3.6-volt level. Ripple is 0.2% at full load for the 6-volt section, and 1.0% at full load for the 3.6-volt section.

Inside the counter. Additional photos with callouts will be published next month.

The 50–300 mV/> 300 mV input-sensitivity switch selects the most beneficial input impedance and protection for the two positions provided.

The input frequency range switch divides input frequencies into two ranges: The F position permits measurement over the 10 Hz to 4 MHz range. The F/10 position causes the input frequency to be divided by 10, extending the range from 4 Hz to 20 MHz. An MC838P DTL decade counter divides the input frequency by 10, as shown in Fig. 2, and requires a 1-μsec fall time for toggle operation. This constraint and the input signal rise time determine the minimum operating frequency of the counter. The maximum operating frequency is determined by the MC838P, which is guaranteed to 20 MHz.

The OPERATE/CALIBRATE switch allows switching from the input to the pulse shaper, to the 60-Hz line frequency for the rough calibration check of ±0.1%.

The FREQUENCY/PERIOD switch selects the mode of operation. Essentially it interchanges the input signal and the internal-oscillator signal routing to the count-gate inputs.

The PERIOD/PERIOD ÷ 10 switch provides a reduced frequency clock signal to the DCU's to allow the longer periods to be read without overranging the readout.

The FREQUENCY/PERIOD multiplier and GATE TIME switch provide decade ranging for both frequency and period measurements, select the gate times for random pulse counting, and establish the recycle time in the automatic reset mode.

The AUTO/MANUAL switch selects the input signal sampling mode. The MANUAL-RESET button is a momentary pushbutton which resets and recycles the input signal sampling manually. **R-E**

	COUNTER SPECIFICATIONS
Waveforms measured:	sine, square, or negative pulses with greater than 30 nanosecs duration
Type of measurement:	frequency, period, random pulse counting with selected gate times
Input impedance:	10,000 ohms typical, 7000 ohms minimum (ac impedance in the sensitive voltage range depends on the forward conductance of the input protection diodes, and diminishes rapidly under overdriven conditions)
Input frequency range:	10 Hz–20 MHz guaranteed; 4 Hz–30 MHz typical
Input period range:	50 nsecs to 100 msecs
Gate time selection:	1 msec to 10 secs in decade steps
Input protection:	±50 Vdc; 1 volt peak in the unattenuated position; conservatively up to 200 volts peak in the attenuated position
Input sensitivity:	50 mV rms guaranteed, 25 mV rms typical
Readout:	4-digit decimal; fixed decimal point location; ranging accomplished by rotary switch
Accuracy:	±0.05%. ±1 count; with self-calibration using line frequency, to ±0.1%
Resetting:	manual or automatic

Heathkit® — Your Best Buy In Color TV

NEW Heathkit Ultra-Deluxe "681" Color TV With AFT ... Power Channel Selection & Built-In Cable-Type Remote Control

The new Heathkit GR-681 is the world's most advanced Color TV with more built-in features than any other set on the market. Automatic Fine Tuning on all 83 channels ... eliminates touchy fine tuning forever, power push button VHF channel selection, built-in cable-type remote control ... or you can add the optional GRA-681-6 Wireless Remote Control any time you wish ... plus the built-in self-servicing aids that are standard on all Heathkit color TV's but can't be bought on any other set at any price. Other features include a bridge-type low voltage power supply for superior regulation; high & low AC taps to insure that the picture transmitted exactly fits the "681" screen. Automatic degaussing, 2-speed transistor UHF tuner, hi-fi sound output, two VHF antenna inputs, top quality American brand color tube with 2-year warranty.

GRA-295-4, Mediterranean Cabinet shown **$119.50***

Heathkit "295" Color TV

Big, Bold, Beautiful ... with the same high performance features and built-in servicing facilities as the GR-681 above ... but less the Automatic Fine Tuning, push button VHF power tuning and built-in cable-type remote control. You can add the optional GRA-295-6 Wireless Remote Control at any time.

GRA-295-1, Contemporary Walnut Cabinet shown **$62.95***

Both the GR-681 and GR-295 fit into the same Heath factory assembled cabinets; not shown, Early American style at $99.95.*

NEW Deluxe Heathkit "581" Color TV With AFT

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

GRA-227-2, Mediterranean Oak Cabinet shown **$99.50***

Heathkit "227" Color TV

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

GRS-227-6, New Cart and Cabinet combo shown **$49.95***

Both the GR-581 and GR-227 fit into the same Heath factory assembled cabinets; not shown, Contemporary cabinet $59.95.*

NEW Heathkit Deluxe "481" Color TV With AFT

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

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

Heathkit "180" Color TV

Feature for feature the Heathkit "180" is your best buy in color TV viewing ... has all the superlative performance characteristics of the GR-481, but less Automatic Fine Tuning. For extra savings, extra beauty and convenience, add the table model cabinet and mobile cart. Get the value-packed GR-180 today.

GRS-180-5, Table Model Cabinet & Cart combo **$39.95***

Both the GR-481 and GR-180 fit the same Heath factory assembled cabinets; GRA-180-2, Early American Cabinet $75.00.*

Add the Comfort And Convenience Of Full Color Wireless Remote Control To Any Rectangular Tube Heathkit Color TV ... New Or Old!

Kit GRA-681-6, for Heathkit GR-681 Color TV's **$59.95***
Kit GRA-295-6, for Heathkit GR-295 & GR-25 TV's **$69.95***
Kit GRA-227-6, for Heathkit GR-581; GR-481 & GR-180 Color TV's **$69.95***

Now There Are 6 Heathkit® Color TV's To Choose From

2 Models In 295 Sq. Inch Size

NEW Kit GR-681 With AFT **$499.95*** (less cabinet)

Kit GR-295 **$449.95*** (less cabinet)

2 Models In 227 Sq. Inch Size

NEW Kit GR-581 with AFT **$419.95*** (less cabinet)

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

2 Models In 180 Sq. Inch Size

NEW Kit GR-481 with AFT **$359.95*** (less cabinet)

Kit GR-180 NOW ONLY **$329.95*** (less cabinet & cart)

FREE! Heathkit Catalog

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

HEATHKIT
a Schlumberger subsidiary

HEATH COMPANY, Dept. 20-18
Benton Harbor, Michigan 49022

☐ Enclosed is $________________, plus shipping.

Please send model (s)________________

☐ Please send FREE Heathkit Catalog. ☐ Please send Credit Application.

Name________________

Address________________

City________________ State________________ Zip________________

*Mail order prices; F.O.B. factory. Prices & specifications subject to change without notice. CL-359

Circle 20 on reader service card

NEW FOR YOU

For manufacturer's literature, circle No. 26 on Reader Service Card.

Koss ESP-6, ESP-7 and ESP-9 stereo headphones

I like listening to stereo with a pair of good stereo headphones. They let me turn up the level as high as I wish without driving my neighbors to pounding on my door and without disturbing the rest of the family.

When I was asked to test a pair of the Koss ESP-6 electrostatic stereo headphones I didn't expect anything new. But the ESP-6 is new. It delivers sounds I haven't heard before through stereo phones.

This pair of $95 phones serves up smooth, peak free response from 35 to 10,000 Hz within 2.5 dB and 27 to 19,000 Hz within 5 dB. The push-pull electrostatic design automatically cancels second-harmonic distortion.

The phones are heavy, 27 ounces. They are perhaps the heaviest pair of headphones sold today. But once you have them on you find them comfortable. Ear cushions are fluid-filled to give high ambient noise isolation and the wide headband is sponge foam padded for comfort.

Now the ESP-6 has two companion electrostatic models: the ESP-7 and ESP-9. The ESP-7 is basically the same as the ESP-6, but it has some of its electronics removed from the headset and placed in a separate box.

The ESP-9 on the other hand is even better than the ESP-6. It reproduces all of the ten audible octaves, 15 to 15,000 Hz within 2 dB. It goes for a lot more—$150.

The ESP-6 connects without any series resistance to the speaker output terminals of most amplifiers. It operates with 3 volts of signal from an 8-ohm source (about 1 watt) and delivers 90 dB of sound level pressure. This is equivalent to 10th row volume for a 75 piece orchestra playing loud passages.

Power handling capability of transients varies somewhat with frequency. But for example, at 40 Hz the waveform begins to become affected when signal level reaches 9

volts (about 10 watts) because of core saturation of a small coupling transformer. In practice, it is unlikely you will ever notice this effect. *Warren Roy*

SPECIFICATIONS

Source Impedance: 4-16 ohms
Sensitivity: 90 dB at 1 KHz with 1 volt at the input
Frequency Response:
27-10,000 Hz ± 5 dB
35-10,000 Hz ± 2.5 dB
Isolation From External Noise: 40 dB
Total Harmonic Distortion: Less than 0.2% at 110 dB

PROGRAMMED

HOW TO USE TRIGGERED SCOPES

by LARRY ALLEN, cet

THESE CAPSULES SHOW YOU HOW TO USE THESE popular triggered scopes. Just study each easily digested frame of information, then test your grasp of it by answering a multiple-choice question. If you choose correctly, you're guided automatically to the next programed capsule. If you miss, don't worry; programed extra information helps you to a correct answer. **Start with Frame 1.**

1

Triggered scopes get their name from the fact that the sawtooth generator, which drives the CRT beam from side to side, is not free-running. Instead, it is one-shot, triggered by a pulse. Where the pulse comes from depends on what you're using the scope for. Generally it is a sample of the waveform you want displayed on the screen. When a trigger pulse reaches it, the sawtooth generator makes one cycle or sweep, and stops. It repeats only when another pulse arrives.

The time it takes the CRT beam to complete one sweep across the screen determines how many cycles of the test waveform you see. If it's slow, you see more cycles; fast, you see fewer. The timing circuits in the sawtooth generator are very accurate, and the control knob for them is marked in milliseconds (msec) and microseconds (μsec). The marks indicate how long the beam takes to sweep horizontally 1 centimeter (cm).

So, when a trigger pulse fires the sawtooth generator, the beam moves from left (resting) to right. If the screen is 10 cm wide, and the timing circuits are set for 10 μsec/cm, the generator takes 100 μsec to sweep the beam across the screen once. When the beam snaps back to its rest position, it stays there unless another trigger pulse fires the generator again.

Question: *The pulse that triggers the sawtooth generator comes from where?*

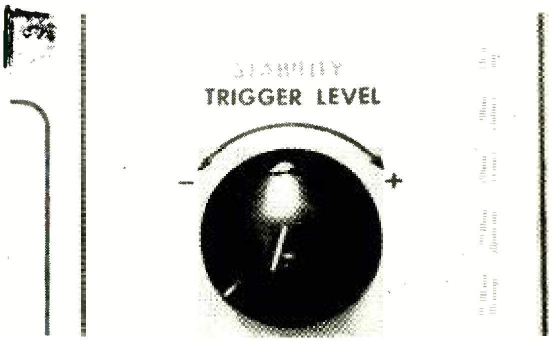
- ☐ A timing circuit in the generator. **Go to Frame 4.**
- ☐ The input waveform that is being displayed. **Go to Frame 18.**
- ☐ A trigger generator that is an accessory. **Go to Frame 23.**

2

Pretty close, but you're not being accurate enough. For practical troubleshooting, your answer would be okay. But why not give the photo another look and **pick out a precise answer in Frame 26?**

3

You've got it. If the POSITION controls happen to be off center, the dot can't be seen. The beam isn't hitting the phosphor screen. Start with VERT POSITION at extreme DOWN. Move it a little way UP, and swing the HORIZ POSITION control all the way from LEFT to RIGHT. Move the VERT control UP a little more, and again move HORIZ from LEFT to RIGHT. Keep it up till you see the beam. Then go ahead with FOCUS and ASTIGMATISM adjustments.



Find the STABILITY control (you turned it counterclockwise earlier). Turn it up till you suddenly see a trace extend across the screen. Then turn it down just enough to eliminate the trace. It is important that you do not move the STABILITY knob after this step. You have set it so the sawtooth generator can be triggered easily but won't self-trigger.

Question: *What is the purpose of the STABILITY control?*

- ☐ Keeps the graticule from wiggling. **Go to Frame 22.**
- ☐ Biases the sawtooth generator off, so it can make only one sweep each time it's triggered. **Go to Frame 9.**
- ☐ Adjusts the height of the triggering pulse for easy triggering. **Go to Frame 8.**

4

No sale! You're thinking about the right things, but you didn't read closely enough. The timing circuit determines the speed of the sweep as it moves from left to right across the CRT. **Read Frame 1 again and try a different answer.**

5

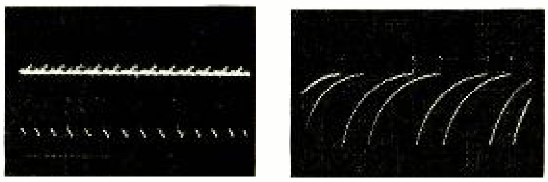
No, it isn't five. A 1000-Hz signal takes 1 msec for each cycle (To figure it out, divide 1 by the frequency.) Five cycles would therefore take 5 msec. If you figure out from the control settings how long the sweep is taking to cross the screen, you'll see that it isn't 5 msec. **The question in Frame 24 should be easier to answer, now that you have these hints.**

6

No . . . you're wrong. Each cycle of 60-Hz signal, whatever its shape or source, takes about 17 msec. And each cycle of 15,750-Hz signal, again regardless of shape or source, takes about 63.5 μsec. You could have figured these durations out for yourself by dividing 1 by the frequency. **Now that you have them, you should be able to answer the question in Frame 20.**

7

The third trick: *Get a preliminary look at the waveform by turning the* TRIGGER LEVEL *control to center (zero level).* The waveform isn't at all stable with that setting, because triggering isn't selective. The sweep triggers on almost every sharp edge of the waveform that exceeds the zero level. So, it can trigger many times on any slightly irregular waveform. The



two photos show TV-set waveforms multiple-triggering.

However, you can see the waveform shape. Seeing it helps you decide how best to trigger it. And that brings you to the fourth trick. But first . . .

Question: *Can you figure out, from what you already know, why the* TRIGGER LEVEL *control setting depends on the height of the display on the screen?*

- ☐ No. There hasn't been enough information given. **Go to Frame 27.**
- ☐ Yes. The amplitude of the trigger pulse must equal the input waveform voltage. **Move on to Frame 12.**
- ☐ Yes. It determines where on the steep slope of the waveform the trigger pulse hits the sawtooth generator. **Go to Frame 11.**

8

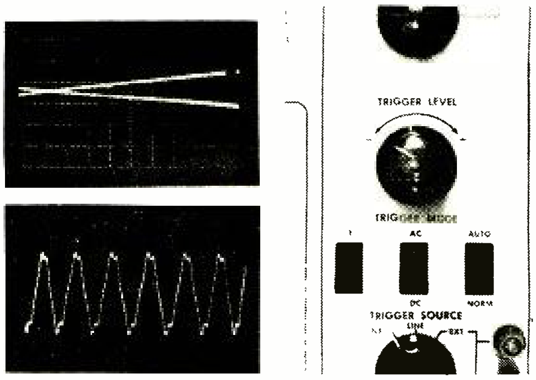
Not quite! If you picked this answer, it shows you're working at it, but you haven't quite got the idea. Until you *have* a trigger signal, it can't make the sawtooth generator run. No, the STABILITY control doesn't have any effect on the height of the triggering pulse, even if you had one. **Try one of the other answers in Frame 3.**

9

You're right. The sawtooth must be set up for critical triggering. If the STABILITY control is set too deep (CCW), it takes too much signal to fire the generator and triggering is erratic. If too shallow, the generator triggers itself even when there's no signal; pulses can't control timing properly.

Now you need an input signal of some kind so you can look at a waveform trace. Unclip the ground lead of the scope's probe and leave it hanging. Grasp the tip of the probe: this injects stray 60-Hz energy your body is picking up. Turn the VERTICAL INPUT switch to 1 V/CM.

Slowly turn the TRIGGER LEVEL control clockwise, toward its center. At some point, a trace appears. It may take any shape; two



possible ones are shown in the left photos. Don't worry about the shape yet; you'll straighten that out next, **as you move to . . . Frame 24.**

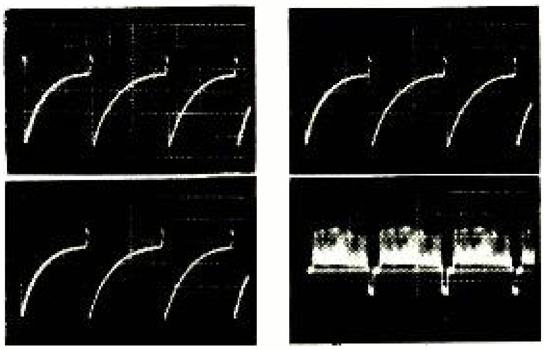
10

Wrong. You missed the implication of the steps for turning on the triggered scope. Recycling the warmup relays, when the scope has them, does nothing to bring the dot out onto the screen. **Carefully reread Frame 14. Then pick another answer.**

11

Yes, the TRIGGER LEVEL control determines where on the steep slope of a waveform the trigger pulse fires the sawtooth generator. And that's where the scope trace begins.

Now, about that fourth trick: *Trigger on the leading edge of the dominating slope.* Look at the first photo below. The waveform is locked on the little positive-going pip at the top . . . see where the trace begins? To trigger the waveform at just that point, you turn the TRIGGER LEVEL 'way over toward the positive end and then bring it back slowly till the trace appears. If you turn the control much further toward center, the trigger hits on the rounded slope and the waveform starts double-triggering **(you saw that in Frame 7).**



The waveform in the second photo (top right) is triggered near the bottom of the steep negative-going slope. To trigger there, the TRIGGER LEVEL control is turned far negative, till the waveform disappears, and then brought back just enough to trigger the signal near the *most negative* end of that steep slope.

In the third photo (bottom left), the TRIGGER LEVEL control has been moved slightly more toward center. The trigger point is still on the negative side of zero, but at a level nearer zero.

Are you catching on? Let's see.

Question: *Where is the* TRIGGER LEVEL *control set to display the waveform in the bottom right photo above?*

- ☐ On the negative side, slightly below sync-tip level. **See Frame 15.**
- ☐ On the negative side, down at the pedestal level. **See Frame 17.**
- ☐ On the positive side, just into the video. **See Frame 17.**

12

Well . . . no. Sorry, but you didn't figure it out. No need to go back to the question; **just move on to Frame 11.**

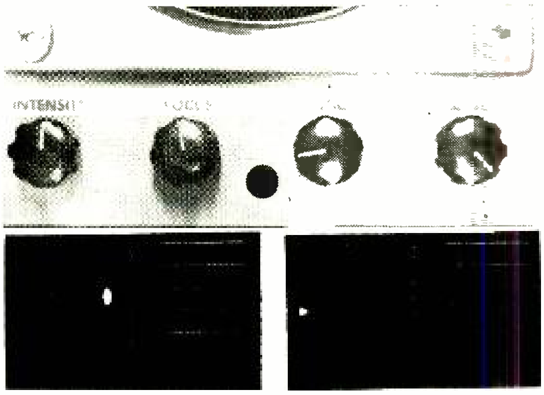
13

Not so. With the MULTIPLIER at 2 and the TIME/CM switch at 100 μsec, each graticule division (1 centimeter) represents 200 μsec. From that, figure out the time one sweep takes to go all the way across the screen. Of course, then you have to know how long each cycle of a 1000-Hz signal is. **With these hints, you should be able to come up with the right answer to the question in Frame 24.**

14

Turn on the ac switch. A cooling fan comes on. If you turn the control further, the graticule lights up. Turn the INTENSITY wide open. While you wait for the scope to warm up, turn the VERTICAL input controls to the highest value and short the input test leads together. Also find the STABILITY and TRIGGER LEVEL controls and turn them full counterclockwise.

After 3 or 4 minutes, if the bright dot hasn't appeared, juggle the POSITION controls to pull it on the screen. If the dot is elongated (bottom left), juggle FOCUS and ASTIGMATISM for the tiniest perfectly round dot you can get. Then position it at the exact left side of the graticule, and precisely on the center horizontal grid line (bottom right). Now turn the INTENSITY down just enough to extinguish the dot.



Don't worry that there's nothing on the screen now. The spot will be plenty bright when the beam is triggered into a trace. From this point on, don't touch INTENSITY, FOCUS or ASTIGMATISM controls.

Question: *What can you do if the dot doesn't appear after the scope has warmed up and the intensity control is turned wide open?*

- ☐ Turn up the graticule lighting control. **See Frame 28.**
- ☐ Turn off the ac switch and let the warmup circuits recycle. **Look at Frame 10.**
- ☐ Make doubly sure the intensity control is wide open and then turn the POSITION controls back and forth to bring the dot onto the face of the CRT. **Go to Frame 3.**

15

Yes. The negative-going sync pulse dictates that the TRIGGER LEVEL be on the negative side of zero. For good, solid locking, a deep trigger is best, as long as it is on a steep slope. The trigger in the lower right photo in Frame 11 is locked well below the tip, but not as far in as the pedestal.

When you use a triggered scope for troubleshooting in stages that carry video waveforms, synchronize on the horizontal version. You can tell more about the waveform, and it's easier to lock than the vertical.

Incidentally, you've just finished the course. If you want to review it, the key frames—in order—are 1, 18, 14, 3, 9, 24, 25, 26, 20, 16, 7, 11, 15. R-E

16

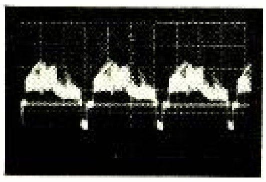
Yes, three is correct. If you worked it out on paper, you divided the frequencies into 1 to learn the duration of each cycle. From the control settings, you know a full-width sweep for horizontal waveforms is 200 μsec and for vertical waveforms is 50 msec. Thus three horizontal waveforms fit into one 200-μsec sweep, with part of a cycle left over. And three vertical waveforms fit almost exactly into one 50-msec sweep.

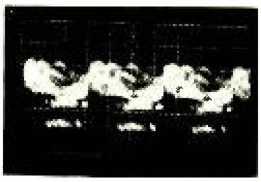
The second trick to viewing TV waveforms on a triggered scope is: *Set the* VOLTS/CM *switch to make the display trace more than 1 cm high.* (More than 2 cm is even better.) When the trigger source is internal, the height of the trace on the screen determines (indirectly) how much trigger pulse is available. Keep turning the VOLTS/CM switch to lower values until the sweep triggers.

If it still doesn't, go to the third trick, which is the subject of Frame 7.

17

No. If the trigger point were near the pedestal, the waveform would be displayed as in the left photo below. The waveform in the question is triggered differently. If the TRIGGER





LEVEL is set on the positive side, it can trigger on any of the video. The photo below (right) shows multiple triggering caused by such a setting. **For an explanation of the right answer, go to Frame 15.**

18

Sure. The waveform you want to watch can always start the sweep at about the right time. So, the most natural source for the trigger pulse is the input waveform itself. An internal trigger circuit shapes a triggering pulse when you set the TRIGGER SOURCE switch to INT.

That gives you a sketchy idea of what a triggered scope is and how it differs from the more familiar recurrent-sweep scope. **Move to Frame 14 and learn to fire up the triggered version.**

19

Oops, wrong! Don't feel bad, though. This is a problem you have to figure out from things you already learned. For example, you can figure out the duration of one cycle of each waveform by dividing 1 by the frequency. Your calculations should tell you that a horizontal waveform takes 63.5 μsec per cycle and a vertical waveform takes 17 msec per cycle. **Maybe that will help you find the right answer in Frame 20.**

20

That's exactly right! You paid attention to the tiny subdivisions along the center vertical grid (sometimes called the Y-axis line). Each centimeter stands for 20 volts, because the VOLTS/CM switch says so. Each little subdivision, then, stands for 4 volts. The waveform is one subdivision short of a full 3 cm. So, its amplitude is 4 volts short of 60 volts peak to peak.

To be practical, you can round off what you see and call it 60 volts p-p (abbreviation for peak to peak). In lab work, precise voltages are more important; lab techs periodically calibrate their triggered scopes.

Any technician who has learned to service TV with a triggered scope will never go back to a recurrent-sweep type. The tight, stable, accurate waveforms have no match in ordinary service scopes. But the uninitiated sometimes think a triggered scope is too complicated, and may have trouble setting up the scope to display TV waveforms. Don't let that deter you. There are four tricks that make it easy. The first: *Know what time base to use for TV waveforms.*

For vertical-rate waveforms, always set the scope for a 5-msec/cm sweep. The TIME/CM switch goes at 1 msec and the MULTIPLIER at 5.

For horizontal-rate waveforms, use a 20-μsec/cm sweep. The TIME/CM switch goes at 10 μSEC and the MULTIPLIER at 2.

Question: *Television waveforms have only two basic frequencies: 60 and 15,750 Hz. How many full cycles should you see of each waveform, with the settings listed above?*

- ☐ One. **See Frame 6.**
- ☐ Three. **See Frame 16.**
- ☐ Five. **See Frame 19.**

21

Nope. What you've done is figure the whole graticule as representing 20 volts. Actually, the 20 on the VOLTS/CM switch means that each centimeter division represents 20 volts. The whole graticule from top to bottom therefore represents 120 volts. **With that clue, and a rereading of the third paragraph of Frame 26, you can probably answer the question without any trouble.**

22

Come on . . . you picked this answer just to see what it says. You know we put it there for a gag. Only loose mounting bolts can let the graticule (the plastic grid in front of the screen) wiggle!!! **Let's get serious again and pick another answer for Frame 3.**

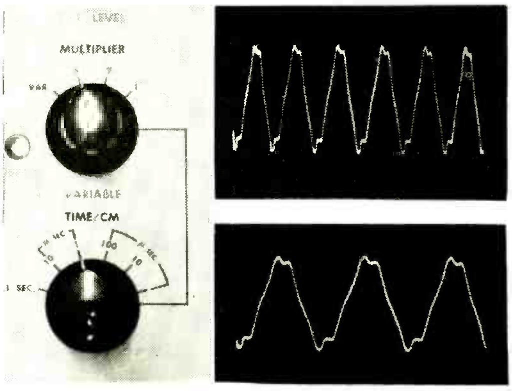
23

No, you're on the wrong track. It is possible to trigger a scope from an external source, but that's only done for lab work. **A rereading of Frame 1 will probably help you find the right answer.**

What you do next is choose a sweep speed that lets you look normally at the waveform you're feeding to the scope. Since this signal is 60 Hz, one cycle of it takes 1/60 second. Stated decimally, that's 0.016667 sec, or about 17 msec. You have to set the timing-circuit controls so the sweep of the CRT beam from left to right takes longer than 17 msec.

Look at the numbering around the TIME/CM knob. The 10 MSEC mark produces a sweep that is 10 msec per centimeter; the 10-cm screen takes 100 msec for for the beam to cross. With one cycle taking up 17 msec, you should see six full cycles at that setting. Try it. The upper right photo shows how the screen looks at that setting; you can't see it in the photo, but the trace flickers.

24



There are alternatives. You can see the waveform better if there are fewer cycles of it. Three cycles consume about 51 msec. You can set the controls to produce a full-screen sweep of 50 msec, by using the MULTIPLIER. With the TIME/CM switch on 1 MSEC and the MULTIPLIER on 5, each centimeter covers 5 msec of sweep time. The full 10-cm grid represents 50 msec. The lower right photo shows the display.

Question: *With the* MULTIPLIER *set at 2 and the* TIME/CM *switch at 100* μSEC, *how many cycles of 1000-Hz signal show on the scope screen?*

- ☐ One. **See Frame 13.**
- ☐ Two. **See Frame 25.**
- ☐ Five. **See Frame 5.**

25

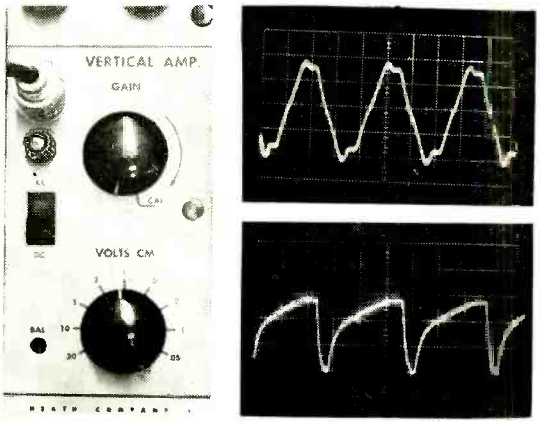
That's right. You understand the principle. Fine. With the MULTIPLIER at 2 and the TIME/CM switch at 100 μSEC, a full sweep across the screen takes the CRT beam 2000 μsec, or 2 msec. Then, if you calculate the duration of one cycle of 1000-Hz signal (divide 1 by the frequency), you discover that two cycles occur while the scope sweep is scanning once. So, those two cycles fill the scope screen. You're progressing well, so **move along to Frame 26 and learn how to measure signal voltages with a triggered scope.**

You measure voltages by the VERT INPUT controls and the graticule. The graticule grid is marked off vertically into centimeter segments. Each represents whatever voltage is set on the VOLTS/CM switch. The GAIN control must be at its CALIBRATED position (usually a switch at the end of rotation).

Use the same 60-Hz signal you used earlier—from your fingers. Set the TIME/CM switch to 1 MSEC and the MULTIPLIER to 5. That lets you see three cycles of the 60-Hz signal.

Vary the VOLTS/CM switch back and forth till you get a visible display on the screen. (You might have to reset the TRIGGER LEVEL to see a display: to do that, turn it full counterclockwise, then clockwise slowly till the trace appears.) Notice the height of the display. Count the number of centimeters. Now multiply that by the setting of the VOLTS/CM switch. The waveform in the top right photo, for example, measures 4 cm on the graticule. With the switch at 1, that means the input signal is about 4 volts peak to peak.

26



It's time you look at some waveforms in a live TV set. That's a good place to check how well you can read voltage amplitudes with the scope. The waveform in the lower right photo was taken in the horizontal sweep circuit of a working TV set. The VOLTS/CM switch was set at 20.

Question: *What is the peak-to-peak voltage of the waveform?*

- ☐ 56 volts peak to peak. **See Frame 20.**
- ☐ 60 volts pak to peak. **See Frame 2.**
- ☐ 9.5 volts peak to peak. **See Frame 21.**

27

Well, okay. It is a tough one, if you aren't familiar with triggered scopes. Instead of worrying about it, **turn to Frame 11.**

28

Not hardly. This only lights the grid that makes calculating waveform height and timing easier. The dot made by the CRT beam may be off screen when you first turn on the scope. Think about that, then go back and **try for the right answer in Frame 14.**

HAS YOUR CAR EVER OVERHEATED AND left you stranded? Or how about the time you ran out of gas? Both times the dash indicators read o.k. Probably neither the sending units *nor* the gauges were wrong. Most likely, the culprit was the regulator used to supply voltage to the gauges.

When something is wrong with the gauging system, usually both gas and temperature gauges will be influenced. The instrument voltage regulator is a small device mounted in a plug-in socket behind the instrument panel. This regulator is an electromechanical unit and can be inaccurate.

This article describes two solid-state, plug-in replacements for the mechanical regulator. Simple and inexpensive to build, they can make your gas and temperature gauges accurate and reliable.

How most gauges work

A typical setup for indicating temperature and gas tank contents in a modern automobile is shown in Fig. 1. The sending unit in the gas tank is a potentiometer with its wiper arm attached to a float. Usually an empty tank will provide a 60–65-ohm resistance reading, while the full reading is 10–11 ohms.

The temperature sensor in Fig. 1 is a thermistor (temperature-dependent resistor) mounted in a brass cylinder. It is located in the water jacket of the engine close to the thermostat. A cold resistance reading would be 70–75 ohms, and the resistance just before the water boils would be about 9 ohms.

The gauges are hot-wire milliammeters. This meter type consists of a bimetallic strip connected to the pointer. The bimetallic element is wrapped with insulated heater wire. Voltage applied to the heater causes the bimetallic strip to bend; the amount of bending is proportional to the current.

The regulator contains a bimetallic strip heated by the passage of current through a separate heater wire wrapped around it. As the bimetallic strip heats, it bends because the two metals have different expansion rates. When a predetermined amount of current has passed through the winding, the contact is broken. When the bimetal strip cools, it makes contact again and the cycle is repeated.

The ratio of the time *on* to the time *off* determines the effective value of the resulting voltage. It is impossible with any easily available test instrument to determine the output voltage of this regulator. Auto manufacturers' service manuals usually recommend checking with known-good gauges and sending units.

Input voltages to the instrument regulator vary widely. With the engine turning over at 2000 rpm on a cold morning the output from the alternator may be as high as 15.4 volts.

Solid-State Your Car Gages

by JACK SADDLER

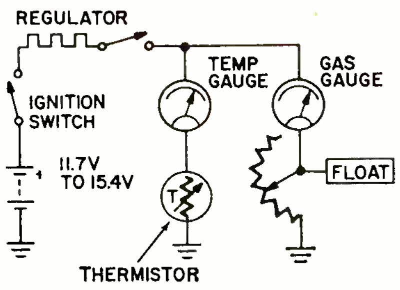
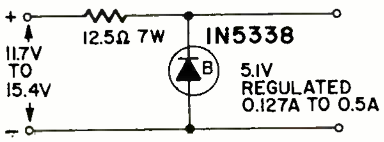
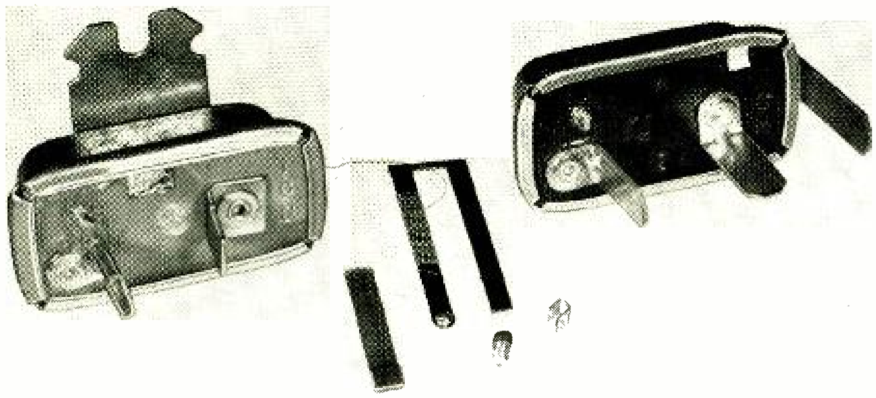


Fig. 1 (left)—Arrangement for gas and temperature gauges in most cars today.
Fig. 2 (below)—Simple shunt regulator replacement for electromechanical devices.
Fig. 3 (photo)—Typical cases for bimetallic-strip regulators with components.





The voltage may drop to 11.7 on a hot summer day.

Each panel gauge has a resistance of about 11.5 ohms. The highest load on the regulator occurs when the engine is hot and the tank is full. The current drains from the fuel-gauging and temperature-sensing system total about 500 mA.

When engine water temperature is low and the gas tank almost empty, the regulator consumes the most power internally but has to put out the least. Total drain for both systems in this case is 127 mA.

Zener–resistor

The simplest solid-state replacement for the electromechanical regulator is shown in Fig. 2. It consists of a shunt regulator made from a resistor and a Zener diode.

The resistor–Zener combination is correct for most U.S.-made autos except those made by General Motors. It was specifically designed for American Motors cars made from 1961 to 1967. Formulas for calculating values for other voltages and current requirements are given later.

The first step is to open the old regulator. The metal case is crimped around a phenolic board (Fig. 3). The best tool to use for uncrimping is a pair of diagonal cutters. The metal lip is loosened all around. After you open the case, bend the bimetallic element up and clip it off even with the terminal. Remove the silver-tipped brass contact blade similarly. Then back out the adjusting screw. All three of these parts can be discarded.

Now solder a 12.5-ohm, 5–7-watt resistor between the two terminals (Fig. 4). The input from the ignition switch is marked IGN. The output terminal is unmarked.

Drill a small hole in the metal cover near the spot-welded ground strap. The negative end of the Zener diode is threaded through this hole. Check to see that neither of the resistor leads nor the positive Zener lead touches the case.

Complete the assembly by recrimping the can with pliers. Bend the Zener diode lead parallel to the can and solder it. The original can is tin-plated and easy to solder. For the final test, connect the positive terminal of a 12-volt battery to the IGN terminal and the negative lead to the case. A voltmeter connected between the unmarked terminal and case should read 5.1 V.

After assembly and test, merely plug the solid-state regulator in place of the electromechanical unit. No alterations are required in the wiring.

Transistor–Zener regulator

The simple resistor–Zener unit has a great advantage over electromechanical unit: with no moving parts, it is quite reliable. Its main disadvantage is that it consumes more power than the bimetallic unit. And since it must regulate for all possible engine-temperature and fuel-tank conditions, it is designed to deliver the regulated voltage under all conditions.

This means some power will be wasted under most conditions. The Zener unit consumes about 8 watts in the worst case. When things are going well with the car there's no problem. But there are times when even the power consumption of the transistor radio is bad. For this reason the second circuit in Fig. 5 is shown.

While this system is slightly more complex, it is a more efficient regulator. It consumes only about 2 watts when the input voltage is low and output current demands are at a minimum.

How does it work? The transistor is in series with the positive supply line. It acts as a variable resistor. The Zener diode and R2 together act like the sliding contact on a potentiometer. As the supply voltage rises, more current flows through R2. The Zener diode and the transistor base split this current to maintain the output voltage at 5 volts. The ability of this circuit to maintain a constant output voltage is even better than the Zener alone. The control effect of the Zener is transferred to the transistor so that output voltage is rock-solid regardless of changes in input voltage or output current.

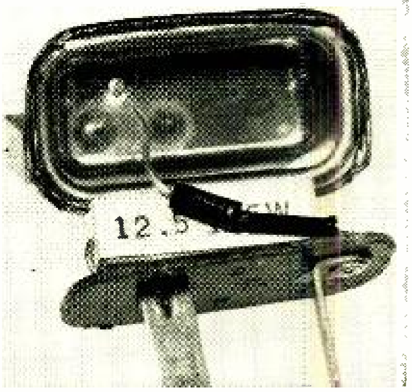
As in the Zener regulator, first open the case and remove the old bimetallic element. Drill a 7/64-inch hole in the case along the center line at a convenient distance from the end. This hole will be used for mounting the transistor.

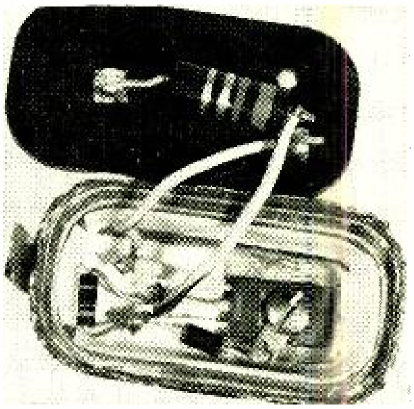
Before mounting the transistor, its leads must be bent away from its heat sink at about a 30° angle.

Cover the inside of the can with plastic electrical tape except for the area where the transistor will be mounted (Fig. 6).

The collector of the transistor is connected to the bare metal spot on its case. In this circuit, it must be electrically isolated from the heat sink (the case of the plug-in unit). For this reason the transistor is mounted with a mica insulator between the transistor and case. The insulator is supplied by the manufacturer. Use silicone grease on both sides of the insulator to provide a good heat path to the case.

The mounting is completed with a solder lug atop the transistor as shown in Fig. 7-a. The connections are shown in Fig. 7-b. When soldering the leads and wire to the transistor, make sure the leads are freshly tinned. Clamp the transistor lead with diagonal pliers or an aluminum clip-on heat sink. The silicon transistor is quite rugged, but it's best not to take a chance of damaging it by overheating. The 7.5-ohm resistor is an IRC





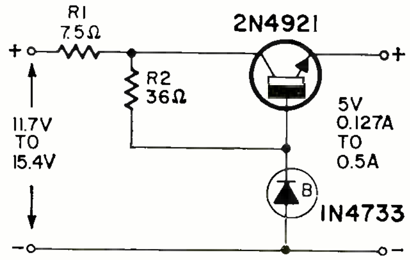
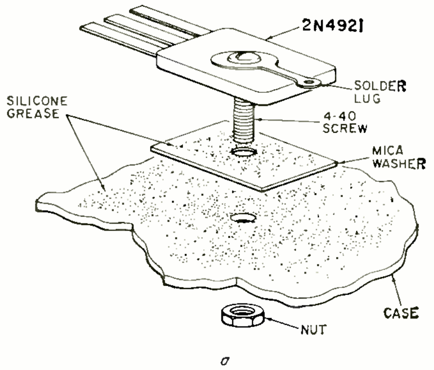
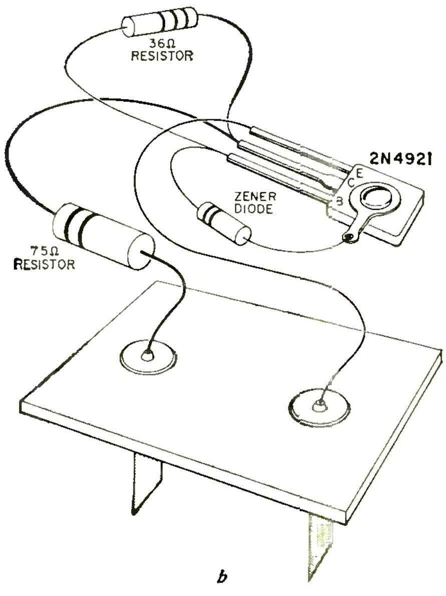


Fig. 4 (top right)—Photo shows positioning of resistor–Zener regulator combination.
Fig. 5 (above)—Transistor–Zener circuit.
Fig. 6 (photo)—Layout for transistor regulator in tape-insulated mounting case.
Figs. 7 a,b—Drawing shows transistor isolation and connections for the components.



a



b

type BWH. It is 1-watt composition size but is capable of dissipating 2 watts.

After soldering all parts together, close the case. If the unit is correctly assembled, an ohmmeter should read infinity with its negative lead connected to IGN and positive lead to case. Reversing the ohmmeter leads will give a low reading—something between 100 and 350 ohms. Similar readings taken between the unmarked output terminal and case should be identical to input readings.

Zener regulator with other cars

The resistor-Zener combination shown in Fig. 2 is designed specifically for 1961 through 1967 Rambler cars. It is also useful with Fords and Chryslers. Some cars measure oil pressure electrically and the regulator must supply the current. It is best to review wiring diagrams to determine what circuits are connected to the regulator. If your service manual shows different resistance values for the sending units or the meters, jacket and gas tank, here are the measurements needed:

1. Normal voltage output from instrument regulator. 2. Empty-gas-tank sending-unit resistance. 3. Full-gas-tank sending-unit resistance. 4. Cold-engine sending-unit resistance. 5. Hot-engine sending-unit resistance. 6. Gauge resistance.

And here are the calculations:

$$\textit{Min. output current} = \frac{\textit{regulator voltage}}{(\textit{empty tank resistance} + \textit{gauge resistance})} + \frac{\textit{regulator voltage}}{(\textit{cold thermistor resistance} + \textit{gauge resistance})}$$

$$\textit{Max. output current} = \frac{\textit{regulator voltage}}{(\textit{full-tank resistance} + \textit{gauge resistance})} + \frac{\textit{regulator voltage}}{(\textit{hot-thermistor resistance} + \textit{gauge resistance})}$$

$$\textit{Series resistance} = \frac{\textit{min. battery voltage} - \textit{regulator design voltage}}{1.1\ (\textit{max. output voltage})}$$

$$\textit{Resistor pwr. rating} = (15.4 - \textit{regulator voltage})(\textit{max. output current} + 0.1)$$

(The power rating will be conservative.)

$$\textit{Max. Zener current} = 1.1\ (\textit{max. output current} - \textit{min. output current})$$

$$\textit{Zener power rating} = \textit{regulator voltage}\ (1.1\ \textit{max. current} - \textit{min. current})$$

$$\textit{Zener voltage} = \textit{regulator design voltage}$$

(The 1.1 is an empirical safety factor used to assure correct performance of the Zener diode when it draws minimum current.)

Generally the Zener diode can be mounted by its leads. In my system the diode is capable of dissipating 5 watts at all temperatures to 167° F with the case ⅜ inch from the solder joint. The 1N5333 series is available with voltages from 3.3 to 200 volts. Should more dissipation be required from the Zener, the 1N3993R series can be used. In this series, the 1N3996R is the 5.1-volt Zener. These are stud-mounted units and can be fitted inside the case. It's snug-fit with the resistor, which should be as small as possible.

Transistor–Zener calculations

The 2N4921 transistor is quite adequate for any system requiring 8 volts or less. All calculations below are based on the use of this transistor. Measurements in the car or from a service manual are the same as for the Zener unit. Minimum and maximum currents required by the sending units are also the same. To make calculations easy some elements of the equations are combined.

Zener voltage = required output voltage + 0.6 V

The 0.6 volt is the maximum voltage drop from collector to emitter for the transistor used.

$$R1 = \frac{E_{min} - E_Z - 2.6}{I_{max}}$$

The 2.6 volts is composed of 0.6 volt for the collector–emitter voltage drop, and the 2.0 volts is a collector–base voltage that will keep the transistor out of saturation.

$$R2 = \frac{52}{I_{max} + \textit{factor from chart}}$$

$$I_Z = \frac{E_{max} - E_Z}{R2 + R_Z}$$

where E_{min} *is minimum input voltage*
E_{max} *is maximum input voltage*
E_Z *is Zener voltage*
I_{max} *is maximum output current*
$I_{Z\,max}$ *is maximum Zener current*
R_Z *is Zener resistance (see Table I)*

The maximum current through the Zener diode must be calculated to insure its power rating is not exceeded. The maximum currents shown in Table I limit dissipation of the Zener to about 1 watt. The 1N4728 series is capable of handling twice the current shown if the leads are less than ⅜ inch long and the heat sink is adequate.

The only remaining calculations necessary are the power ratings of the two resistors:

$$\textit{Power rating, } R1 = (I_{max} + 0.1\, I_{Z\,max})^2\, R1$$

$$\textit{Power rating, } R2 = (I_{Z\,max})^2\, R2$$

Either of these regulators in your automobile will give you more confidence in the gauge readings. You might save a long walk to the gas station or a costly repair bill. **R-E**

Table I—Zeners for Output Voltages

Desired output voltage	Zener voltage	Type	Max. current amps	Resistance ohms	Factor*
3.0	3.6	1N4729	0.252	10.0	1.38
3.3	3.9	1N4730	0.234	9.0	1.28
3.7	4.3	1N4731	0.217	9.0	1.16
4.1	4.7	1N4732	0.193	8.0	1.06
4.5	5.1	1N4733	0.178	7.0	0.98
5.0	5.6	1N4734	0.162	5.0	0.90
5.6	6.2	1N4735	0.146	2.0	0.82
6.2	6.8	1N4736	0.133	3.5	0.74
6.9	7.5	1N4737	0.121	4.0	0.68
7.6	8.2	1N4738	0.110	4.5	0.62
8.5	9.5	1N4739	0.100	5.0	0.56

**This factor combines several design factors and is useful only with the 2N4921 transistor. The complete design calculations are in the Motorola Zener Diode Handbook.*

TECHNICAL TOPICS

Fire detector, 45-minute timer and two unusual audio circuits for you

by ROBERT F. SCOTT
SENIOR TECHNICAL EDITOR

BEFORE WE REALLY GET ROLLING THIS month, let me pass on to you one of the most useful hints I've seen in many a moon. We've all run across a chassis caked with layers of dirt, grease and grime and have suspected this gunk of being the primary cause of spurious oscillations, noise and intermittents that defy correction.

Well, in *QST*, W4YOK tells how he cleaned his Drake TR-3 by dunking it in a mixture of 8 oz of household ammonia, 5 oz of Mr. Clean, 4 oz of acetone and 7 pints of water and then brushing away the gunk with a small brush. A thorough washdown with a hose and a 4-hour bake in a 145° oven completed the job. Capacitor bearings, switch surfaces and other controls must be lubricated with appropriate service chemicals. (NOTE: *In many areas, the water from faucets is quite hard and, when evaporated, leaves scale which may be more damaging to electronic components than the grime you have removed. Better rinse with distilled water. Softened water isn't good either.*)

Reliable fire detector

Many inexpensive fire detectors use bimetal thermostats as transducers. Some of these are unreliable because of wide temperature tolerances, metal fatigue and other causes. Fig. 1 is the circuit of a solid-state fire detector that gives an alarm if the rate of temperature rise exceeds a given level and also if the ambient temperature rises above a preset level.

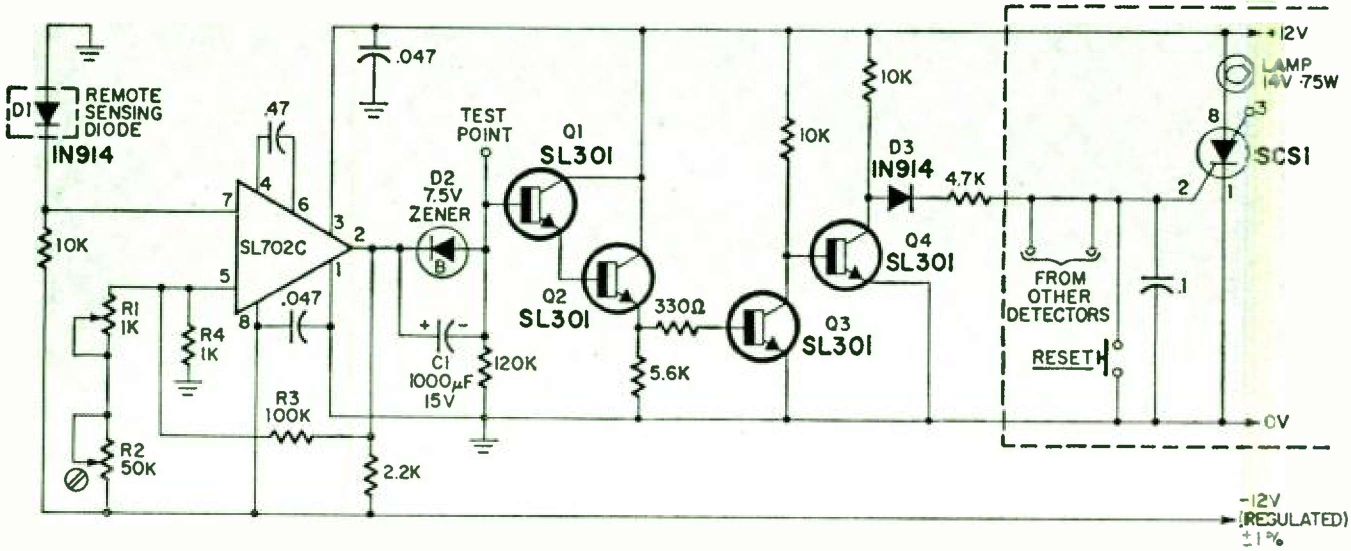


Fig. 1—Unique solid-state fire detector sounds alarm when temperature soars rapidly or climbs above a preset level. The heat sensor is a 1N914 silicon diode.

In this circuit, described in *Electronic Engineering* (London, England), a 1N914 silicon diode is the heat-sensitive transducer. Its forward voltage is linear at 3 mV/° C. If the temperature rises above the alarm level—as determined by the settings of R1 and R2—the voltage decreases at the noninverting input of the SL-702C operational amplifier. The op amp's output goes positive and causes Zener diode D2 to conduct. Darlington amplifier Q1–Q2 conducts and develops a signal which—after amplification in Q3 and Q4—turns on the silicon controlled switch (SCS) used as the driver for the fire-indicator lamp.

If the temperature rises rapidly, C1, which with the 120,000-ohm resistor has a 2-minute time constant, charges and turns on the Darlington amplifier before D2 conducts.

The gain of the SL702 op amp is adjusted to 100 by feedback network R3–R4 which sets the voltage at the inverting input at zero volts. To adjust the detector circuit, place D1 in an ambient temperature just below the temperature you select for the alarm level. Set R1 and R2 (*with C1 disconnected*) so any further increase in temperature drives the amplifier output more positive and causes D2 to conduct. Reconnect C1.

The semiconductors (except D1, D2 and D3) are European types and not readily available. However, it should not be difficult to make substitutions. The Darlington amplifier turns on with + 2 volts at its input. For SCS1 you might try one of G-E's

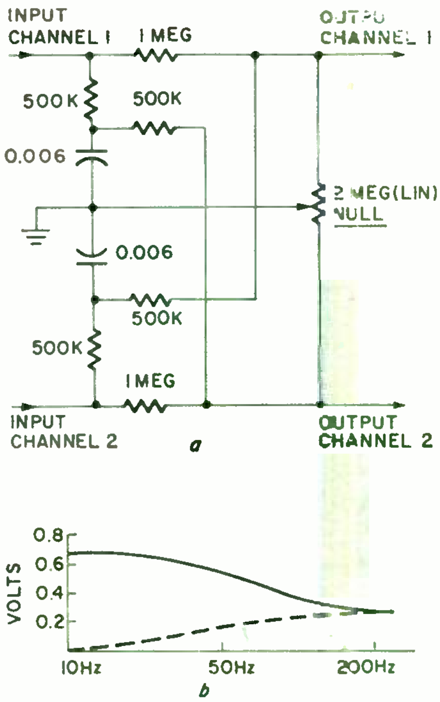


Fig. 2-a—Rumble-cancelling circuit for stereo. b—Stereo and monophonic curves.

3N80 series or even an SCR with suitable modifications.

Now for some audio circuits

Some record players develop low-frequency rumble and/or acoustic feedback on stereo records, but not when monophonic records are played. The reason is both rumble and feedback are produced by vertical forces acting on the stylus, and the stereo cartridge produces equal out-of-phase voltages. When the same type of interference forces occur on a mono record, the noise is not heard because the two channels are connected so the out-of-phase voltages cancel.

David Ralph, writing in *Wireless World* (London, England), describes a circuit (Fig. 2-a) that effectively adds rumble and acoustic feedback voltages from a stereo phonograph and combines them so they cancel just as they would in mono reproduction. The low-frequency voltages—mainly those below about 200 Hz—are boosted by 0.006-μF capacitors. A portion of this low-frequency voltage is tapped off and fed to the opposite channel through 500,000-ohm resistors. Rumble and feedback voltages from the right channel cancel those in the left and vice versa. *When the circuit is in use, stereo signals below 200 Hz are reproduced in mono and those above in normal stereo.* The 2-megohm pot is used to balance the circuit so interference is nulled out. The curves in Fig. 2-b show circuit performance with 1 volt input to each channel. The solid curve is the response when the phonograph is set for mono and the dashed line is for stereo.

Treble control with "presence"

The usual "losser" type universal tone controls have bass, treble-boost and cut-response curves that begin at a point somewhere between 500 and 1000 Hz, depending on the circuit constants. Korting, a German hi-fi equipment manufacturer, has developed a simple modification of the treble control to permit the user to set the treble turnover point anywhere between 500 and 1000 Hz. The modification, see Fig. 3, consists of adding a 50,000-ohm potentiometer between the arms of the bass and treble controls. (The basic circuit is called a "losser" type because the circuit loss—when the controls are in the flat position—is equal to the maximum available boost, generally 18–20 dB.)

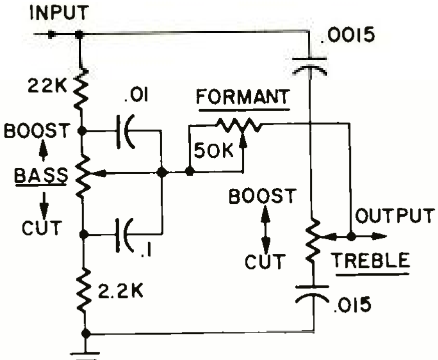


Fig. 3—Format control adds presence and enhances action of treble control.

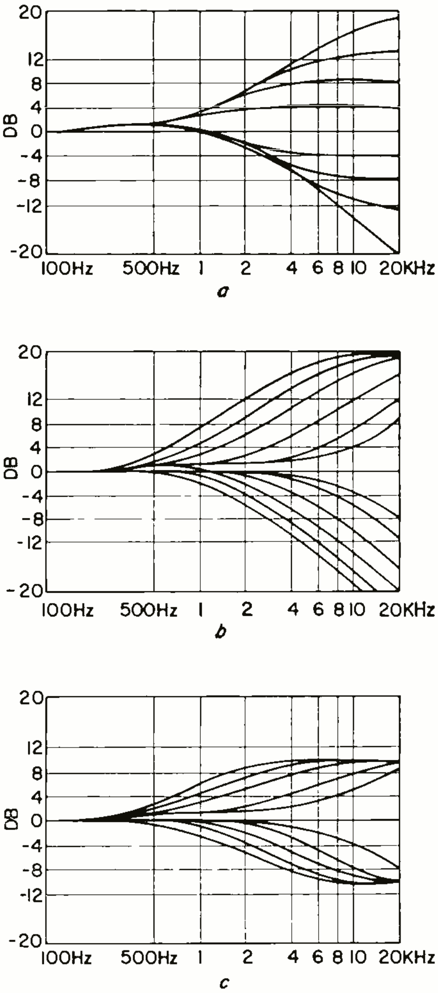


Fig. 4-a—Response of treble control without Formant control; b *and* c *with.*

The treble response for the circuit without the added potentiometer is shown in Fig. 4-a. Note that the frequencies at which the response is cut or boosted 3 dB are about the same, regardless of the amount the control is offset from the flat position. Compare this with the curves in Fig. 4-b and c. By varying the setting of the added FORMANT or "presence" control, the maximum cut or boost, as well as the frequency at the ± 3 dB points, can be shifted above and below the usual points.

Korting demonstrated the new circuit to a number of European editors. A writer for *The Gramophone*, a British hi-fi magazine, reported that when the FORMANT control resistance is high and the treble control is set for medium boost, frequencies in the speech band between around 600 and 2000 Hz are emphasized without unnecessary boosting of the higher frequencies. When the FORMANT control resistance is low and the treble control set for maximum boost, we have a loudness-control effect. Soft background music has a wide frequency range and appears to come from a great distance.

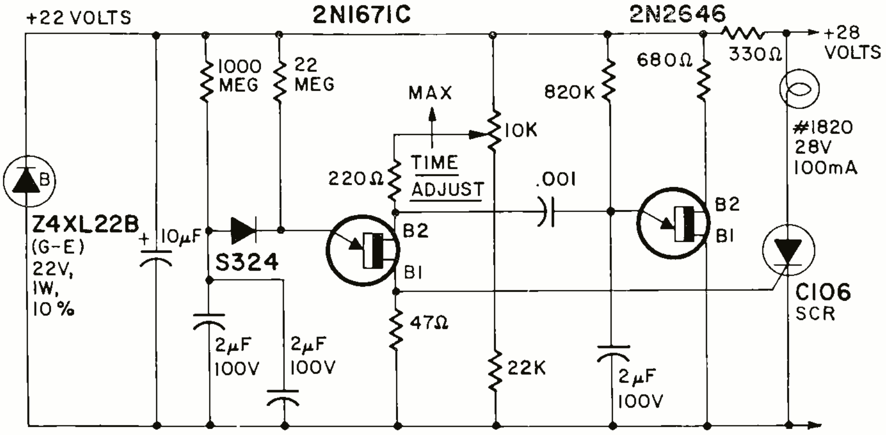
Forty-five-minute timer

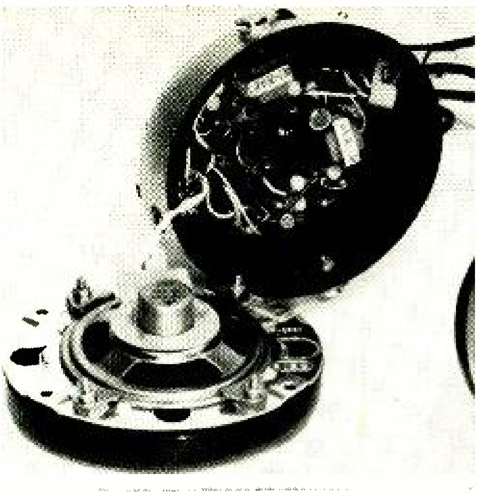
Clockworks are generally used for timers and time delays beyond around 2 minutes because the conventional RC timer network requires very large capacitors. The values required are generally available in electrolytics and their inherent leakage makes the circuit erratic and unreliable.

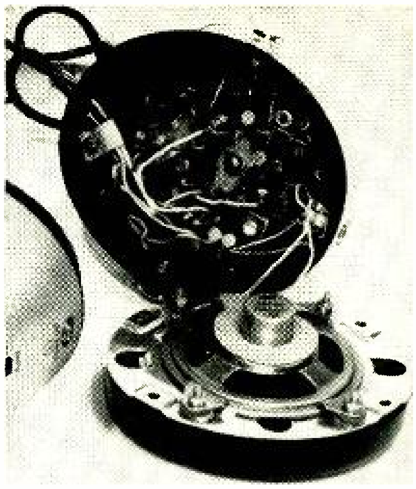
The timer in Fig. 5 provides delays up to 45 minutes without using electrolytics or expensive tantalum capacitors. Base 2 of the 2N1671C unijunction is fed a sampling pulse from the 2N2646. This effectively reduces the required trigger current to 1/1000 or less of the normal value. The S324 diode has leakage less than 0.1 nA.

This timer and a host of other interesting circuits will be found in *Application Information Sheet* 671.3 (3/66) from G-E's Semiconductor Products Department. **R-E**

Fig. 5—Time delays adjustable for up to 45 minutes are featured by this timer.







FM STEREO IN THIS HEADSET

These stereo headphones pack a surprise. There's an FM stereo solid-state receiver hidden inside!

By CHESTER H. LAWRENCE

WANT TO LISTEN TO SOMETHING REALLY DIFFERent? Then you've got to try the Panasonic Model RF-60. That's the code name for those special headphones adorning the head of that good-looking gal on this month's cover. If you haven't already looked, do so now.

Inside the rather conventional appearing headset is the flock of electronics you see at the top of this page. (The complete circuit is on the next page.) And it all adds up to a stereo FM receiver-headphone combination that sounds great.

The parts that make it go include five integrated circuits, three transistors and twelve diodes. The ingeneous part of the whole thing is how, except for the visible control or two, you wouldn't think there's anything really different going on.

Two telescoping antennas, one on each of the earpieces might cause you to startle bystanders if you took a walk down Main Street while wearing this set, but once you start listening, you'll find the performance even more startling.

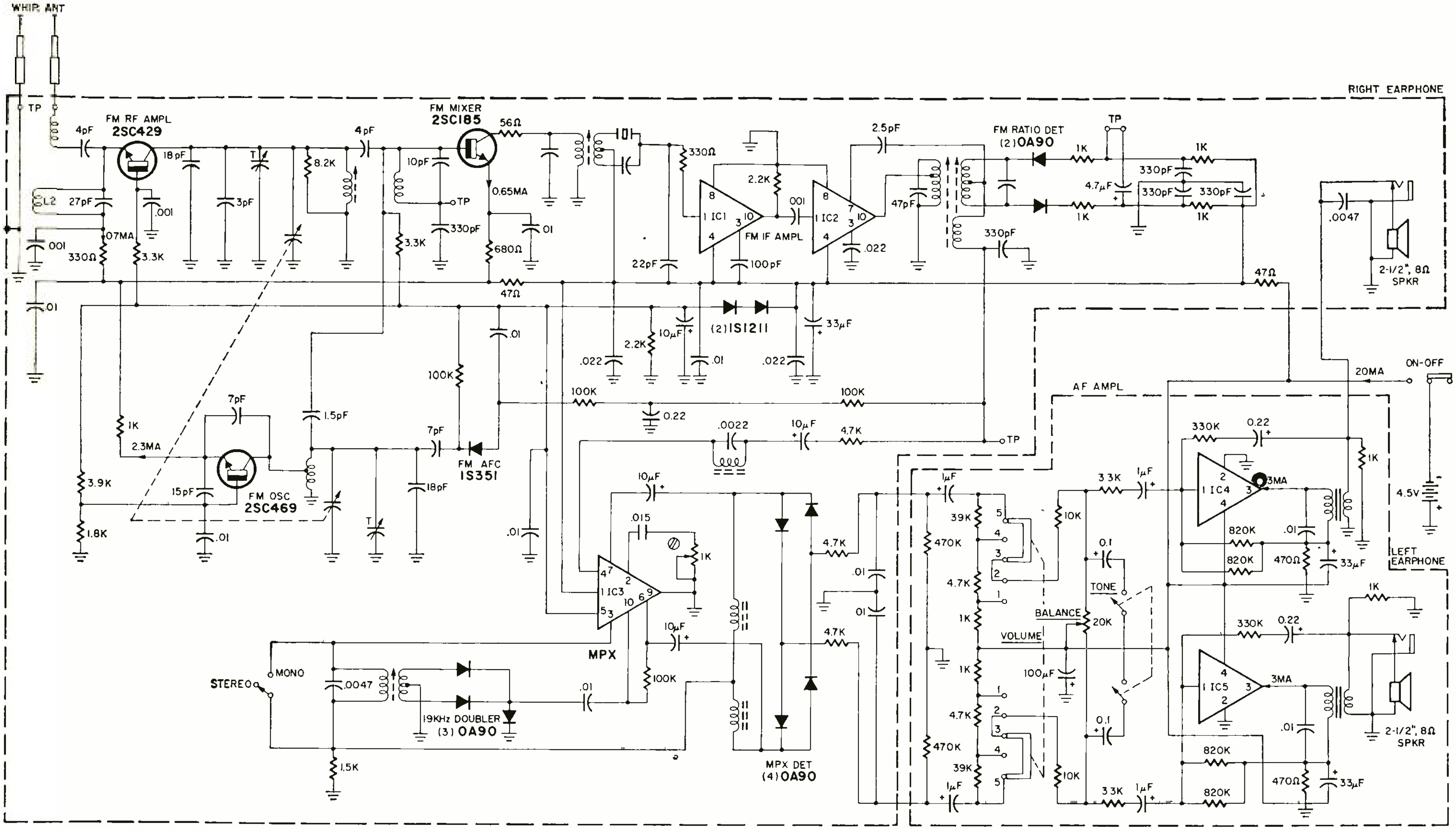
Physical construction is interesting. The three penlight cells that power the radio are inside a secret compartment inside the band that goes across your head. That's where you'll also find the protruding slide switches that turn the unit on and off and select the tone.

The station selector is easy to find. With the phones on just lift your right hand to your right ear. Turn the knob while listening to select the station you want. To tune the headset to some specific frequency you'll have to remove it or read backwards in the nearest mirror. The mono-stereo selector switch, another slide switch, is also here.

The other headset houses the balance control and the volume control. Don't look for a knob to turn to adjust volume though—it's a three-position slide switch and you pick either low, medium or high—according to station strength and ear durability.

The headset is heavy but comfortable and can be worn for long periods without it becoming disturbing.

Each headpiece also has a special output jack. Plug jumper cables between these output jacks and another set of ordinary stereo headphones and you and your favorite girl can do all the dancing you wish without the music disturbing anyone else. But enough. Now try them yourself. You may find it's a gas. R-E



Complete circuit of the Panasonic Stereo Headphone Receiver. It includes all features you would expect to find in a top-of-the-line console stereo receiver. The two-IC i.f. strip incorporates a crystal filter for greater selectivity. Limiting is built into the second IC. Afc is taken off the ratio detector. Another IC forms the heart of the multiplex circuit. Two IC's, one for each channel, form the complete audio amplifier and drive the speakers through output transformers.

TRANSISTOR COUNTER DECADE

THIS CIRCUIT MAKES AN EXCELLENT FREquency divider capable of high accuracy. It may be used to divide from 10 to 1 kc, for example, or from 1 kc to 100 cycles in counters and frequency calibrators.

Normally there is very little voltage across D1 so it conducts. This maintains the base bias at 10 volts positive, enough to block Q1. The signal pulses (which may be of 5-volt amplitude and 10-μsec duration) are negative, so they block D1. Therefore Q1 passes current to charge C1 during pulse intervals.

D2 is normally blocked by the positive potential (5 volts) applied to its cathode from the voltage divider. When the charge on C1 has risen to 5 volts, D2 conducts and a positive pulse is applied to Q2's base.

Q2 and Q3 form a regenerative combination. Normally Q2 is blocked because its base returns to −16 volts. With no flow through R2, the base of 3 is also biased to nonconduction.

The trigger pulse through D2 unblocks Q2 and results in current flow through R2. Q3 also conducts. This generates a positive pulse which is passed through D3 back to Q2 to drive it further into conduction, and so on. Q3 saturates quickly, discharging C1 to −10 volts.

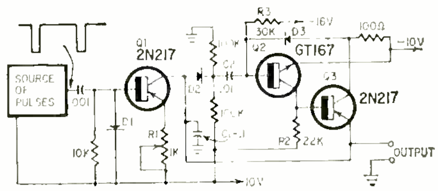


Fig.1

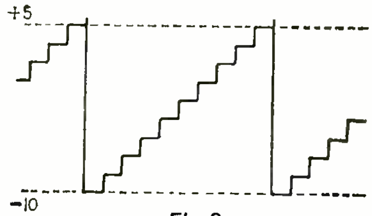


Fig.2

Fig. 2 shows that the trigger pulse (spike) is soon followed by a sudden drop to −10 volts across the output. Due to saturation, Q3 cannot recover immediately and it keeps C1 discharged throughout the pulse. Otherwise this same pulse would be included in the total count and result in error.

R1 controls the amount of current through Q1. Therefore it determines the amount of charge flowing into C1 (the height of each voltage step) during each signal pulse. For decade counting, and with the values shown in Fig. 1, it should be 300 ohms. This limits the charging current to 15 ma.

This circuit is described in patent No. 3,105,158, isued to Basil B. Nichols and assigned to Daystrom, Inc. **R-E**

RF CIRCUIT PROTECTION

In many transistorized converters and high-frequency front ends, especially those designed for mobile two-way radio and amateur applications, a potential condition exists which could easily destroy the input transistor. Figure 1 is a schematic of such a front end. When the transmitter is turned on the antenna changeover relay is supposed to short the receiver input to ground. Even if the relay does make excellent contact, a small signal is usually induced in the primary of the receiver's rf transformer, (T1) especially if the operating frequency is in the uhf region.

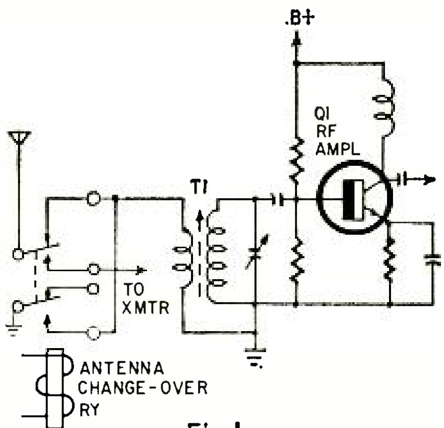


Fig.1

If, on the other hand, the relay makes poor contact, a substantially large signal can appear at this coil. Since T1 is a stepup transformer (usually 50Ω to 200Ω or so) approximately twice the primary voltage appears in the secondary between the base and emitter of Q1. Assuming the transmitter puts out only 10 watts into a 50Ω antenna, we have about 60 volts peak-to-peak at the antenna. Unless that shorting contact is pretty good, we can say goodbye to Q1, which can only take a maximum of 3-4 volts between base and emitter. Let's say that everything is working properly however. This condition still exists.

When S1 switches from transmit to receive, there is an instant when the receiver line is not shorted and the transmitter is still delivering power. This is due to the fact that the electrolytics in the transmitter take some time to discharge, therefore even if the transmitter supplies power for only 50 milliseconds (0.05 sec) after the relay opens, Q1 will still be destroyed by the high-voltage pulse produced.

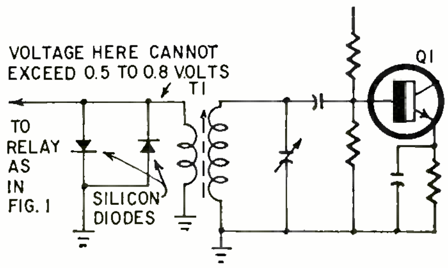


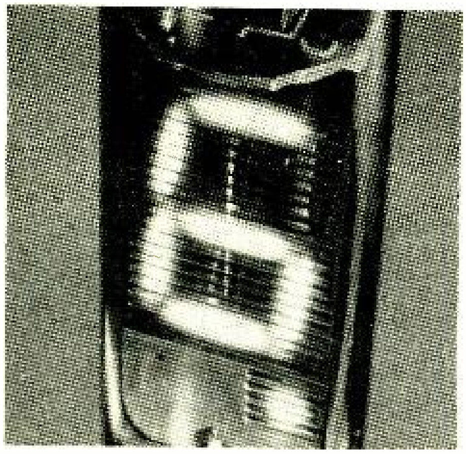
Fig.2

A simple method for protecting against accidental overloads of this nature is given in Fig. 2. Two silicon switching diodes are connected in parallel opposing across the input coil. These diodes exhibit extremely high forward resistances when the voltage applied to them is below 0.5 to 0.8 volt. Any higher voltage causes the diodes to conduct and the forward resistance drops to a couple of ohms. In this manner, the input voltage to the rf amplifier is always kept to a safe level. Any medium- to fast-speed silicon switching diodes can be used in this circuit. Germanium diodes do not have the same low-voltage characteristics and will not work.

—*Irwin Math*

FUN WITH ELECTRONICS

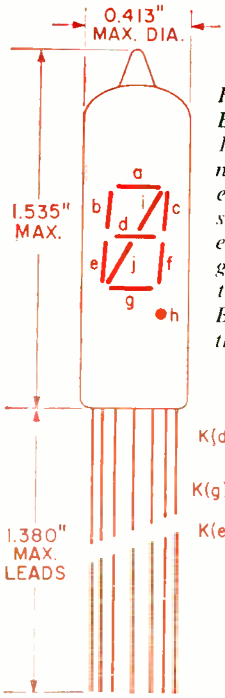
EXPERIMENT WITH DIGITAL READOUTS



New miniature indicator lamp displays both letters and numbers. Circuits show you how to get crisp, brilliant alphanumeric readouts

By JIM ASHE

THE RACE CONTINUES. BOTH SOLID-state and neon-glow alphanumeric indicators have their special advantages, but now the neons are coming on strongly in the form of some new subminiature indicators.



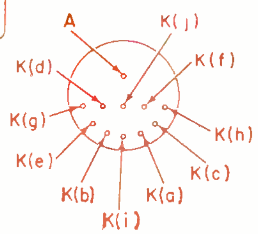


Fig. 1 (left)—Size of Elfin is just over 1½ inch. Each of the nine separate cathode elements are on the same plane. Dark elements make neon glow stand out (photo). Fig. 2 (below)—Base connections for the new indicators.

Alco Electronic Products Inc. (Lawrence, Mass.) recently introduced MG-19 Elfin indicators for small instrument work. Their crisp, bright red-orange images are adequate in almost any illumination.

How Elfins work

The new indicators are tiny but complex cold-cathode neon lamps. Unlike other similar devices, they offer a single-plane display composed of nine segments (Fig. 1). Depending on your needs, a fairly complex circuit may be required to decode a binary-coded decimal or other signal. But Elfin indicators can display many alphabetic as well as all numeric characters.

Each Elfin indicator bulb has 10 electrical connections (Fig. 2). Lead A is the common anode, and the other nine leads go to the segments shown in Fig. 1. If the anode is connected to about +200 volts and the cathode leads are grounded through a 220,000-ohm resistor, the segments will glow. The decimal point, a smaller element, requires a series resistor several times larger.

Electrically, the Elfin is merely a glorified neon lamp. However, its turn-on and turn-off voltages are considerably higher than ordinary neon lamps, perhaps as a result of a special gas mix for its "prolonged life span" specification. The manufacturer's specs appear in Table I. Notice the lower current for the

TABLE I
ELFIN SPECIFICATIONS

ANODE SUPPLY:	230V dc
BREAKDOWN:	+180V dc
CATHODE CURRENT:	
SEGMENT	500µA
DECIMAL PT.	200µA
AMBIENT TEMP:	-65°C – +70°C
DC PEAK CATHODE CURRENT:	
SEGMENT	4 MA.
DECIMAL PT.	200µA.
PULSED OPERATION PERMISSIBLE	

decimal point.

The brightness of these little indicators is quite surprising. This is partly due to the light-absorbent quality of the electrical elements, which provides a dark background area even when the Elfin is unmounted. But the neon glow is very bright in itself. Manufacturer's specs suggest 1 mA cathode current is not excessive, and tests at this level gave a brightness suitable for any ambient lighting short of direct sunlight. For longer life, the Elfins operate at several tens of microamps per cathode, but brightness is considerably reduced.

The operating curve I ran (Fig. 3) is provisional, since specified operating voltages are higher than those I obtained by testing preproduction samples I used.

This graph shows what we expect: for a given current there's a definite voltage across the lamp, and the voltage increases as the current rises in the usual operating range. Since neon lamps show a very sharp current—voltage dependence, we get this curve by varying the overall voltage through a large series resistor. I adjusted the current to 0.5, 1.0, and 1.5 mA, measured the voltage across the elements at each setting and checked at 0.2 mA for the decimal point. There was some variation between elements and from one tube to another.

Some basic circuits

Although Elfin firing and operating voltages look like something from a history book, it's not hard to generate adequate voltages at the required low currents. A gas regulator tube or two can provide stabilization. Since a voltage-regulator tube can handle up to 25 or 30 mA of output current, we can easily operate at least six Elfins at fairly high current levels.

Elfins are excellent for nearby or remote indication of switch position, servo function and other jobs where the control system consists of a switch assembly, a power supply and perhaps a lot of wire. With the diagram in Fig. 4 you can work out your own design for this purpose.

Here, each Elfin cathode element has a series current-limiting resistor, with the dot element (if used) having a larger resistor since it requires less current. A single resistor is not used in the anode element, as with Nixie tubes, because as different configurations of lighted elements are selected the total anode current varies. This simple switching system requires no diodes or other semiconductors. Simply wire the fixed contacts so all the appropriate elements are connected to ground for each switch position.

In this arrangement a separate switch wafer for each element is necessary. That works out to a seven- or a nine-wafer switch, and one position per character to be displayed. With diodes this complexity can be reduced to a single-wafer switch (see Fig. 5).

In position 1, only cathode K_a sees an electrical connection to ground. In position 2, only cathode K_b fires, in position 3 they both fire and so on. Design this system to your specs by choosing a given switch position and marking each intersection for the input line to the appropriate cathode. During assembly, wire a diode around each marked intersection.

If you don't understand what the diodes do, imagine one replaced by a piece of wire, and then run the switch through its positions. This is simply a diode matrix, requiring 49 diodes to read out the integers 0–9 from a single-pole 10-position switch. Power diodes rated at 200 PIV can be used in the matrix, rather than the more expensive signal diodes.

How about Elfin indicator control with solid-state switches? Nixies are sometimes controlled directly by the circuit shown in Fig. 6, but transistors for this application would need 200-volt V_{CEO} ratings. A catalog disclosed no possibilities of the small-signal, inexpensive variety. We will have to try strategy, and the answer appears back in Fig. 3, the measured EI curve.

By switching the Elfin between some off state of insufficient voltage to some on state of adequate current, the voltage swing can be low enough to be handled by ordinary transistors. A workable scheme appears in Fig. 7.

It works this way. Suppose switch S is closed. We have +90 volts from supply to ground through the switch. (If you feel uncomfortable about that, you're thinking about ordinary neon indicators that would be destroyed in this circuit.) Our measured EI characteristic shows there's no current flow with 90 volts applied. There will be about 0.8 mA flowing from ground to the minus supply. Then switch S is opened.

This gives us the sum of the positive and negative supply voltages applied to the Elfin indicator through at 150,000-ohm resistor. The Elfin fires, and the supply voltage goes to about 120 volts across the indicator, about 80 volts across the resistor, and perhaps 0.5 mA flowing. The upper switch contact falls from zero volts to −30 volts, acceptable to an ordinary transistor. We see this requires a pnp transistor.

Now let's do this with transistors. The complete indicator circuit appears in Fig. 8. Here, a bias resistor

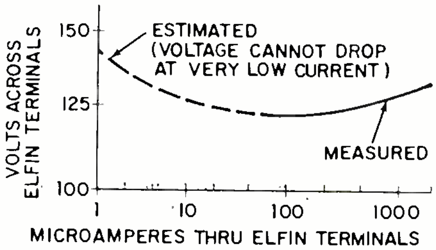


Fig. 3—Voltage-current characteristics measured from three preproduction Elfins.

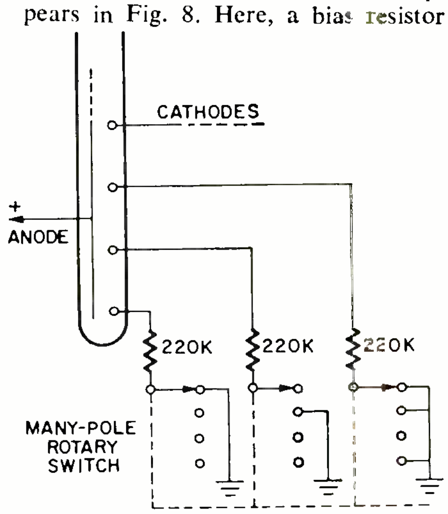


Fig. 4—Driving the Elfin from a multiple-wafer switch, at one wafer for each cathode.

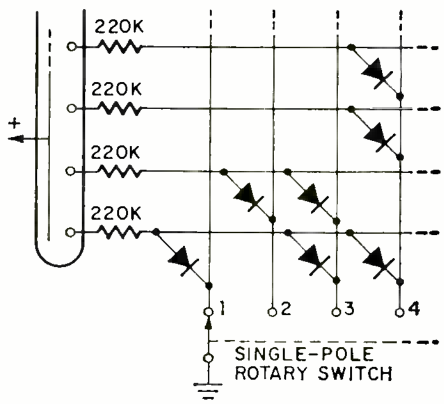
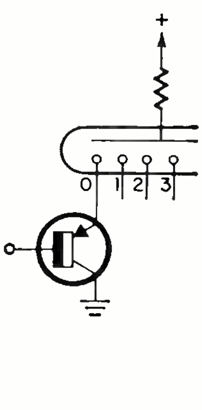


Fig. 5—Diode matrix arrangement permits use of single-pole switch to light tubes.



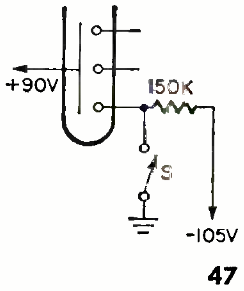


Fig. 6 (below, left)—Transistor switching arrangement possible with low-voltage Nixie tubes. Fig. 7 (below, right)—Firing voltage and typical setup to operate Elfins.

from base to minus holds each pnp transistor saturated until a turnoff signal is applied. This signal switches the transistor off, and its Elfin element lights up. Diodes D1, etc. prevent excessive transistor-base turnoff voltages, and may be omitted in many designs of known drive and transistor ratings.

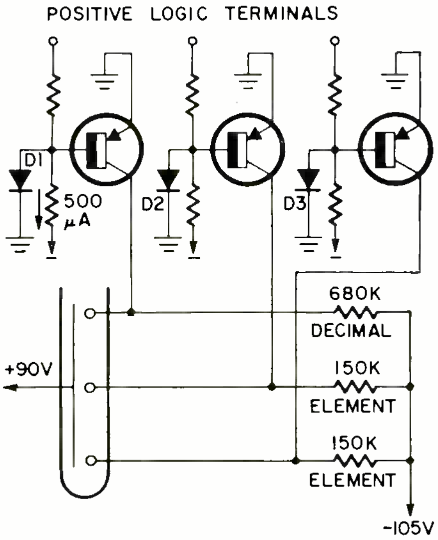
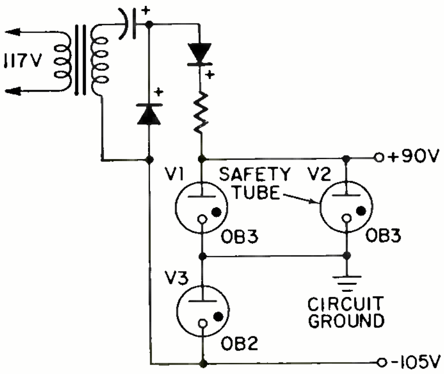


Fig. 8 (below left)—Transistor circuit for controlling Elfins. High V_{CE} is not needed, since transistors are clamped.

Fig. 9 (below)—Power supply for indicators can use extra VR tube for safety.



This circuit is controlled by positive logic, and since the transistor base terminals are clamped only a few hundred millivolts negative, we can easily use conventional positive-supply, positive-logic IC's. Now, if you want to drive the indicator from a parallel line at one lead per character, you can use the matrix idea previously mentioned to translate from character logic to element logic.

There are now lots of appropriate transistors. Since the V_{CEO} rating is a pessimistic one established under open-base connections, a 25-volt rating may be adequate. I'd choose at least 30 volts, and General Electric's 2N5365 transistor, prices at 55¢, is rated at V_{CEO} = 40 volts.

Fig. 9 shows a simple power supply circuit. If later samples of the Elfins turn out to have higher operating voltages than my preproduction samples, simply choose higher-voltage regulator tubes and review the design.

What if regulator V1 fails? That would overvolt the Elfins in turnoff, and we could expect a disastrous failure costing us an Elfin and many transistors per integer displayed. The answer is simple: simply add another similar tube in parallel with V1 and mark on the chassis which tube should fire in normal operation. If you check one day and the wrong tube is lit, your safety factor has diminished but is easily restored by a new VR tube. **R-E**

FET SQUARE-WAVE GENERATOR

FET's can be used to make an excellent square-wave oscillator (astable multivibrator), consuming little power, yet putting out a signal with an overall voltage swing equal to about 90% of the supply potential. The circuit in Fig. 1 is about as simple a multivibrator as can be made. The square-wave output has an overall voltage swing of 8 volts, and battery-power consumption is only 360 microamperes at 9 volts.

Output waveform is symmetrical for the component values given when the transistors are a matched pair. Check your FET's in the simple test circuit of Fig. 2, choosing a couple which have identical drain current for use in your square-wave oscillator. The value of the drain load resistors (R1 and R2) in any particular setup may be made equal to ½ the battery potential (in volts) divided by the measured drain current, expressed in amperes. This worked out to 18,000 ohms for the transistor pair used by the author.

Repetition rate is determined primarily by capacitor C1 and resistor R3 although it is affected to some extent by the battery voltage and by the characteristics of the particular transistors used. Thus, for any individual application, these values are best worked out experimentally. For the values given in Fig. 1, the author's

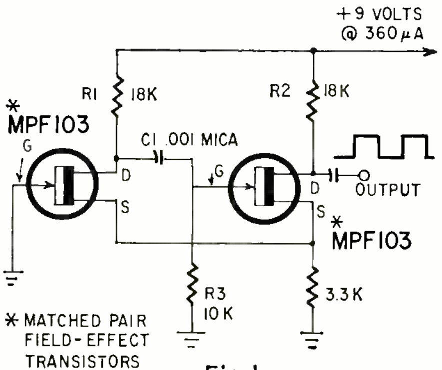


Fig. 1

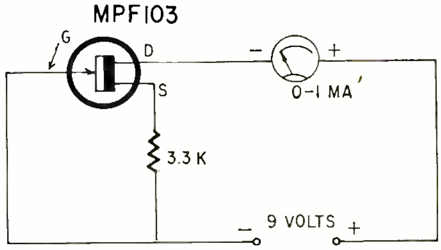
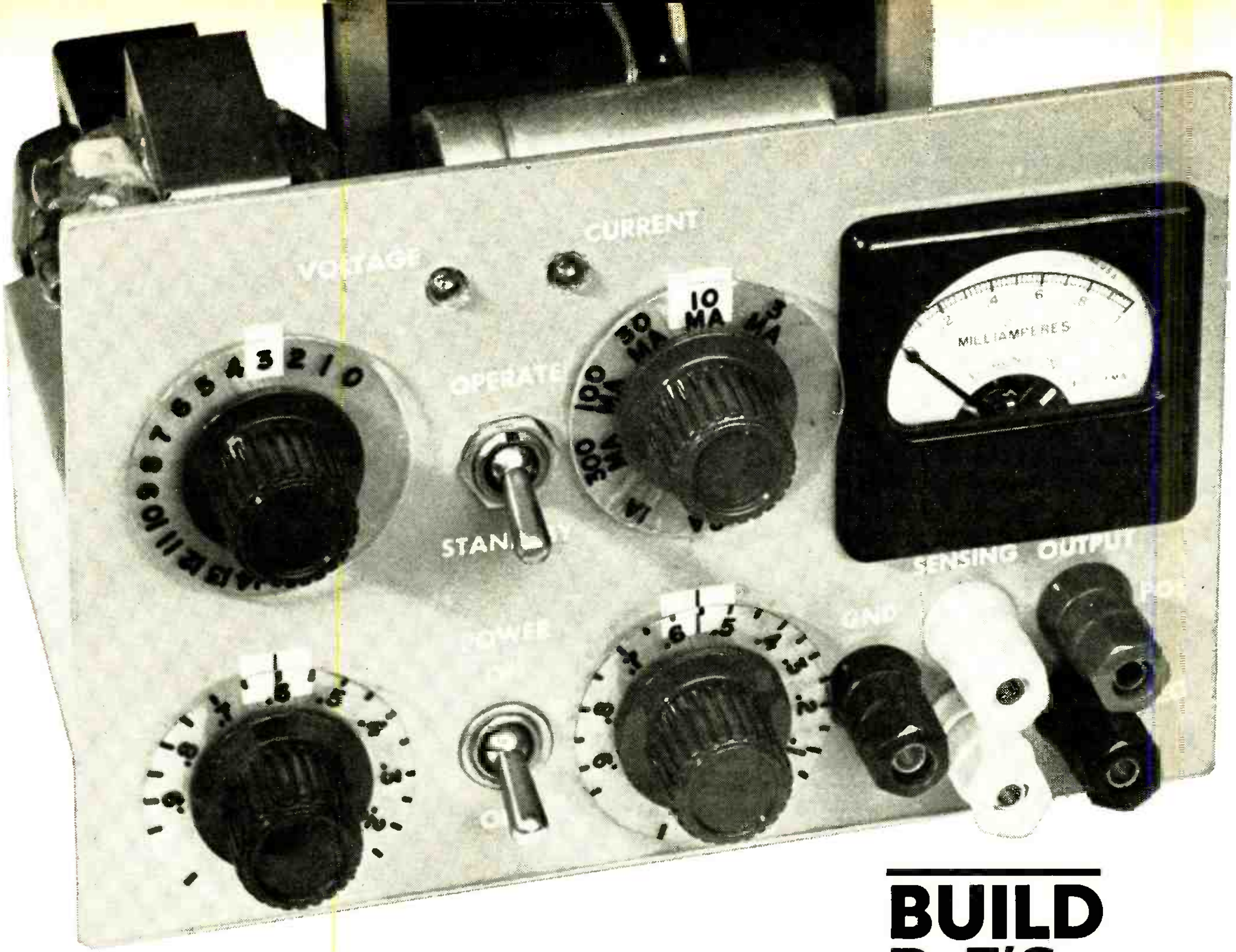


Fig. 2

setup had a repetition rate of about 15 kHz.

When the circuit was checked at 150 kHz, the leading edge of the waveform was found to be rounded. Such rounding is not an unusual phenomenon. Astable multivibrator circuits using bipolar transistors have this characteristic even at low frequencies. If it is objectionable in a particular application, it is easily eliminated by feeding the output of the multivibrator into a simple squaring circuit using a single bipolar transistor. At the high end of the audio-frequency spectrum, the waveform at the output of the circuit in Fig. 1 had insignificant rounding.

The oscillator may be synchronized by connecting a resistor between the gate of the left transistor and ground (instead of the direct ground connection), and feeding the sync pulse to the gate through a capacitor. This resistor should have as small a value as possible, since its presence degrades rise and fall time. And the sync signal should be no larger than needed to lock the oscillator in step, for it tends to appear superimposed on the output waveform.—*Frank H. Tooker*



BUILD R-E'S

IC LAB POWER SUPPLY

OP-amp regulator circuit maintains constant voltage and current

by LEONARD H. ANDERSON

EVER ZAP A BREADBOARD CIRCUIT that overloaded and your test supply had no current limiting? Or short the power leads and inhale the supply rectifier? And do you want to set voltage without squinting at a meter? Here is a power supply that ends these troubles. It has both voltage and current control, and is short-circuit-proof. Very accurate, it can be built to cover any voltage or current range you desire.

Key to its adaptability is a "standardized" control circuit using two linear integrated circuits and a handful of inexpensive components on a single printed-circuit board. Only an unregulated dc supply, a power transistor and a group of resistors are added to make a complete supply. These external components are tailored to fit your requirements. The same control circuit is used for any voltage or current range.

Flexibility is possible through "resistance programing." To understand this system better, let's look at some basic circuits. The most common type of constant-voltage supply is in Fig. 1-a. A high-gain error amplifier adjusts the base input of the series regulator transistor by comparing a reference voltage with a sample of the output. The purpose is to maintain a zero volt difference between inputs. Output voltage is varied by adjusting either divider resistor (R_{D1} or R_{D2}) but cannot be set lower than reference voltage.

Another constant-voltage supply is shown in Fig. 1-b. It has a different comparison circuit. Reference supply current I_R flows through resistors R_F and R_E. The error amplifier tries to balance the circuit so its inputs have zero voltage difference. Selecting a value for R_F that produces a voltage drop from I_R equal to the reference voltage keeps amplifier input voltage at zero—resistor voltage drop is opposite to reference polarity but equal in value. This balance holds only if the supply output voltage is equal to the reference-current voltage drop in R_E. By making the reference voltage and R_F fixed, output voltage is proportional to R_E.

Output voltage can be varied from zero to nearly raw-dc value with a linear change of voltage equal to linear change of resistance.

A constant-current regulator (Fig. 1-c) can use the same system. Here, load current produces a voltage drop in current range resistor R_S. Again, I_R times R_F is kept equal to the reference voltage. The circuit balances when the reference current drop through R_1 is equal to load current drop through R_S. Variation of R_1 is linearly proportional to output current. Unfortunately, under conditions of low current and high resistance in the load, some reference current will flow through R_S and produce an error—reference current in opposite direction to load current.

The upper limit of the output current is established by dissipation in R_s and error-amplifier voltage swing. Several values of R_s can be selected by a range switch. Potentiometer then controls current from zero to 100% of any range.

Both circuits (Figs. 1-b and 1-c) can be combined into one (Fig. 2-a). Reference currents are made equal. If the raw-dc supply voltage is greater than the sum of each reference voltage, the reference current bypasses R_s and eliminates this error possibility.

The CONTROL SELECTOR switch can be made automatic. It would use the positive-going oversetting amplifier signal. The differential-input emitter follower of Fig. 2-b is our "automatic switch." Its transistors must be complements of all other transistors; npn if all others are pnp. Regulator base drive is controlled by whichever input is the most positive.

Automatic switching is possible, thanks to the sharp-cutoff characteristic of silicon transistors when the base is less than +0.6 volt compared to the emitter. The conducting transistor of the pair in Fig. 2-b will establish an emitter-to-common voltage—by common-resistor voltage drop—that is 0.6 volt less than the controlling base input. The other transistor will not conduct until its base-to-common voltage is equal to or greater than the first transistor's base-to-common voltage. When the second transistor conducts, its base establishes a new emitter-to-common voltage and the first transistor's V_{BE} will be insufficient for conduction.

Both error amplifiers must have considerable voltage gain. There must always be some negative voltage on the output for series transistor conduction, so there will always be some input error. Amplifier gain must be at least 10,000 for millivolt regulation errors.

One common integrated-circuit (IC) amplifier is very good for this application. This is the 709. It is stable, not fussy about supply voltages, and has a minimum voltage gain of 15,000. Best of all it is available from several manufacturers.

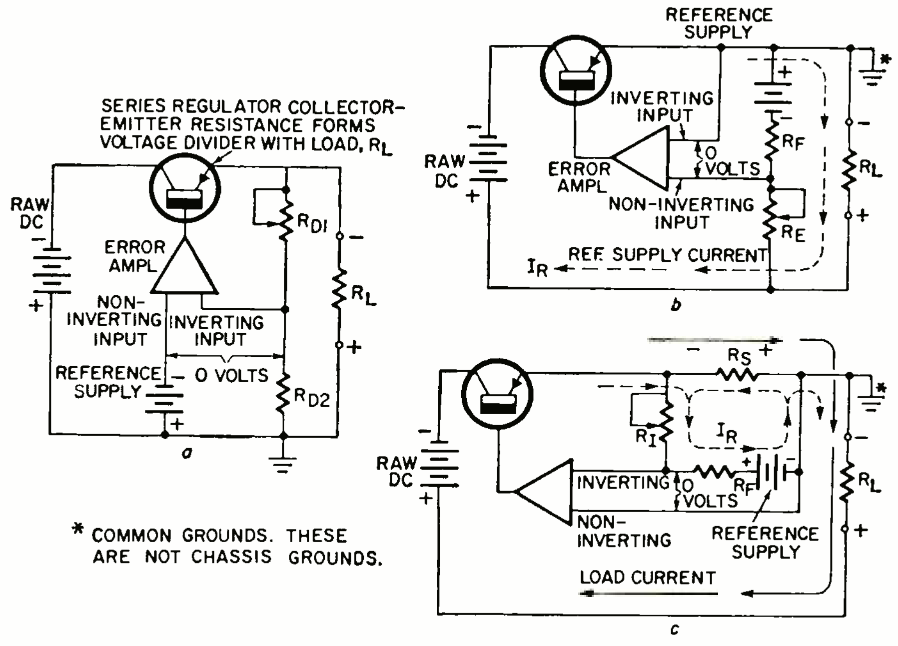


Fig 1-a—*A common constant-voltage regulator arrangement.* b—*Fully adjustable constant-voltage regulator.* c—*Adjustable constant-current regulator setup.*

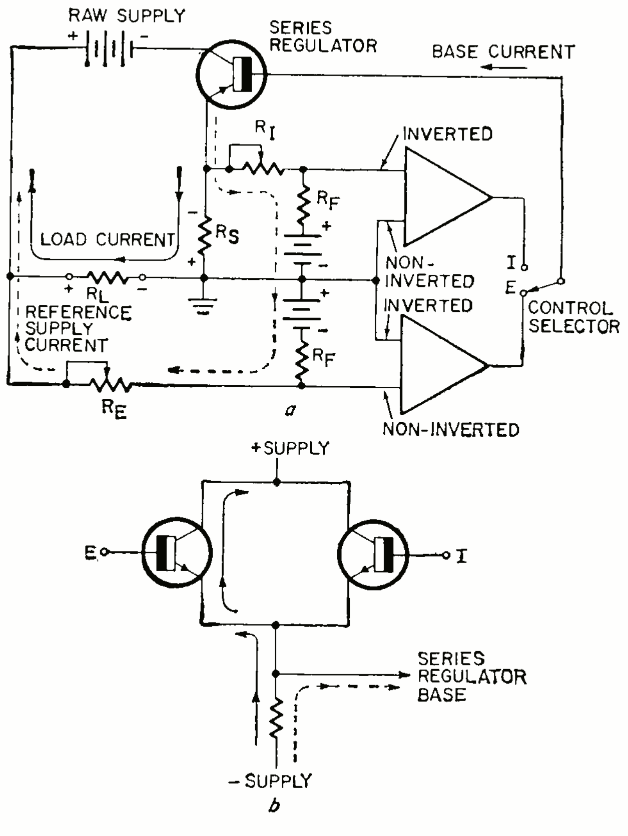


Fig. 2—Combining voltage and current regulating features of circuits above gives configuration used for the supply (a). *Error amplifiers (triangles) maintain constant current or voltage from the raw supply by maintaining zero voltage difference at their inputs and regulating base current of the series-regulator transistor. The differential-input emitter follower circuit in* b *is used for the selector switch, automatically switching in voltage and current error amplifiers.*

Theory into hardware

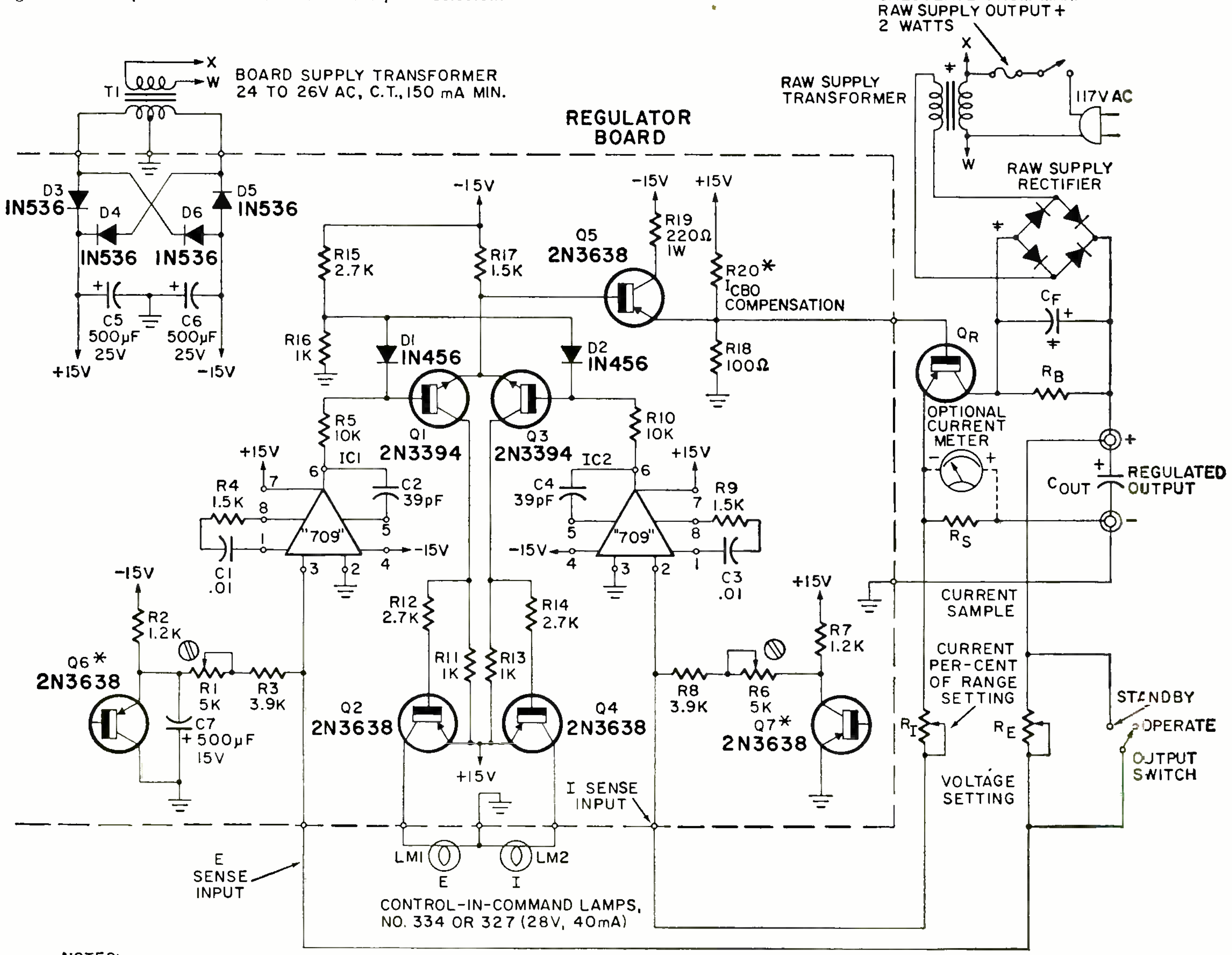
The complete power supply circuit is in Fig. 3. Circuitry inside the dotted lines is on the printed-circuit "regulator board." Circuitry outside of this area, except for the PC board supply transformer, deliberately does not have values or type numbers. All these values can be selected to fit any voltage or current range, any control configuration desired. The same regulator board will work with any combination. Selection and design rules are given later.

Voltage and current control circuits are symmetrical except for input polarity. Two additional circuits are included: emitter follower Q5 for greater series-transistor base drive, and lamp drivers Q2 and Q4 for control-in-operation indication.

Reference supply "Zeners" Q6 and Q7 are reverse-connected 2N3638 transistors with bases open. The reversed-bias collector–emitter junction of a 2N3638 delivers excellent temperature-compensated Zener action at 6 mA and about 6.5 volts. A conventional Zener diode can be used but costs two to five times as much.

Reference current is 1 mA for control-resistance values of 1000-ohms-per-volt. Trimmer potentiometers R1 and R6 allow calibration to exact current. Voltage-reference Zener Q6 has an added bypass capacitor to filter out regulator supply ripple voltage.

Fig. 3—Complete schematic for the IC, lab-quality power supply. Voltage/current capabilities can be varied with parts selected.



NOTES:
1. POLARITIES GIVEN FOR PNP SERIES REGULATOR.
2. RESISTORS ±10%, 1/4W UNLESS NOTED.
3. SEE TEXT NOTES FOR VALUES NOT INDICATED.
4. BASES NOT CONNECTED ON Q6 & Q7

✱ SEE TEXT
✚ SEE TABLE I

PARTS LIST FOR FIGURE 3

Components marked with * have alternates and are described in the text.

R1, R6—5000 ohms (PCB-mounting trimmer potentiometer, Bourns type 3067-P "E-Z Trim" or equivalent)*
R2, R7—1.2K*
R3, R8—3.9K*
R4, R9, R17—1.5K
R5, R10—10K
R11, R13, R16—1.0K
R12, R14, R15—2.7K
R18—100 ohms
R19—220 ohms, 1 Watt
R20—12K*
R_E, R_I, R_S, R_B—Depend on voltage and current ranges chosen*

Unless otherwise specified, resistors are ±10%, 1/4 Watt.
C1, C3—.01 μF, 25 V or greater, disc ceramic
C2, C4—39 pF, 25 V or greater, disc ceramic
C5, C6—500 μF, 25 V, electrolytic
C7: 500 mF, 15V, electrolytic
C_F, C_{out} depend on voltage and current ranges chosen*
D1, D2—Any small-signal diode with high back resistance, 1N456 or equivalent
D3 thru D6—Any rectifier with 200 mA I_{FWD} and 50 piV or greater, 1N536 or equivalent
Raw-DC Supply Rectifier—depends on voltage and current ranges chosen*
IC1, IC2—Motorola MC1709CG or Fairchild U5B770939X

Q1, Q3—2N3394 for PNP series transistor, 2N3702 for NPN series transistor, or their equivalents*
Q2, Q4, Q5—2N3638 for PNP series transistor, 2N3708 for NPN series transistor
Q6, Q7—2N3638
Q_R—Depends on voltage and current range selected*
T1—Transformer: 24 to 26 V rms, ct, 200 mA, Triad F-45X or equivalent.
TS1—Terminal strip, 6 terminals (H. H. Smith 3006)
TS2—Terminal strip, 3 terminals (H. H. Smith 3003)
LM1, LM2—subminiature lamps, 28 V, 40 mA, (No. 334 or 327)

Capacitors C1–C2–R4 and C3–C4–R9 establish frequency and phase response of the IC amplifiers. R5 and R10 limit amplifier output current and aid control switching action.

"Base-catcher" diodes D1 and D2 limit negative excursions of the control switch bases to prevent reverse base–emitter breakdown. Divider R15–R16 establishes clamping level.

Lamp driver turn-on is supplied by the voltage drop of R11 or R13 from the conducting switch transistor. Output current to the lamps is limited via series base resistors R12 and R14.

Transistor Q5 permits up to 50 mA of series-regulator transistor base drive. Resistor R19 reduces dissipation within Q5 by lowering V_{CB} on high-current conditions. Resistors R18 and R20 provide I_{CBO} compensation for the series transistor. Values are fairly typical but an I_{CBO} check is detailed later. Collector–base leakage current increases with temperature and acts the same as drive current from Q5—R20 shunts most of the leakage current to +15-volt supply.

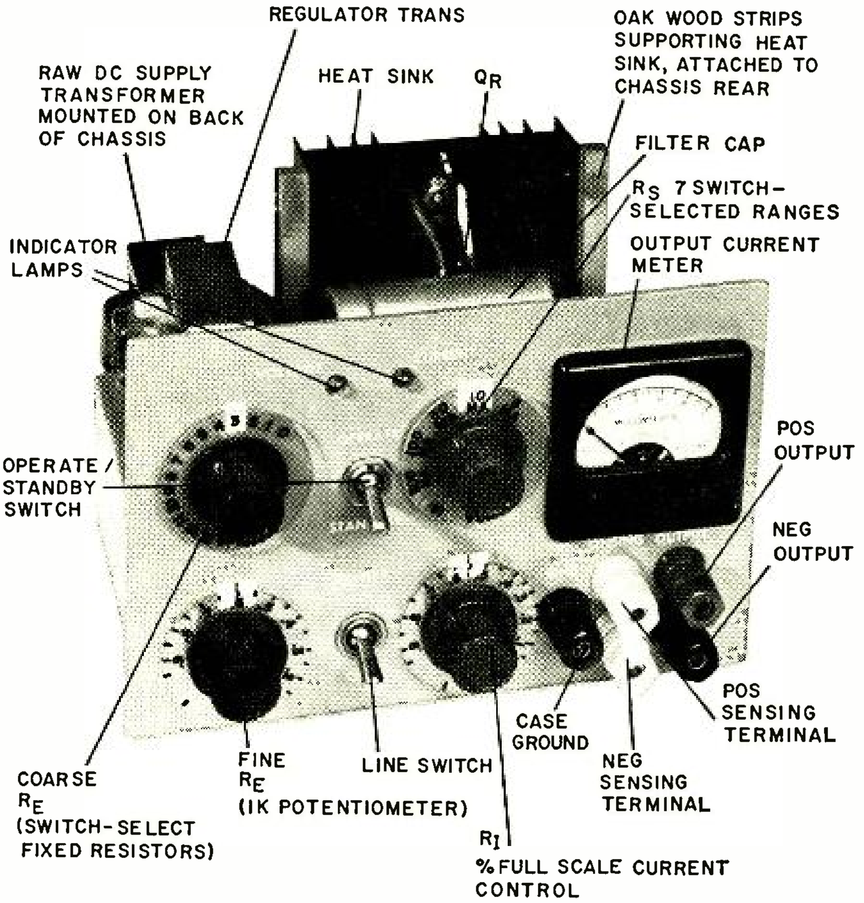
Any supply transformer with a secondary voltage rating from 24 to 26 volts rms, center-tapped, is suitable.

Flexibility within the regulator board circuitry is also possible. All transistor types are shown for a pnp series transistor. With an npn series transistor, all polarities, voltages, diodes and transistor types are reversed. However, 709 supply voltage and input connections must remain the same. The board layout drawing in Fig. 4 shows both arrangements.

Conventional Zener diode installation and an option for fixed calibration resistors are also in Fig. 4. Calibration is done only once but trimmers are recommended for easy adjustment.

Many transistors will fit the circuit, and any units with breakdown voltages of at least 18 volts and frequency response exceeding 10 MHz can be used. Transistors Q2, Q4 and Q5 must have 250 mW dissipation and current gain minimum of 20 while Q1 and Q3 must have an h_{FE} minimum of 50 at 10 mA.

Any Zener diode of 5 to 9 volts can be used but the associated resistors must be selected for proper Zener current and 1-mA reference current.



Author's 14-volt, 2-amp supply set for 3.6V, 5.5 mA (55% of the 10-mA range).

External circuit design

Because of the great variety of ranges possible, only design rules are given. A listing of suitable components for various voltage and current ranges is in Table I. But any components meeting design specifications will work.

Maximum output voltage is established by the raw-dc supply transformer secondary voltage. This is computed by:

$$V_{out}\,(max) = 1.23E - 2.5$$

(Note: In this and following calculations, E is transformer secondary voltage in ac rms and I is maximum dc amperes desired from completed power supply.)

If output voltage is known and the transformer is to be selected, its minimum voltage is:

$$E = 0.81V_{out}\,(max) + 2.0$$

Rectifier forward current should be equal or greater than maximum dc output. The piv rating for a bridge circuit must exceed 0.7E, and 1.4E for full-wave, center-tapped or half-wave circuits.

The filter capacitor is computed from:

Table I—Suitable Components and Values for Various Voltage and Current Ranges

Any equivalent part or parts meeting specifications called out in text may be substituted for those listed. Other ranges may be used with appropriate components. ! mark beside current range indicates maximum controlable current with h_{FE} of listed transistor. Other maximum current ranges determine transistor power dissipation and heat sink size.

MAXIMUM RANGE	TRANSFORMER SECONDARY RATING	BRIDGE RECTIFIERS	FILTER CAPACITOR	SERIES TRANSISTOR	MAXIMUM DISSIPATION (WATTS) & TEMP. RISE (°C) WITH WAKEFIELD ENGR. HEAT SINK NO.
5 V, 2 Amp	6.3 V @ 3A	1N253	8200 µF, 10 V	2N555	12 w, 28°/NC403A
5 V, 4 Amp!	6.3 V @ 6A	1N1612	18,000 µF, 10 V	2N2156	24 w, 32°/NC421B
13 V, 2 Amp	12.6 V @ 3A	1N253	4000 µF, 25 V	2N555	29 w, 30°/NC423A
13 V, 3 Amp!	12.6 V @ 5A	1N253	6000 µF, 25 V	2N3613	44 w, 39°/NC423A
13 V, 4 Amp!	12.6 V @ 5A	1N1612	8500 µF, 25 V	2N2156	58 w, 33°/NC441K
20 V, 1 Amp	18 V @ 3A	1N253	2100 µF, 30 V	2N555	22 w, 30°/NC421A
20 V, 3 Amp!	18 V @ 6A	1N253	5500 µF, 40 V	2N3312	65 w, 38°/NC441K
45 V, 1 Amp	36 V @ 3A	1N253	950 µF, 75 V	2N3442	48 w, 56°/NC421A
96 V, 500mA	80 V @ 1.2A	1N253	200 µF, 150 V	2N3442	53 w, 58°/NC421A
*155 V, 162mA	50 VA 1:1	1N4364	150 µF, 250 V	2N3583	25 w, 58°/NC403K
*200 V, 120mA	150 V 750 mA	1N4365	100 µF, 250 V	2N3584	25 w, 50°/NC403K
*250 V, 100mA	184 V @ 260mA	1N4365	100 µF, 350 V	2N3585	25 w, 50°/NC403K

**Filter capacitance increased to reduce ripple and increase maximum avail. output volt.*
All germanium transistor case-temperature-rise-above-ambient values held to 40° C maximum.

$$C_F\ (\mu F) = \frac{25{,}000\ I}{E}$$

This is a minimum value for 12% maximum ripple, full-wave rectification, and 60-Hz line frequency. For half-wave rectification, double the value. Increase each value by 20% for 50-Hz line frequency. Working voltage rating must be at least 1.4E.

Series transistor current gain h_{FE} must be enough to meet maximum dc output current with 50-mA base drive. For example, a 2-amp output requires a minimum h_{FE} of 40. Be careful of manufacturers' rating sheets. Minimum h_{FE} given does not necessarily occur at maximum collector current.

An extra emitter follower can be inserted between the regulator board and the series transistor to boost drive. Power dissipation for the extra transistor must be within ratings, and I_{CBO} compensation must be made.

Power dissipation in series regulator transistor Q_R will be maximum at zero voltage and maximum current settings. This determines the degree of heat sinking required and is computed by:

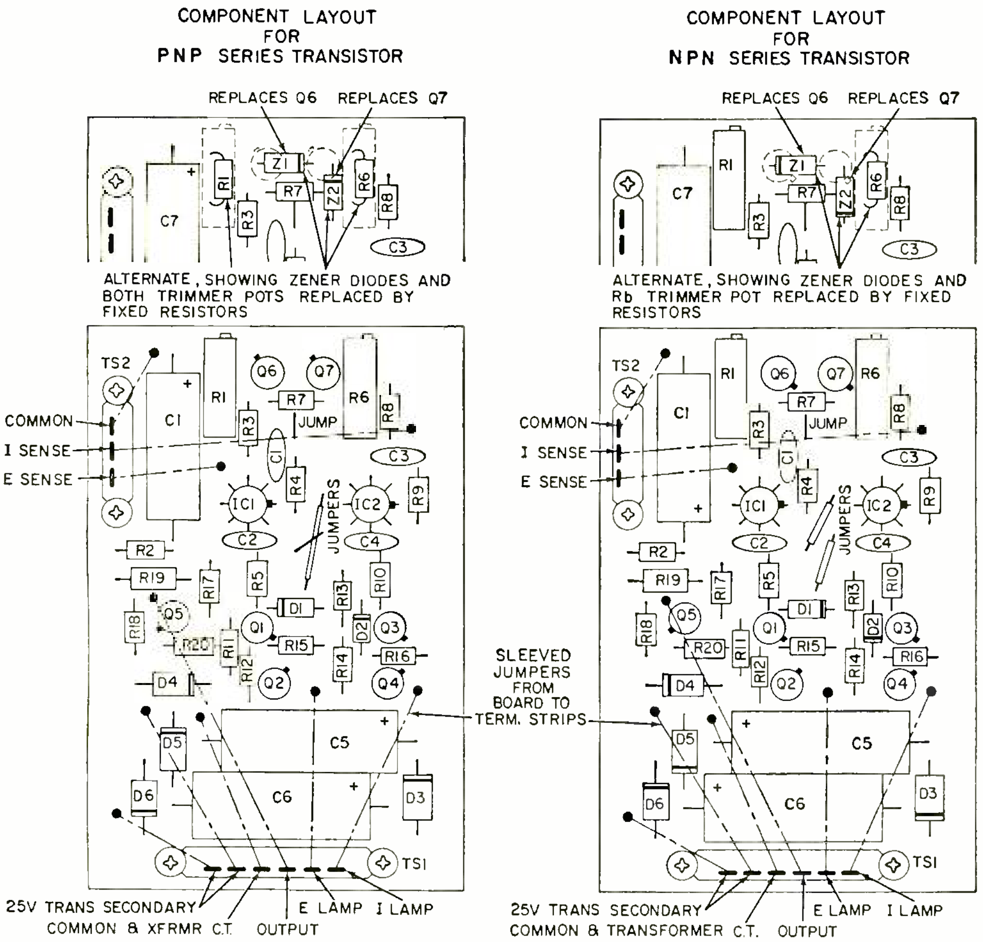
$$\text{Dissipation (Watts)} = I\,(1.32E - 2.1)$$

Transistor case temperature must be kept within maximum ratings. Dissipation and heat-sink area determine case temperature rise above ambient temperature. Allowable dissipation decreases as temperature increases. Most TO-3 diamond-case transistors must be derated 1 watt per °C above 25°C. For example, 20 watts dissipation from a transistor rated at 50 watts at 25°C requires a heat sink large enough to limit case temperature to 55°C. **R-E**

NEXT MONTH

Next month, the tolerances and accuracy of the control and sensing circuitry will be described. Also, detailed calibration and test procedures for power supply are outlined.

Fig. 4—Circuit board parts layouts for pnp and npn regulator transistors. The alternate drawings show how "Zeners" Q6 and Q7 can be replaced by standard types.



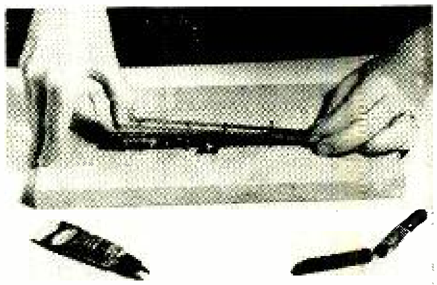
REPAIRING FERRITE RODS

One common casualty in a dropped transistor portable is the brittle ferrite core of the antenna. Replacement can be a serious problem. If you're stuck, you can rejoin the broken pieces with almost any good adhesive. Performance is not noticeably affected.

Best for the job are the epoxy-resin cements, but ordinary acetate service cement will do. Even "white glue" (like Elmer's) has been used successfully.

About the only way to apply pressure along the rod to keep the two pieces together while the glue dries, and at the same time apply lateral force to keep the joint from buckling, is to whip up a little jig like that in the photos. Drive small brads into a scrap of board—two rows, spaced the width (or diameter) of the ferrite rod, and each nail spaced about an inch. Leave room on the board for another set of brads, to accommodate a core size that won't fit the first.

Bring the two glue-coated ends together and lay the rod between the



rows of brads. Now stretch a sturdy rubber band around the rod and nails. Lay the whole thing aside out of the way to dry.

For high curing temperatures, you will have to fabricate a jig out of metal. Follow the glue manufacturer's directions about setting and curing time and temperatures.

When the repair is dry, smooth off bits of dried cement with a file and sandpaper. Be careful not to stress the joint too much, or it may come apart again.

Hollow ferrite cores usually have too little surface exposed to make a strong glued joint. To repair those, shape a plastic or wooden dowel to fit the hollow core. Coat it with glue; it will act as a splint and strengthen the joint tremendously. Don't use a metal rod.

Much of this material comes from *Werkstatt Praxis*, a service publication of Siemens-Electrogerate AG, Berlin and Munich.—*Peter E. Sutheim*

Better than 9 out of 10 CIE men win their "ticket" the very first time they try

(NATIONAL AVERAGE IS ONLY 1 OUT OF 3)

Cleveland Institute of Electronics

WARRANTY

of success in obtaining a Government FCC License

The Cleveland Institute of Electronics hereby warrants that upon completion of the Electronics Technology, Broadcast Engineering, or First-Class FCC License course, you will be able to pass the FCC examination for a First Class Commercial Radio Telephone License (with Radar Endorsement);

OR upon completion of the Electronic Communications course you will be able to pass the FCC examination for a Second Class Commercial Radio Telephone License;

AND in the event that you are unable to pass the FCC test for the course you select, on the very first try, you will receive a FULL REFUND of all tuition payments.

This warranty is valid for the entire period of the completion time allowed for the course selected.

G. O. Allen

You can earn more money if you get an FCC License

...and here's our famous CIE warranty that you will get your license if you study with us at home

NOT SATISFIED with your present income? The most practical thing you can do about it is "bone up" on your electronics, pass the FCC exam, and get your Government license.

The demand for licensed men is enormous. Ten years ago there were about 100,000 licensed communications stations, including those for police and fire departments, airlines, the merchant marine, pipelines, telephone companies, taxicabs, railroads, trucking firms, delivery services, and so on.

Today there are over a million such stations on the air, and the number is growing constantly. And according to Federal law, no one is permitted to operate or service such equipment without a Commercial FCC License or without being under the direct supervision of a licensed operator.

This has resulted in a gold mine of new business for licensed service technicians. A typical mobile radio service contract pays an average of about $100 a month. It's possible for one trained technician to maintain eight to ten such mobile systems. Some men cover as many as fifteen systems, each with perhaps a dozen units.

Coming Impact of UHF

This demand for licensed operators and service technicians will be boosted again in the next 5 years by the mushrooming of UHF television. To the 500 or so VHF television stations now in operation, several times that many UHF stations may be added by the licensing of UHF channels and the sale of 10 million all-channel sets per year.

Opportunities in Plants

And there are other exciting opportunities in aerospace industries, electronics manufacturers, telephone companies, and plants operated by electronic automation. Inside industrial plants like these, it's the licensed technician who is always considered first for promotion and in-plant training programs. The reason is simple. Passing the Federal government's FCC exam and getting your license is widely accepted proof that you know the fundamentals of electronics.

So why doesn't everybody who "tinkers" with electronic components get an FCC License and start cleaning up?

The answer: it's not that simple. The government's licensing exam is tough. In fact, an average of two out of every three men who take the FCC exam fail.

There is one way, however, of being pretty certain that you will pass the FCC exam. And that is to take one of the FCC home study courses offered by the Cleveland Institute of Electronics.

CIE courses are so effective that better than 9 out of every 10 CIE-trained graduates who take the exam pass it. That's why we can afford to back our courses with the iron-clad Warranty shown on the facing page: you get your FCC License or your money back.

There's a reason for this remarkable record. From the beginning, CIE has specialized in electronics courses designed for home study. We have developed techniques that make learning at home easy, even if you've had trouble studying before.

In a Class by Yourself

Your CIE instructor gives his undivided personal attention to the lessons and questions you send in. It's like being the only student in his "class." He not only grades your work, he analyzes it. Even your correct answers can reveal misunderstandings he will help you clear up. And he mails back his corrections and comments the same day he receives your assignment, so you can read his notations while everything is still fresh in your mind.

It Really Works

Our files are crammed with success stories of men whose CIE training has gained them their FCC "tickets" and admission to a higher income bracket.

Mark Newland of Santa Maria, Calif., boosted his earnings by $120 a month after getting his FCC License. He says: "Of 11 different correspondence courses I've taken, CIE's was the best prepared, most interesting, and easiest to understand."

Once he could show his FCC License, CIE graduate Calvin Smith of Salinas, California, landed the mobile phone job he'd been after for over a year.

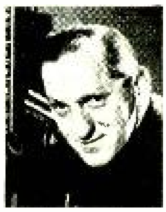
Mail Card for Two Free Books

Want to know more? The postpaid reply card bound-in here will bring you free copies of our school catalog describing opportunities in electronics, our teaching methods, and our courses, together with our special booklet, "How to Get a Commercial FCC License." If card has been removed, just mail the coupon at right.

THESE CIE MEN PASSED THE FCC LICENSE EXAM . . . NOW THEY HAVE GOOD JOBS

Matt Stuczynski, Senior Transmitter Operator, Radio Station WBOE

"I give Cleveland Institute credit for my First Class Commercial FCC License. Even though I had only six weeks of high school algebra, CIE's AUTO-PROGRAMMED® lessons make electronics theory and fundamentals easy. I now have a good job in studio operation, transmitting, proof of performance, equipment servicing. Believe me, CIE lives up to its promises."



Chuck Hawkins, Chief Radio Technician, Division 12, Ohio Dept. of Highways

"My CIE Course enabled me to pass both the 2nd and 1st Class License Exams on my first attempt...I had no prior electronics training either. I'm now in charge of Division Communications. We service 119 mobile units and six base stations. It's an interesting, challenging and rewarding job. And incidentally, I got it through CIE's Job Placement Service."

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.

Cleveland Institute of Electronics
1776 E. 17th St., Cleveland, O. 44114

Please send me without cost or obligation:

Your 40-page book "How To Succeed In Electronics" describing the job opportunities in Electronics today, and how your courses can prepare me for them.

Your book on "How To Get A Commercial FCC License."

I am especially interested in:

- ☐ Electronics Technology
- ☐ Electronic Communications
- ☐ Broadcast Engineering
- ☐ Industrial Electronics
- ☐ First Class FCC License
- ☐ Electronics Engineering

Name ________________ (PLEASE PRINT)

Address ________________

City ________________

State ________ Zip ______ Age ____

☐ Check here for G.I. Bill information

RE-63

2 NEW CIE CAREER COURSES

1. **BROADCAST (Radio and TV) ENGINEERING**...now includes Video Systems, Monitors, FM Stereo Multiplex, Color Transmitter Operation and CATV.

2. **ELECTRONICS ENGINEERING**...covers steady-state and transient network theory, solid state physics and circuitry, pulse techniques, computer logic and mathematics through calculus. A college-level course for men already working in Electronics.

CIE Cleveland Institute of Electronics
1776 East 17th Street, Cleveland, Ohio 44114

Circle 25 on reader service card

BUILD ANOD—AN AUDIBLE NOISE OVERRIDE

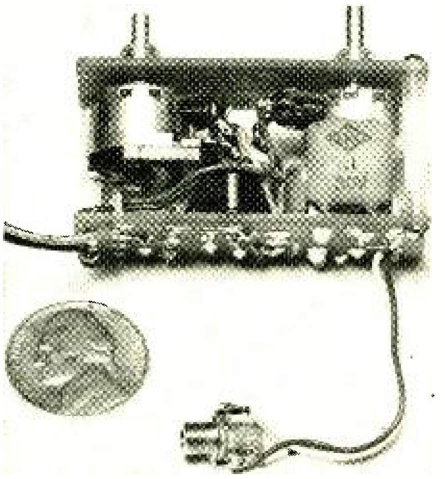
Have peace and quiet in the midst of distracting noise

By RICHARD W. BAILEY

HERE IS A SIMPLE DEVICE THAT ALLOWS a person to work or relax in an area that has a considerable amount of ambient random noise. Its principle is based on the assumption that a person is able to concentrate in a high-noise area if the noise is constant or monotonous. For example, a person easily can become accustomed to the noise from an electric motor running under a constant load, although the sound may be quite loud. However, a television or radio set with its random noise may be very bothersome. The circuit is fairly simple, enabling you to build a small and inexpensive device that can significantly reduce this problem of random noise. The device generates a monotone signal in a headset at a volume sufficient to drown out any random noise present. The frequency of the signal as well as the volume are adjusted to individual tastes.

Fig. 1 is the schematic diagram of "ANOD" (*A*udible *N*oise *O*verride *D*evice). A variable-frequency blocking oscillator drives a crystal headset. To understand the operation of the circuit, refer to the timing chart of Fig. 2 along with Fig. 1.

Assume capacitor C1 is initially charged at time t1. The plate of C1 that is connected to the base of transistor Q is assumed to be positive with respect to ground so that Q is cut off. Shortly after time t1, C1 begins to discharge. The discharge paths are through R1–R2, R3, base-emitter diode Q and the battery.



Ohio State University

These rather complicated discharge paths make calculating discharge time C1 rather involved. Qualitatively, however, at time t2, C1 has discharged enough so that the base of Q becomes slightly negative owing to current flow in R1–R2. At this instant, Q turns on. The collector current in Q increases and the potential at the collector starts downward.

The heart of the blocking oscillator is a subminiature driver transformer (T) with a 10,000-ohm primary and 2,000-ohm center-tapped secondary. In this application, T is connected backwards so the 2,000-ohm center-tapped winding is used as the primary.

The collector load is one half of the primary of audio transformer T. As the current increases in this half of the primary of T, a voltage is induced in the other half of the primary. That voltage is coupled via C1 back to the base of Q. This voltage is 180° out of phase with the collector voltage and thus is of such phase as to forward-bias Q. This regenerative action continues until C1 charges enough to cut off Q (time t3). The cycle then repeats itself.

The secondary of T is used to drive the headset. Resistors R4 and R5 along with capacitor C2 form an integrating network that smooths the pulse waveform generated by the oscillator, and thus produces a more pleasant tone. R2 is the tone control which varies the frequency of oscillation. R5 is the volume control. **R-E**

COMING NEXT MONTH

Begin a regular feature of special tear-out articles that you can clip and insert in a handy binder to start compiling your new **R-E Reference Annual.** Next month you'll get an 8-page tear-out on pliers and cutters.

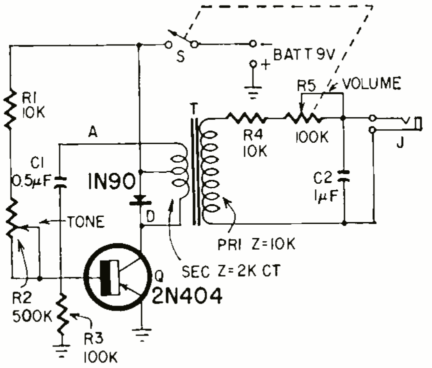


Fig. 1—A variable-frequency oscillator is used to drive a headset at level needed.

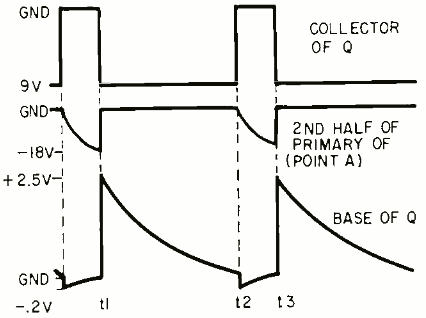


Fig. 2—Waveforms show timing relationship between the collector and base of transistor Q and the transformer primary.

PARTS LIST

R1, R4—10,000 ohms, 1/4 watt
R2—Pot, 500,000 ohms, 0.2-watt (Clarostat 44-500K-W, or equiv.)
R3—100,000 ohms, 1/4 watt
R5—Pot, 500,000 ohms with spst switch (Clarostat 44S-500K-W or equiv.)
C1—.05 μF, 30 volts, ceramic
C2—0.1 μF, 30 volts, ceramic
T—Miniature driver transformer, Sec. 2,000 ohms ct, Pri. 10,000 ohms (Lafayette 99 T 6126 or equiv.)
Q—2N404
D—1N90 diode
S—spst on R5
BATT—9 volts, NEDA No. 1604 or equiv.
J—Miniature phone jack to match plug on headphones
Printed or perforated board, knobs, miscellaneous hardware.

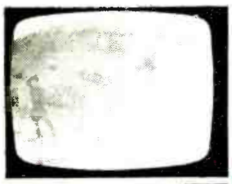
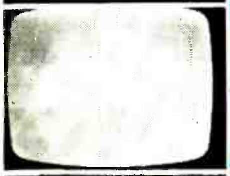
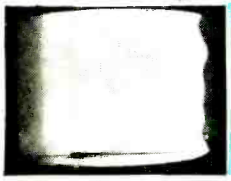
Video amplifier output
high-level contrast control;
dc restored

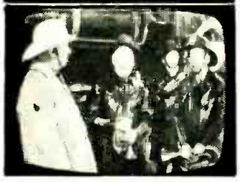
NEW R-E EXCLUSIVE

Kwik-Fix™ picture and waveform charts

by Forest H. Belt & Associates*

SCREEN SYMPTOMS AS GUIDES

	DESCRIPTION	WHERE TO CHECK FIRST: VOLTAGE	WAVEFORM	PART
	Washed out pic, without other symptoms. Simple lack of contrast.	plate pin 9	WF3 WF4	R5 R9 C8
	Ringing; grainy; very poor sync; jitter and wave; possible phase ghost.	not much help	WF2 WF3	R3
	Screen black. No video, no raster. May only be almost dark.	CRT pin 2	not much help	C7 R8 R10
	Blank raster. No video. Screen just white.	plate pin 9 screen pin 8	check all five	almost any part
	Too much contrast. Control can't turn it down.	CRT pin 2	not much help	C6 C7
	Blank raster. No video. Scalloped right edge; vertical shading.	grid pin 7 screen pin 8	not much help	R3
	Smear. Plenty of contrast. Sync okay.	grid pin 7	not much help	R7 R9
	Washout. But looks silvery, like agc overload. Some video may be slightly visible.	screen pin 8	WF5	C2
	Smear, poor contrast. Sync may be poor, too.	grid pin 7 plate pin 9	WF2 WF3	R3 R4
	Overload and washout. Sound noisy. Slight video, sometimes.	not much help	WF4	C5

	Vertical lines in picture wavy, not straight. Sync touchy.	screen pin 8	WF5	C2
	Sound "beat" or "grain." Clears up—almost—with fine tuning.	not much help	not much help	L4–C4
	Ringing and low contrast.	key point A grid pin 7	WF2	R1 R2

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

Study the screen and the action of contrast and brightness controls.

Most helpful clues to fault are found at key test points listed.

Make voltage or waveform checks as suggested for screen symptom.

Use voltage or waveform guide *to analyze results of checks.*

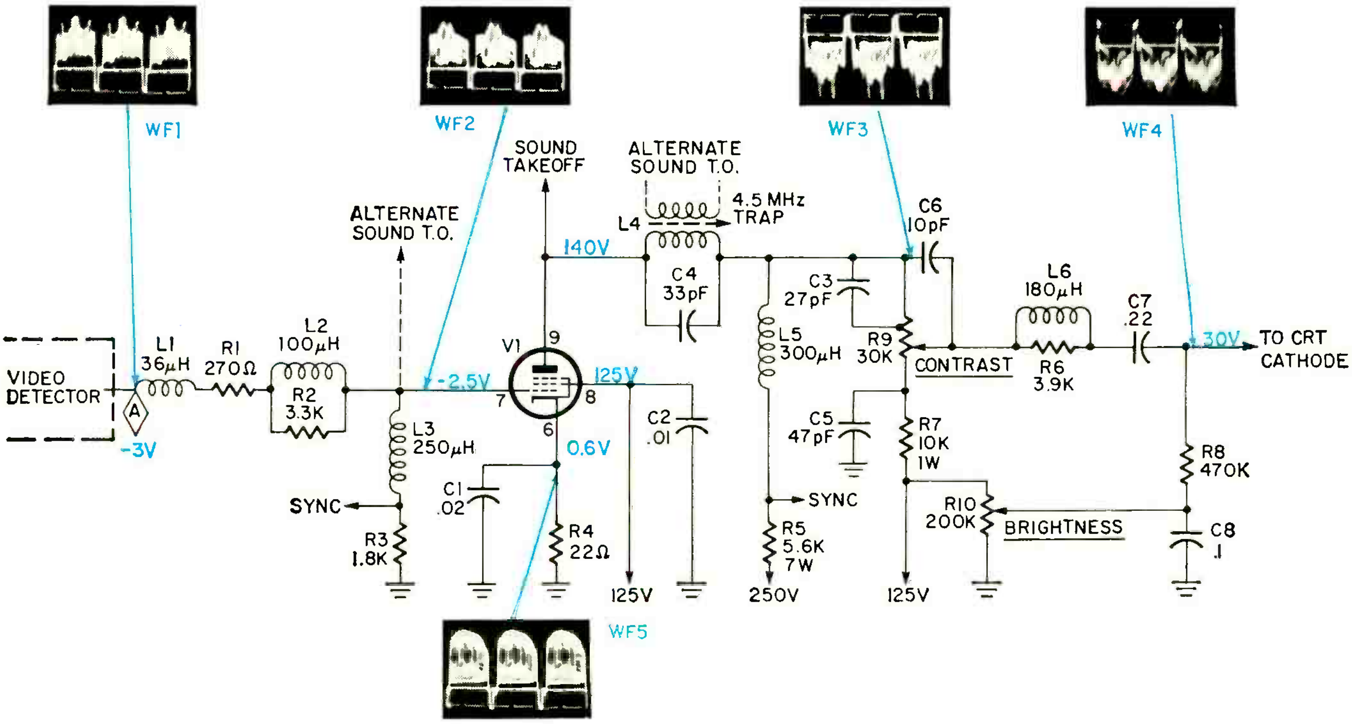
For quick check, test or substitute parts shown as most likely cause of symptom.

IN THE MOST POPULAR VIDEO STAGE IN BLACK-AND-white TV sets nowadays, input is dc-coupled from the video detector. Usually there are two sync takeoffs—one high-level for feed to sync stage, one low-level for the noise-canceling feature of sync/agc. Alternate sound takeoffs are shown. A sound-beat (4.5-MHz) trap is sometimes in the grid circuit.

Video signal comes from detector. It is peaked by L1 and L2; R2 keeps L2 from overpeaking. L3–R3 is the grid load for V1. C1 improves low-frequency response in the stage to avoid overpeaking.

L4–C4 is tuned to 4.5 MHz to trap out the sound intercarrier. In some sets, an extra winding on L4 couples sound i.f. to sound stages. L5 and R5 are the plate load for video signals. Sync remains with video through V1. L5 and other components in the sync feed line (not shown) pass amplified sync along and attenuate video to some extent. A similar arrangement feeds unamplified sync from the grid circuit. C2 is the screen decoupling capacitor for high-frequency video signals (any that escape the B filter capacitor).

Output of V1 is across R7 and R9, the contrast control. C3 and C6 are peaking capacitors, which boost high-frequency response. C5 helps low-end response by decoupling R7 at high video frequencies. L6–R6 is the peaking circuit; the resistor prevents overpeaking.



DC VOLTAGES AS GUIDES

Voltage change	to zero	very low	low	slightly low	slightly high	high
Key point A Normal —3 V Varies from —0.5 without signal to —4 with. Value changes with video content of program scenes.	R4 V high R5 open C8 short L5 open	R4 high R5 low	R9 open		R3 open C2 leaky L3 open	R1 open R3 high C5 leaky L1 open
Cathode pin 6 Normal 0.5 V Varies hardly at all with signal strength.	C5 leaky C8 short	C2 leaky	R3 open L3 open	R5 open L5 open		R4 open, hi R5 low
Grid-pin-7 Normal —2.5 V Varies from —0.5 V without signal to —3 V with strong signal.	R1 open R4 V high R5 open C8 short L1 open L5 open	R4 high R5 low		R7 open R9 open		R3 open, hi C2 leaky C5 leaky L3 open
Screen pin 8 Normal 125 V	C8 short	C8 leaky	R1 open R5 open C2 leaky L1 open L5 open	R5 low C5 leaky		R3 open, hi R4 open, hi L3 open
Plate pin 9 Normal 140 V Varies with signal strength. From 110 V without, to 150 V with strong signal.	R5 open L5 open		R1 open L1 open		R3 high R4 high	R3 open R4 open, V hi R5 low C2 leaky C5 leaky C8 short L3 open
CRT pin 2 Normal 30 V For viewable picture. Varies from 20 V to 115 V with Brightness control.			R5 open C8 short L5 open	R5 low	C7 leaky	C7 leaky, short R8 open R10 open

Use this guide to help you pinpoint the faulty part.
Measure each of the six key voltages with a vtvm.
For each, look across to the column that describes any change you find.

Notice which parts are shown as possible causes of that change.

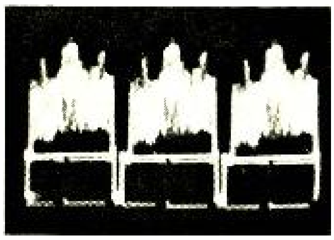
Finally, notice which parts are repeated in the combination of changes you found.

Test those parts individually for the fault described.

NOTE: For more guides to narrow down the faulty part further, see waveform guide.

WAVEFORMS AS GUIDES

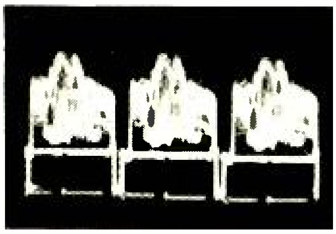
V p-p low	V p-p high	V p-p zero



WF1 Normal 3 V p-p

Taken at output of video detector and input of this stage, at key point A. Total amplitude depends on white content in picture, but amplitude of sync tips is steady. Normal V p-p voltage depends on station signal strong enough to build up some agc (see "Quick Troubleshooting"). Only clues in this waveform are from reaction of agc stage (not shown here) to sync signals (or lack of them) coming from this video stage. No noticeable changes in waveshape from any fault in video stage.

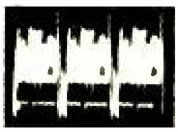
V p-p low	V p-p high	V p-p zero
C2 leaky C5 leaky	R4 high R5 low	R4 V high R5 open C8 short L5 open



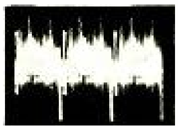
WF2 Normal 3 V p-p

Taken at grid pin 7, waveshape is essentially same as WF1. Amplitude is also unchanged. Input components are merely for peaking video response, and have little noticeable effect on sync-pulse shape. This, and all other waveforms in this *guide*, are taken with scope set for about 5 kHz. That shows three cycles of 15.75-kHz horizontal sync. Horizontal-rate video waveforms are much more informative for troubleshooting than vertical-rate (60-Hz) waveforms; also easier to synchronize on scope. Set scope sync control for "+" or "—", whichever direction sync-pulse tips point.

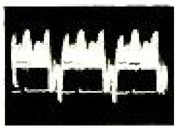
V p-p low	V p-p high	V p-p zero
R1 high R4 high R5 low	C2 leaky C5 leaky	R1 open R3 open R4 open, V high R5 open R9 open C8 short L1 open L3 open L5 open



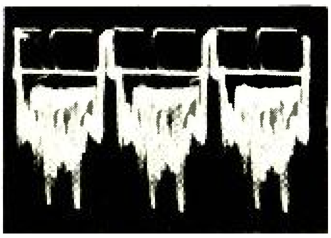
R1 high



R3 low



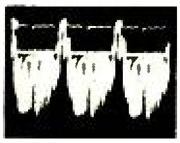
R3 high



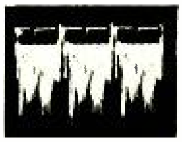
WF3 Normal 60 V p-p

Taken at top of contrast control, with low-capacitance probe. Direct probe usually distorts waveshape here. Amplitude is good measure of gain in video amplifier tube. In this chassis, with 90° picture tube, 20× is normal amplification. In chassis with 110° CRT's, 30× and 40× are more common. Naturally, higher-gain tube is used in them. Shape of WF3 is essentially same as WF1 and WF2, but polarity is reversed. Sync pedestal and tip may be more squarely defined, due to additional peaking in tube's output circuit.

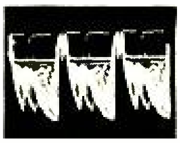
V p-p low	V p-p high	V p-p zero
R1 high R4 low R5 low		R1 open R3 open R4 open, V hi R5 open C2 V leaky C5 leaky C8 short L1 open L3 open L5 open



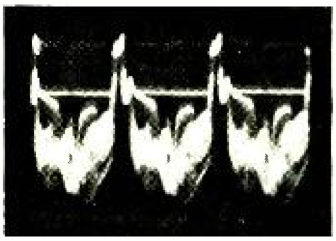
R1 high



R3 low

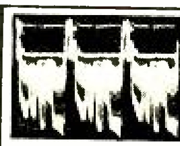
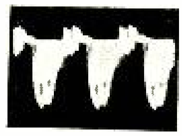
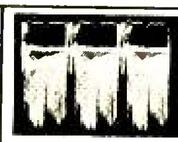
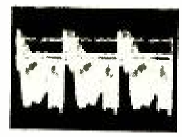
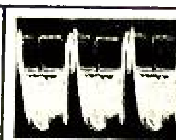
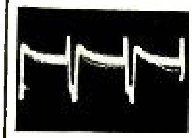
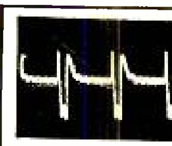
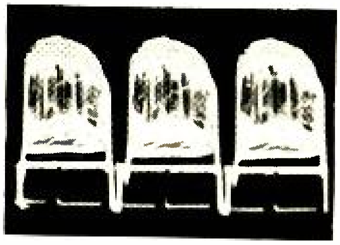
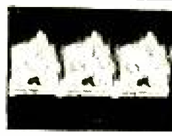


R3 high



WF4 Normal 40 V p-p

Taken at CRT pin 2 (in this chassis), with low-capacitance probe, this waveform offers most clues for troubleshooting. Evidence is number of "shape-changed" symptoms below. Sync tips are slightly sharper than in WF3, because of added peaking from C3, C6, L6 and C7. Polarity is same as WF3, with sync tips pointing upward (on scopes that don't have reversing switch set wrong). Amplitude is double or triple this p-p voltage in chassis that use high-gain video amplifier tube and 110°–114° picture tubes.

R4 high R5 low		R1 open R3 open R4 open, V hi R5 open C2 V leaky C8 short L1 open L3 open L5 open	 R1 high  C5 leaky	 R3 low  R7 low	 R3 high  C7 open	 C4 open
	**WF5 Normal 0.4 V p-p** Taken at cathode pin 6, low amplitude is due mainly to low value of cathode resistor, not to bypassing by C1. Capacitor C1 primarily prevents overpeaking in the stage; improves low-frequency response. Opening C1 doesn't reduce amplitude—merely changes shape of sync pedestal, almost imperceptibly. WF5 isn't especially helpful as troubleshooting clue, but does clue some symptoms.					
R4 low R5 low C1 leaky C2 leaky C5 leaky		R1 open R3 open R4 open, V hi R5 open C8 short L1 open L3 open L5 open	 C2 leaky			

Use this guide and the voltage guide *to help pin down fault possibilities.*

Using probe indicated in each waveform description, check the five key waveforms. Set scope at H or at about 5 kHz.

Note amplitude of each. If it's low or high, check parts listed in those columns.

Note waveshapes. If there's a change in one, check part or parts indicated.

NOTE: Only waveforms that help most with diagnosis are included in this guide.

Signal is coupled to the CRT by C7. (The CRT cathode pin may be 2, 3, 7, 11, or whatever the CRT manufacturer decided on.) Decoupling capacitor C8 keeps video out of the brightness-control circuit.

Grid pin 7 is in the dc path from the detector through L1, R1, L2, L3 and R3. Judging by negative grid voltage, output of video detector diode is from anode end. Current through the tube and R4 develops slight positive bias at the cathode, adding to grid voltage for tube bias.

Chief plate-current path for V1 is up through R4, through tube, L4, L5 and R5 to high B+. There's a dc path through R9 and R7 to low B+ voltage, but resistor values are so much higher than those in the main plate circuit that they have no noticeable effect on voltage at plate pin 9. The bottom of R7 returns to the 125-volt line mainly to use the B+ filter capacitor as a ground return for compensation network C3–C6–R9–C5–R7.

The brightness control and its slider are the divider for dc voltage from low B+ line. Biasing voltage for the CRT cathode finds a path through R8. When the CRT cathode is driven more positive, the screen goes dark because that increases CRT bias and cuts down beam current.

Station signals have considerable effect on dc voltages in this stage, and some effect on amplitude of video waveforms. Increasing station-signal strength drives dc voltage on V1's grid more negative. By the same token, setting agc control (not shown) can affect dc grid voltage. More negative grid means less plate current, so voltages at cathode pin 6 and at plate pin 9 shift somewhat.

The brightness control sets the voltage on cathode pin 2 of the CRT, but has little effect on any other portion of the stage.

A good way to start is by making sure the signal fed into receiver is steady and of known strength. Waveforms and dc voltages in ***speedi-guide*** schematic were taken with just enough station signal to develop about 4 volts of agc (the amount recommended for clamping during alignment). With this "standard" signal, you can best evaluate results of troubleshooting steps. If you have a video test-pattern generator, it's even better because waveform patterns stay the same.

A scope helps most, because the majority of toughdog symptoms are signal problems. Signal-trace with a scope. Waveforms on the schematic are best clues, but you can trace at circuit points between other parts. For example, an okay WF1 and bad WF2 means trouble between. Check at the junctions of L1–R1 and R1–L2. Also at L3–R3 junction, at plate pin 9, at L5–R5 junction, at R9–C5–R7 junction, at slider of R9, at L6–C7 junction.

and interconnection metalization.

the width (into the paper) about 6 mils.

At this stage slice processing is complete. A completed slice is shown in Fig. 5. The 1.25-inch diameter slice contains approximately 300 complete integrated circuits. An enlarged view of one circuit is in Fig. 6. On this particular slice, each circuit is 60 mils square, and contains 8 transistors, 12 diodes, and 12 resistors.

Slice probe testing

While still in slices all individual IC's are probe-tested. A typical probe testing machine has up to 20 pointed probes which can be accurately positioned to make electrical contact to the terminal contact pads on the IC. On a typical circuit wafer 50 mils square, there may be 12 terminal pads. After the probes have been aligned to the first circuit, they must be raised, the slice stepped one circuit along in sequence and the probe head lowered each time so the probes contact with the pads of each circuit in turn.

Mainly dc tests are performed. A few ac measurements are made, but switching speed and high frequency tests are limited by the capacitance and inductance of the probe head and the connections between the probe head and the measuring circuit. Despite these limitations, it is possible to select good circuits with a probability of about 80%. Any circuits failing to meet the test standards are automatically marked with an ink spot so that they can be readily identified and rejected after the slice has been cut into individual chips.

Individual circuit chips

Now the silicon slice is separated into individual IC chips. The most common method is *scribing and breaking*, a process similar to glass cutting. Lines are scribed across the slice between the circuits using a fine diamond point (Fig. 7). Then the slice is placed on a rubber pad and stressed by running a roller over it. The slice breaks into the individual chips. The chips are sorted, and rejected units marked with the ink spot during the probe test are thrown out.

Assembly processes

Each IC chip is now assembled into a package, sealed and tested. Two main forms of packaging are used, a hermetically sealed package called a "flip-pack" because of its thin rectangular configuration, and a "dual-in-line" plastic molded package. A dual-in-line is shown in Fig. 8. In each case, the chip must first be mounted into position in the package. It can be mounted either by soldering down to the base with a suitable metal alloy or, since electrical contact to the bottom of the chip is not required, a low-melting-point glass frit can be used to "cement" the chip down.

With the chip firmly mounted in the package, the electrical connections from the circuit terminal pads on the chip to the package leads are made. The most widely used method is thermal compression bonding. Gold wire about 1 mil in diameter is used with a process called "ball-bonding." The gold wire is fed through a capillary needle as in Fig. 9-a. Then a minute hydrogen flame is passed across the wire, melting it and forming a ball on the end.

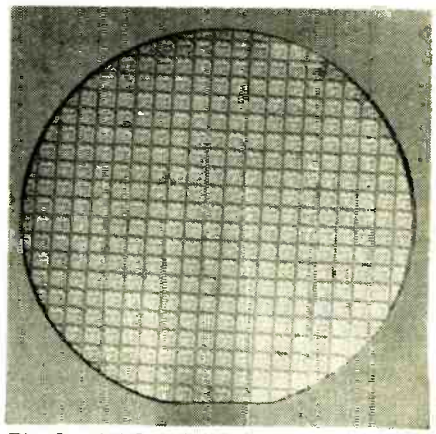


Fig. 5—A 1.5-inch silicon slice containing 300 integrated circuits, each 60 mils.

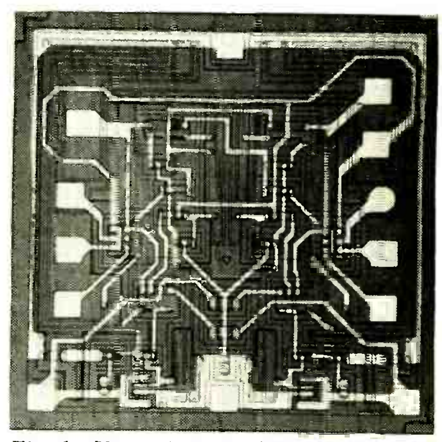


Fig. 6—View of a typical IC (60 mils sq.).

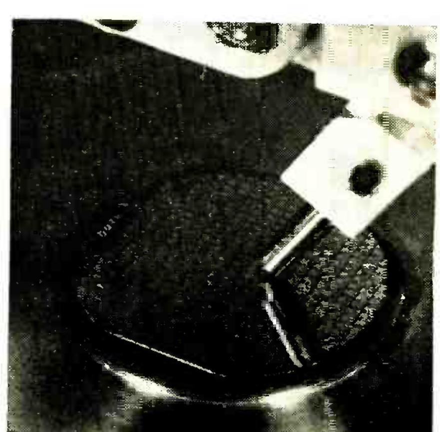


Fig. 7—A diamond-point scribe cuts each IC from the slice, similar to cutting glass.

The package with the mounted chip is heated to about 300°C and the capillary lowered so that the ball on the end of the wire contacts the terminal pad on the chip (Fig. 9-b). Pressure is applied to flatten the gold ball. and the combination of pressure and temperature welds the wire to the circuit pad (Fig. 9-c). Then the capillary is raised up the wire, moved horizontally until it is over the package terminal, and lowered to weld the wire onto the terminal (Fig. 9-d). After this second weld, the capillary is raised again and the wire "cut" by passing the flame across the wire. This also forms a new ball on the end of the wire, ready to repeat the sequence for the next connection (Fig. 9-e).

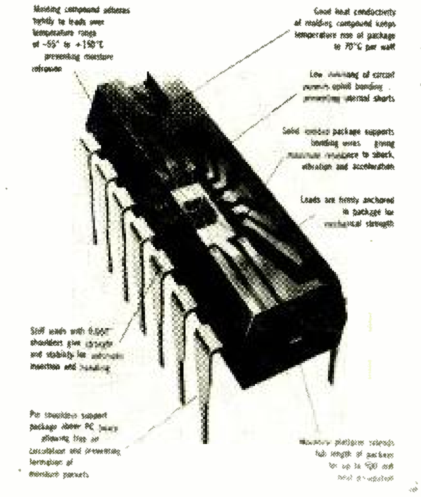


Fig. 8—A dual-in-line IC plastic case.

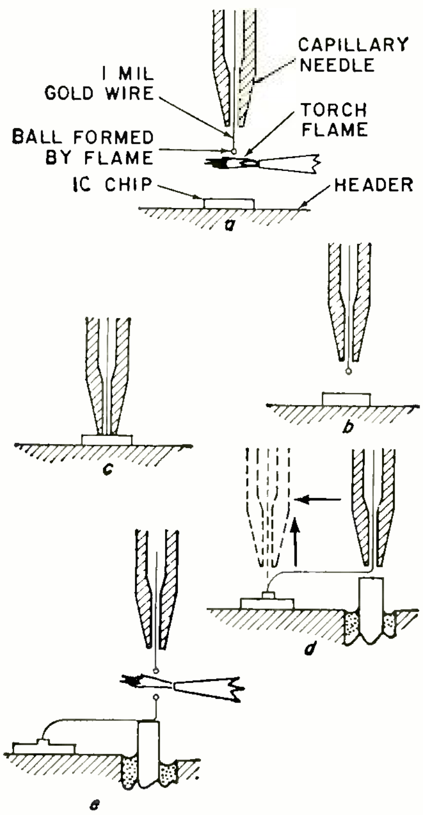


Fig. 9—Steps a–e show bonding process. Gold wire is heated and melted ball is pressed to weld wire to pad. Capillary is raised and process repeated for the second (pin connection) weld point.

After all connections have been made, the assembly is ready for finishing. Flat-packs and TO-5 packages call for welding on a lid to give a hermetic enclosure. With the plastic unit, the assembly is placed in a mold and the plastic body molded around it. A "leak" test after sealing checks that the units are completely airtight.

The last step in the manufacture is a series of electrical measurements to determine whether the performance of the circuit is up to the required standard. The nature of the final test depends upon the type of circuit, but is a combination of dc and ac measurements and functional performance of the complete circuit.

Yield considerations

Many sequential steps go into making an IC. The majority cause some loss. Such yield losses occur at each of the oxide removal and diffusion steps due to causes such as imperfections in the original silicon, incomplete cleaning of the slices, uneven photoresist application and removal, the presence of dust particles and unwanted impurities contaminating the diffused areas, incomplete control over the etching processes, mechanical breakage of the slices and so on.

Although the loss at each operation is small, only 1% or 2%, there are so many sequential operations that the cumulative good yield after scribing the slice into chips and sorting can be quite low—between 10% and 40% depending on the circuit. After this, additional good units may be damaged during assembly. And there will be a further loss at final test due to units not meeting specification. Therefore, the overall yield can be as low as 5% or perhaps as good as 20%, depending on the type of circuit.

A 5% yield appears extremely low compared to discrete component electronic assembly, but as 500 circuits are fabricated simultaneously on a slice a 5% overall yield giving 25 good circuits from one slice can be profitable. **R-E**

NEXT MONTH

Some months back, we promised R-E readers detailed plans for an IC digital clock if they'd write us. You did! So we picked the best—and least expensive—version available for our September issue. You'll find complete plans for building a digital clock that winks off hours, minutes and, if you've got the cash, seconds! There'll be photos showing several ways to mount the IC circuitry.

Convergence Problem

I have just finished putting a Heathkit color set together, and I have some problems. With the service switch in "service" position, I can't get the lines to overlap.

The raster won't go out when I move the brightness control all the way to "off" (CCW). Contrast control doesn't have enough effect. Pictures are pale. What to do?—J. H., Edmonton, Alberta, Canada.

You're making a couple of small mistakes. Don't try convergence with the switch in "service" position. This is merely for setting your screens. Pay no attention to the *position* of these lines, just their brightness.

Set the switch to "service" and adjust each screen control until the line is barely extinguished. If it won't go out on any of them, turn your CRT bias control down a little. If the screens controls are set too high, you can't get enough bias on the CRT to cut it off and make the raster go out. Too much brightness will look a lot like too little contrast.

Check the agc setting. If you're in a remote area, it may not be high enough—a possible cause of pale pictures. This also affects color, making it appear washed out.

COMING NEXT MONTH

SEPTEMBER 1969

■ **TV Antenna Tests**
Lowdown on the latest color models. Don't miss the results of R-E's tests.

■ **IC's in TV Circuits**
An expert describes how integrated circuits are used in TV and how to trouble shoot them.

■ **Build a 15-Watt IC Hi-Fi**
Details on a new hybrid IC that delivers power and performance. Just add a power supply and a few components.

■ **IC Digital Clock**
Complete details for building a Nixie-readout clock that can show seconds.

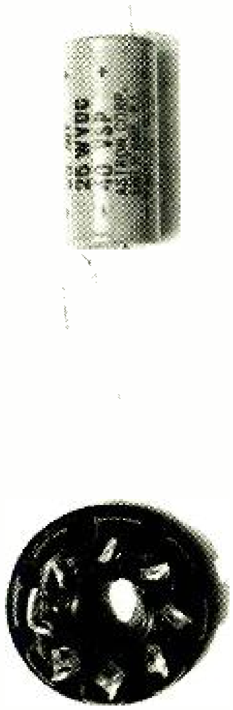
■ **Tools for Electronics**
There's more to everyday and specialized tools than you'd imagine. A new series shows how to select and use them.

■ **Kwik-Fix™**
Learn how to troubleshoot B+ and the i.f. stages in this continuing pictorial series.

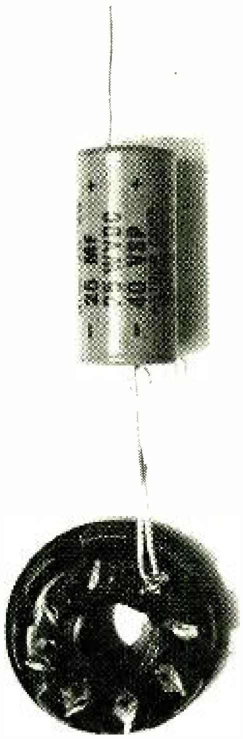
TRY THIS ONE

COMPONENT CONSERVATION HINTS

When wiring up a temporary or experimental circuit, it is desirable to avoid cutting component leads. Leaving the leads full length preserves the maximum usefulness of the components for future projects. However, wiring with maximum lead lengths



does not make a neat assembly. This problem can be avoided by shortening a lead by bending it back upon itself, as shown in the first photo. When pressed together (see second photo) the lead will be almost as compact as a cut lead. When wiring to a terminal, just tack the lead to the terminal or



slip the flattened bend through the hole. Do not hook the bent-over end through the hole, as that will make disassembly very difficult.

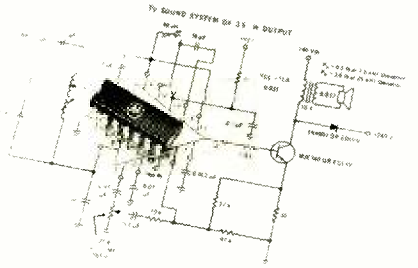
When the circuit is disassembled, it is very easy to remove the solder and straighten the lead to its original length.—*Charles Erwin Cohn* **R-E**

NEW TUBES AND SEMICONDUCTORS

MONOLITHIC TV SOUND IC

The MC1351P is a monolithic IC for TV sound circuits. It consists of a 3-stage high-gain amplifier/limiter, a full-wave FM quadrature detector and a 3-stage audio preamp/driver. This Motorola IC is also useful for FM radio i.f. amplifiers.

The i.f. amplifier/limiter has



three single-ended differential amplifiers connected by emitter followers for level shifting and broadbanding. Typical voltage gain is 65 dB at 4.5 MHz. Input voltages as low as 80 μV provide 3 dB of limiting.

The quadrature detector consists of three balanced transistor pairs (gates). The first pair is driven by the emitter of the limiting amplifier, while the other two gates are controlled by the output voltage of the quadrature tank circuit. Only one RCL phase-shift network is needed to set the 90° reference angle for the detector.

The audio preamp/driver has three transistor stages providing an output voltage swing of 3.5 volts rms.

A 7-volt Zener diode provides internal voltage regulation and has a built-in limiting resistor in the preamp section for short-circuit protection. Housed in a 14-lead, dual-in-line TO-116 package, the MC1351P costs $2.75 in 100-up quantities.

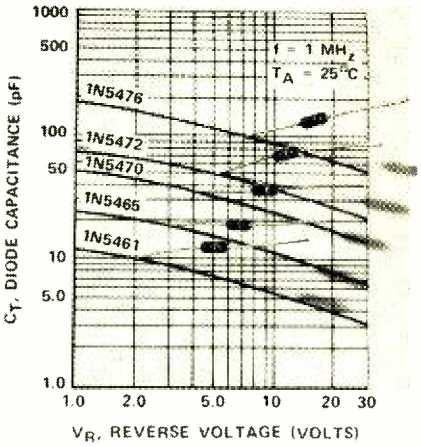
HIGH-Q VVC DIODES

The 1N5461-A, -B, -C through 1N5476-A, -B, -C make up a new series of high-Q, premium voltage-variable capacitance diodes from Motorola. They operate over a 30-volt range and are available with a nominal capacitance tolerance of 2% (designated by the "C" suffix). This high uniformity is essential where stage-to-stage tracking in tuning is required or where minimum circuit-to-circuit alignment is a consideration. Units with "B" and "A" suffixes have 5% and 10% tolerances, respectively.

These VVC diodes have nominal capacitance (measured at 4 volts reverse bias) ranges running from 6.8 to 100 pF. The minimum Q (at 4 volts reverse bias and 50 MHz) is 600 for the 1N5461-A (6.8 pF) and 200 for the 1N5476-A (100 pF). The minimum tuning ratio (capacitance at 2 volts/capacitance at 30 volts) is 2.7 for the 1N5461 and 2.9 for the 1N5476-A.

These abrupt-junction epitaxial

DIODE CAPACITANCE vs REVERSE VOLTAGE



devices are packaged in DO-7 glass. The 100-and-up prices are $4.50, $5.80 and $8.00 each for the A, B and C types, respectively. The industrial version of this line (1N5441-A, -B, -C through 1N5456-A, -B, -C) has slightly broader tolerances and is priced at $2.50, $3.00 and $3.80.

Further technical information and specifications can be obtained from the Technical Information Center, Motorola Semiconductor Products, PO Box 20924, Phoenix, Ariz. 85036.

FOUR NEW FET FAMILIES

3N160 and 3N161. These 25-volt p-channel MOSFET's feature low leakage and high input impedance, minimizing drift in opamps and providing high accuracy in electron meter circuits. Other applications include use in shift registers, timers, proximity detectors and in other areas requiring interface between MOS and bipolar logic.

Pertinent characteristics (at 25° C) include maximum drain current (I_{DSS}) of -10 μA, typical gate current (I_{GSS}) less than 1 pA; low threshold voltage of -1.5 to -5 volts and transconductance as high as 6500 μmho. The 3N161 features a Zener-protected gate to reduce the possibility of damage from static charges.

2N25545, -46, -47. Dual FET's with improved matching and tracking characteristics. Maximum gate-source differential for the 2N25545, for example, is 5 mV and tracking with temperature change is less than 10 μV/°C. Output admittance is matched within 1 μmho.

2N5549 Switching FET. N-channel FET for choppers, logic switches, multiplexers, rf and vhf amplifiers and high-current source followers. Transconductance above 6000 μmhos, feedback capacitance less than 2 pF and on-resistance below 100 ohms result in a gain of around 15 dB and 3.5 dB at 100 MHz.

2N5543 and 2N5544. Serve as replacements for vacuum tubes in high-voltage switching and amplifying circuits. Minimum drain–gate breakdown voltage is 300 volts for the 2N-5543 and 200 volts for the 2N-5544. Maximum on-resistance is 2000 ohms, transconductance is 750 μmhos minimum and maximum input capacitance is 10 pF.

Additional technical information on these transistors can be obtained by writing to "FETs", Texas Instruments Inc., Inquiry Answering Service, PO Box 5012-MS/308, Dallas, Texas 75222. **R-E**

NEXT MONTH

September is a special color TV antenna issue. Find out how the latest antennas perform at the RADIO-ELECTRONICS test site. Don't miss this special.

fixes it.—*Admiral Service News Letter* **R-E**

NOTEWORTHY

Getting Started in ELECTRONIC ORGAN SERVICING

Learn the ABC's of a booming new repair field

By Donald A. John
**National service manager, Thomas Organ Co.*

WITH WELL OVER A MILLION INSTRUMENTS in operation, the electronic organ industry is one of the fastest growing businesses in the home entertainment field.

Recent engineering and manufacturing advances have resulted in a number of excellent, low cost instruments in the $500 to $1000 price range. This has brought the electronic organ into the reach of many thousands of new families.

To the electronic technician, organ servicing offers a profitable new source of business and income. A shortage of qualified servicemen exists in every area of the country. Major markets such as New York and Chicago have few firms servicing electronic organs, and consequently there is a ready market for this service.

Many dealers, especially those in smaller communities, do not maintain a service department. There may be several reasons for this: sales volume may not justify this expense, or the volume of service work may not warrant the cost of maintaining a shop, equipment and personnel.

A phone call to a few organ dealers should indicate whether a potential market for this service exists in your community. This could result in an arrangement with one or more dealers to handle all or part of their service work. In this way valuable experience can be gained in organ servicing.

Technical background

A musical background is definitely not a prerequisite to oragn servicing. It can be helpful, but basic information covering music fundamentals is all that's really necessary.

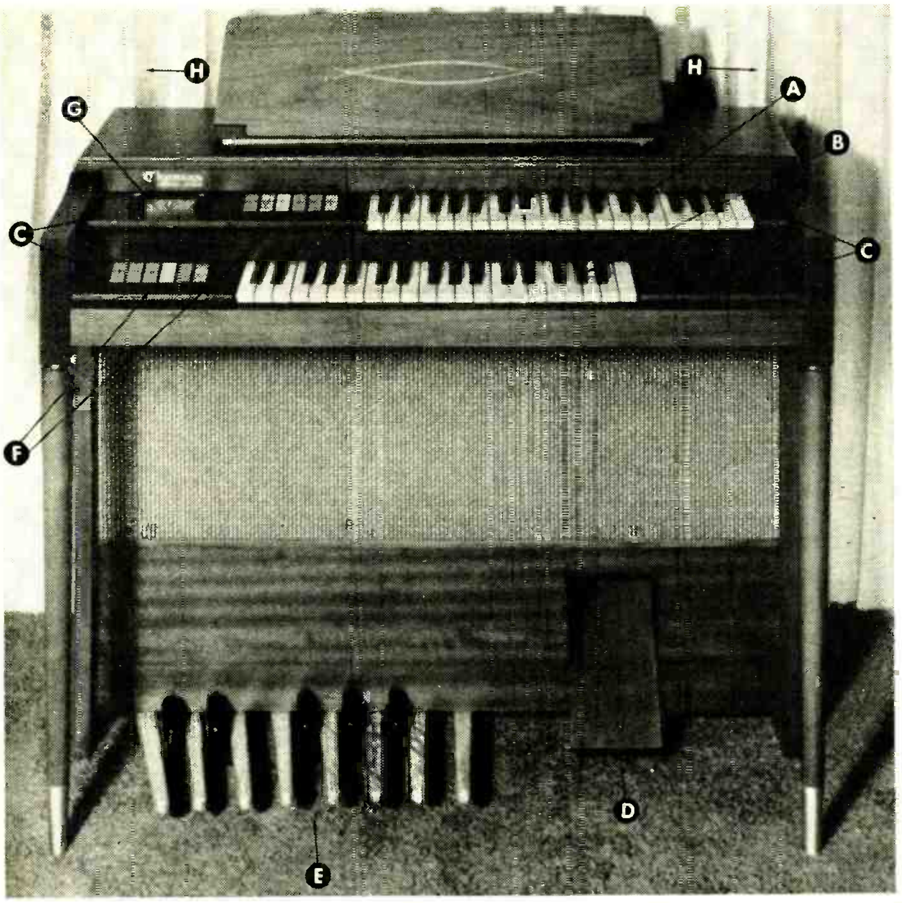
There are several ways in which this may be obtained. A few hours with a music instructor or organ dealer can be invaluable, or it might be advantageous to take two or three organ lessons. The ability to play a few bars of "Long, Long Ago" can provide a definite psychological advantage in gaining the customer's confidence.

Another means of learning about electronic organs is to assemble one of the kit instruments. In this way much can be learned about the general design, construction, adjustment and maintenance of organs.

History and terminology

Organs have a long and colorful musical history dating back to 300-250 B.C. Today's instruments are, however, more the electronic counterpart of the nostalgic pipe organs of the silent movie era. While they may never replace the pipe organ, they have succeeded in reproducing many realistic instrumental voices within the confines of a spinet cabinet and the average family budget.

Much of the classic pipe organ terminology is still used to describe the voices, keyboards, action and other features of today's instruments. Therefore the electronics technician may find himself acquiring an entirely new vocabulary. There are a number of good books on electronic organ servicing, which contain glossaries of terms explaining such words as "presets & pistons," "vibrato and tremolo," "couplers," and so on. An understanding of these and other organ terms will enable the serviceman to accurately interpret and diagnose a ser-



A. UPPER KEYBOARD—
That keyboard on which the solo part is normally played. Also referred to as: Swell Keyboard, Swell Manual, Solo Manual, etc.

B. LOWER KEYBOARD—
The keyboard on which the accompaniment is normally played. Also referred to as: Great Keyboard, Great Manual, Accompaniment Manual, etc.

C. CHEEKBLOCKS—
The areas immediately adjacent to both ends of the keyboards. The voicing tabs or stops are located on these panels in many instruments.

D. EXPRESSION PEDAL—
A foot operated volume control that allows the organist to vary the overall volume of sound produced. Also referred to as: Swell Pedal, or Swell Shoe.

E. PEDAL KEYBOARD—
The keys of the organ that are played using the feet. Also referred to as: Pedal Clavier, Pedalboard, etc.

F. VOICING TABS—
The switches that enable the organist to select the voices desired, in playing the instrument. Also referred to as: Stops, Stop Tablets, Draw Bars, Drawknobs, etc.

G. FUNCTIONAL CONTROLS—
The switches and controls that operate circuits other than for voicing. Such as: On-off switch, Percussion tabs, etc.

H. ORGAN CONSOLE—
All of the instrument contained within the main cabinet. Example: The pedalboards, speakers, or amplifier/speaker combination are often detachable and not a part of the main console on large instruments.

vice problem described by the customer.

The parts of a small organ are shown (Fig. 1, above). In some cases more than one term may be used to describe the same section of an instrument, depending upon the manufacturer and specific organ type.

Basic circuitry

Electronic organs are basically alike and consist of: tone generators, keyboards (keyswitching), voicing circuits, an amplifier and speaker system. However, most instruments differ considerably in their methods of attaining the desired musical result.

For example, there are several types of tone generators employed: individual oscillators (for each note), or a master-oscillator/frequency-divider system. Tubes or transistors, tone

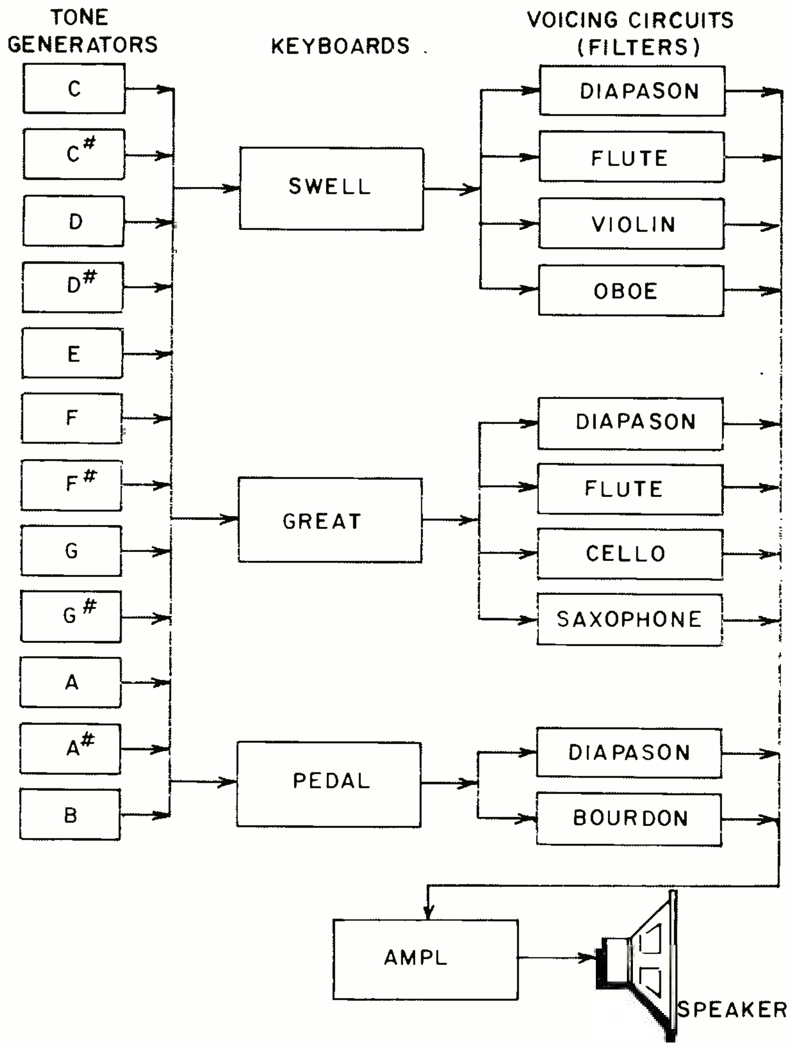


Fig. 2—Block diagram of basic electronic organ system.

TONE GENERATORS
Every organ has at least 12 tone generators, one for each note of the musical scale. Most organs produce from 3 to 6 octaves of tone on each generator, or 36–72 tones in "separate oscillator" systems.

KEYBOARDS
Organs normally have two or three keyboards plus a pedalboard.

VOICING CIRCUITS (FILTERS)
Number and type of voicing circuits, and the type of oscillator signal vary from organ to organ.

AMPLIFIER
May be monaural or stereo, driving one or more speakers. Has a conventional design, with good low-frequency response.

wheels or neon bulbs, even optical, taped or electrically recorded systems are used.

Does this business require more study than it's worth? Actually, an electronic organ uses a few circuits duplicated many times. Once these basic circuits are understood, servicing becomes a matter of isolating the trouble to a relatively simple circuit. The block diagram in Fig. 2 illustrates a basic organ system. These basic organ circuits are normally identical in all models of the same manufacture. The differences between models and prices are usually in the number of keys on each keyboard, the number of tones generated and the number of voices available. Of course there may also be additional features or special-effects sections in the larger instruments.

Test equipment

Organ circuits are not unlike those in TV, radio and hi-fi sets, and most of the same test equipment can be used in their servicing. A vacuum-tube voltmeter (or vom) is the most useful single piece of test equipment. Since organ circuits are repeated many times over, comparison voltage readings may be taken between a good oscillator and the faulty one to locate the defective component. In addition, there are often hundreds of switches and interconnecting wires, so an ohmmeter is very useful in tracing circuits and locating broken connections. An oscilloscope is helpful in tracing audio signals through voicing circuits, etc., to pinpoint the trouble source.

The only essential specialized equipment required in organ servicing is a tuning instrument. A substantial part of this business consists of tuning organs, and unless the serviceman has received specialized training, an electronic organ cannot be tuned adequately by ear. The "beat method" of organ tuning is based on counting the number of beats within a given interval of time and is an approximate method requiring practice and experience.

The beginner would do well to invest in an electronic tuner.

Tuning instruments can be purchased at prices ranging from about $40 to several hundred dollars.

Since electronic organs deal primarily with the generation, switching, and modification of audio signals, a bypass capacitor connected to a jumper wire can be a useful servicing aid. It can be used to bypass voicing circuits, locate broken leads or open components and as a means of injecting oscillator signals at various circuit locations to pinpoint a source of trouble.

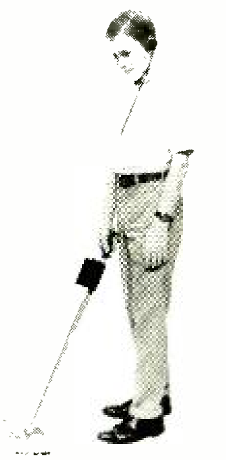
Technical information

Today most organ manufacturers will supply service manuals at a reasonable cost. One of the reasons in charging for this material is to discourage unqualified individuals from obtaining it. Several companies offer a subscription service which includes both service manuals and technical bulletins that are released during a specified period of time.

The electronic technician seriously interested in entering the organ service business should visit a few organ dealers, find out about the products and write the manufacturer of those instruments he is interested in servicing. **R-E**

NEW PRODUCTS

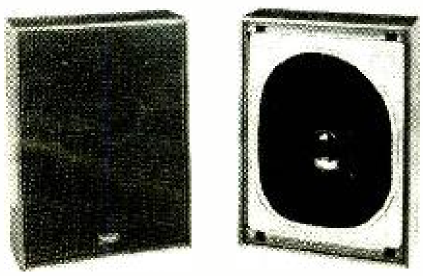
More information on new products is available from the manufacturers of items identified by a Reader Service number. Use the Reader Service Card at the left and circle the numbers of the new products on which you would like further information. Detach and mail the postage-paid card.



TREASURE LOCATOR KIT, *Model TRL-1,* powered by 9 V battery, consists of 3 FET's and 2 silicon transistors. Handle folds in the middle for convenient storage. 6" etched circuit "search" coil is adjustable to any angle. Unit weighs only 24 oz. $29.95, complete with wire, solder and headphone.—**Caringella Electronics Inc.,** Upland, Calif.

Circle 46 on reader service card

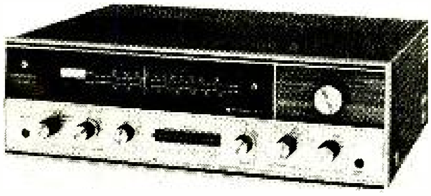
SPEAKER SYSTEMS come in two 8-ohms models; *Model NS-15,* 15 watts, includes a 13" x 17" speaker plus a 2" cone; *Model NS-10,* 10-watt, 11" x 15" speaker. Speakers are irregularly shaped



and "flat." Edge of speaker cone is locked into an aluminum casting which permits full range vibrations through bending motions.—**Yamaha International Corp.,** Los Angeles, Calif.

Circle 47 on reader service card

FM/AM STEREO RECEIVER, *Model KR-77,* solid-state, power output IHF of 75 watts at 4 ohms and 56 watts at 8 ohms. Includes 2 IC's, 2 FET's and 4-



gang tuning capacitor front end. Sensitivity: 1.9 μV. Selectivity: 45 dB. Capture ratio: 2.5 dB. Front-panel keyboard controls for interstation muting, loudness, low/high filter plus dubbing/tape recording jack and headphone jack. $239.95.—**Kenwood Electronics Inc.,** Los Angeles, Calif.

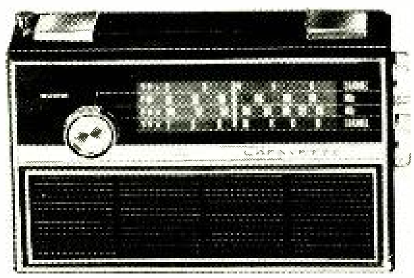
Circle 48 on reader service card

ELECTRONIC MULTIMETER, *Model LV-77,* has 7 dc/ac ranges from 0.5V–1,500V. Resistance: 10 ohms–10 megohms. Power levels from −10 dB to +16

dB may be measured directly. Input impedance: 11 megohms. Frequency response: 25 Hz–1 MHz. Accuracy: ±3%. Only one test probe is used for all measurements. $89.50.—**Leader Instruments Corp.,** Long Island City, N.Y.

Circle 49 on reader service card

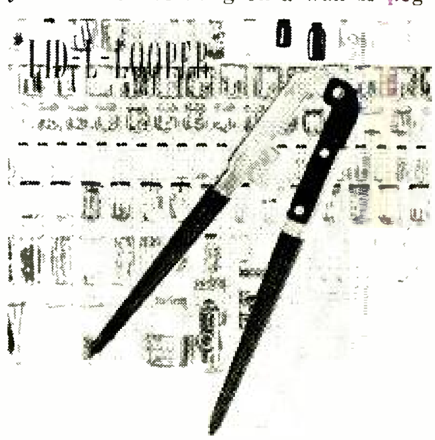
FM/VHF PORTABLE RADIO, stock No. *99-3563L,* solid-state, 4-band, operates on batteries or with ac adapter. Receives sound portion of TV broadcasts



from channels 2–13, standard FM broadcasts and fire, police and weather broadcasts in the 146–175-MHz band. Unit includes 14 transistors, 3 diodes and 1 thermistor, built-in telescopic whip antenna and 3" speaker. $39.95, with 4 C-batteries and earphone.—**Lafayette Radio Electronics Corp.,** Syosset, N.Y.

Circle 50 on reader service card

LOOP MAKER, *Lid-L-Looper,* forms a loop in the lid of any jar or bottle from 1-oz to 1-gal size when it is placed between the two handles and squeezed. Jar can then be hung on a wall or peg-



board. Pegboard hooks or ordinary finishing nails can be used to support the jars and their contents. $3.95.—**P.L. Co.,** Compton, Calif.

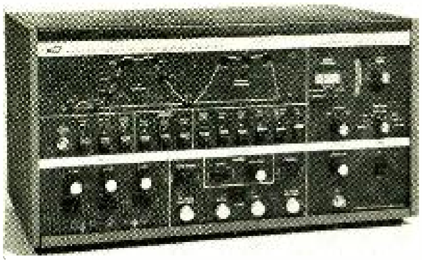
Circle 51 on reader service card

WOW AND FLUTTER METERS, *Model ME 102B* (illus.) and *Model ME 104,* feature separate instruments indicating drift and contain a 3150-Hz oscillator which permits recording the test signal as well as calibration of the metering section. Input circuitry above 30 mV.

Model ME-102B, metering between 1–315 Hz, has a relay to prevent erroneous readings from insufficient signal level and provides switching between 3000/3150 Hz for international and US frequency standards.—**Gotham Audio Corp.,** New York, N.Y. 10036

Circle 52 on reader service card

SWEEP/MARKER GENERATOR, *Model 415,* solid-state, with dual-gate MOSFETs'. Provides crystal-controlled rf on channels 4 and 10. Sweep frequency: 10.7 MHz for FM, 4.5 MHz for TV audio. Output impedance: 72 ohms, 300 ohms for rf output to antenna. Available outputs: sweep chroma and band-



pass, TV i.f. and FM i.f. Includes 10 crystal-controlled i.f. markers, standard and 100-KHz markers to align aft discriminators. $349.95.—**Dynascan Corp., B & K Div.**, Chicago, Ill.

Circle 53 on reader service card

AM/FM TUNER, *Model TX-500,* solid-state, uses low-noise silicon transistors

with multiplex circuitry providing wide channel separation. Noise filter reduces undesirable multiplex broadcast noise. Front-panel controls for manual on/off noise-filter selection. Sensitivity: 2.5 μV. Signal to noise: 50 dB. $99.95.—**Pioneer Electronics USA Corp.,** Farmingdale, L.I., N.Y.

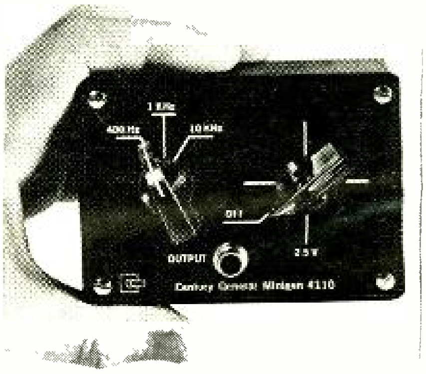
Circle 54 on reader service card

RECORDER/PLAYER, *Viking Model 811-R,* 8-track, operates on ac with external stereo music system. Turns on automatically when cartridge is inserted. Has automatic and pushbutton track se-

lection and numerical program indicator. 4 logic circuits allow choice of auto-stop at end of any single track or completion of all 4 tracks. $189.95—**Telex Communications Div.,** Minneapolis, Minn.

Circle 55 on reader service card

AUDIO GENERATOR, *Minigen 4110,* solid-state, provides three tones—400Hz, 1KHz and 10KHz—which can be converted to 5 KHz by slight internal modification. Output: 0–2.5V. Measures 2⅞" x 4" x 1⅛" and weighs 7½ oz. $14.95



complete with probe and standard 9V transistor battery.—**Century General Corp.,** New York, N.Y.

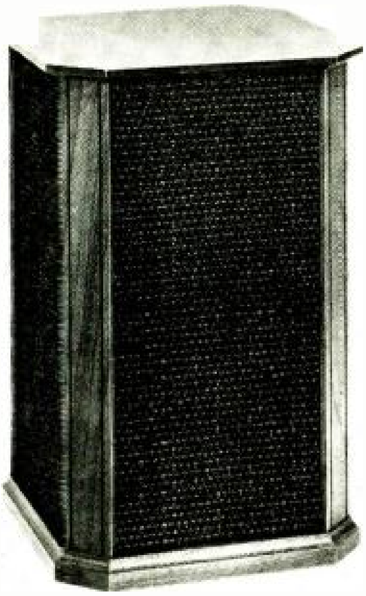
Circle 56 on reader service card

SOLDER GUN, *Model 6760,* solid-state and transformerless, provides two tip

temperature ranges—approximately 500° or 900°F. User simply slides a thumb switch on handle to LO or HI. Tips are independent of heating element for replacement purposes. A knurled nut locks heat cartridge into gun barrel. Loosening nut rotates entire cartridge to orient the thread-on tips.—**Ungar, Div. of Eldon Industries**, 233 East Manville St., Compton, Calif., 90220

Circle 57 on reader service card

QUADRANT SPEAKER SYSTEM, *Model Q-1000*, 80 watts, produces a 3-dimensional stereo effect from 8" woofers on sides one and three of system and



a 3" midrange/tweeters on all four sides. Frequency range, 38–20,000 Hz. Impedance, 6–8 ohms. $149.95.—**H. H. Scott Inc.**, Maynard, Mass.

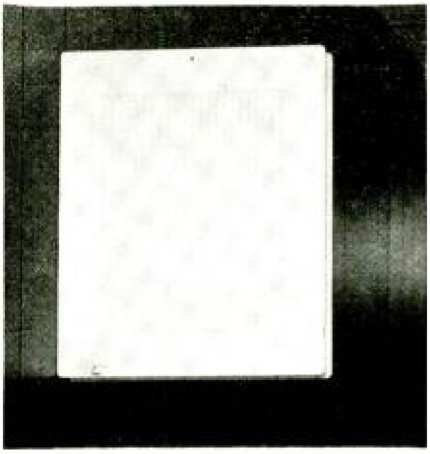
Circle 58 on reader service card

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

CASSETTE STORAGE ALBUM of black styrene is 10" x ⅜" and securely holds 6 individual cassette cartridges and

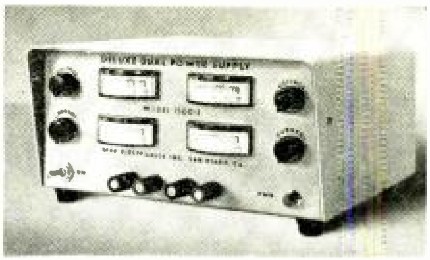
"pop" the cartridge easily and quickly releases them at a finger touch. Pressing either side of the stored cassette will into the user's hand. Cassette hubs are automatically locked when placed in the album and their surfaces are protected from outside damage.—$2.98.—**Recordings Unlimited**, 64 E. Van Buren, Chicago, Ill.

LOUDSPEAKER, *Poly-Sonic*, features a power capacity of 20 watts peak; input impedance 8 ohms. Punch-out screw holes on molded plastic baffle simplify



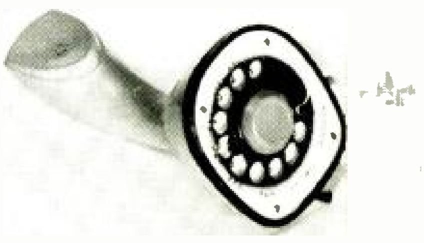
edge mounting or hanging. Model weighs less than 4 lb. $19.95, with mounting hardware, stand and 8' of audio wire.—**Magitran Div., ERA Acoustics Corp.**, 311 East Park St., Moonachie, N.J.

DC POWER SUPPLY, *Model 1500-1*, fully metered, features an adjustable voltage of 0–17V or 0–34V dual and adjustable current at 0.05–1.5 amps. Power input: 50–400 Hz. Ripple output:



0.2 mV at 1.5A. Impedance output: 0.04 ohm/100 Hz. 8⅜" x 4½" x 8½"; 7½ lb. $145.—**Spar Electronics Inc.**, 7969 Engineer Rd., San Diego, Calif. 92111

EXTENSION PHONES, Ericofon Style 29. Complete with bottom dial, cord and plug. Lift to get dial tone. Turn over to dial. Set down to disconnect. Available in



all standard colors. Plugs into standard phone jack. $39.95. If buzzer needed $10.00 additional.—**Retail Phone Corp.**, 66 W. 38 St., New York, N. Y. 10018. R-E

Circle 107 on reader service card

NEW LITERATURE

All booklets, catalogs, charts, data sheets and other literature listed here with a Reader's Service number are free for the asking. Turn to the Reader Service Card facing page 79 and circle the numbers of the items you want. Then detach and mail the card. No postage required!

DIGITAL VOLTMETER SYSTEM, *Model 2700,* solid-state, measures voltage from 0.0001 to 999.9V on 4 digital readouts; an accuracy of ±0.05% of reading, ±1 digit over temperature range of ±20 to 30°C; and an input impedance of 10.2 megohms, is described in a 2-page catalog, *T-1020A.*—**Simpson Electric Co.,** Chicago,

Circle 60 on reader service card

MICROPHONES described in *Catalog 2520,* 20 pages, are for professional mobile and transistorized mobile and base station, paging, public address and tape recording purposes. Microphone cartridges, stands and accessories also covered. Specs, technical data and details of manufacture are provided.—**Turner Co., Subsidiary of Conrac Corp.,** Cedar Rapids, Iowa. Ill.

Circle 61 on reader service card

PROGRAM-CENTER BROCHURE *12-1030,* 8 pages, provides specs for each of 12 program-center home-distribution amplifiers for city/suburban/weak-signal areas. Also illustrated are several new kits which expand a 4-outlet coaxial cable system or a 4-outlet 300-ohm system into 8-outlet systems.—**JFD Electronics Co.,** Brooklyn, N.Y.

Circle 62 on reader service card

ELECTRONIC INSTRUMENTS including FET vom, SCR ignition systems, computerized tachometer and a high-voltage analyzer are described with complete technical details and specs plus schematics in a literature package.—**Delta Products Inc.,** Grand Junction, Colo. 81501

Circle 63 on reader service card

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

MATV PLANNING MANUAL, 30 pages, describes MATV systems products and the fundamentals of system design and design calculations. Sample vhf and all-channel systems, a dB-to-voltage multiplier chart, coax cable and transmission-line guide, TV channel assignments and a glossary of the most used MATV terms are also given. $1 each. Write to **Finney Co.,** 34 W. Interstate St., Bedford, Ohio 44146

FM TRANSMITTERS in the range of 250–20,000 watts plus stereo generator, *Model 2202,* all solid-state, are described with details and specs in various brochures. Transmitter *Models FM-5HB* and *FM-1KB* both have one tube design and *Model FM-20KB,* 2 tubes. *Model FM-5HB* may be equipped with *Model 2202* which features distortion of less than 0.1%; power output, 10 watt; channel separation, 40 dB min., audio distortion, 100-15,000 Hz.—**American Electronic Laboratories,** Lansdale, Pa.

MID-1969 CATALOG containing information on 9800 obsolete tubes, circa 1925-1930, plus listings and prices of many other items is available from **Arcturus Electronics Corp.,** Union City, N.J.

SEMICONDUCTOR DEVICES ranging from a single-chip transistor rated at 250 amps to rectifier assemblies are described with specs, charts and dimensional diagrams in 20-page *Catalog 54-000.* Rectifier and thyristor assemblies for a wide range of circuit applications are also discussed.—**Westinghouse Electric,** P. O. Box 868, Pittsburgh, Pa. 15230 **R-E**

NEW BOOKS

99 WAYS TO USE YOUR OSCILLOSCOPE, by Albert C. W. Sanders. *Tab Books, Blue Ridge Summit, Pa. 17214. 5¾" x 8¾", 191 pp. Clothbound $6.95; paperbound $4.95.*

A well-illustrated step-by-step guide to using an oscilloscope for waveform and frequency measurements, making circuit gain and distortion measurements, and for testing many types of components and circuits. A must for the beginner and very useful for the most experienced hand in scope techniques.

MOST-OFTEN-NEEDED 1969 TELEVISION SERVICE INFORMATION. Compiled by M. N. Beitman. *Supreme Publications, 1760 Balsam Road, Highland Park, Ill. 60035. 8½" x 10¾", 191 pp. Paper, $4.*

Vol. TV-28 is the latest in the long line of service manuals featuring reprints of original set makers' circuit diagrams and service data on tube and solid-state b-w TV sets. Although books in this series are valuable additions to any service technician's library, we feel that the publishers should either include color TV data in the TV series or perhaps bring out a new series devoted entirely to color sets.

TRANSISTOR AND DIODE LABORATORY COURSE, by Harry E. Stockman. Hayden Book Co. Inc., 116 W. 14 St., New York, N. Y. 10011. 7½" x 10", 128 pp. Softcover, $3.95.

The experiments presented provide a basic ground-work in transistor technology. Some of the areas covered are: plotting characteristic curves; measuring parameters of the three basic transistor connections; and investigating the audio amplifier, the phase splitter and the output stages. Answers to questions posed in the text are at the end of the book.

CLOSED-CIRCUIT TV FOR ENGINEERS & TECHNICIANS, by Leonard C. Showalter. Howard W. Sams & Co. Inc., 4300 W. 62 St., Indianapolis, Ind. 46206. 5¾" x 8¾", 272 pp. Hardcover, $7.95; softcover, $4.95.

This book is intended as both a reference and a text for those who operate, maintain, and design closed circuit TV systems. The reader should have a fundamental knowledge of electronics, but no advanced mathematics is needed. This is a practical discussion of circuits and applications, not a book on theory.

104 EASY TRANSISTOR PROJECTS YOU CAN BUILD, by Bob Brown. TAB Books, Blue Ridge Summit, Pa. 17214. 5½" x 8¾", 224 pp. Hardcover, $6.95; softcover, $3.95.

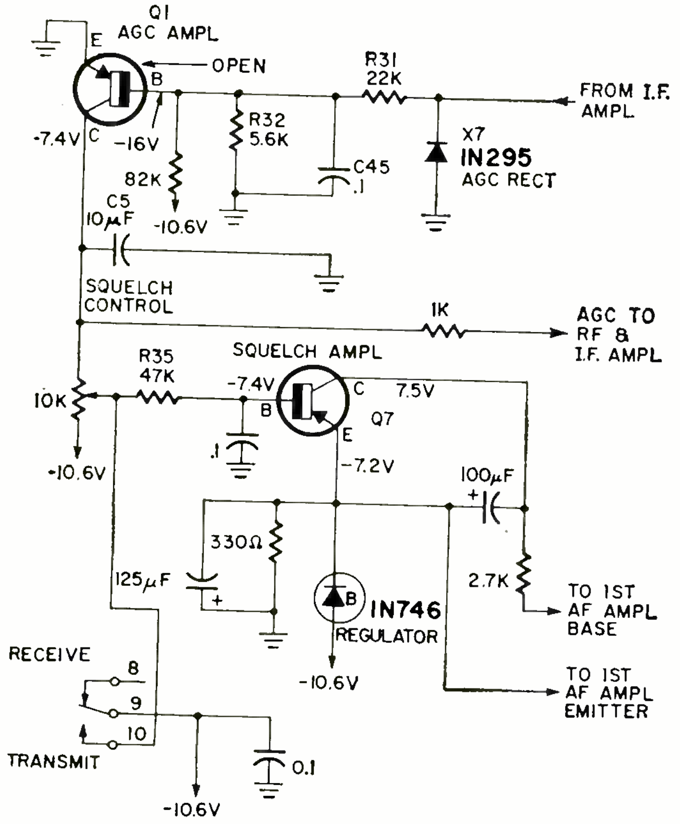
A new circuit/projects book for hobbyists, experimenters, hams, audiophiles and technicians. Includes a high-gain telephone pickup, wireless mike, electronic megaphone, CB receiver, light dimmer, fence charger and more. All projects use 4 transistors or less and each includes schematic, parts list and description of circuit operation. **R-E**

CB Troubleshooter's Casebook

Compiled by
Andrew J. Mueller*

Case 1: Distorted receive function and inoperative squelch. Transmit function OK.

Common to: Hallicrafters CB-12

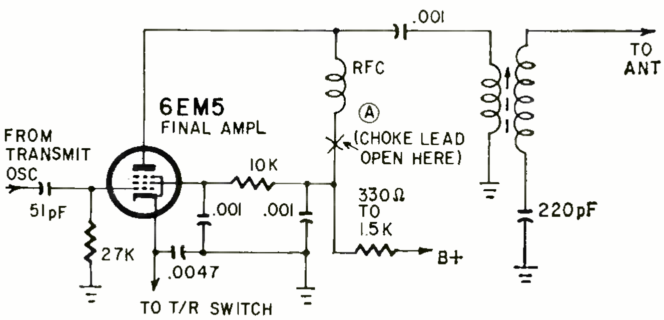


Remedy: Replace Q1.

Reasoning: Q1 is the agc amplifier transistor. Its function is to amplify the agc voltage from the detector and feed it to the controlled stages and the squelch gate. In this case Q1 is open. Therefore no agc voltage is applied to the proper stages. The receiver runs at maximum gain, which distorts the incoming signal while the squelch circuit will not open.

Case 2: Unit does not transmit. Receives OK.

Common to: E.C.I. Courier 1 and 1M

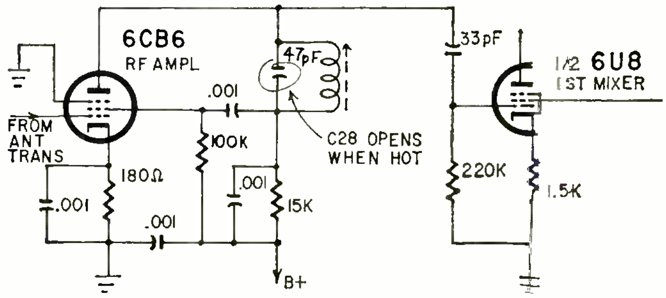


Remedy: Resolder rf choke at point A.

Reasoning: There is a bad solder joint at point A. The enamel was not completely removed from the wire where it was soldered to the lead on the rf choke. The B-plus lead to the plate of the 6EM5 opened causing no rf output. A careful tinning and resoldering of the wire to the lead restored the radio to normal operation.

Case 3: Receive is weak when the radio is hot. Transmit OK.

Common to: Knight C-27



Remedy: Replace capacitor C28.

Reasoning: C1 opened up when it became warm. This detuned the rf amplifier plate circuit Hence very little signal is transferred to the mixer stage. When replacing C28, be sure to use a high-quality ceramic or silver mica capacitor. R-E

*Service manager, Tel-Air Communications, Inc., Pewaukee, Wis.

In the Shop . . . With Jack

by **JACK DARR**

SERVICE EDITOR

THE ENGINEERING APPROACH TO SERVICE

British TV technicians are called "service engineers." This isn't just a "glory title". US or UK, we *do* engineering work—diagnosing and repairing faults in an immensely complicated piece of electronic equipment.

We need to use the "engineering approach." When we run into a problem, the first thing to do is to *state* the problem in our minds. Then, we use a logical method of analysis to locate the cause. Once we know what we're looking for we can tell how to find it.

Step 1: Locate the major symptom. Dark screen, for instance. As you know and I know, there's no such thing in electronics work as a problem with only one answer. So, we have a list of possible causes in our mind. We simply go through this list, in the *order of maximum probability*.

Step 2: We *test* to find out what conditions exist in the circuit. Some of these tests are almost instantaneous. We've made one already—looked at the CRT screen and saw that it wasn't lit. This is an *abnormal* reaction, so the cause of this symptom is what we have to find. Next, we make more of this type of test. We look at the neck of the picture tube, and at the horizontal output, oscillator and damper tubes, to see if their filaments are lit (normal) and if the horizontal output tube plate is glowing red (abnormal). So, there are several tests, all useful, and all made in about 5 seconds.

From circuit knowledge, we know that any circuit must have the right operating power supply, or it can't work. So we read the dc supply voltage with a meter. Now we're past the visual-observation stage and must use instruments from here on. The success of this method does not depend on the instruments themselves, but on our *interpretation* of the *meaning* of their readings.

Finding +100 volts at a certain point means absolutely nothing. Not unless we know what the voltage *should be* at that point! Thus, +100 volts on an audio preamp plate is ok, but +100 volts on the control grid of a horizontal output tube means trouble.

From this we can make up a list of "Normal Operating Conditions." It might be something like this:

1. Tubes lit.
2. Dc voltages present at rated value.
3. Cathode current flowing at rated value.
4. High-voltage dc output present at rated value.

Now go down this list one patient step at a time until you find one item that is *abnormal*. This list must be worked out in the order of a maximum *probability*. In plain words, which one of these things is the *most likely* to cause trouble?

Tubes cause a lot of this kind of trouble so try a new tube. If this fails, we have *eliminated* one of the items on the list! A negative test result is as useful as a positive one. We know that there are so many items on the list, and we must be prepared to go through the whole list if we have to.

If new tubes won't cure it then we know that it must be a supply voltage problem. This can be caused by a failure of the supply itself, failure of a part in the supply network, or something in that section. (Notice how the new list is forming?) The logical test would be to measure the supply voltage.

If the supply is ok, check the network of parts which feeds the voltage to our circuit next. We can have open circuits or short circuits—this makes no difference to our basic method. They're both faults, no matter what has caused them. This approach is not limited to dc supply voltages, incidentally. In this section, the high-voltage ac drive signal to the horizontal output tube is a part of the "supply"—one of the things which must be there if the stage is going to work normally. To the picture tube, the high-voltage dc supply is "normal." If it isn't present, the picture tube can't work; so, we make up another list of things which could cause the HV to fail, and check them.

There's the method; its key words are "process of elimination." By a patient, methodical process of elimination, we went down the list, checking each item off. When we found one that showed an abnormal response, that was it. Now, we stopped and subdivided the list, and started a new list of possibilities. We checked these out one at a time. When we got to the end of that list, we had found the trouble.

The most valuable single asset you can have is a completely *open mind*. Don't "play favorites." Don't begin the diagnosis thinking, "This has to be a bad tube; it was the last time!" Be completely impartial; after all, what do you care what it is? The idea is to find the trouble and get the set working again in the shortest possible time, and the heck with *what* caused it!

Don't even try to form an opinion until you have enough *data*. anything before this isn't an engineering opinion, it's a pure guess. All diagnoses must be *based on facts*, facts which you have discovered while making tests.

This is the "engineering method" of making diagnoses. Get some facts and *then* make a tentative diagnosis of the cause. If this doesn't work out when confronted with the facts, throw it out without hesitation and make a fresh diagnosis based on the new facts (one of which is that the original diagnosis wasn't correct!). Don't hang on to it! **R-E**

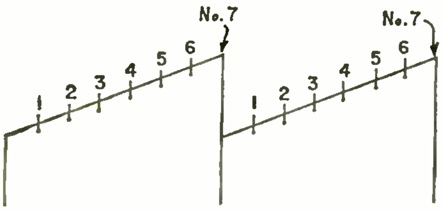
Service Clinic

By JACK DARR
SERVICE EDITOR

Generator alignment

I'm having trouble setting up a bar-dot generator with a scope. I get a stable pattern on one stage, but when I go on to the next it's unstable. Happens mostly around the 4500- to 31,500-hertz stages. What's causing this?—O. H., Ripon, Wis.

I think this is a case of making the same mistake twice. (You made it once and I made it once!) From your description, the stage will set up and lock while the scope probe's hooked to it, but when you go to the next one (that is, when you unhook the scope probe), it becomes unstable. So, this is exactly the trouble I got into



in a similar case: you're tuning up the circuit, *plus* the scope capacitance! The scope input capacitance is a part of the tuned circuit. So, when you take this much capacitance off, the circuit changes frequency enough to become unstable, and won't lock properly.

The solution is to use much smaller series capacitors on the scope probe, thus reducing the capacitive effect on the circuit. In the one I had, 3.0 pF was about right. In the 4500–31,500-Hz stages, you ought to get a waveform with 7 small pips between the major ones, as in the diagram. This waveform is seen on the output of the 4.5-kHz multivibrator.

There's another method, suggested to me by a test equipment company engineer: Keep a TV set hooked to the bar-dot generator's output while you are setting it up. In a case such as you had, where the pattern was *almost* stable enough, watch the TV screen, and very carefully "fiddle" the setup control until the pattern stabilizes! This will work in many cases. Of course, you don't want to move it too much.

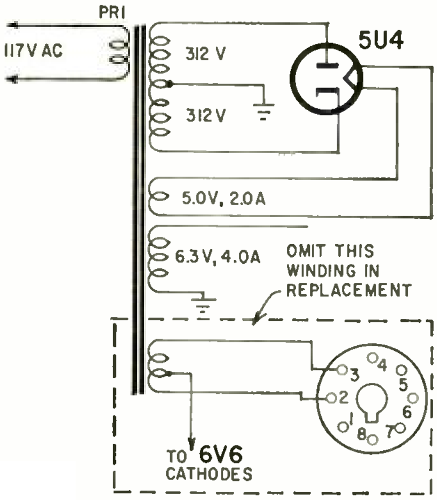
This column is for your service problems—TV, radio, audio or general and industrial electronics. We answer all questions individually by mail, free of charge, and the more interesting ones will be printed here.

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

Transformer replacement

I've got a Stromberg-Carlson Model 1121 PL radio; the power transformer is burnt out. This seems to be a special transformer; there are two extra wires going to a socket on the back, and another going to the 6V6 cathodes. What's the number of a good replacement?—S. O., Chester Depot, Vt.

Actually, this isn't a *special* transformer, in the sense that it can't



be replaced. The extra wires you see go to a wire-recorder input plug; they are probably for a motor or the recorder heater circuit; the connection to the 6V6 output-tube cathodes is evidently to put a dc bias on these leads. They can be omitted when putting in a replacement transformer.

You'll need high voltage of 312–0–312 volts ac at 200 mA; 5.0 volts at 2.0 amps for the 5U4, and 6.3 volts ac at 4.0 amps for the filaments.

Vtvm test batteries

I like to use a dry battery to check my vtvm. How can I tell whether I have a fresh battery?—L. B., Los Angeles, Calif.

Use a mercury battery. You can get these with several voltages, and their shelf life is very long. Also, they hold their open-circuit voltage almost until they are dead. **R-E**

MARKET CENTER

ELECTRONICS

Discharge IGNITION, PHOTOFLASH. Free catalog parts, kits. **TRANSPARK,** Carlisle, Mass. 01741

LOWEST PRICES Japanese electronic products information $1.00 refundable. **PRENTZAS,** 406 Crestland, Greensboro, N.C. 27401

Ultra-sensitive and powerful METAL DETECTORS join the many who are finding buried coins, minerals, relics and artifacts. Don't buy till you see our free catalog of new models. Write **JETCO**—Box 132-RE, Huntsville, Texas 77340

TUBES—LOWEST PRICES in the world. Hard to get British, German, foreign and American obsolete and present day special purpose transmitting tubes. Send for giant tube and parts catalog. **UNITED RADIO CO.,** Dept. R-56, Ferry St., Newark, N.J. 07105

Independent News Company, Inc. is pleased to announce a Retail Display Plan which includes Radio-Electronics as part of a group of magazines available for the earning of a Display Allowance.

To obtain details and a copy of the formal contract please write to **Marketing Department, Independent News Co., Inc., 575 Lexington Avenue, New York 10022 (Attention Mr. Paul Hendershott).** Under the Retail Display Plan in consideration of your acceptance and fulfillment of the terms of formal contract to be sent to you upon request, you will receive a Display Allowance of 10% of the cover price per copy of each magazine in the group sold by you. This plan will become effective with all issues of the magazine group delivered to you subsequent to the date your written acceptance is received and accepted by our Company.

PEP'S Dollar Sale

$1 Money Back guarantee $1

1 Amp Silicon Rectifier choice of package Bullet—Miniature Glass-Metal

- ☐ 5-800V units $1.00
- ☐ 4-1000V units $1.00
- ☐ 3-1200V units $1.00

3 AMP Epoxy Package

- ☐ 10-100V units $1.00
- ☐ 5-400V units $1.00
- ☐ 2-1000V units $1.00

5 AMP Epoxy Package

- ☐ 8-100V units $1.00
- ☐ 6-200V units $1.00
- ☐ 3-800V units $1.00

SILICON STUD MOUNT 12 AMP

- ☐ 5-100V units $1.00
- ☐ 2-800V units $1.00
- ☐ 1-1000V units $1.00

SILICON STUD MOUNT 20 AMP

- ☐ 3-100V units $1.00
- ☐ 1-1000V unit $1.00

SILICON STUD MOUNT 40 AMP

- ☐ 3-50V units $1.00
- ☐ 2-100V units $1.00

SILICON STUD MOUNT 60 AMP

- ☐ 2-50V units $1.00
- ☐ 1-1000V unit $1.00

SILICON GLASS DIODES DO-7

- ☐ 10-100V units $1.00

NO SALES TAX
WE PAY POSTAGE

SCR Silicon Controlled Rectifier TO-S Package

- ☐ 5-40V units $1.00
- ☐ 4-100V units $1.00
- ☐ 3-200V units $1.00
- ☐ 2-400V units $1.00

7 AMP SCR

- ☐ 4-50V units $1.00
- ☐ 3-100V units $1.00
- ☐ 2-200V units $1.00
- ☐ 1-1000V units $1.00

20 AMP SCR

- ☐ 2-50V units $1.00
- ☐ 1-300V unit $1.00

Gen Purpose PNP Germ Transistor Similar to 2N404

- ☐ 8 For $1.00

ZENER DIODES 1 Watt

1 ea 4V · 6V · 8V · 10V
- ☐ 4 units $1.00

ZENER DIODES 10 Watt

1 EA 4V-6V-8V-10V
- ☐ 3 units $1.00

GERM GLASS DIODES DO7 GEN PURPOSE

- ☐ 20 Units $1.00

Replaces 1N-34 1N-60 1N-64 1N-295

Zener Diodes 250 to 400 Millawatt

1 EA 2V-4V-6V-8V-10V
- ☐ 5 units $1.00

Power Transistors

2N-155
- ☐ 3 units $1.00

2N-176
- ☐ 2 units $1.00

PARK ELECTRONIC PRODUCTS

P. O. Box 78 N. Salem, N. H. 03073

Circle 120 on reader service card

ARCTURUS SALE

- 1700 transistor types at 39¢ each.
- 40 watt germanium power transistor, same as Delco 501, 2N278 (etc.). Cat. #349, 59¢ each.
- Color TV cartridge focus rectifier 6.5 kv. Used in every color TV. Cat. #CFR-20, 79¢ each.
- Motorola 2500 ma. at 1000 piv, high voltage/current epoxy silicon rectifier, axial leads. Cat. #HEP-170, 49¢ each.
- 2 Printed circuit I.F. transformers, 4 lug, 455 kc input and output, cat. #1909P4, 99¢ each.
- RCA UHF transistor type TV tuners, KRK-120 (long-shaft) cat. #UHF-20; KRK-120 (short-shaft), cat. #UHF-21, each $4.98.
- RCA VHF transistor type TV tuners, KRK-146, cat. #VHF-74, $9.99 each.
- 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. #UHF-567, $4.95.
- U.H.F. Tuner-original units as used in TV sets such as RCA, Admiral, etc. covering channels 14 through 82, as part #94D173-2. Complete with tube. Drive gearing is removable. Can be used in most sets. Cat. #UHF-3, $4.95.
- Color yokes, 70° for all round color CRT's. Cat. #XRC-70, $12.95. 90° for all rectangular 19 to 25" color CRT's. Cat. #XRC-90, $12.95.
- Kit of 30 tested germanium diodes. Cat. #100, 99¢.
- Silicon rectifier, octal based replacement for 5U4, 5Y3, 5AS4, 5AW4, 5T4, 5V4, 5Z4. With diagram. Cat. #Rect-1, 99¢ each.
- 7", 90° TV bench test picture tube with adapter. No ion trap needed. Cat. #7BP7, $7.99.
- Tube cartons 6AU6 etc. size, $2.15 per 100. 6SN7 etc. size, $2.55 per 100. 5U4GB size, $2.95 per 100. 5U4G size, 4¢ each.

Send for complete free catalog. Include 4% of dollar value of order for postage. $5 MINIMUM ORDER. Canadian check, 8% dollar differential.

ARCTURUS ELECTRONICS CORP.

502-22nd St., Union City, N.J. 07087

Dept. MRE

Phone: 201-864-5568

Circle 121 on reader service card

ADVERTISING INDEX

RADIO-ELECTRONICS does not assume responsibility for any errors which may appear in the index below.

HIGH-AMPERAGE low voltage 750VA transformer 24/12 volts 36/60 amps from 115/230 $10.00. Nicklecad batteries 4AH $1.95, 8AH 2.50. Free catalog with order. **ARROW SALES,** 2534 S. Michigan, Chicago, Ill. 60616

RADIO & TV TUBES 33¢ each. One year guaranteed. Plus many unusual electronic bargains. Free catalog. **CORNELL** 4217-E University, San Diego, California 92105

INTEGRATED CIRCUIT KITS: computer, audio, others. New catalog free. **KAY ENGINEERING,** Box 3932-D, Long Beach, California 90803.

POWER SUPPLIES $3.98. Nixies $5.00. Counter $2.00. $1.00 component packages. Catalog. **MURPHY,** 204 Roslyn Ave., N.Y. 11514

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, Texas 77018

RECEIVING & INDUSTRIAL TUBES, TRANSISTORS, All Brands—Biggest Discounts. Technicians, Hobbyists, Experimenters—Request FREE Giant Catalog and SAVE! **ZALYTRON,** 469 Jericho Turnpike, Mineola, N.Y. 11501.

GOVERNMENT SURPLUS

JEEPS Typically From $53.90 . . . Trucks From $78.40 . . . Boats, Typewriters, Airplanes, Multimeters, Oscilloscopes, Transceivers, Electronics Equipment, Used. 100,000 Bid Bargains Direct From Government Nationwide. Complete Sales Directory and Surplus Catalog $1.00 (Deductible First $10.00 Order). **SURPLUS SERVICE,** Box 820-REL, Holland, Michigan 49423

WANTED

QUICK CASH . . . for Electronic EQUIPMENT, COMPONENTS, unused TUBES. Send list now! **BARRY,** 512 Broadway, New York, N. Y. 10012, 212 WALKER 5-7000.

TECHNICAL WRITERS needed. Freelance. Electronics topics. Send resume. **ELECTRONIC WRITERS and EDITORS, INC.** P.O. Box 504, New Hyde Park, N.Y. 11040

INVENTIONS & PATENTS

FREE "Directory of 500 Corporations Seeking New Products." For information regarding developments, sale, licensing of your patented/unpatented invention. Write: **RAYMOND LEE ORGANIZATION,** 230-U Park Avenue, New York City 10017.

INVENTORS: protect your ideas! Free "recommended procedure". **WASHINGTON INVENTORS SERVICE,** 422X Washington Building, Washington, D.C. 20005

INVENTIONS WANTED. Patented; Unpatented. **GLOBAL MARKETING,** 2420-AE 77th Ave., Oakland, Calif. 94605

AUDIO — HI-FI

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,** 5280 RE West Pico Blvd., Los Angeles, Calif. 90019.

TAPE RECORDER SALE. Brand new nationally advertised brands, $10.00 above cost. Amazing discounts on stereo components. **ARKAY ELECTRONICS,** 1028-E Commonwealth Avenue, Boston, Mass. 02215

RECORDS, Stereo, Hi-Fi. LP's $1.25, 5 for $5. 45's five $1, 30 for $5. All new, never played, name brands. Sample one LP and one 45 for $1.50. **WARREN ROY,** 24 Straw La., Hicksville, N. Y. 11801

Circle 122 on reader service card

Circle 123 on reader service card

MARKET CENTER

RENT 4-track open reel tapes—all major labels—3,000 different—free brochure. **STEREO-PARTI,** 55 St. James Drive, Santa Rosa, Ca. 95401

WRITE for highest discounts on components, recorders, tapes, from franchised distributors. Send for FREE monthly specials. **CARSTON,** RFD #3, Route 7, Brookfield, Conn. 06804

PHOTOFACTS, 221 sets, $49.50 for all. Supreme radio diagram manuals, 14 volumes, $14.95, postpaid. Mixed television-radio diagrams, 20 pound carton, $9.95. **BEITMAN,** 1760 Balsam, Highland Park, Ill. 60035.

GENERAL

TREASURE HUNTERS! PROSPECTORS! Relco's new instruments detect buried gold, silver, coins. Kits, assembled models. Transistorized. Weighs 3 pounds. $19.95 up. Free catalog. **RELCO**-A25, Box 10839, Houston, Texas 77018

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.

250 EACH—Letterheads, statements, envelopes and business cards. Send copy (up to 5 lines) and $17.75 to **THE WRIGHTWAY,** 404 East Green, Champaign, Illinois 61820

HEARING AIDS below wholesale. Smallest, most powerful. Free home trial. No salesman will call. Free details. Write **PRESTIGE** C-43, Box 10880, Houston, Texas 77018

JAPANESE NEW PRODUCTS MONTHLY! $1.00. Refundable. **DEERE,** 10639 Riverside, North Hollywood, Calif.

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

CLASSIFIED COMMERCIAL RATE (for firms or individuals offering commercial products or services). 70¢ 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 October issue must reach us before July 11.

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.

The FM-2400C provides an accurate standard frequency signal for testing and adjustment of mobile transmitters and receivers at predetermined frequencies between 25 and 500 MHz. Up to 24 crystals may be inserted into the meter. The frequencies can be those of the radio frequency channels of operation, and/or of the intermediate frequencies of the receivers between 5 MHz and 40 MHz. Frequency stability (standard) ±.001% from 32° to 122°F. Frequency stability with built-in thermometer, calibrated crystals and temperature corrected charts, .00025% from +25°F to +125°F. (.000125% special 450 MHz crystals available)

FM 2400C (Meter Only)	**$445.00**
RF Crystals	
Hi Band	**$24.00 ea.**
Lo Band	**15.00 ea.**
IF Crystals	**8.00 ea.**

Write for free catalog.

INTERNATIONAL
CRYSTAL MFG. CO., INC.
10 NO. LEE • OKLA. CITY, OKLA. 73102

Now With Solid State Circuitry & Rechargeable Batteries

ICM FM-2400C frequency meter....

- *Completely Portable*
- *Tests Predetermined Frequencies 25 MHz - 500 MHz*

Circle 129 on reader service card

NEW KENWOOD QUARTET

....variations on a theme of excellence

Whether you go lavish or low-budget, one of KENWOOD's superb new stereo receivers is waiting to enrich your listening pleasure. And whatever the price, you'll find that KENWOOD has a knack for adding the extra touches that make the difference between the ordinary and the excellent! Check the specs. Check the performance. Then pamper yourself with a KENWOOD for the greatest stereo you've ever heard!

FOUR NEW KENWOOD STEREO RECEIVERS TO CHOOSE FROM:

KENWOOD KRS-44 . . . 48-Watt, FET, IC, SOLID STATE FM/AM RECEIVER and TWO MATCHING SPEAKERS

Complete with its own duo of compatible stereo speakers, the KRS-44 brings "Instant Stereo" to the budget-minded who want to play now, add-to later **$239.95***

Stereo Receiver KR-44, also available separately, provides ample tape, phono, and other inputs for a complete stereo system . . . terminals for second speaker set **$179.95***

KENWOOD KR-70 . . . 75-Watt, FET, IC, SOLID STATE FM STEREO RECEIVER

For the FM buff, this excellent and economical FM receiver with great sensitivity of 1.9 μV IHF . . . excellent stereo separation . . . alternate channel selectivity of 45 dB . . . and a raft of professional convenience features that will keep any FM devotee devoted to KENWOOD **$199.95***

KENWOOD KR-77 . . . 75-Watt, FET, IC, SOLID STATE FM/AM STEREO RECEIVER

A multitude of professional features not generally found in the medium-price range make the KR-77 an extremely popular model. Inputs for 2 record players, left-and-right channel output and main amp input, allow the greatest flexibility in creating a diversified stereo system **$239.95***

KENWOOD KR-100 . . . 140-Watt, FET, IC, SOLID STATE FM/AM STEREO RECEIVER

Featuring a particularly efficient silicon power transistor amplifier and an extremely sensitive front-end, the KR-100 is a truly deluxe stereo receiver with superior broadcast reception and controls to accommodate the most sophisticated stereo system **$299.95***

*Including cabinets

. . . the sound approach to quality

INSTITUTE OF HIGH FIDELITY INC

KENWOOD

3700 S. Broadway Pl., Los Angeles, Calif. 90007
69-41 Calamus Ave., Woodside, N. Y. 11377
Exclusive Canadian Dist. — Perfect Mfg. & Supplies Corp. Ltd.

Circle 130 on reader service card

How do you "install" confidence when you install an RCA color picture tube?

The surest way to compliment a customer is to agree with his opinion. This is pretty easy to do when it comes to deciding which brand of replacement color picture tube to install in his set.

Here both set owner and service technician agree—and by a wide margin—on RCA! And for one very good reason: RCA's reputation...for experience, quality, and proven performance...over the years. More years than anyone else in the business.

Place your confidence in the company that perfected the color TV system in use today. Introduced more technical innovations than any other company. Stays on top of the state-of-the-art not just in technology, but in tube sizes as well.

Whether it's an all-new RCA HI-LITE or the popular priced quality rebuilt RCA Colorama—when you recommend RCA—you'll not only flatter your customer, you'll also be protecting your own hard-earned service reputation. That's because RCA picture tubes are designed to protect the biggest reputation in the COLOR TV industry.

RCA Electronic Components, Harrison, N.J.

RCA