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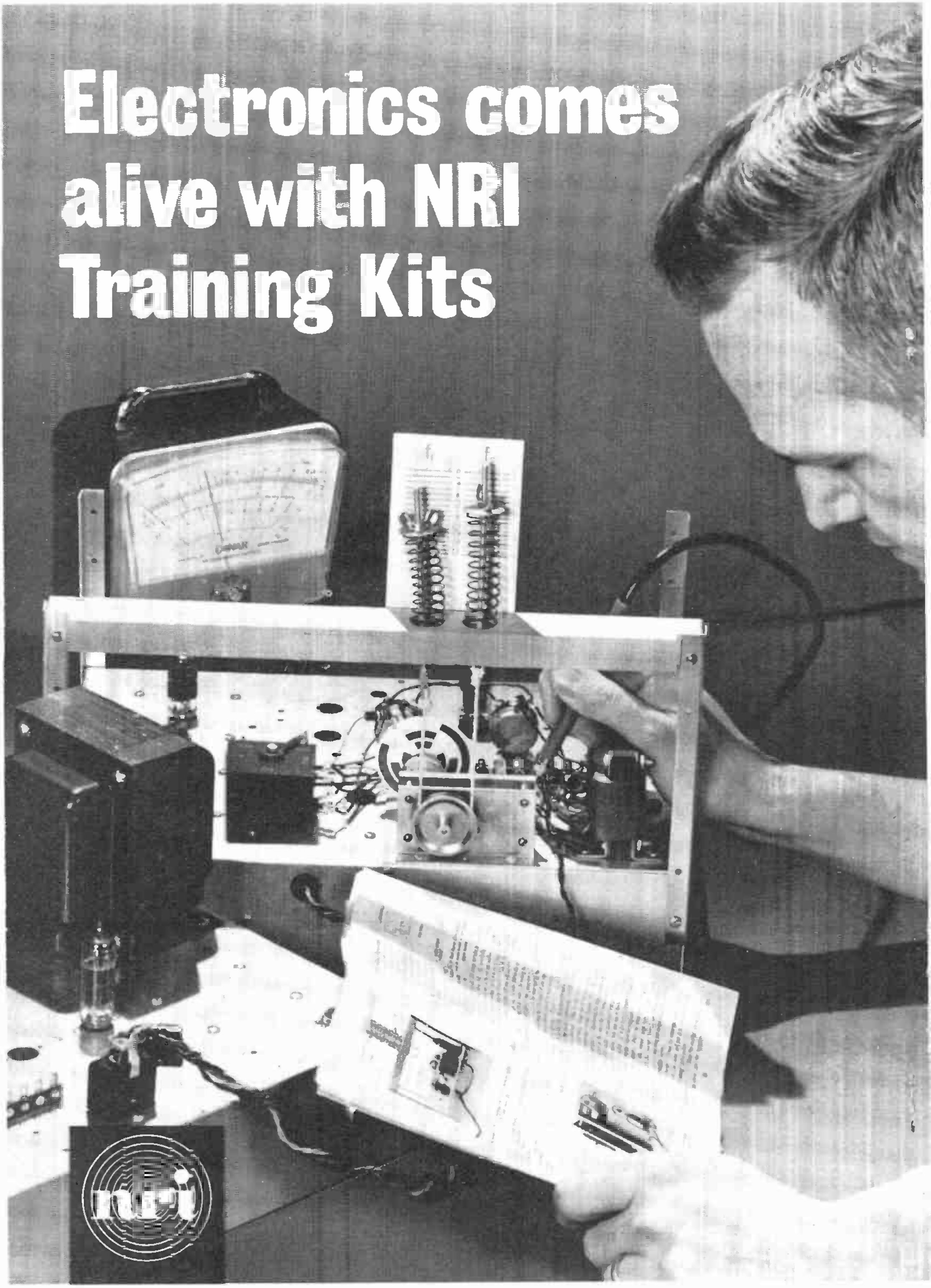
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VOLUME 33 NUMBER 4 **OCTOBER 1970**

Popular Electronics

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FEATURE ARTICLES

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This month's cover photo by Justin Kerr

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DIRECT & CURRENT

Second in a Monthly Series by Oliver P. Ferrell, Editor

CB! FOR BETTER? OR WORSE?

Since its introduction to the 27-MHz band, millions of words have been written about the pros and cons of CB. From that plethora of verbiage, there has been little objectivity, substantial denegation of facts, and an incomprehensible attitude toward CB by the Federal Communications Commission. Exactly how the FCC can ignore 4,000,000 CB transceivers and 875,000 "licensed" CB stations defies rational explanation. But, ignored it is—castigated on occasion—and a source of enormous revenue to the FCC.

Even the most cursory tally shows that CB license fees and forfeitures provided 7% of the money spent by the FCC in 1969—more than any other radio service. This was achieved at an expenditure of around $300,000. The FCC's return on its investment is about 500% and if that situation is not a shocker, bear in mind that the FCC expects CB to make up 17½% of its annual budget starting August 1, 1970. For this larger sum, the FCC apparently expects to provide little or no additional services.

Several years ago the FCC proposed an independent study of CB regulatory problems and budgeted money to get the program under way. When Congress didn't approve of all the FCC proposed expenditures, what money was available went to the Broadcast Bureau and hopes of finding a solution to CB went down the drain.

Popular Electronics feels that the time is past for the FCC to "make something" as is out of 27-MHz CB. The $20 license fee (up from $8) will be ignored by an ever-increasing number of illegally operating CB'ers. In its unthinking haste to make itself look good fiscally on paper, the FCC has created a behemoth out of a monster. Rather than take the initiative and right the wrongs of CB, the FCC has opened the floodgates to put more stations on the air with fewer and fewer controls.

When will the FCC learn that they *must* live with CB? It cannot be hidden away in the attic or swept under the rug. Through its own inadequate planning and slavish responsiveness to broadcasting lobbies at the sacrifice of all other radio services, the FCC is now in a cul-de-sac.

Popular Electronics finds no valid argument for the FCC's continuing to think of CB solely in terms of 23 channels scattered around 27 MHz. The FCC must consider either the allocation of additional channels between 26.1 and 27.54 MHz (90 channels possible) or close down the 27-MHz citizens band within 5 years and move it en masse to the 450-MHz band.

NEW LITERATURE

To obtain a copy of any of the catalogs or leaflets described below, fill in and mail the Reader Service blank on page 15 or 115.

Dynascan Corp. has released a 24-page catalog of B&K Professional Test Equipment for electronics servicing and school, laboratory, and industrial applications. Solid-state design is dominant in the instrument listing, including a FET VOM, an rf signal generator, a sine/square-wave generator, and a tube tester with lockout pushbuttons that provide positive short indications. Other instruments listed include: a sweep/marker generator, oscilloscope/vectorscope, capacitor analyst, color bar generators, etc. Probes, adapters, and other accessories are also included.

Circle No. 75 on Reader Service Page 15 or 115

A 24-page illustrated catalog has just been published by *Turner Company* describing its complete line of microphones and accessory equipment. The catalog, No. 2620, contains specifications and prices of professional, recording, broadcast, and PA cardioid dynamic mikes; standard and transistorized mobile communications mikes; tape recording and general-purpose mikes; paging and PA mikes; and stands, cartridges, and accessories.

Circle No. 76 on Reader Service Page 15 or 115

For the automobile enthusiast who demands high performance from his wheels, *Automotive Research Electronics* has available a catalog of electronic device listings for mobile use. Among the items listed are a capacitive discharge ignition system, a dwell stretcher, street and strip r/min limiter, road and track r/min limiter, and a digital racing timer.

Circle No. 77 on Reader Service Page 15 or 115

The *Space Support Division*, Sperry Rand Corp., is offering Scanning Electron Microscope (SEM) services at its Microanalysis Laboratory on a machine-hour basis. The SEM has a useful range from 20X to 50,000X and is capable of examining, with little or no special preparations, surface details of almost any kind of specimen in such diverse fields as biology, microelectronics, and material science. A photograph which faithfully rep-

LITERATURE *(Continued from page 8)*

resents the surface features of the test sample can be provided within a few seconds at any stage of the examination. Flyers are available on request.

Circle No. 78 on Reader Service Page 15 or 115

A two-page data sheet, No. 5170, that describes the company's new Models 8000 and 8000-A digital volt-ohm-milliammeters is available from *Triplett Corp.* The two-color data sheet provides complete electrical and mechanical specifications.

Circle No. 79 on Reader Service Page 15 or 115

Catalog No. 710, available from *Lafayette Radio Electronics*, is a complete buyer's guide to current home entertainment, hobby, and experimenter parts and equipment. It includes the latest in hi-fi tuners, receivers, and amplifiers; turntables; reel-to-reel, cartridge, and cassette recorders and decks; TV receivers; test equipment; auto accessories; and many other items.

Circle No. 80 on Reader Service Page 15 or 115

International Rectifier's No. JD352 "Diamond Line" catalog for 1970 will be of interest to anyone involved in electronics either as a hobby or a livelihood. It lists such items as Diacs and Triacs, IC's, silicon and germanium diodes and transistors, photocells, heat exchangers, and electrolytic capacitors. Also included is a two-page cross reference guide to IR transistor and diode replacements.

Circle No. 81 on Reader Service Page 15 or 115

An 80-page catalog of computer parts, Geiger counters, electronic parts and equipment, cameras, telescopes, watches, a tachometer kit, and many other surplus parts and items from government and industry is available from *B. & F. Enterprises.* The catalog lists some real bargains on electronic parts.

Circle No. 82 on Reader Service Page 15 or 115

Sharpe Audio Division of Scintex, Inc., is offering their price list and catalog of newly developed audio visual products. Included are high-quality headphones, headset microphones, cordless induction-type headsets, wireless headsets, and audio station and sound centers. There is also an extensive listing of impedances and radio frequencies.

Circle No. 83 on Reader Service Page 15 or 115

A new full-line, 68-page dealer catalog of selected electronic products has just been published by *North American Electronics, Inc.* The various items listed are in discrete product groupings which include virtually everything in electronics from test equipment to unit parts such as resistors and capacitors. The number of items in standard packages is listed.

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CIRCLE NO. 5 ON READER SERVICE PAGE→

Electronics LIBRARY

ABC's OF THERMISTORS

by Rufus P. Turner

This book tells, in simple language, how the thermistor works and how it can be used in representative circuits. The text should be equally useful to the student and practicing technician. *Soft cover. 96 pages. $2.95.*

101 QUESTIONS & ANSWERS ABOUT HI-FI & STEREO

by Leo G. Sands & Fred Shunaman

Whether you are interested in building and servicing hi-fi equipment or in how well hi-fi equipment can reproduce music, there should be something for you in this book. The simple question-and-answer format of the text seems to be the best approach to the subject. *Soft cover. 128 pages. $3.50.*

COLOR-TV TROUBLE CLUES (Volume 3)

Since the first two volumes of Trouble Clues were published, remarkable changes have taken place in the television industry. This volume contains information on receivers produced since Volume 2 was published. It is not intended to replace the earlier volumes; rather to provide additional, up-to-date material. *Soft cover. 128 pages. $3.50.*

TAPE RECORDER SERVICING GUIDE

by Robert G. Middleton

In this book are presented both the electronic circuit theory and mechanical construction of tape recorders. The magnetic and biasing circuits unique to tape recorders are emphasized in the text. *Soft cover. 96 pages. $3.95.*

Above four titles published by Howard W. Sams & Co., Inc., 4300 West 62 St., Indianapolis, IN 46268.

ELECTRIC MOTOR REPAIR, Second Edition

by Robert Rosenberg

For many years, there has been a need for a practical nontheoretical book on electric motor repair and control that could be used by men with little background or knowledge of electrical engineering. This book appears to fill that need admirably. Both alternate and direct current motors are treated, and extensive consideration is given to the connections and troubles in controllers. Although numerous changes and additions have been made in this edition, nearly all of the material that appeared in the first edition has been

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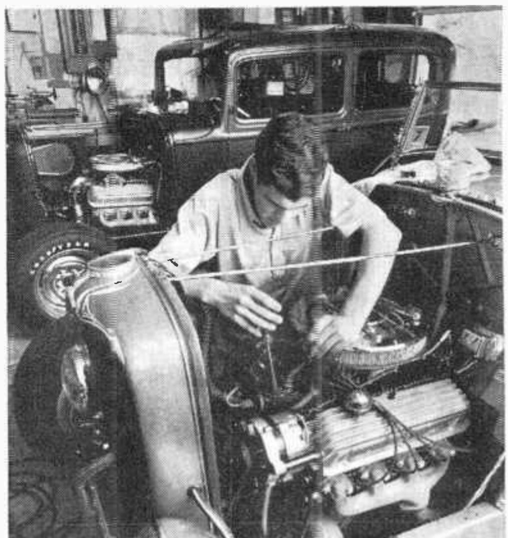

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retained. Because solid-state electronics is important to motor control, a section on solid state controls has been added. Study questions for each chapter are included. The physical design of the book is practical; all illustrations appear at the reader's left on a separate wire ring binder, while at the right is the text.

Published by Holt, Rinehart and Winston, Inc., 383 Madison Ave., New York, NY 10017. Soft cover. 750 pages. $12.95.

CB RADIO

by Leo G. Sands

Since the Federal Communications Commission established the Class D Citizens Radio Service, more than one million station licenses have been issued authorizing the use of some four million CB transceivers. Here, in this one compact volume, is the entire story about the most widely used and fastest growing form of radio communication. The book describes the Citizens Radio Service and its many applications. Equipment is discussed in detail, and information on equipment installation and maintenance as well as on operating rules is presented. The book is a basic introduction to CB radio.

Published by A.S. Barnes & Co., Box 421, Cranbury, NJ 08512. Hard cover. 143 pages. $6.95.

AUDIO CYCLOPEDIA, Second Edition

by Howard M. Tremaine

Most books dealing with the subject of audio cover only specialized topics—such as hi-fi amplifiers, tape recorders, etc.—or touch on a broad range of subjects without really going into detail. The *Audio Cyclopedia*, however, combines specialized topics from all areas of audio and discusses them in detail. Primarily a reference source, this book is of particular importance to the audio engineer but will also be used by anyone whose interest in audio goes beyond just listening. The text coverage is complete and is supported by numerous schematic diagrams, photographs, line graphs and charts.

Published by Howard W. Sams & Co., Inc., 4300 West 62 St., Indianapolis, IN 46268. Hard cover. 1757 pages. $29.95.

INTRODUCTION TO SWITCHING CIRCUIT THEORY

by Donald D. Givone

Most books on switching circuit techniques are either too basic or too technical. Here the author attempts to hit a happy medium by integrating the two extremes—first providing the fundamental mathematical principles of switching circuit theory and then letting the mechanics of logic design be a direct consequence of the theory. Because this book is for a first course on the undergraduate level, mathematical development is presented in detail. Special features include: a chapter devoted to universal logic operations; transformation development between switching expressions involving these opera-

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tions and the more conventional operations of Boolean algebra; and a study of fundamental mode and pulse mode sequential circuits.

Published by McGraw-Hill Book Co., 330 West 42St., New York, NY 10036. Hard cover. 494 pages. \$14.50.

DESCRIPTIVE ELECTRONICS

by R.R. & C.A. Huffsey

On the beginning electronics level, this volume proposes to explain both tube and solid-state circuits without the extensive use of mathematics. After an introduction to the concepts of current and voltage and a discussion of basic electronic components, the text continues with detailed explanations of circuit operations. Examples of power supply, amplifier, oscillator, and detector circuits are analyzed. Experiments suggested in the book are adaptable to almost any existing laboratory situation—including the hobbyist's and experimenter's bench.

Published by Holt, Rinehart and Winston, Inc., 383 Madison Ave., New York, NY 10017. Hard cover. 365 pages. \$9.95.

FILTER SYSTEMS DESIGN: ELECTRICAL, MICROWAVE, AND DIGITAL

by Yale Jay Lubkin

Employing an informal but thorough approach, this book is designed to extend the working engineer's knowledge of electrical filters and to provide him with tools he can use immediately. Presented are the fundamental concepts of electrical filters: why and how the various kinds originated, what types of problems they solve, and their limitations. Some of the concepts developed have never before appeared in printed form; and, while they are rather advanced in nature, they are nevertheless understandable. Aimed at the engineer, this book requires little mathematical sophistication; the math needed is developed with the flow of the text.

Published by Addison-Wesley Publishing Co., Inc., Reading, MA 01867. Hard cover. 212 pages. \$11.50.

FET APPLICATIONS HANDBOOK, Second Edition

by Jerome Eimbinder

For anyone who needs practical design data on FET circuits, here is possibly the most current and comprehensive guide currently available. In its second edition, the book contains almost 25 percent more material than before, to the tune of six entirely new chapters. The text covers FET types, parameters and characteristics, and operational modes. Emphasis is on applications from linear to switching circuits and IC's. For the engineer interested in photo-FET design, the last two chapters offer new data and many practical and unusual applications, including a FET electrometer amplifier. More than 250 schematics and graphs illustrate

(*Continued on page* 117)

Second in a series...

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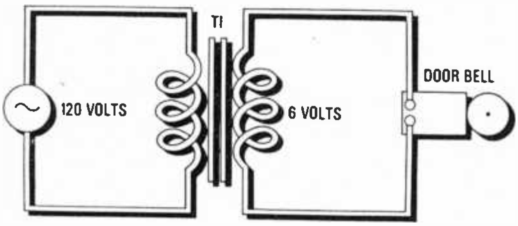
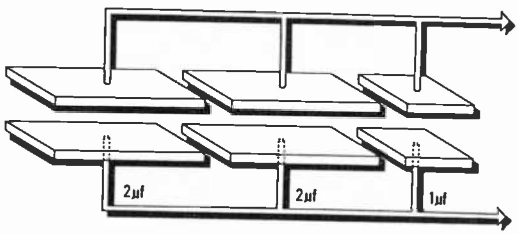


In this door bell circuit, which kind of transformer is T_1 — step-up or step-down?

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

This one is more advanced.



What is the total capacitance in the above circuit?

Note: you'd know the solution to the problem if you'd taken only the first two lessons in RCA's new Communications Electronics Program.

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Answers: Step-down.
5 μf

NEW PRODUCTS

Additional information on products described in this section is available from the manufacturers. Each new product is identified by a corresponding number on the Reader Service Page. To obtain additional information on any of them, circle the number on the Reader Service Page, fill in your name and address, and mail it in accordance with the instructions.

SONY REEL-TO-REEL/CASSETTE SYSTEM—If you're in a quandary about the reel-to-reel vs cassette debate, the Sony Model 330 provides a workable solution. Billed as a Stereo Tape System/Control Center, the 330 permits reel recording, editing, and re-recording to cassette. Or, if you have too many bulky reel tapes, the cassette may be your answer by simply transferring one format to the other. Modestly priced, the 330 has 3 reel tape speeds, dual VU meters, tone controls, separate volume controls, headphone output jack, 5" lid-integrated stereo speakers and two cardioid microphones. Adding a tuner and changer, you have a full complement of a low-cost stereo system.

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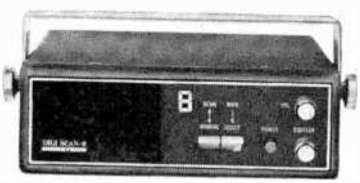

UNIMETRICS MONITOR SCANNER—Simplicity seems to be the keynote in the appearance of the *Unimetrics, Inc.* Digi Scan-8 VHF/UHF automatic scanning receiver. Only two lever switches are seen on the panel. One lever sets the receiver up for scanning up to 8 preselected crystal-controlled channels or permits manual channel selection. The second selects the appropriate channel after manual setup. Readout of the channel being monitored is through a bright, segmented digital indicator. Manufacturer claims a 0.5-μV sensitivity and −60-dB image rejection.

Circle No. 86 on Reader Service Page 15 or 115

SENCORE POWER MONITOR—Using the Sencore PM157 Power Monitor, radio-TV technicians have a new test instrument for solving problems concerning excessive power drains. The technician first reads line voltage on an expanded scale covering 65 to 135 volts ac. Then the drain is measured and can be read in values up to 10.0 amperes and/or 1150 watts. The PM157 also contains a bridge circuit to permit measurement of dc up to 10 amperes and/or a combination of ac and dc, such as might be found in fuse resistors. In fact, a separate scale on the PM157 reads the drain on fuse resistors with the common values of 4.7, 5.6, 7.5, 9-10, 22, 47, and 100 ohms. The PM157 is protected by a circuit breaker.

Circle No. 87 on Reader Service Page 15 or 115

NIKKO "DO EVERYTHING" STEREO RECEIVER—A recent entry in the American market, Nikko Electric Corp., has announced its feature-loaded 1101 stereo receiver. Rated at 160 watts (IHF) at plus or minus 1.0 dB and 4 ohms (112 watts at 8 ohms) the claimed frequency response of the amplifier is 10-70,000 Hz, also

Newest SAMS Books

Hi-Fi Stereo Servicing Guide

by ROBERT G. MIDDLETON. A complete guide to effective hi-fi and stereo servicing. Provides the basis for a full understanding of hi-fi tuner and amplifier circuitry and procedures for servicing this type of equipment. The proper use of audio test and measurement equipment and the basic principles of acoustics are also given. Covers all hi-fi components (except record players and tape recorders). Order 20785, *only*... $3.95

ABC's of Avionics

by LEX PARRISH. Provides a basic understanding of avionics—the electronic equipment used to insure the safety of crew and passengers. The type of equipment and the techniques employed in private aircraft operations are featured. Discusses requirements for basic communications, navigation aids, instrument flight aids, weather guidance, and flight control safety devices.
Order 20764, *only*............ $3.50

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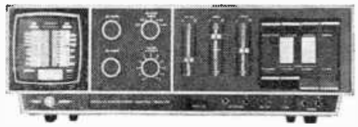
CIRCLE NO. 22 ON READER SERVICE PAGE

at plus or minus 1.0 dB. Besides receiving AM/FM/FM stereo, the Nikko 1101 has the following somewhat "different" features: VU metering in the stereo amplifier; plus 10 dB speaker compensation at 30 Hz; stepped volume control for remote (second pair) speaker system; rear panel patch cords to disconnect stereo preamp from stereo power for insertion of special components; triple circuit breakers; plug-in circuit board construction; etc. All solid-state, the Model 1101 uses 6 FET's, 12 IC's, 25 transistors, and 22 diodes. Available in either a black metal or walnut ($20 extra) cabinet.

Circle No. 88 on Reader Service Page 15 or 115



HARMAN-KARDON CAD5 CASSETTE RECORDER—One of the chief complaints about cassette recordings has been the presence of high-frequency noise. The Dolby noise reduction system, a technique recently introduced to get rid of a lot of this noise, is an integral part of Harman-Kardon's CAD5 tape cassette deck. It is said that the system extends the frequency response of cassettes to beyond 12,500 Hz. The CAD5 can play standard tape cassettes or Dolby processed tapes without special adjustment and the Dolby controls (per channel) can be set for special tapes. An electronic speed control assures minimum speed variation and professional-type sliding potentiometers set the recording level.

Circle No. 89 on Reader Service Page 15 or 115

ABPHOT AC VOLTMETER—Measuring low-level signals in audio equipment is made easier with the Model 1001 Electronic Analog Voltmeter, a solid-state instrument with a range of 30 microvolts to 100 volts in the frequency range from 10 Hz to 1 MHz. Sensitivity is 300 microvolts FSD and internal noise is typically −108 dBm on the 300-microvolt scale. Battery operation eliminates troublesome ground loops and beat effects while making measurements in the vicinity of the line frequency. Accessory Series 900 plug-in notch filter makes possible measurements at spot frequencies. These RCL bridged-T networks plug directly into the meter.

Circle No. 90 on Reader Service Page 15 or 115

PIONEER AUTOMATIC-TUNING RECEIVER — The ultimate for dial twisters is Pioneer's AM/FM/FM stereo Model SX-2500 receiver with precision automatic tuning. With a 340-watt (IHF) output, the receiver can be set to hunt out strong local stations or weak stations or to stop only on stations broadcasting in stereo. A muting level control permits the listener to determine the amount of muting beween FM stations. The SX-2500 also has a remote control unit for automatic tuning and volume control from distances up to 23 feet. The FM front end tuner uses FET's, IC's and crystal filters and has a sensitivity of 1.6 microvolts per meter. Selectivity is 65 dB at 98 MHz and signal-to-noise ratio is over 70 dB.

Circle No. 91 on Reader Service Page 15 or 115

A Question Of Semantics

WHO DID INVENT RADIO?

BY FRED SHUNAMAN

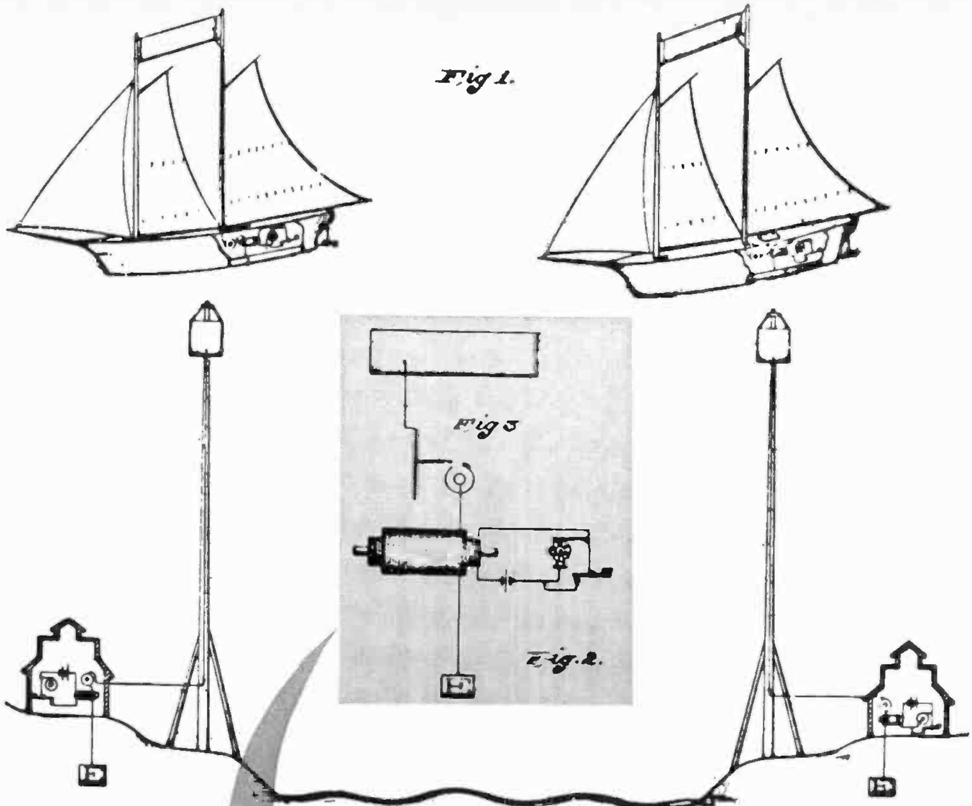
IN ALL PROBABILITY there will never be total agreement on the question of who actually discovered radio. In fact, the word "radio" itself does not stand up to a strict historical interpretation. Does the "first radio" mean the first two-way wireless communication? Or a one-way wireless transmission? Or would a minor laboratory demonstration and a patent establish the precedency of the discoverer/inventor?

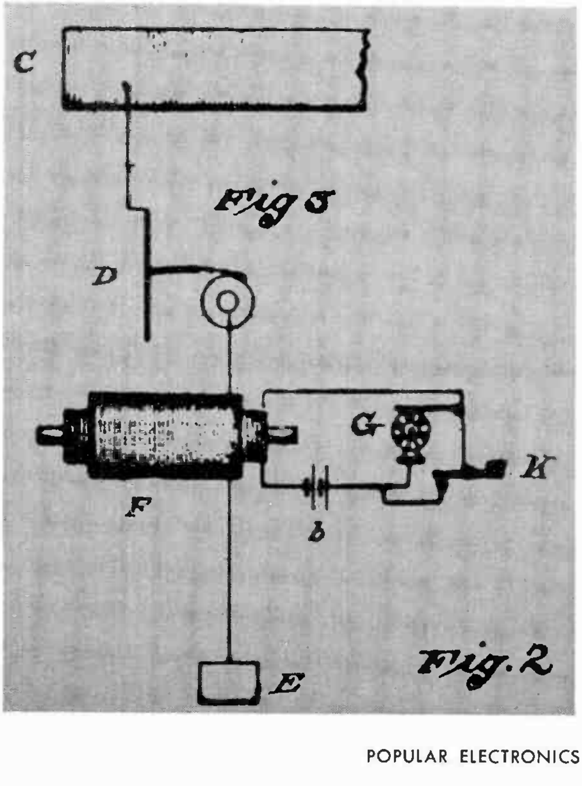
In one way or another, Marconi, Popov, Loomis, Butterfield, Lodge, Hertz and Tesla all qualify as discoverers of radio. However, history now shows that none of these men has the supporting evidence of discovery that belongs to Thomas Alva Edison—to whom the honor may rightfully belong.

A simple language difficulty may have cost Edison the credit for first discovering and using radio as a means of communication. He announced the discovery of "etheric force" when Marconi was only a year old and while Tesla was still attending school. And, in 1885, two years before Hertz announced the discovery of electromagnetic waves, Edison applied for a patent on a complete wireless system. Submitted with his application were patent drawings of radio towers and antennas on the masts of ships.

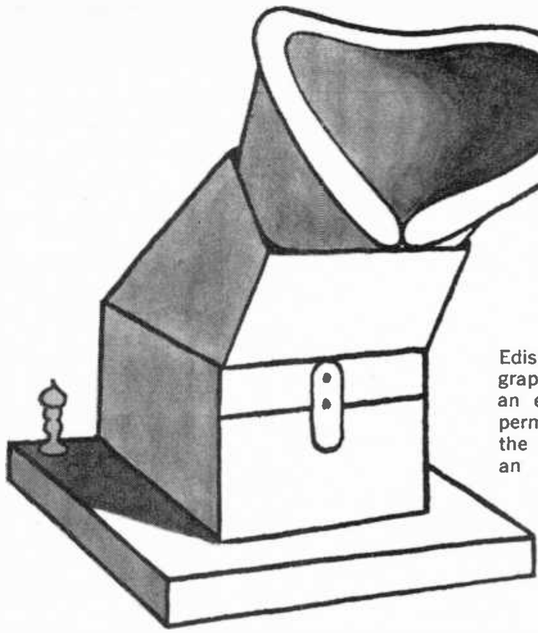
How It All Began. During the evening of November 22, 1875, Edison was studying the action of a magnetic vibrator. He noticed a tiny spark between the armature and core of the vibrator as the armature approached the core. Suspecting faulty insulation, he checked the coil but found everything in order.

However, Edison reported that: "If we touched any part of the vibrator we got the spark," and that "the larger the body of iron touched to the vibrator, the larger the spark." If a wire was connected between the vibrator





Above is one of the drawings from Edison's Patent No. 465,971, Dec. 29, 1891, describing a "Means for Transmitting Signals Electrically." Particularly interested in transmitting across bodies of water, he showed high towers and ships carrying "condensing surfaces" (which we would call antennas). At the right is an enlargement of the insert, in which Edison described how signal was generated and transmitted to antenna.



Edison's "black box" 1881 demonstration had graphite points which could be connected to an external circuit. The extension eye-shade permitted viewer to see, jumping between the contacts, sparks unlike any known to an electrical phenomenon at that period.

and a gas jet on the wall, a spark could be drawn from the gas pipes anywhere in the room.

Then Edison performed the experiment that Hertz was to do 17 years later; he found that "if you turn the wire round on itself and let the point of the wire touch any part of itself, you get a spark. . . . This is simply wonderful and a good proof that the cause of the spark is not *now known force*."

Next, Edison constructed a demonstration apparatus and revealed his new setheric force" to the Polyclinic Club of the American Institute. Many of the members seemed upset by the name he had chosen for the new effect. But Edison was undaunted, and he predicted (in the January 1876 issue of the *Operator*, a telegrapher's magazine) that the new force might become the telegraphic medium of the future. He is quoted as having stated: "The cumbersome appliances of transmitting ordinary electricity, such as telegraph poles, insulating knobs, cable sheathings, and so on, may be left out of the problem of quick and easy telegraphic transmission, and a great saving of time and labor accomplished."

The *Scientific American* of December 1875 stated: "By this simple means signals have been sent [by wire] for long distances, as from Mr. Edison's laboratory to his dwelling house in another part of the town. Mr. Edison states that signals have also been sent the distance of 75 miles on an open circuit, by attaching a conducting wire to the Western Union telegraph line."

As It Developed. A "black box," used by Edison to demonstrate etheric force was sent to Paris where Edison's assistant, Charles Batchelor, lectured on the etheric force. (The black box detector consisted of a pair of adjustable graphite points in a shaded enclosure, with terminals to attach it to an external circuit.) There is a bare possibility that Heinrich Hertz might have heard about Edison's experiments, for his spark points with the micrometer adjustment are virtually identical to those in the black box, and he repeated the experiment of turning the wire back upon itself.

Work on the telephone took Edison's attention away from etheric force for some time. But in 1885 he applied for a patent for a wireless telegraph system based on his etheric force. The patent drawings show towers that are easily recognizable as radio masts, and two ships with broad ribbon-like antennas hung between their masts! The text of the patent application goes into detail about the equipment shown in the drawings.

"The wire (from the 'condensing surface' C) extends through an electromotograph telephone receiver D (Fig. 2) or other suitable receiver, and also includes the secondary circuit of an induction coil F. In the primary of this coil is a battery *b* and a revolving circuit-

Thomas A. Edison, from a print dated 1877, about the time he was working on his "etheric force" invention. This and other illustrations in this article are adapted from those appearing in "Menlo Park Reminiscences," Vol. I, by F. Jehl, Edison Institute, Dearborn Park, Mich.

breaker G. This circuit-breaker . . . is short-circuited normally by a backpoint key K, by depressing which . . . the circuit-breaker makes and breaks the primary circuit of the induction coil with great rapidity," Edison wrote.

Explaining the phenomenon as he saw it, Edison went on to state: "These electric impulses are transmitted inductively to the elevated condensing surface at the distant point . . ."

Here is where the confusion in language occurred. At the time, the term *induction*, unless otherwise explained, meant *electrostatic induction* (a tendency that still lingers on in some elementary physics textbooks). The transformer had just been invented, and magnetic induction was a laboratory curiosity. The term "electrostatic" drifted into obscurity as the art progressed, and later writers referring to the "induction telegraph" unquestioningly accepted the term to mean *magnetic* induction.

The confusion was increased because the only commercial use Edison made of his invention was the "grasshopper telegraph," a system of telegraphing from moving trains to the telegraph wires alongside the tracks. This was a distance that could be covered easily by electromagnetic induction, and historians who believe that radio communication started with Tesla, Lodge, and Marconi assumed that this was the case. Yet, in explaining the "grasshopper telegraph" to a reporter, Edison said, "The system works by electrostatic induction."

So, a change in the generally accepted meaning of a word with the changing times buried the fact that Edison invented, described, patented, and *operated* a radiotelegraph system in 1886—a year before Hertz explained the cause of the etheric force, which he called electric force.

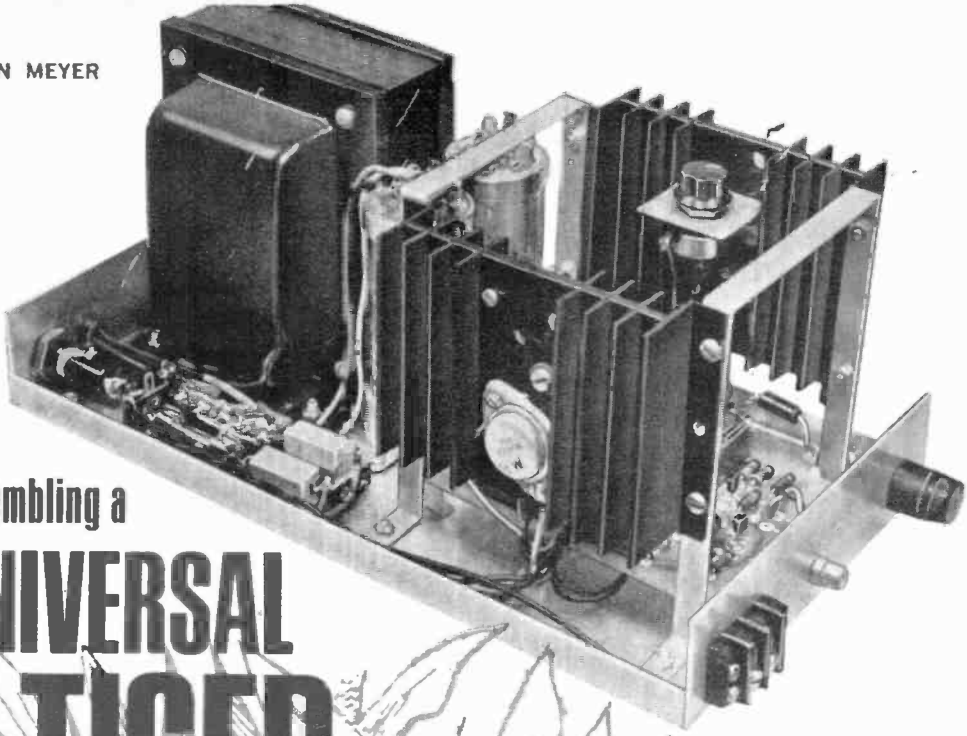
What other "firsts" may lay buried or attributed to other discoverers because semantics denied the original inventor or discoverer his due? At least now Thomas Alva Edison's long list of achievements will have numbered among them the discovery of radio waves—even if he did not title them as such. -30-

Editor's Note: We are given to understand that the graphic-points "black box" is still in existence and has been exhibited on the second floor of the restored Edison Laboratory.

In his book, "Menlo Park Reminiscences" (now believed to be out of print and unobtainable), author Jehl says that Edison was intrigued by the spark and performed many experiments to seek an explanation of its nature. Edison did find that the spark was unpolarized; had no respect for the usual types of insulation; would not discharge a Leyden jar; and had no effect on his electroscopes.

Unquestionably, Edison had stumbled onto radio-wave transmission, but the fact that energy could be propagated through the atmosphere and not via wires was alien to all of his telegraphy experiments.

BY DAN MEYER



Assembling a UNIVERSAL TIGER

A UBIQUITOUS, 125-WATT-PER-CHANNEL DESIGN

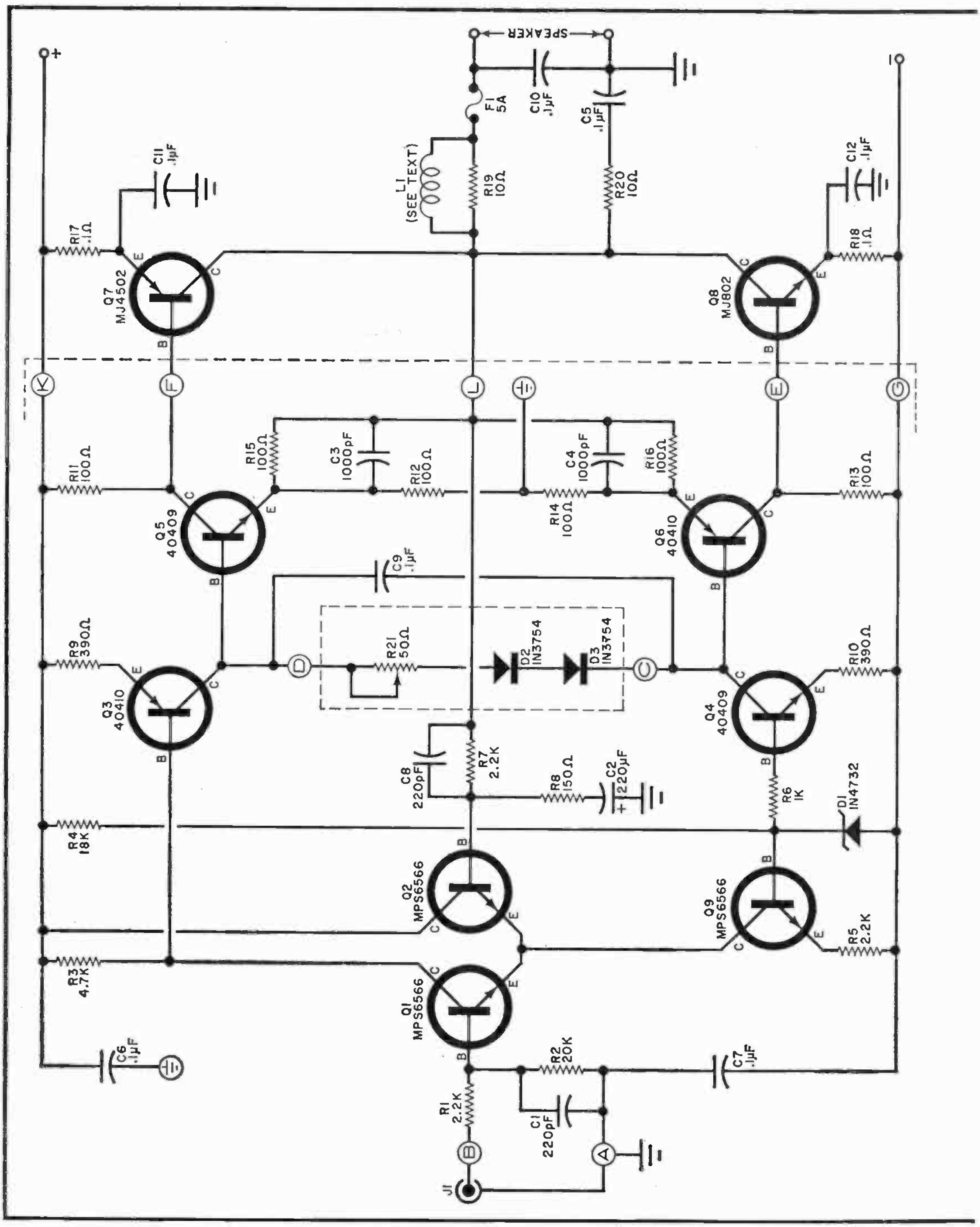
This power amplifier design is the culmination of various "Tiger" amplifier projects developed by the same author. It is virtually indestructible and our exhaustive tests reveal that no combination of input-output mismatching and short circuits can cause amplifier failure. The performance specifications equal or better numerous commercial quality hi-fi power amplifiers.

NO HI-FI power amplifier can be all things to all men, but the "Universal Tiger" comes closer to the ideal than you might think. Consider the following: The output power of the Universal Tiger can be set to any level between 10 and 120 watts rms/channel by connecting to the amplifier circuit an appropriate power supply (12-40 volts dc). Over the audio spectrum, distortion is never more than 0.5% and it can be reduced to less than 0.05% at the user's option. The bandwidth between the 3-dB down points is 1-100,000 Hz.

And that's not all. No external load, short circuit, or input condition can cause amplifier failure. The most that will happen is a blown fuse. Thermal stability is so good that the output transistors operate with a heat sink temperature of 100° C (the boiling point of water) with no tendency to self-destruct. Nor is there any danger of speaker damage due to a starting transient since there are no large capacitors in the circuit that must charge up before normal operation can begin. When the Universal Tiger is turned on, a small click is heard in the speaker system, then instant sound.

Construction. The driver and voltage amplifier stages of the Universal Tiger are assembled on a printed circuit board, the actual size etching guide and component placement diagram for which are shown in Fig. 2. The circuit board is designed to match the space requirements of the "Super Tiger" (see "Tigers That Roar," POPULAR ELECTRONICS, July 1969) so that builders of the earlier project can easily update it.

The chassis and power supply for the Super Tiger can also be used with the Universal Tiger if no more than 80 watts mono or 60 watts/channel stereo output is desired. If you want a lower output power, one of the low-voltage transformers listed in the sidebar should be used. And with a 4-ohm load and a heavy-duty power supply (see Fig. 3) for *each* channel, a 125 watts rms/channel stereo system can be built.



The power supply circuit is simple and straightforward. However, depending on the amount of power you want from your amplifier, you will have to select the proper secondary voltage-current rating for transformer *T1* and the current rating of fuse *F1* from the table in the sidebar.

The power supply mounts directly on the steel chassis that accommodates the amplifier circuits. Point-to-point wiring is used throughout, but be extremely careful during wiring to make sure diode and capacitor polarities are correct.

Since the physical layout of the Super Tiger was presented previously, this article will focus on the construction of only the 125-watt mono version with power supply.

Unless you purchase the steel chassis with the complete kit from the source listed in the Amplifier Parts List, you will have to machine your own, using the photos given in this article to guide you.

After mounting and soldering into place the components on the circuit board, solder 8" lengths of #18 or larger stranded hookup wire at hole locations C and D from the *foil* side of the board and at locations G, GND, E, L, F, and K from the component side. Twist together 2½" lengths of black and white wires. Solder the black wire to A and the white wire to B on the component side. Then mount the circuit board in its proper location on the chassis.

At the opposite end of the chassis, anchor the power transformer with #8 hardware and the filter capacitors with #6 hardware. Fasten the power supply primary fuse holder and line cord with strain relief in their appropriate holes on the rear apron of the chassis. Then bolt down the secondary fuse block and the terminal strips associated with

PARTS LIST
AMPLIFIER

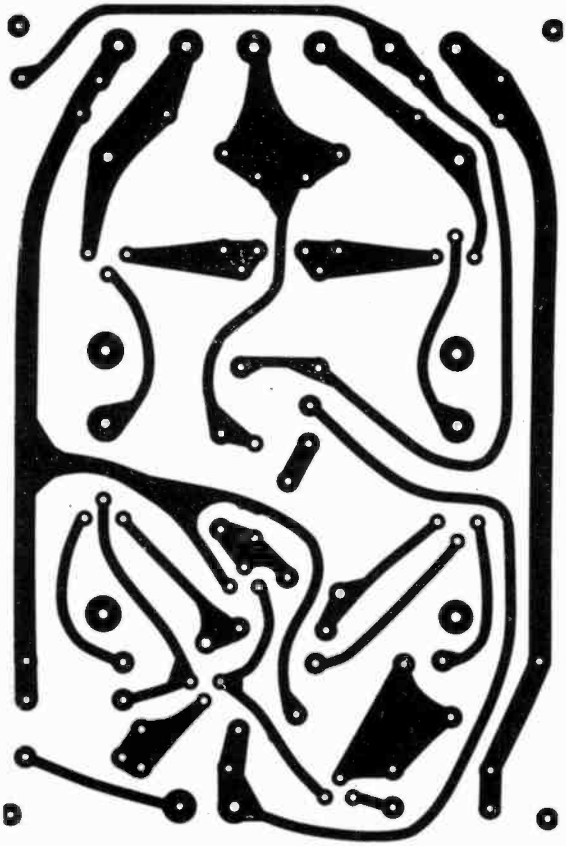
C1,C8—220-pF capacitor
C2—220-µF, 6.3-volt electrolytic capacitor
C3,C4—1000-pF capacitor
C5-C7,C9—0.1-µF capacitor
C10-C12—0.1-µF disc capacitor
D1—4.7-volt zener diode (1N4732 or HEP602)
D2,D3—1N3754 or HEP 156 silicon diode
F1—5 ampere standard—NOT slow-blow—fuse
J1—Phono Jack
Q1,Q2,Q9—MPS-6566 transistor
Q3,Q6—Transistor (RCA 40410)
Q4,Q5—Transistor (RCA 40409)
Q7—Transistor (Motorola MJ4502)
Q8—Transistor (Motorola MJ802)
R1,R5,R7—2200-ohm, ½-watt
R2—20,000-ohm, ½-watt
R3—4700-ohm, ½-watt
R4—18,000-ohm, 1-watt
R6—1000-ohm, ½-watt
R8—150-ohm, ½-watt
R9,R10—390-ohm, ½-watt
R11-R16—100-ohm, ½-watt
R17,R18—0.1-ohm, 5-watt
R19,R20—10-ohm, 1-watt
(R1 through R20: All resistors 10% tolerance)
R21—50-ohm potentiometer

Misc.—Steel chassis (6" x 11"); Wakefield Semiconductor No. NC403C or Thermalloy Co. No. 6403B heat sinks (2); two-lug ungrounded terminal block; four-lug terminal strip; 22-18-gauge aluminum stock for U and L brackets; #18 or larger stranded hookup wire; fuse holder; #6 and #4 machine hardware; diode clamps (2); solder lugs (2); three-lug terminal strips (2); transistor mounting hardware; solder; etc.
Note—The following items are available from Southwest Technical Products Corp., 219 West Rhapsody, San Antonio, TX 78216: circuit board (No. 175B) for $2.75; complete amplifier as listed, but excluding chassis (No. 175C) for $30 plus shipping and insurance on 3 lb; complete stereo version with punched chassis and power supply (No. 2S-175) for $80 plus shipping and insurance on 17 lb; complete single-channel version with punched chassis and power supply (No. S-175) for $60 plus shipping and insurance on 14 lb.

Fig. 1. Circuit of power amplifier is simple and foolproof in design. Note absence of "weak link" large-value capacitors. Two such amplifier circuits are required for stereo system.

TECHNICAL SPECIFICATIONS

Output power: Up to 80 watts/channel with 8-ohm load; to 120 watts/channel with 4-ohm load
Distortion: Less than 0.5% from 20 to 20,000 Hz standard; less than 0.05% from 20 to 20,000 Hz with optional low distortion adjustment
Frequency response: 3 dB down at approximately 1 and 100,000 Hz
Hum and noise: Better than 80 dB below 1 watt rms output
Damping factor: Better than 100 with 8-ohm load
Sensitivity: 1.5 volts rms input for full output
Stability: Completely stable with any source impedance; can be used with any load impedance as low as 3 ohms or capacitive loads to 1 µF.



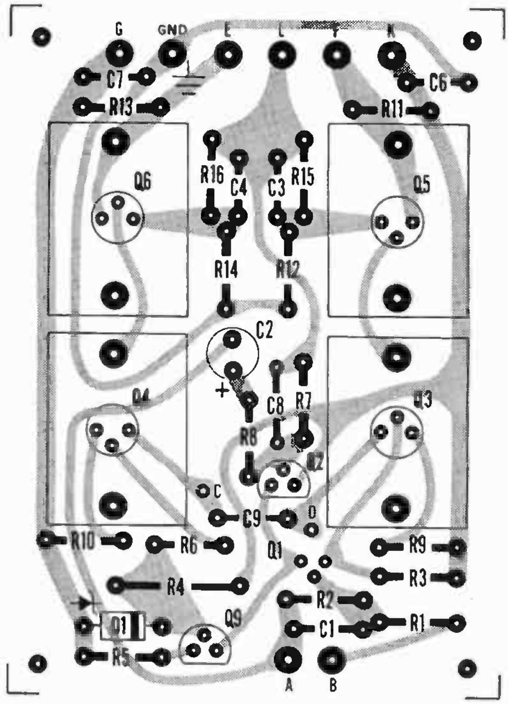


Fig. 2. Actual size etching guide is shown at left. In component layout and orientation diagram (above), boxes around Q3-Q6 represent outlines of heat sinks on these transistors.

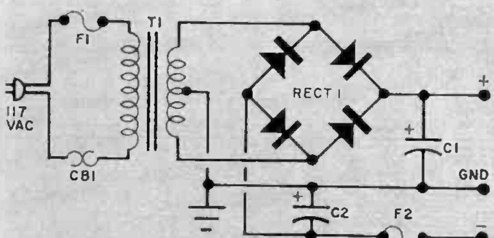


Fig. 3. Negative dc supply voltage is taken from right side of F2. Table lists ratings of F1 and T1 for desired amplifier output.

POWER SUPPLY COMPONENTS

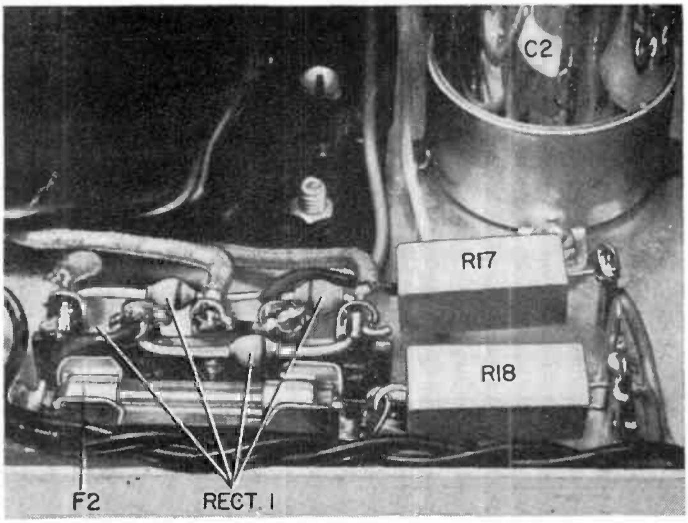
Output Power	F1 Current	T1 Secondary Voltage & Current	DC Output
125 W*	2.6 A	62 V ct, 3 A	±40 V
80 W	2.6 A	62 V ct, 3 A	±40 V
40 W	1.5 A	45 V ct, 2 A	±28 V
20 W	1.0 A	34 V ct, 1.5 A	±20 V
10 W	1.0 A	24 V ct, 1 A	±15 V

**At 4-ohm load; all other power ratings referenced to 8-ohm load impedance.*

POWER SUPPLY PARTS LIST

C1,C2—4000-μF, 50-volt electrolytic capacitor
CB1—200° thermostat (No. L200 88-4, available for $5 from Elmwood Sensors, Inc., 1655 Elmwood Ave., Cranston, RI 02907)
F1—Slow-blow fuse (see table for rating)
F2—5-ampere standard—NOT slow-blow—fuse
RECT1—Full-wave bridge rectifier assembly (Motorola MDA962-3), or substitute four 3-ampere, 200 PIV silicon diodes
T1—117-volt primary (see table for secondary voltage and current ratings) power transformer
Misc.—Fuse holder; fuse block; ac line cord with plug; line cord strain relief; #18 or larger stranded hookup wire; #6 and #8 machine hardware; two-lug—neither grounded—terminal strips (2); five lug—center lug grounded—terminal strip; solder; etc.
Note—All above items available from Southwest Technical Products Co. as part of kits S-175 and 2S-175 (see Amplifier Parts List).

Fig. 4. Power supply secondary fuse and bridge rectifier assembly diodes mount on fuse block and terminal strip. Resistors R17 and R18 connect output of power supply to Q7 and Q8 in amplifier circuit.



the power supply (see Fig. 4). Now, referring to Fig. 3, wire together the power supply circuit, using #18 or larger stranded hookup wire. (Note: Where #18 or larger wire is specified, do not substitute a smaller size wire. The circuits to which these wires connect carry as much as 10 amperes when the amplifier is driven to full power. If too small a wire size is used, power will be sacrificed and damping will suffer.)

Returning to the amplifier end of the chassis, mount input jack *J1*, the speaker fuse holder, and the output terminal block on the front apron. Solder the white wire from hole B on the circuit board to the center contact of *J1* and the black wire from hole A to the other lug on *J1*. Bolt a four-lug terminal strip (one lug grounded) to the chassis at the right of the circuit board and in line with the speaker fuse holder.

Close-wind one layer of #26 enameled wire along the entire length of the body of *R19* (10-ohm, 1-watt resistor). Scrape the ends of the wire and solder them to the leads of the resistor. Then solder one lead of this *L1/R19* assembly to the center lug on the output fuse holder and connect the other lead to the lug nearest the fuse holder on the last terminal strip mounted.

As shown in Fig. 5, connect *C5* and *R20* to the terminal strip near *R19/L1*. Solder only the ground lug that serves as the tie

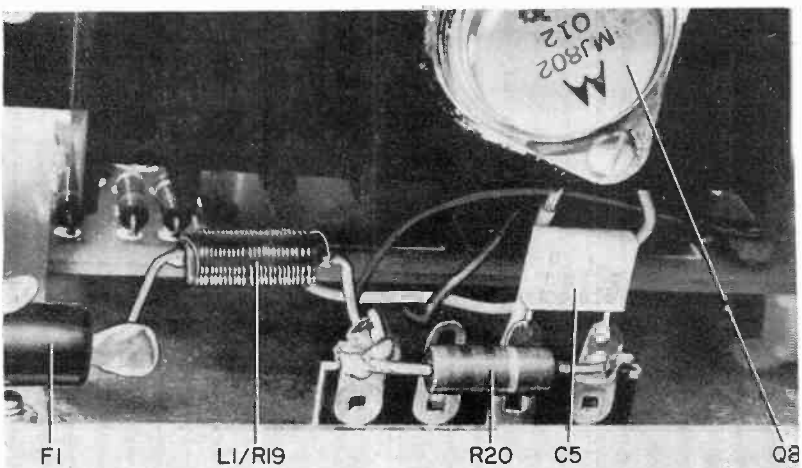


Fig. 5. Close-wind a single layer of #22 enameled wire along the entire length of R19 and solder the wire ends to the resistor leads to make the L1/R19 assembly.

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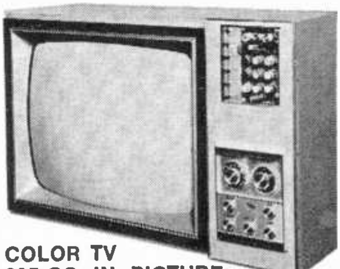

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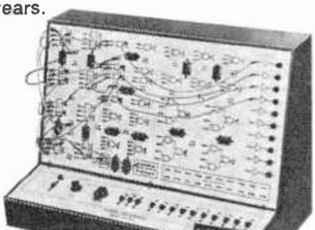

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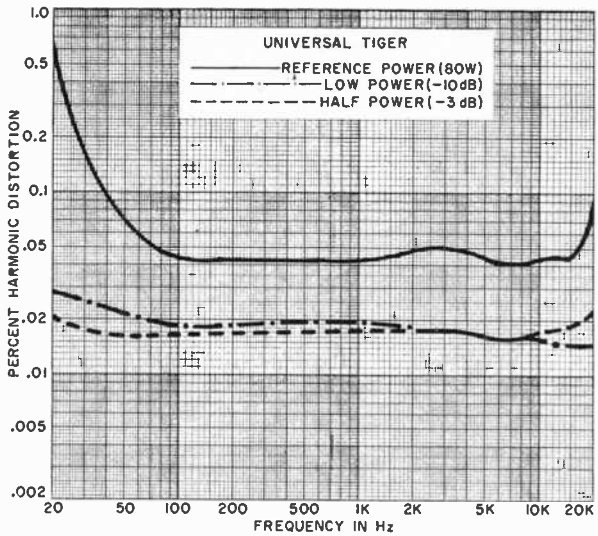


HIRSCH-HOUCK LABORATORIES

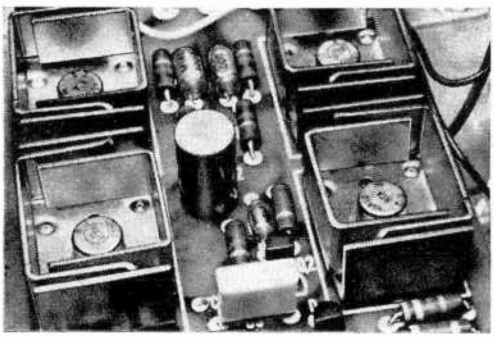
Project Evaluation

This is a very impressive basic amplifier for a home-brew project. The schematic diagram of the "Universal Tiger" is reminiscent of the new Harman-Kardon "Citation 12," with an operational amplifier input configuration and overall direct-coupled feedback to maintain the speaker at dc ground. However, unlike the Citation 12, the Tiger uses complementary symmetry output transistors, and opposite polarities on the other transistors.

In general, we confirmed Mr. Meyer's specifications figures. Where he claims a 0.01% or less distortion under most operating conditions, we feel that he is a trifle optimistic, but he certainly comes close. At 80 watts, the distortion is typically less than 0.05% from 70 to 17,000 Hz, rising to slightly in excess of 0.5% at 20 Hz. At half power or less, the distortion is typically less than 0.02% from 20 to 20,000 Hz.

At 1000 Hz, distortion falls from 0.15% at 0.1 watt to a minimum of 0.009% at 20 watts and rises to 0.1% at 85 watts, which is just below clipping level. These powers were measured with an 8-ohm load and a 117-volt line.

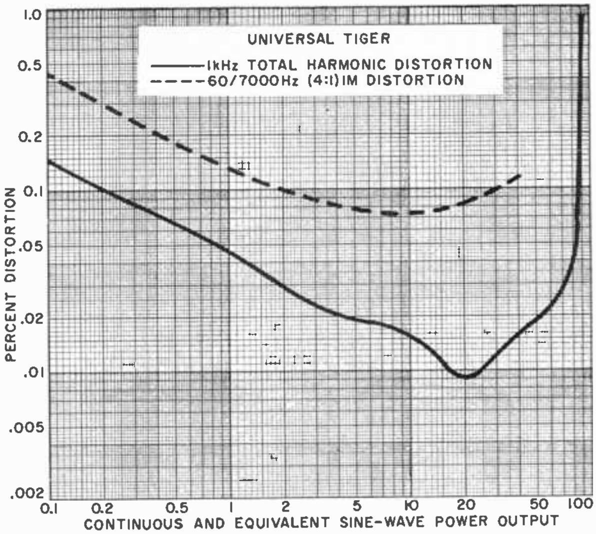
Intermodulation distortion was slightly higher. But at most power levels greater than one watt, it was less than 0.1%. We did not have enough voltage from our IM analyzer to drive the amplifier to more



When mounting Q3-Q6 on printed circuit board, make certain that triangular lead configurations and heat sink tabs line up with holes in circuit board.

point for both *C5* and *R20*. Temporarily set aside the chassis assembly.

Spread a film of silicone paste on the bottom of the case of *Q7* (MJ4502) and slip onto the pasted side a mica insulator. Spread another film of the paste on one of the heat sinks in the area over which *Q7* is to be mounted. Then seat *Q7* on the heat sink. Push a #4 machine screw through the mounting hole tabs in the case of the transistor, turn over the assembly, and slide onto each screw a shoulder fiber washer. Make sure that the shoulders engage the oversize holes in the heat sink. Then place a solder lug over the screw nearest the edge of the heat sink and a three-lug terminal strip and a diode case



than 40 watts. These figures were measured with the bias adjust control set as received with best thermal stability. The low-level distortion could be reduced substantially with this control set at its opposite limit, where the measured reduction was from 0.045% to 0.023% at one watt and from 0.15% to 0.047% at 0.1 watt. However, it is hardly worth the bother to play with the bias adjust control, since we doubt that many people have the test equipment needed to make the adjustment.

Into 4 ohms, the maximum power at the clipping point was 97 watts; into 8 ohms, it was 92 watts; and into 16 ohms, it was 53 watts. An input of 0.9 volt was needed for a 10-watt output (our standard reference level) and hum and noise were 86 dB below 10 watts—a very low figure.

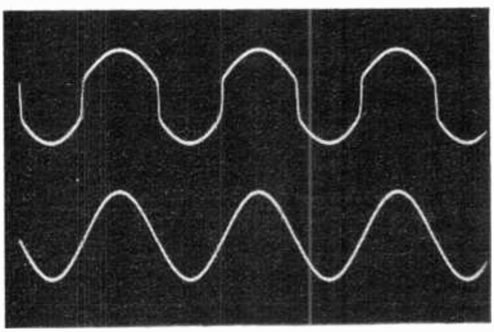
The frequency response of the Universal Tiger was ±0.2 dB from less than 10 Hz to beyond 20,000 Hz. It was down 0.3 dB at 5 Hz and 50,000 Hz, and the higher end was slightly better than claimed, being down 1.1 dB at 100,000 Hz and 3.9 dB at 200,000 Hz. Square wave tests showed a rise time of about 2.5 microseconds.

In all, the Universal Tiger is one of the best power amplifiers we have had the pleasure of testing. Short-circuiting the output at full power blew only the speaker fuse, while full power square-wave drive at 100,000 Hz blew only the power supply fuse after a few moments. But nothing seemed to damage the amplifier circuit itself.

clamp over the other screw. Fasten the screws with appropriate nuts. Use #4 hardware to bolt *CB1* in place.

Repeat the above procedure for the second heat sink and *Q8* with the following changes. Anchor only the diode clamp and solder lug to the hold-down screws for *Q8*. Mount *R21* on an L bracket and fasten the bracket and a three-lug terminal strip to the heat sink with #4 hardware and shoulder fiber washers.

Slide *D2* and *D3* into the diode clamps and push onto the diode leads 1" lengths of plastic tubing. Connect the leads to the *ungrounded* lugs of the terminal strips. Solder a 10"-long wire to the lug to which the *anode* lead of *D3* is connected and a 1" wire from lug 3



In upper waveform, crossover distortion at base of Q4 can be seen; lower trace shows undistorted waveform (F=1000 Hz at 0.25 watts into 8-ohm load).

THEORY OF CIRCUIT DESIGN

The circuit of the Universal Tiger is a combination of operational amplifier and complementary output techniques. As shown in Fig. 1, transistors *Q1* and *Q2* form a differential amplifier. The input signal is applied to the base of *Q1*, with negative feedback on the base of *Q2*.

Zener diode *D1* maintains a constant bias voltage on *Q9* so that the current is constant through the base-emitter circuit of the transistor for any supply potential exceeding 4.7 volts. Hence, the *Q9* circuit functions as a constant-current source for *Q1* and *Q2*. Since *C2* provides for 100 percent negative feedback in the circuit, the output voltage offset is on the order of a few millivolts; any unbalance is immediately corrected by the *Q1/Q2* differential stage. And the ratio of *R7* to *R8* determines the amount of overall ac negative feedback. (Note that *C2* is the only element in the circuit that prevents the amplifier from responding down to dc)

From the collector of *Q1*, the amplified signal goes to the base of *Q3*. Normally, *Q3* would be the voltage amplifier that supplies the large voltage swing needed to drive the impedance-matching driver/output circuit. Here, however, it is limited in voltage gain and, working with *Q4*, it provides some unique characteristics.

In most of the common amplifier circuits, the voltage amplifier load resistor is split (as in Fig. A), and a "bootstrap" capacitor is connected to the output. This causes the voltage across collector load resistor R_L to remain at a constant value so that collector current is constant. If a constant-current circuit were not used, the amount of current available to drive the output circuit would drop to zero as the positive peaks of the waveform approach the peak positive potential of the power supply. This would result in a considerable amount of distortion on positive peaks that would be difficult or impossible to correct no matter how much degenerative feedback was used.

In the circuit of the Universal Tiger, an active current source is used instead of the more common bootstrap system. The results are the same with one important exception. The driver is not affected by supply voltage variations, due to the use of a constant load resistance, and a solution is provided for the crossover distortion problem because the active current source supplies a *constant* current to *Q3* at all times. The bootstrap circuit, obviously, does not.

Consider what happens if a portion of the output waveform is flat, as from A to B in Fig. B, due to an underbiased condition in the output stage. During this portion of the cycle, there is no increase in output voltage, and, as a result, no bootstrap action by the capacitor. And during this time the circuit does not provide the driver transistor with a constant current. With the active current source, this does not occur.

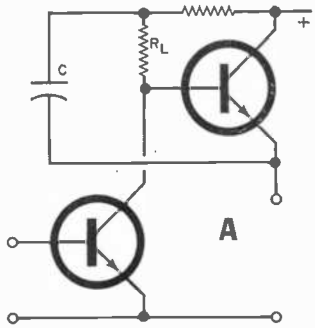
The active current source actually eliminates most of the crossover distortion that can occur due to an underbiased condition in the output circuit. We can see why if we consider what a constant current source does. It adjusts the voltage to keep the current through the circuit constant. But what happens if an underbiased condition exists in which *Q5* and *Q6* are both cut off?

As the driving voltage approaches zero, the active driver begins to turn off, but the voltage is not yet sufficient to cause the other driver to conduct. The loading on the current source becomes far less during this period since no current can be supplied to either driver while both are cut off. Hence, the current source increases the voltage in an attempt to maintain a constant current through the amplifier circuit. And the driving voltage jumps very quickly from the cutoff point of one driver to the conduction point of the other driver, resulting in the minimum of effect on the output waveform during the crossover period.

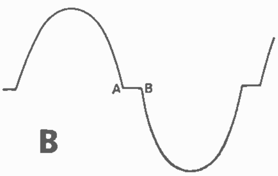
In a case like this, the bias on the output stage would normally be adjusted so that both output transistors are conducting at a low level to avoid crossover distortion. However, if it is possible to avoid having to make a critical bias adjustment, so much the better. Without making this adjustment, a considerable problem in thermal stability will result. As the transistor's temperature increases, the same bias voltage will cause a considerable increase in collector current, opening the way to possible thermal runaway. The use of diodes *D2* and *D3* in the Universal Tiger provides automatic adjustment which helps to eliminate the thermal problem.

The diodes are actually mounted on the heat sinks used for *Q7* and *Q8*. Now, any temperature changes in the output transistors are detected by the diodes, whose resistances vary with temperature. As the diode resistances change, so do the bias voltages to driver transistors *Q5* and *Q6*. Hence, if *Q7* and *Q8* begin to operate abnormally hot, the diodes increase the bias voltage to *Q5* and *Q6* and indirectly lower the operating temperature of *Q7* and *Q8*.

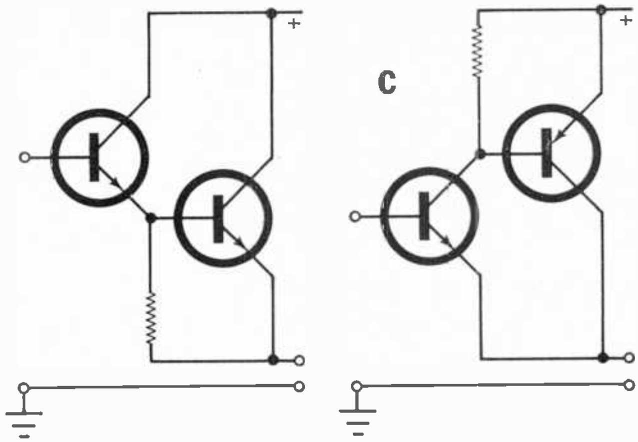
There are two types of compound connections commonly employed in the output stages of transistor power amplifiers. These are shown in Fig. C. The quasicomplementary circuits which use only one polarity of power transistors have one of each type in their output stage. The double emitter follower compound system requires two diode drops to bias it on, while the double common emitter compound requires only one diode. This is a slight ad-



A



B



C

vantage since one less diode must be included in the temperature-compensated bias network.

Neither compound has any voltage gain; both require a driving signal voltage swing equal to the needed output. Since the common emitter driver compound at the right in Fig. C has 100 percent degenerative feedback, gain matching is not required in the output transistors, just as in the double emitter compound also shown.

Comparison of the two circuits as a power output stage gives the circuit at the right a slight advantage in lowest distortion and other areas if the circuit has overall negative feedback.

While testing a full complementary circuit using the common emitter compound. it appeared that there was really no reason why 100 percent degenerative feedback should be necessary or even desirable in the driver transistor. With a complementary circuit it is not necessary to rely on a double emitter follower for half of the output—which requires a second half with matching drive voltage requirements. A complementary circuit allows the use of any amount of degenerative feedback from zero to 100 percent in the driver portion of the circuit. A circuit with no degeneration can provide the maximum amount of voltage gain from two transistors, but it requires matched gains in the output transistors.

Since there is plenty of gain available elsewhere in the circuit of the Universal Tiger, a 50 percent feedback arrangement was selected for the driver stage. This gives a gain of two in the output stage and enough feedback to make transistor matching unnecessary.

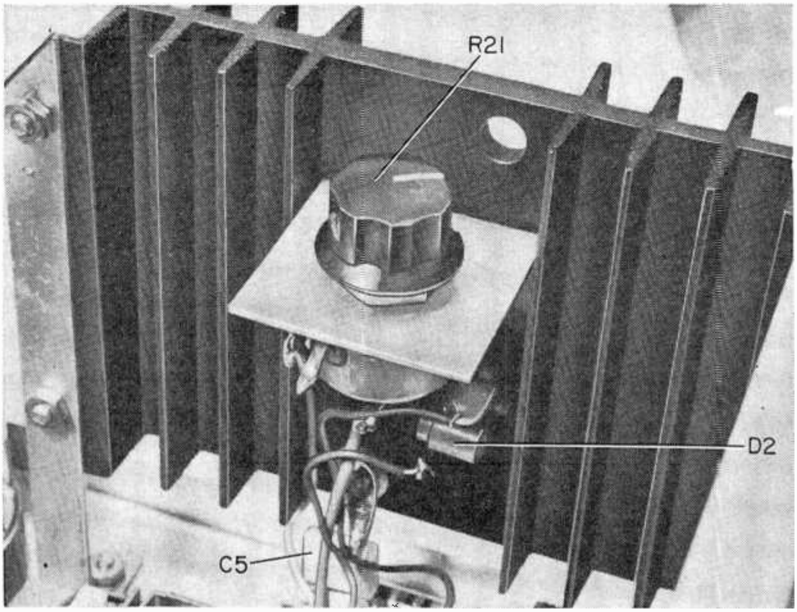
The gain of only two might appear to be too small, but it does provide several substantial benefits. First, the peak-to-peak drive voltage excursion need be only half that of the peak supply voltage. This simplifies design demands. Second, it is possible to keep distortion down to much lower levels in the driver circuit if it does not have to develop full supply positive and negative excursions. Additional temperature stability, by using 50 percent feedback in the output stage, is yet another advantage.

Even without the current drive system, the circuit of the Universal Tiger would have been many times more stable than circuits employing 100 percent degeneration in the driver. Another bonus is that the output stage is virtually failure proof.

If the output of the circuit in Fig C is short circuited, or too low an impedance load is connected to it, the driver transistor would attempt to put enough current through the base-emitter junction of the output stage to bring the voltage up (due to overall feedback effects). This can cause the collector current rating of the driver transistor or the base-emitter rating of the power transistor, or both, to be exceeded. The same thing can also happen in the second circuit, but in a slightly different manner; therefore elaborate protection circuits must be designed to prevent this.

This situation cannot occur with a 50 percent feedback arrangement. The driver's emitter resistor limits the amount of current that can pass through the emitter-collector circuit and into the base of the output transistor. The base current is limited to a value that does not allow collector current in the output transistor to exceed its rating. Hence, short-proof protection is built in and works automatically.

Since the output transistors specified in Fig. 1 have a 30-ampere rating, a fuse in the output line and another in the primary circuit of the power supply transformer will circumvent any possible damage that might otherwise result from overloading. Also, to provide the maximum amount of protection against damage *CB1* in Fig. 3 is used on one of the output transistor heat sinks. -30-



Distortion control R21 fastens to heat sink on which Q8 is mounted with small L bracket and machine hardware. Terminal strip for D2 mounts directly below R21.

of *R21* to the *anode* lug of *D2*. Then solder an 8"-long, #18 or larger wire to the solder lug on *Q7* and a 3"-long wire to the solder lug on *Q8*.

Use #6 hardware to bolt the U brackets to the chassis. Mount the heat sink assembly on which *Q7* is mounted to the left sides of the brackets. Solder the wire from hole C on the circuit board to the *cathode* lug of *D3* on the terminal strip. Connect and solder a 6"-long, #18 or larger wire between *R17* and the emitter lead of *Q7*. Then solder the lead from hole F on the circuit board to the base lead of *Q7*. Route the lead connected to the solder lug on *Q7* under the board, and connect it to the lug at the junction of *L1/R19* and *R20*.

Now, mount the other heat sink assembly in place. Connect and solder the lead from the solder lug on *Q8* to the *L1/R19* and *R20* junction lug. (There should now be five wires connected to this lug.) Locate the lead from hole D on the circuit board and remove ¾" of insulation from the free end. Connect and solder this wire to lugs 1 and 2 of *R21*. Route an 8"-long, #18 wire from the emitter of *Q8*, under the board, and to *R18*. Solder both connections. Then route the 10" wire from the anode connection lug of *D3* under the board and connect the free end to the *cathode* connection lug for *D2*. Solder the wire from hole E on the board to the base lead of *Q8*.

Finish the wiring as follows. Solder a 6" wire between the side lug on the speaker fuse holder and the lug nearest the fuse holder on the output terminal block, and an 8" wire from the ground lug on the rectifier bridge terminal strip to the other lug on the terminal block. Cut two wires to 12" lengths, strip the ends, twist them together, and connect one end of the pair to the lugs on *CB1* and the other end to the lugs on the terminal strip located between the two fuse holders in the power supply. Finally, solder the free ends of the wires on the circuit board to the appropriate points in the power supply filter section.

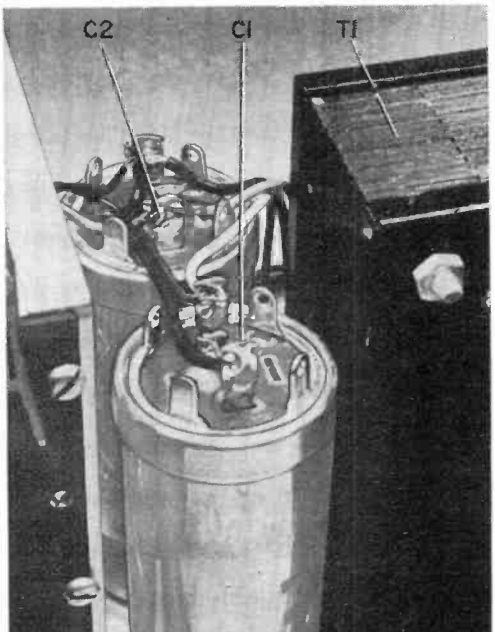
Insert a 5-ampere *standard* fuse in both the speaker fuse holder and the power supply secondary fuse block. For the rating of the primary fuse, refer to the table in the power supply sidebar for the particular output power selected.

Adjustment and Use. If the Universal Tiger is to be used with any but the very best speaker system, the circuit can be assembled without distortion control *R21*. (In this event, simply connect the wire from hole D on the circuit board directly to the lug to which the anode of *D2* is connected.) However, with a first-rate speaker system where there is a possibility of noticing the difference between 0.1% and 0.01% distortion, *R21* should be added as shown.

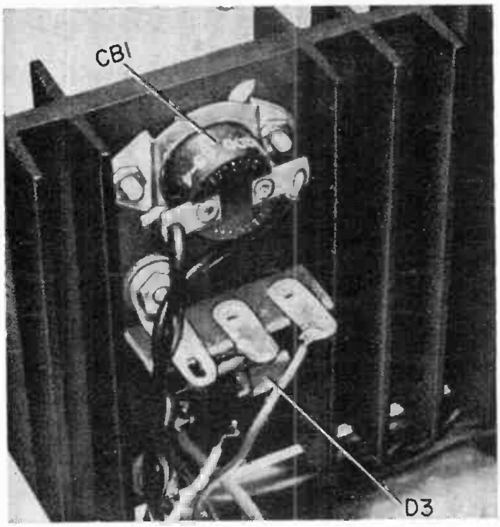
Control *R21* allows adjustment of the bias to eliminate crossover distortion completely. Thermal stability will not be quite as good, but with a sound system there is little danger of overheating since few people would operate the amplifier continuously at its full rated power.

To set *R21*, adjust the potentiometer for minimum resistance and the amplifier for approximately a 1-watt output into a load. Observe the waveform at the base of *Q5* on an oscilloscope. Increase the resistance of *R21* until the waveform is distortion free. Check the idle current of the amplifier; it should be approximately 50 mA. Then seal the adjustment.

The Universal Tiger should give years of trouble-free operation if it is properly assembled. It is doubtful that any improvements in amplifier design during the next few



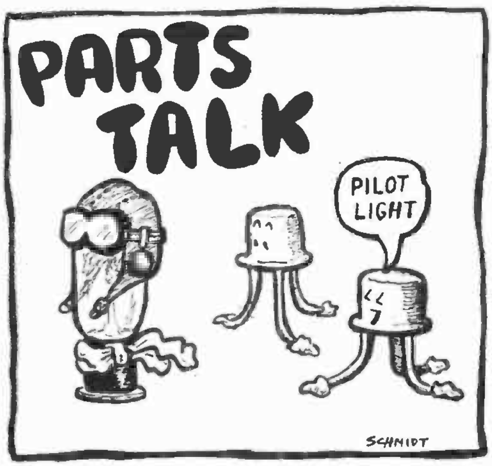
Filter capacitors C1 and C2 in power supply mount between amplifier assembly and power transformer.

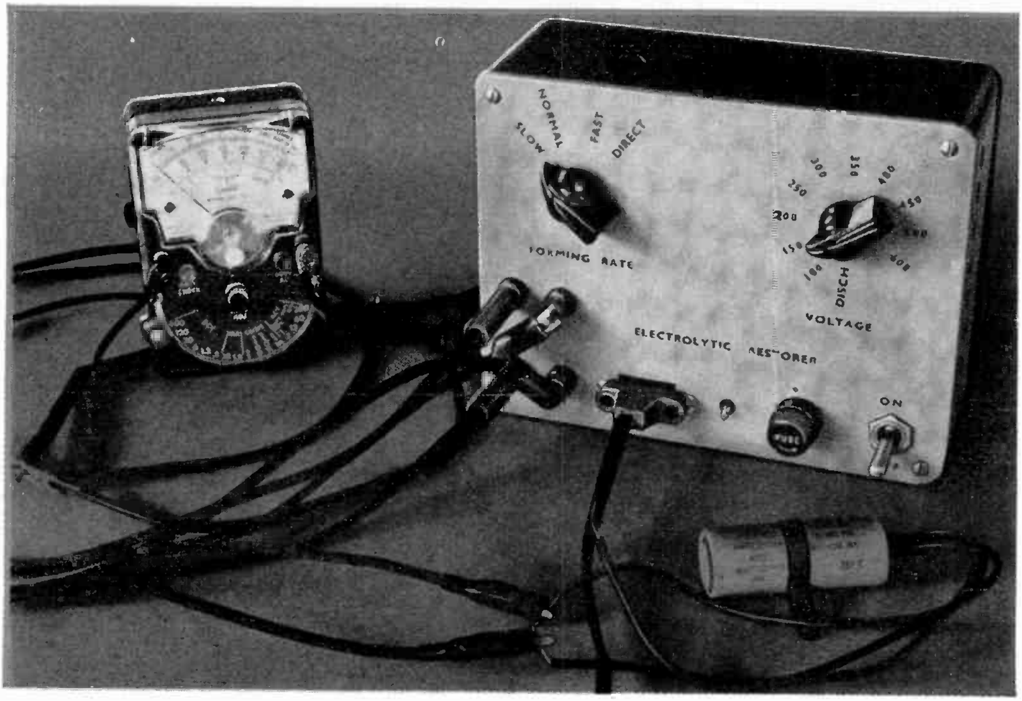


For proper operation, sensing element of thermal circuit breaker CB1 must contact Q7's heat sink.

years will produce an improvement in sound quality when compared with this amplifier. With distortion levels as low as they are in the Universal Tiger, speaker, cartridge, and tuner distortion will have to be reduced by a factor of at least ten to make the amplifier distortion a significant contributor to overall distortion.

If you decide to build any of the high-power versions of the Universal Tiger, remember that most speaker systems are rated for *peak* power handling ability. This means that in most cases you have to divide the peak power by two to determine roughly the amount of *rms* power the speaker can tolerate without damage. Other than this, there are no precautions that have to be taken. -30-





BUILD AN

Electrolytic Restorer

PREVENT HIGH-VOLTAGE CAPACITOR BREAKDOWN

This project is used to restore (reform) the dielectric in electrolytic capacitors that have not been in use for an extended period of time. Half-wave rectified ac is switch-selected and applied to the capacitor. As the dielectric reforms, the voltage increases indicating a reduction in current flow through the capacitor. Various reforming rates are available to the builder, as well as various applied voltages from 100 to 600 volts.

WHEN a high-voltage electrolytic capacitor has been unused for too long a time, it is customarily looked upon as a possible troublemaker. Too often, when power is applied to such units, the dielectric punctures, destroying the capacitor and probably the associated circuit. Unfortunately, many people have some of these capacitors in their junk boxes (they were quite common in power supplies for vacuum-tube circuits), but hesitate to use them. Since they are fairly expensive, it behooves the electronics experimenter or serviceman to salvage such capacitors by restoring the dielectric so that there is no chance of its breaking down when put to use.

However, before finding out how to restore an electrolytic, let's be sure we know the exact nature of the trouble.

What Is an Electrolytic Capacitor? An electrolytic capacitor usually consists of two flexible sheets of aluminum foil separated by gauze impregnated with an electrolyte. Leads are connected to each foil section. The foil connected to the positive lead has an

BY GEORGE J. PLAMONDON

oxide coating which serves as the capacitor's dielectric. It is the thickness of this coating that determines the working voltage of the capacitor.

While the capacitor is being used, the oxide coating is preserved by chemical processes resulting from the voltage impressed across the terminals. Unfortunately, when it is in storage, time and ambient heat take their toll and the oxide deteriorates. When the full working voltage is applied to a capacitor whose oxide is weak, the latter breaks down and a short circuit is placed across the circuit.

Reforming the Dielectric. The dielectric of a suspect capacitor can be reformed by connecting a low dc voltage across the capacitor and slowly increasing the voltage until the rated value is reached. This must be done over a long period of time to allow the oxide to reform properly.

The "Electrolytic Restorer" described here

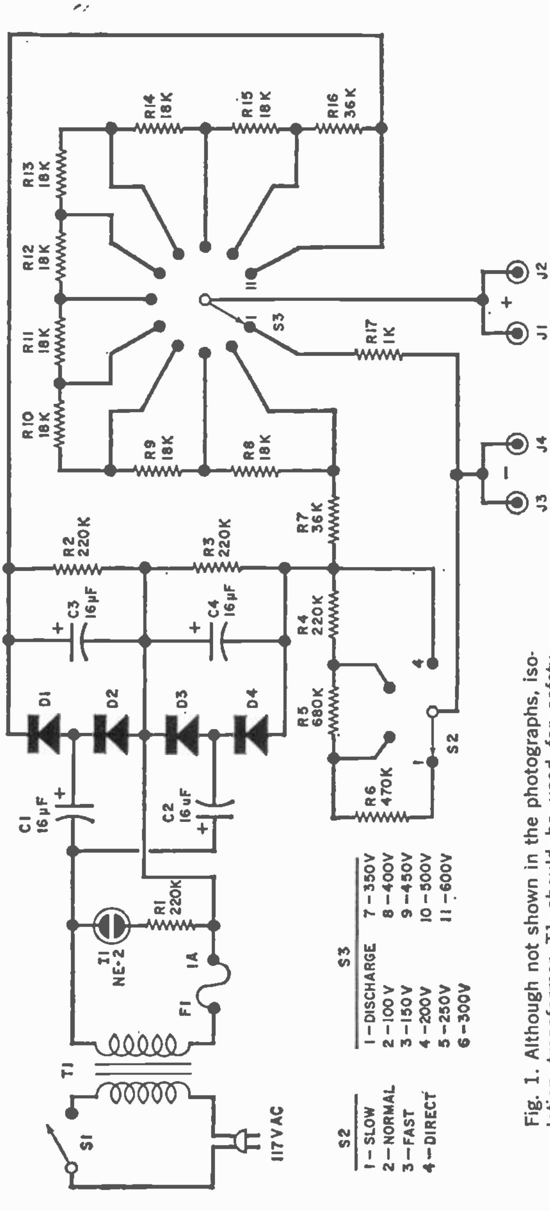
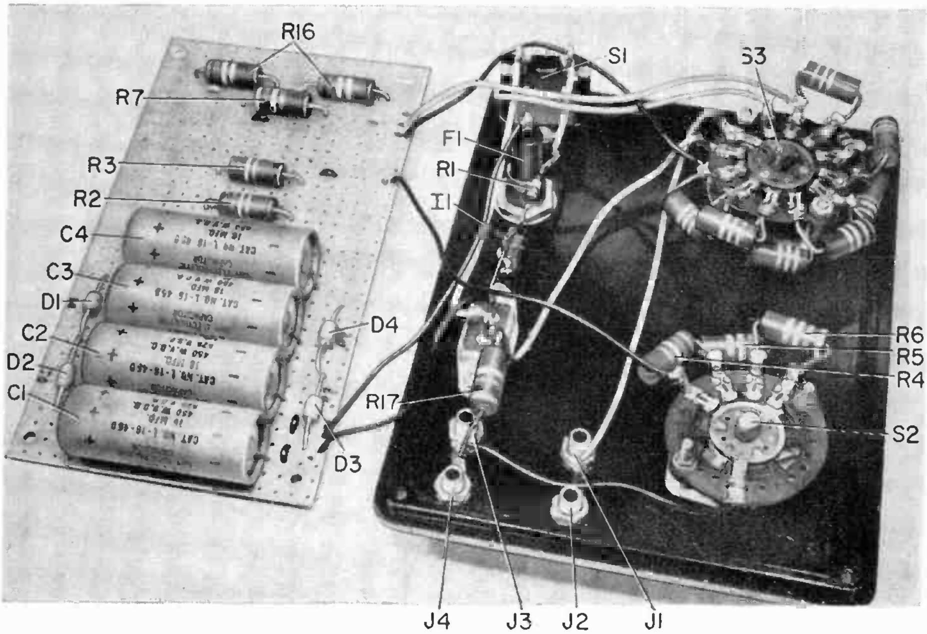


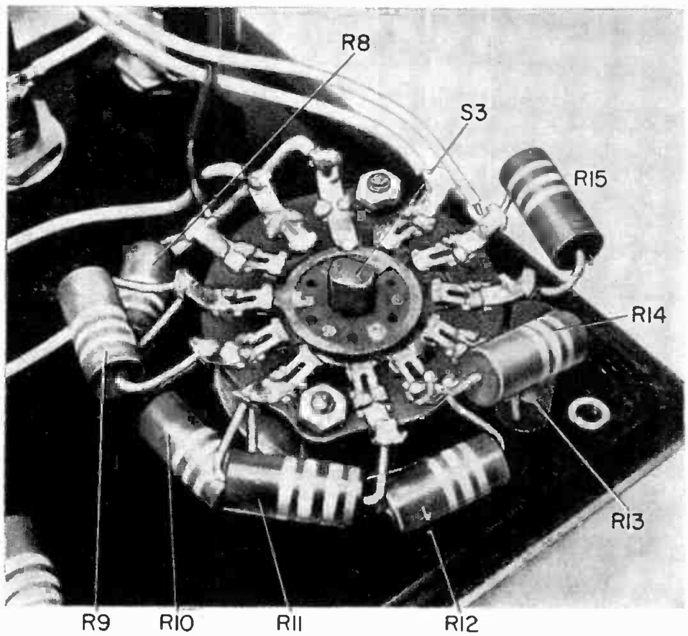
Fig. 1. Although not shown in the photographs, isolation transformer T1 should be used for safety. The voltage range of the reformer is sufficient to effect repairs on a wide range of electrolytics.

PARTS LIST

C1-C4—16-µF, 450-volt electrolytic capacitor
D1-D4—400-PIV, 200-mA silicon diode
F1—1-A fuse and holder
I1—NE-2 neon lamp and holder
J1,J2—Red banana jack
J3,J4—Black banana jack
R1—220,000-ohm, ½-watt resistor
R2,R3,R4—220,000-ohm 2-watt resistor
R5—680,000-ohm, 2-watt resistor
R6—470,000-ohm, 2-watt resistor
R7—36,000-ohm, 2-watt resistor
R8-R15—18,000-ohm, 2-watt resistor
R16—36,000-ohm, 4-watt resistor (or two 18,000-ohm, 2-watt resistors in series)
R17—1000-ohm, 2-watt resistor
S1—Spst switch
S2—1-pole, 4-position rotary switch
S3—1-pole, 12-position rotary switch (Mallory 4M21112C or similar)
T1—1:1, 117-volt isolation transformer (optional)
Misc.—Plastic case and cover, line cord, knobs, perforated board, spacers, etc.



Perf board construction may be used with the operating controls and jacks mounted on the front panel of the selected cabinet. A TV-type "cheater" connector is used to make the power connection. Mount the perf board on suitable spacers and be sure that components on the board do not make electrical contact with any of the front-panel elements.



does this job automatically, and requires only an occasional look at a dc voltmeter to check progress. The cost of the project is about $14 if all parts are bought new.

Construction. The prototype shown in the photos was housed in a conventional plastic case although any type of arrangement will suffice. The schematic of the circuit is shown in Fig. 1. Exact placement of parts is not given since dimensions are not critical and the control locations can be changed depending on personal preferences.

Most of the circuit can be assembled on perforated board. The front panel controls and jacks are mounted directly on the case cover, making sure that all leads are long enough to reach the electronics board. For

THEORY OF CIRCUIT DESIGN

Diodes *D1* through *D4* and capacitors *C1* through *C4* form a half-wave voltage quadrupler rectifier with a dc output of approximately 600 volts. Resistors *R7* through *R16* form a voltage divider network and *S3* selects the desired voltage and applies it to the parallel-connected positive output jacks *J1* and *J2*. The negative side of the power supply is connected through a switch-selected resistor network consisting of *R4* through *R6* to the parallel-connected negative jacks *J3* and *J4*. The use of *S2* determines the forming rate. The DIRECT position permits the unit to be used as a high-voltage, low-current power supply. This position can be eliminated if desired.

The DISCHARGE position of *S3* places *R17* across the output to discharge the formed capacitor, while resistors *R2* and *R3* keep a small load on the power supply and discharge the power supply capacitors.

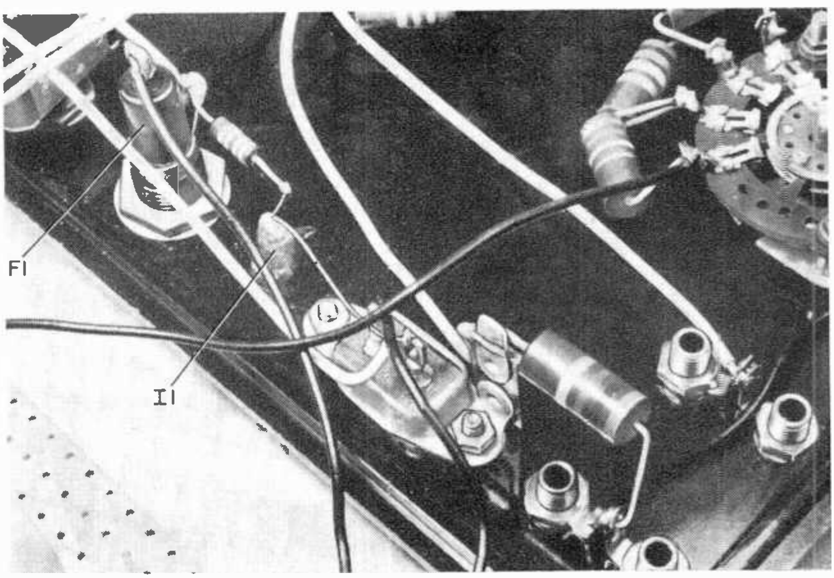
During the forming process, the capacitor's resistance is low so most of the voltage is dropped across the limiting resistor. As the oxide coating in the capacitor is re-formed, less current flows through the capacitor, causing the voltage across it to increase. When this voltage equals the preset voltage on *S3*, the reformation is complete.

safety, a 1:1 ac line isolation transformer should be used, though this is not shown in the prototype.

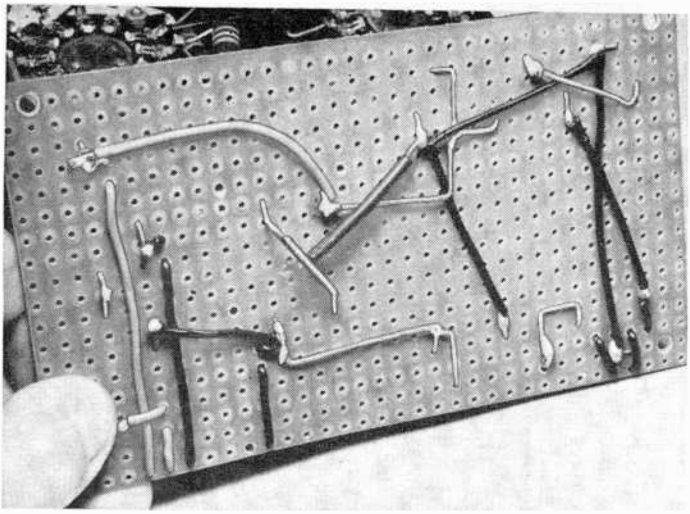
Operation. The electrolytic capacitor to be reformed is connected to the output jacks, making sure that the polarities are observed. The positive side of the capacitor is connected to either *J1* or *J2* and the negative side to either *J3* or *J4*. The dc voltmeter for checking the reforming action is connected to the remaining two jacks. Make sure that the polarity and voltage range are correct. The voltmeter can be disconnected and reconnected at any time without affecting the operation.

Place *S3* in the DISCHARGE position, plug the unit in, and turn on the power. Neon indicator lamp *I1* should glow. Set the desired forming rate on *S2* and then rotate *S3* to the working voltage of the capacitor. If the capacitor is unformed, the voltmeter will indicate a much lower voltage than that set on *S3*.

Note that the voltmeter indication starts to increase quickly at first, then slows down as the dielectric forms. The rate of increase is determined by the condition of the capacitor and the setting of *S2*. When the SLOW setting is used, the operation takes longer but the oxide formed will be of better quality. The opposite is true for the FAST setting. Use the NORMAL position for most cases.



Be careful when drilling the holes in the plastic front panel as it will chip easily. The neon indicator lamp is cemented in the hole, other components use hardware.

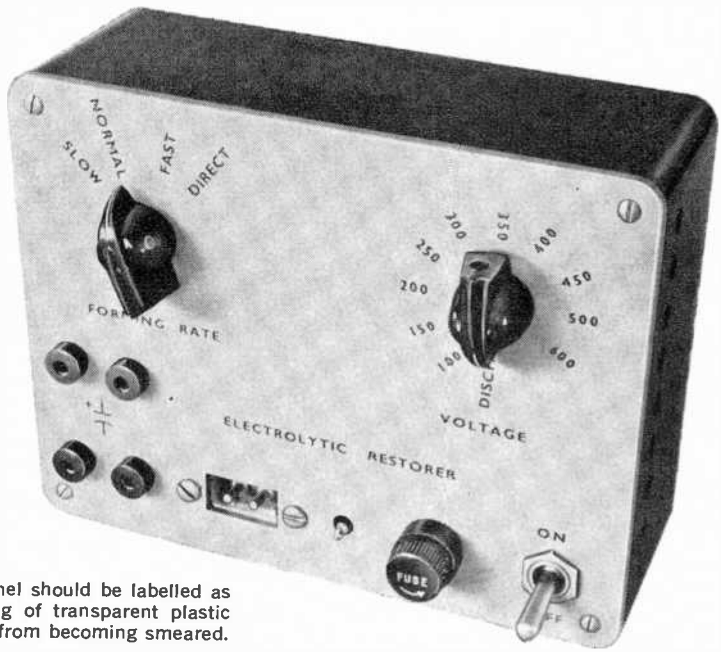


Insulated wiring is used to make interconnections. If a metal case is used, make sure spacers keep connections from touching the case.

When the voltage across the capacitor is approximately equal to the set on *S3*, put the switch on DISCHARGE and remove the capacitor. No harm will be done if the capacitor is left connected longer than required, so it is not necessary to check progress constantly.

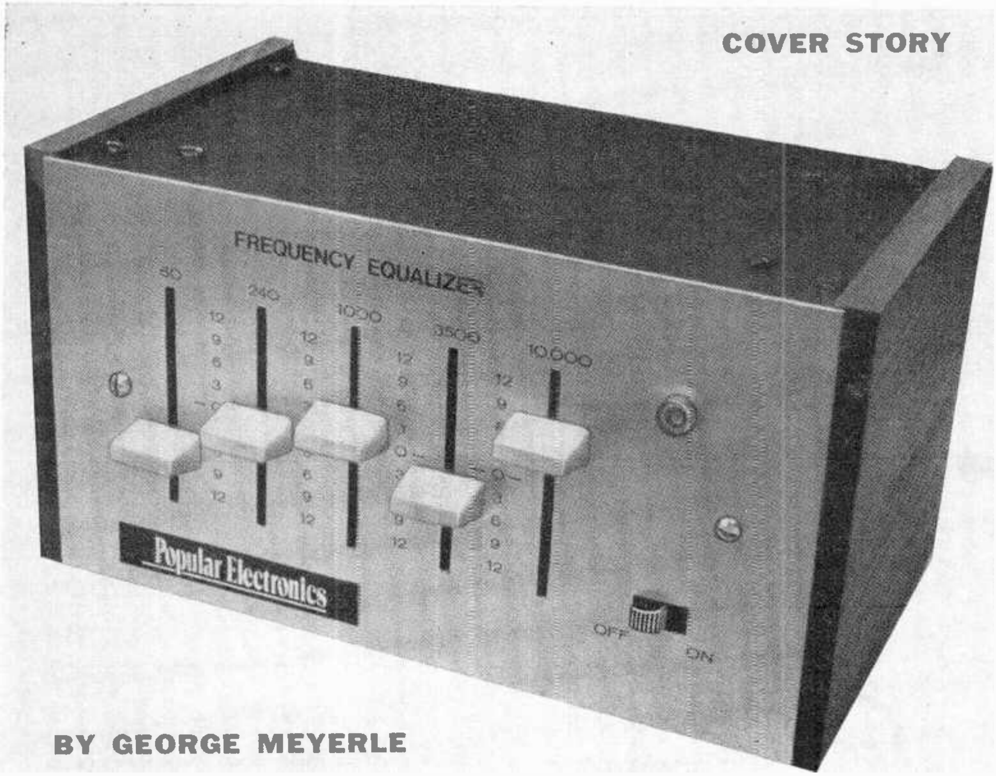
To use the unit as a high-voltage, low-current power supply, set the forming rate switch (*S2*) to DIRECT. A current of 4 mA may be drawn continuously, and somewhat higher currents for a short period of time. (A load current of 10 mA causes a dissipation of 3 watts in the divider resistors.)

The Electrolytic Restorer can also be used for a quick go-no-go check of voltmeters. Comparison of voltage switch settings and voltmeter readings will reveal any gross inaccuracies. —30—



The finished front panel should be labelled as shown here. A coating of transparent plastic spray keeps lettering from becoming smeared.

COVER STORY



BY GEORGE MEYERLE

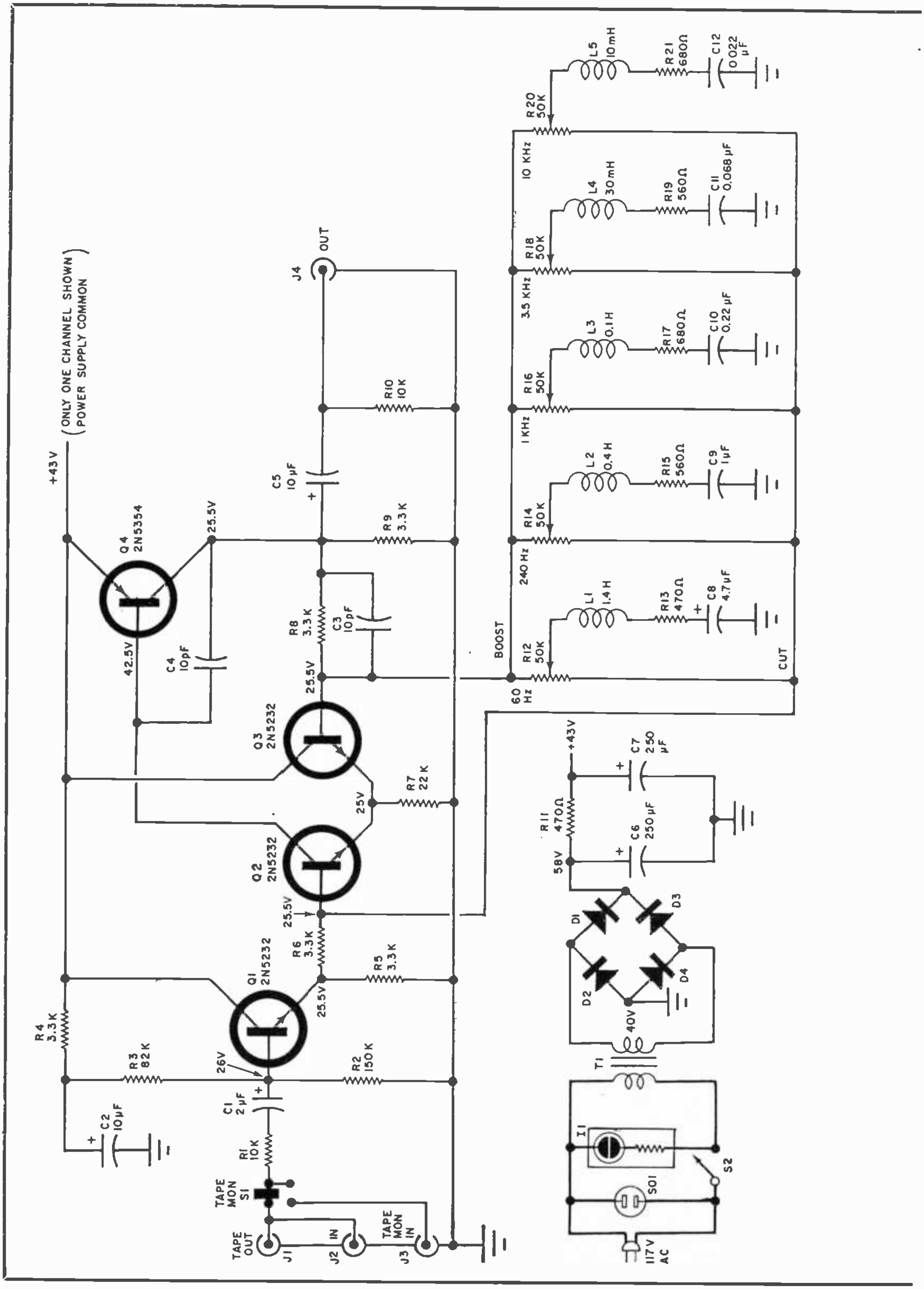
assemble a Frequency equalizer

THE NEW THING—
Segment tone adjustment

This unity gain amplifier is inserted in a stereo system between the preamp and the power amplifier. Five manually operated controls vary segments of the audio spectrum around 60, 250, 1000, 3500, and 10,000 Hz through a range of plus or minus 12 dB. The Equalizer introduces no distortion, hiss, or ac hum. Suggestions are made enabling the connection of this device to an integrated stereo system.

SO YOU SPENT a lot of time and money putting together your separate-component stereo system. Now you are starting to wonder where you went wrong because some program material sounds terrific and some not so hot—especially when you know it should all be good.

Actually, there may be nothing wrong; your problems probably stem from a variety of sources which are difficult if not impossible to control individually. For example, you may have an imported disc recording which was made using a nonstandard recording


(ONLY ONE CHANNEL SHOWN)
(POWER SUPPLY COMMON)
+43V
Q4 2N5354
25.5V
42.5V
C4 10pF
Q3 2N5232
25.5V
R8 3.3K
C3 10pF
R9 3.3K
C5 10µF
R10 10K
J4 OUT
R7 22K
25V
Q2 2N5232
25.5V
R6 3.3K
R5 3.3K
Q1 2N5232
25.5V
26V
R4 3.3K
R3 82K
R2 150K
C2 10µF
C1 2µF
R1 10K
TAPE MON S1
TAPE OUT J1
IN J2
TAPE MON IN J3
BOOST
CUT
60 Hz
240 Hz
1 KHz
3.5 KHz
10 KHz
R12 50K
L1 1.4H
R13 470Ω
C8 4.7µF
R14 50K
L2 0.4H
R15 560Ω
C9 1µF
R16 50K
L3 0.1H
R17 680Ω
C10 0.22µF
R18 50K
L4 30mH
R19 560Ω
C11 0.068µF
R20 50K
L5 10mH
R21 680Ω
C12 0.022 µF
+43V
C7 250 µF
R11 470Ω
C6 250µF
58V
D1
D2
D3
D4
40V
T1
I1
S2
SO1
117V AC

PARTS LIST

*C1—2-µF, 50-volt, electrolytic capacitor**
*C2—10-µF, 50-volt, electrolytic capacitor**
*C3, C4—10-pF disc capacitor**
*C5—10-µF, 50-volt, electrolytic capacitor**
C6, C7—250-µF, 75-volt, electrolytic capacitor
*C8—4.7-µF, 35-volt capacitor**
*C9—1-µF, 100-volt capacitor**
*C10—0.22-µF capacitor**
*C11—0.068-µF capacitor**
*C12—0.022-µF capacitor**
D1-D4—2-A, 600-V silicon rectifier diode
I1—117-volt neon indicator assembly
*J1-J4—Phono jack**
L1—1.4-H inductor (175 ohms dc resistance**)*
L2—0.4-H inductor (60 ohms dc resistance**)*
L3—0.1-H inductor (20 ohms dc resistance**)*
L4—30-mH inductor (140 ohms dc resistance**)*
L5—10-mH inductor (30 ohms dc resistance**)*
*Q1-Q3—2N5232 transistor**
*Q4—2N5354 transistor**
*R1,R10—10,000-ohm, ½-watt resistor**
*R2—150,000-ohm, ½-watt resistor**
*R3—82,000-ohm, ½-watt resistor**
*R4,R5,R6,R8,R9—3300-ohm, ½-watt resistor**
*R7—22,000-ohm, ½-watt resistor**
R11—740-ohm, 1-watt resistor
R12,R14,R16,R18,R20—50,000-ohm linear-taper, dual slide potentiometer (CTS V490 or similar)
*R13—470-ohm, ¼-watt resistor**
*R15,R19—560-ohm, ¼-watt resistor**
*R17,R21—680-ohm, ¼-watt resistor**
S1—Dpdt slide or toggle switch
S2—Spst slide or toggle switch
T1—Power transformer, 40-volt secondary (Triad F-90X or similar)
**For one channel only; duplicate for stereo.*
***Dc resistance is important to avoid lowering Q of circuit.*
Misc.—Chassis, knobs (5), line cord, terminal strips, mounting hardware, metal bracket for slide potentiometers.
Note—The following are available from Metrotec Industries, 1405 Old Northern Blvd., Roslyn, NY 11576: etched and drilled PC board #501 for $2.40; slide potentiometer #502 for $2.20 each; set of 10 coils #503 for $9.50; complete kit of all parts including front panel, knobs, walnut side panels, and instructions, # FEK for $59.95; completely wired and tested unit with 2-year guarantee, # FEW for $99.95. For last two items, add $1.25 shipping charge.
New York State residents add 5% sales tax.

Fig. 1. To avoid confusion, schematic shows only one channel of equalizer; other channel is identical to that shown. Power supply (at lower left) is used for both of the channels.

THEORY OF CIRCUIT DESIGN

The circuit uses a direct-coupled, four-stage amplifier having slightly less than unity gain. The first stage (*Q1*) is an emitter follower for high-impedance input and low distortion. The next two stages (*Q2* and *Q3*) form a differential amplifier having two inputs to allow the application of both signal and feedback. The last stage (*Q4*) is used as a voltage amplifier with high open-loop gain to provide a stable dc operating point.

The five manually operated tone controls are linear slide potentiometers connected between the two differential amplifier inputs. The slider of each potentiometer is returned to ground through a resonant circuit that determines the frequency and range of adjustment. When the slider is at the full cut position, the resonant circuit shunts the input to the differential amplifier to ground. When the slider is in the full boost position, the same resonant circuit shunts the feedback to ground. Thus, a single resonant circuit performs two functions.

By designing the circuit so that both ends of the slide potentiometers are returned to the same potential, the coupling capacitors which would otherwise be required are eliminated. The capacitors in the resonant circuits perform the dc blocking function.

Due to the high feedback and ripple rejection, an inexpensive power supply can be used to full advantage.

The coils are suspectible to magnetic field pickup from the power transformer if not properly oriented. If you follow the physical arrangement shown in the photos, pickup should be at a minimum.

curve. In this case, you may not be able to compensate for the odd sound level.

Your problems may also be due to room acoustics and the response of your speakers. The wall behind a speaker acts as an extension of the speaker mounting board for low frequencies, therefore wall size and how close the speaker is to it can make a dramatic difference in the low-frequency response of the system. The materials of which the floor, walls and ceiling are made can affect the frequencies from the lower mid-range and up. When high-frequency sounds bounce around the hard walls of a room, the net effect is an apparent peaking of the highs. On the other hand, if the floor is carpeted and there are heavy drapes on the walls, the highs may appear dull. Similarly, large sofas and overstuffed chairs absorb certain frequencies and reduce their contribution to the overall sound.

Speakers are particularly suspect. Certain types (even good ones) may have excessive

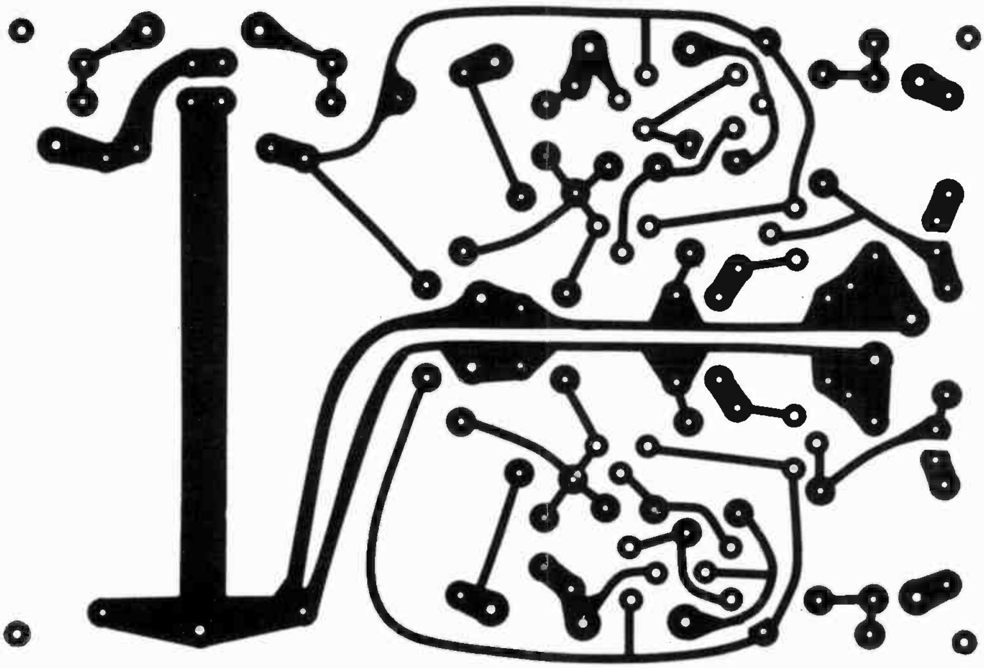


Fig. 2. This actual size etching guide can be used to duplicate circuit board used in original prototype. Dots in corners locate board mounting holes.

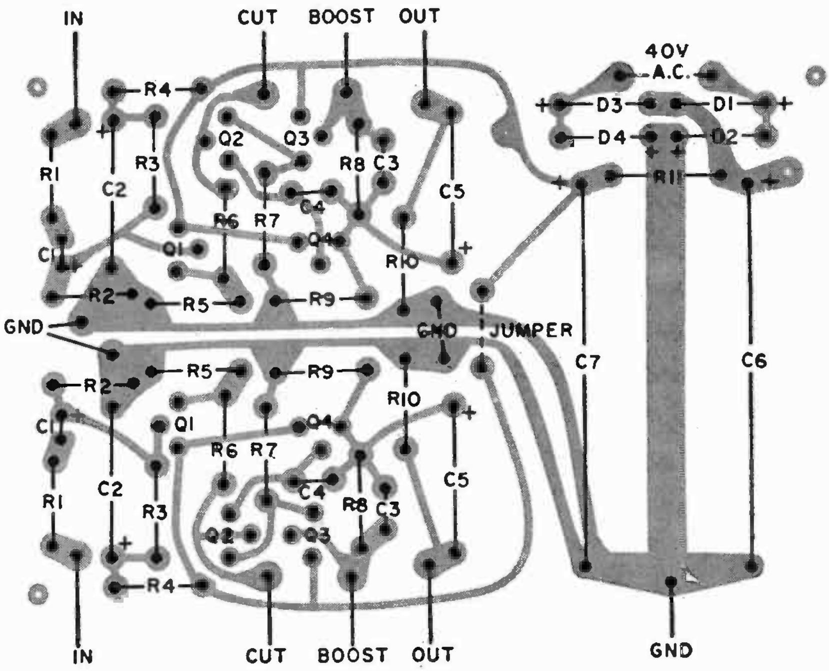


Fig. 3. When mounting components on circuit board, make sure that lead orientations of electrolytic capacitors, diodes, and transistors are correct.

high-frequency response which makes strings sound tinny and strident. Others may be weak in the mid-range, producing a sort of nasal result. There are many reasons why speakers sound different and there's not much you can do about most of them except adjust the frequency response curve.

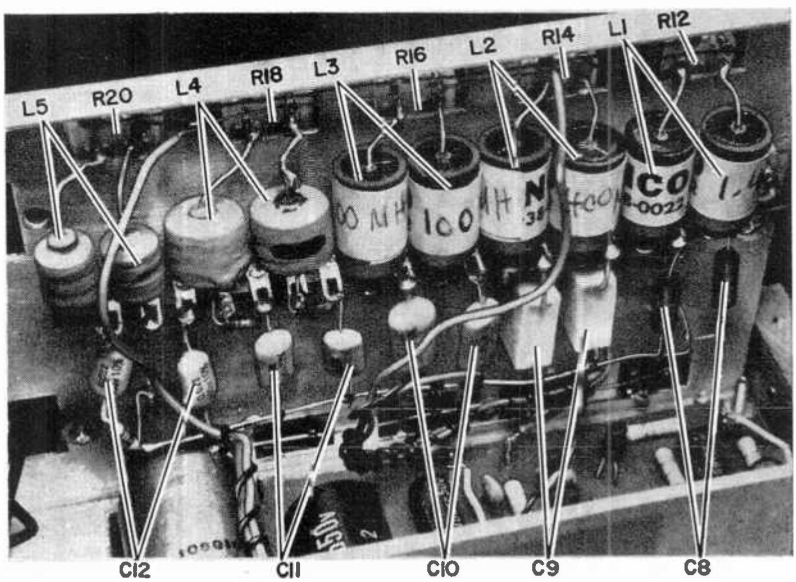
Up to now the high-fidelity industry has tried to solve these problems by supplying tone controls that boost or cut the high and low ends. This has not been satisfactory because such controls cannot compensate for the small changes required in the low and upper mid-ranges without dramatically affecting the extreme lows and highs. For example, if it is desired to boost "presence" at 3000 Hz a few decibels, the standard tone control would also boost 10 kHz about 8 or 10 dB, increasing hiss and record scratch.

What the stereo enthusiast requires is a tone control system that allows adjustment of discrete segments of the audio frequency spectrum so that these individual segments can be tailored to suit a particular requirement, without affecting any other part of the spectrum. The Stereo Frequency Equalizer is just such a system, with five independent frequency range adjustments. While there is no limit to the number of adjustments that could be used, the more adjustments, the sharper the separation filters have to be, and it has been found that sharp, narrow filters have excessive phase shift and may actually cause a whole new series of response problems.

Construction. The Equalizer, whose partial schematic is shown in Fig. 1, should be constructed on a printed circuit board, using the foil pattern shown in Fig. 2. Once the PC board is available insert the components as shown in Fig. 3. Note that the schematic shows only one channel of the stereo system,

TECHNICAL SPECIFICATIONS

Frequency response (flat setting): ±1 dB, 5 Hz to 250 kHz
Tone control range: ±12 dB at 60 Hz, 250 Hz, 1 kHz, 3.5 kHz, and 10 kHz
Intermodulation distortion: 0.05% at 2 volts output
Harmonic distortion: 0.05% at 2 volts output (20 Hz to 20 kHz)
Hum and noise (shorted input): 80 dB below 1 volt
Maximum output: 9 volts
Gain: Unity, plus 0, minus 2 dB
Recommended output load: 10,000 ohms or greater
Output impedance: 10 ohms
Input impedance: 75,000 ohms
Power consumption: 3 watts



Capacitors, inductors, and resistors for filters mount on front panel of chassis. Terminal or tag strip is used to provide interconnection points for components.

HIRSCH-HOUCK LABORATORIES

Project Evaluation

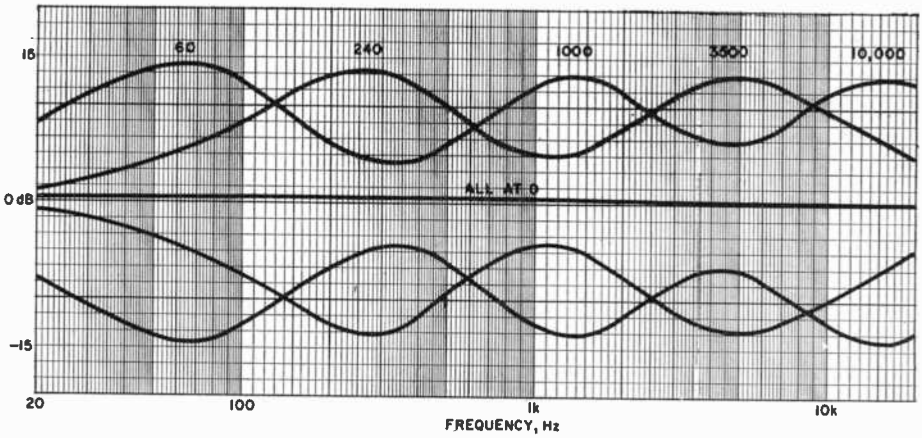
The Frequency Equalizer is one of those add-on devices that go well with almost any stereo setup where tailoring the sound reproduction to the listening environment is desired. The project did a good job of tailoring. It was tested first on the bench, then through objective listening.

The gain of the Frequency Equalizer was measured at 0.79 (−2 dB) at 1000 Hz. It measured within ±0.3 dB from 5 to 500,000 Hz, well under the author's specification. The output impedance is exactly 10 ohms, also as claimed. Into a high-impedance load of about 100,000 ohms, the output clipping level occurred at 9.5 volts. Then into a 10,000-ohm load, clipping occurred at 9.0 volts, which is still ultra-safe for any hi-fi application. Even into a 1000-ohm load, the Equalizer was capable of delivering 3.7 volts, although distortion increased a bit here.

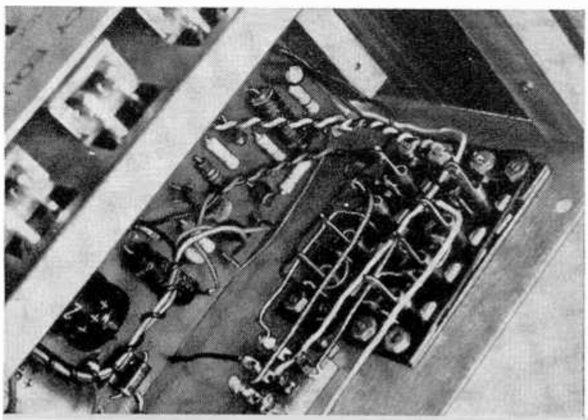
The harmonic distortion at 1000 Hz is virtually nonexistent, unmeasurable below 1 volt and much less than the 0.03% noise level. At one volt output, the first measurement was made—a mere 0.0077% of second harmonic! At the rated 2-volt output, the distortion was only 0.015%, climbing to a maximum of 0.077% at 7 volts.

Intermodulation distortion at 2 volts was measured at 0.016% and fell to a minimum of 0.005% between 10 and 20 dB below the rated output, climbing to 0.015% at 30 dB below 2 volts. This is just about as distortionless as could be desired with modern equipment and techniques.

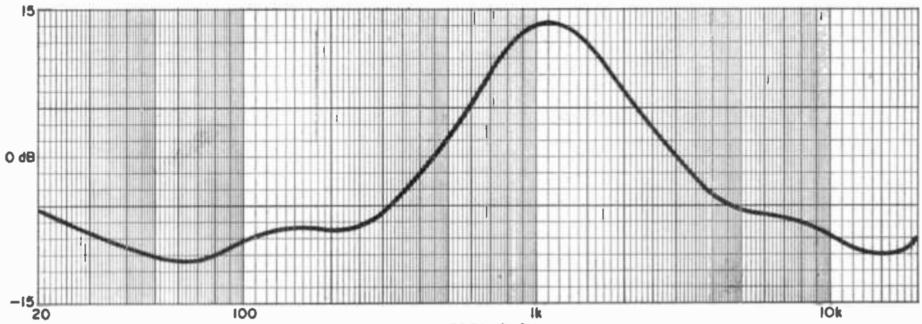
The noise level in the output could not



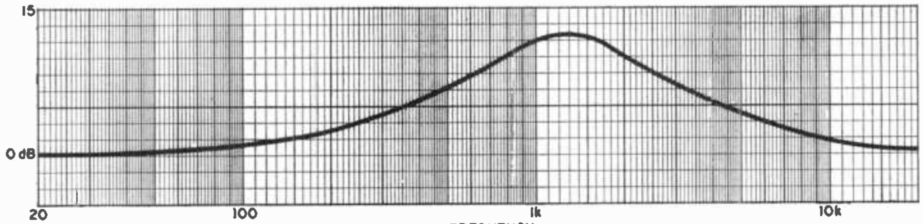
Response of equalizer at maximum and minimum settings; at zero position, response is flat.



Note short wires for input connections and twisted pairs for the two outputs.



This curve was obtained with all controls set at −12 dB, except 1000 Hz control at +12 dB.



New curve was obtained with all controls set at zero, except 1000 Hz control set at +12 dB.

be measured because of a slight subsonic "bounce" at about 70 dB below 1 volt, which masked the actual hiss and/or hum. Judging from the display pattern on an oscilloscope, the noise level in the audio region must exceed the −80-dB rating claimed.

The composite frequency response curve was made with the 60-, 1000-, and 10,000-Hz controls at maximum (and minimum), while the remaining controls were set to zero. Then the controls were set to zero and the 240- and 3500-Hz controls were set to a maximum (and minimum). This gives a rough idea of the variety of curves possible with the Equalizer. Needless to say, there are an extraordinary number of combinations available. Also, note how flat the response is with all controls set to zero.

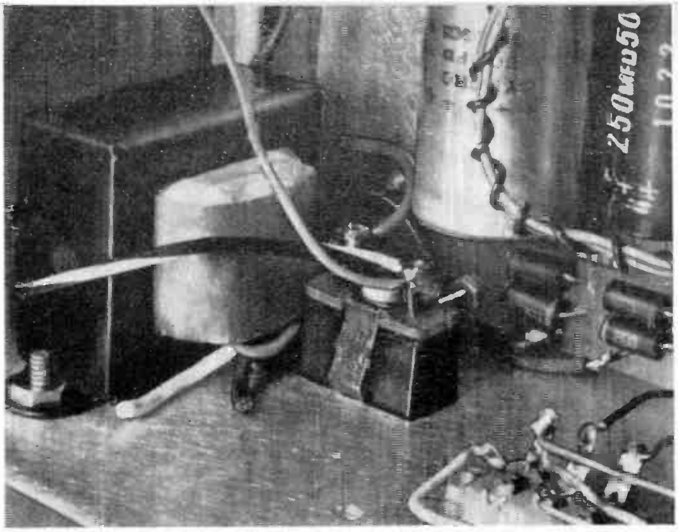
To display the shape of one filter, the 1000-Hz filter was set to maximum with all the other controls set to zero. As an extreme case of correction, all but the 1000-Hz control were set to minimum and the 1000-Hz control to maximum.

As compared to something like the Altec 'Acousta-Voicette," of course, the Frequency Equalizer has rather broad filters. However, they do an effective job and go well beyond the capability of most ordinary tone controls. They are essentially equivalent to the JVC "SEA" amplifier, which is considered to be one of the best from the equalization standpoint. In any event, the Frequency Equalizer performed fine in listening tests. It was able to tailor the sound very well.

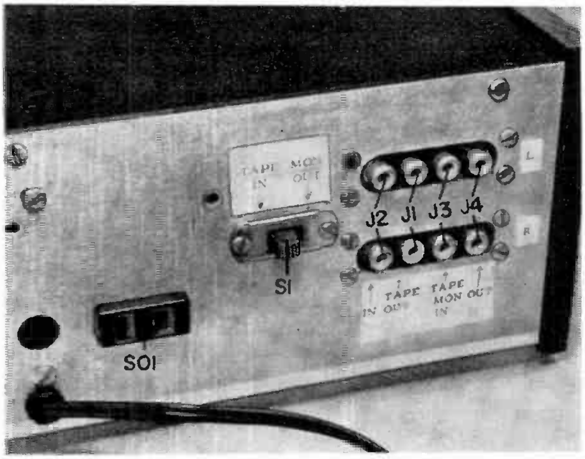
while both channels are on the one PC board. The power supply is common to both channels. Component numbers are identical in the two channels.

A typical mounting and enclosure scheme is shown in the photos—any other arrangement would be equally satisfactory. The PC board is mounted on four spacers at the bottom of the chassis. The power transformer, power outlet *SO1*, tape monitor switch *S1* and two sets of four phono jacks are on the rear apron. Use a grommeted hole for the ac line cord.

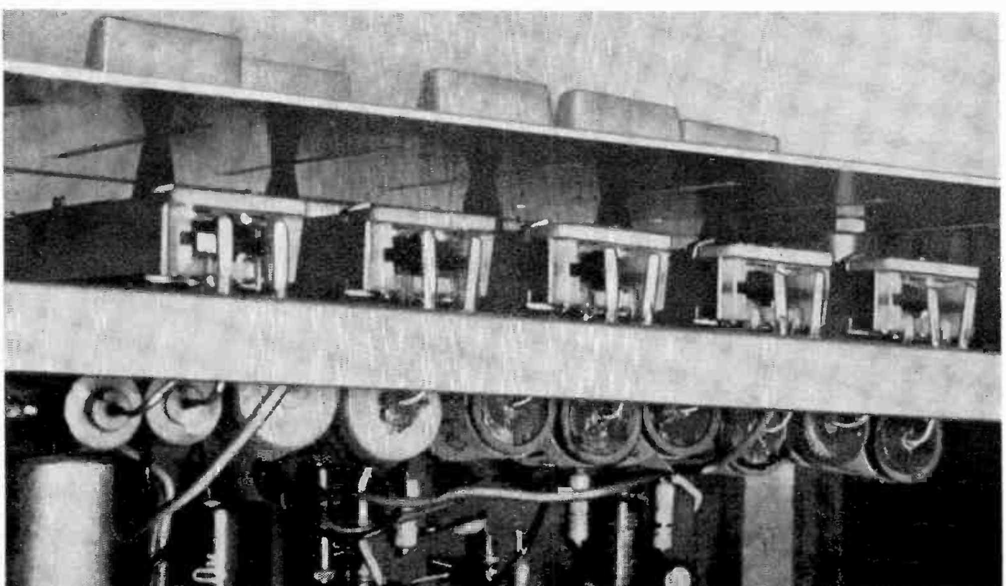
The filter and potentiometer combinations are mounted on a separate metal plate and are arranged so that only the potentiometer shafts protrude through slots on the front panel. The metal plate is drilled to accommodate the five dual-slide potentiometers—which are twist-locked in place if you use the devices specified in the Parts List. Be sure that the end holes for the slide potentiometers

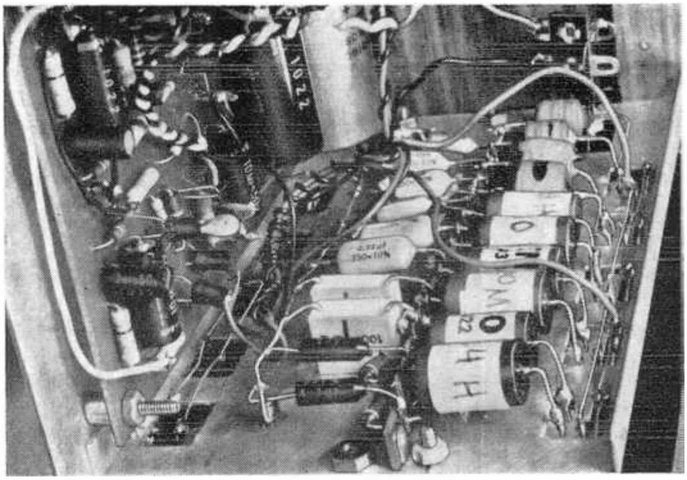


Input and output jacks J1-J4, ac receptacle SO1, and power transformer T1 are mounted on rear apron of chassis as in interior (above) and exterior (right) views. Strain relief protects line cord from sharp edges of entry hole in apron.



Dual slide-type potentiometers fasten to front surface of filter subchassis bracket. After fastening them in place, make certain that control tabs properly mate with slots in decorative front panel.





To provide clearance for and access to solder lugs on potentiometers, cutouts must be made through the filter subchassis bracket.

have sufficient clearance for the potentiometer terminals. One end of each inductor is connected to its respective terminal on the potentiometer; the other end is connected to a terminal strip (insulated from ground) lug. This lug also holds one end of the associated resistor. The other end of the resistor and one end of the associated capacitor are connected to another terminal lug. The other end of the capacitor is connected to a common ground buss that runs the length of the metal plate.

Slots just wide enough for the potentiometer shafts are made in the actual front panel. Power switch *S2* and indicator lamp *I1* are mounted on the front panel. Once all mechanical work is complete, wire the circuit as shown in Fig. 1, remembering that you are dealing with a stereo system.

For a neat appearance, the front panel should be marked with care. Trim the five slots for the potentiometer shafts. Mark each slot with a frequency identifier as shown in the photos. At the exact center of each potentiometer range, mark a zero. Then space the 3-, 6-, 9-, and 12-dB marks evenly above and below the zeros. The 12-dB points should be at the extreme ends of the potentiometer travel.

Use. If your audio system has a preamplifier separate from the power amplifier, connect the Frequency Equalizer between the two, observing the correct channel notations.

If you have an integrated receiver or any combination having a tape monitor switch, use the hookup shown in Fig. 4A. In this case, note that the tape monitor switch on

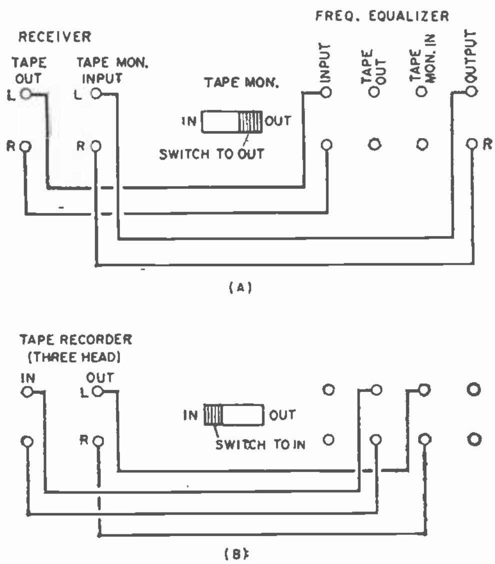
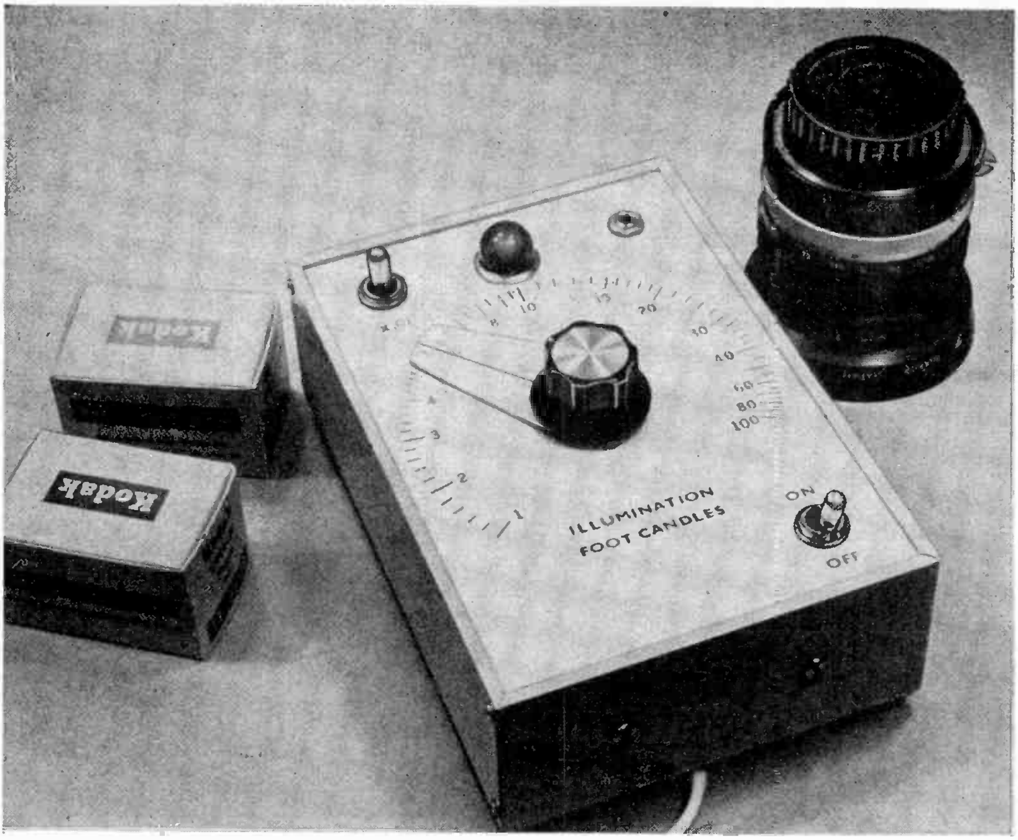


Fig. 5. Wiring diagram (A) shows how to connect equalizer to integrated stereo system. Diagram (B) shows how to make hookup for a tape recorder.

the equalizer is in the "out" position; the receiver switch in the "monitor" position. Use other controls normally. The Equalizer provides a tape monitor feature with an additional pair of jacks at its output, to allow monitoring of the tape as before. For connections to a tape recorder, see Fig. 4B. The other connections are as shown in Fig. 4A.

With the system operating, each slide potentiometer can be adjusted for the desired results, which, of course, are up to you. —30—



BUILDING A

Printing Exposure Lightmeter

Measure Enlarger Light Intensity with Accuracy and Repeatability

Through the use of an LDR as one leg of a dual-range bridge circuit, this lightmeter "trips" on or off a panel indicator lamp. Light level variations are readily detectable and the long-term repeatability of the circuit is excellent. The tripping action is selected by the operator and may be calibrated in foot candles.

FOR THE PHOTOGRAPHY enthusiast who does his own enlarging, an enlarger lightmeter is a must if he expects to work efficiently and economically. By standardizing his enlarger exposures, he can just about eliminate paper waste.

Since enlarging paper requires much closer control than photographic film, an enlarger lightmeter should include a well-subdivided

BY A. A. MANGIERI

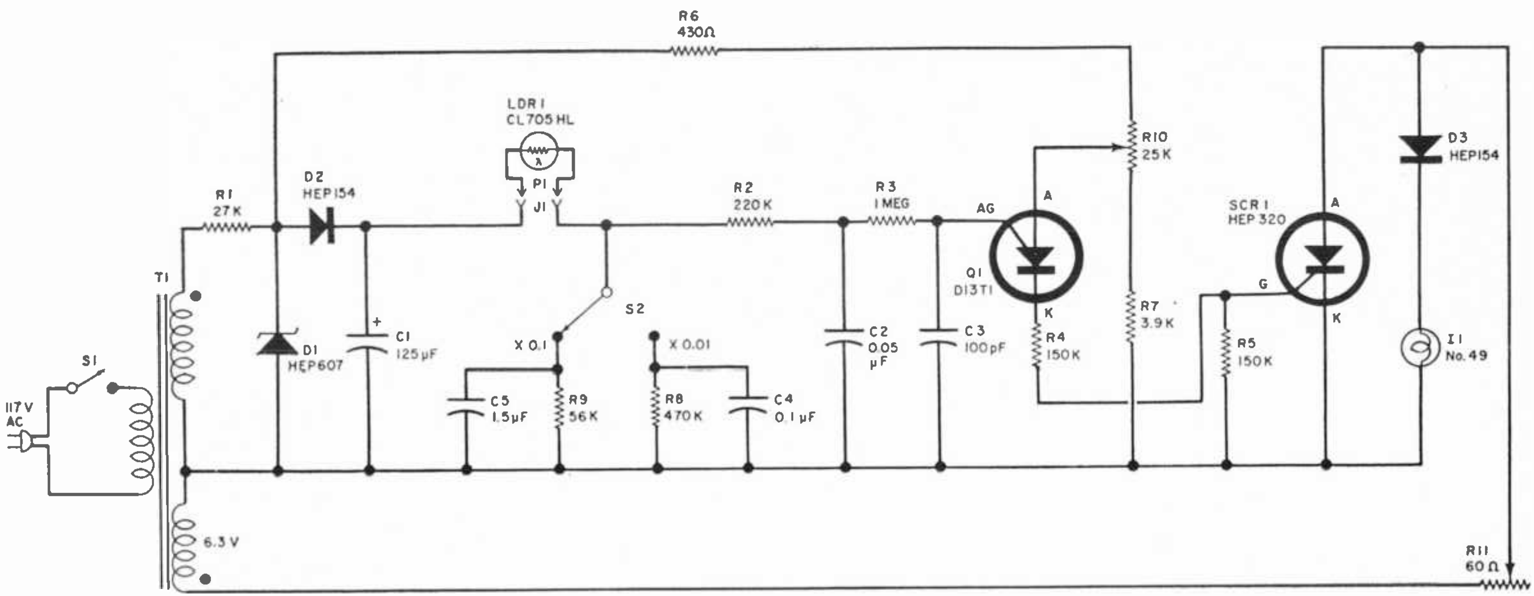
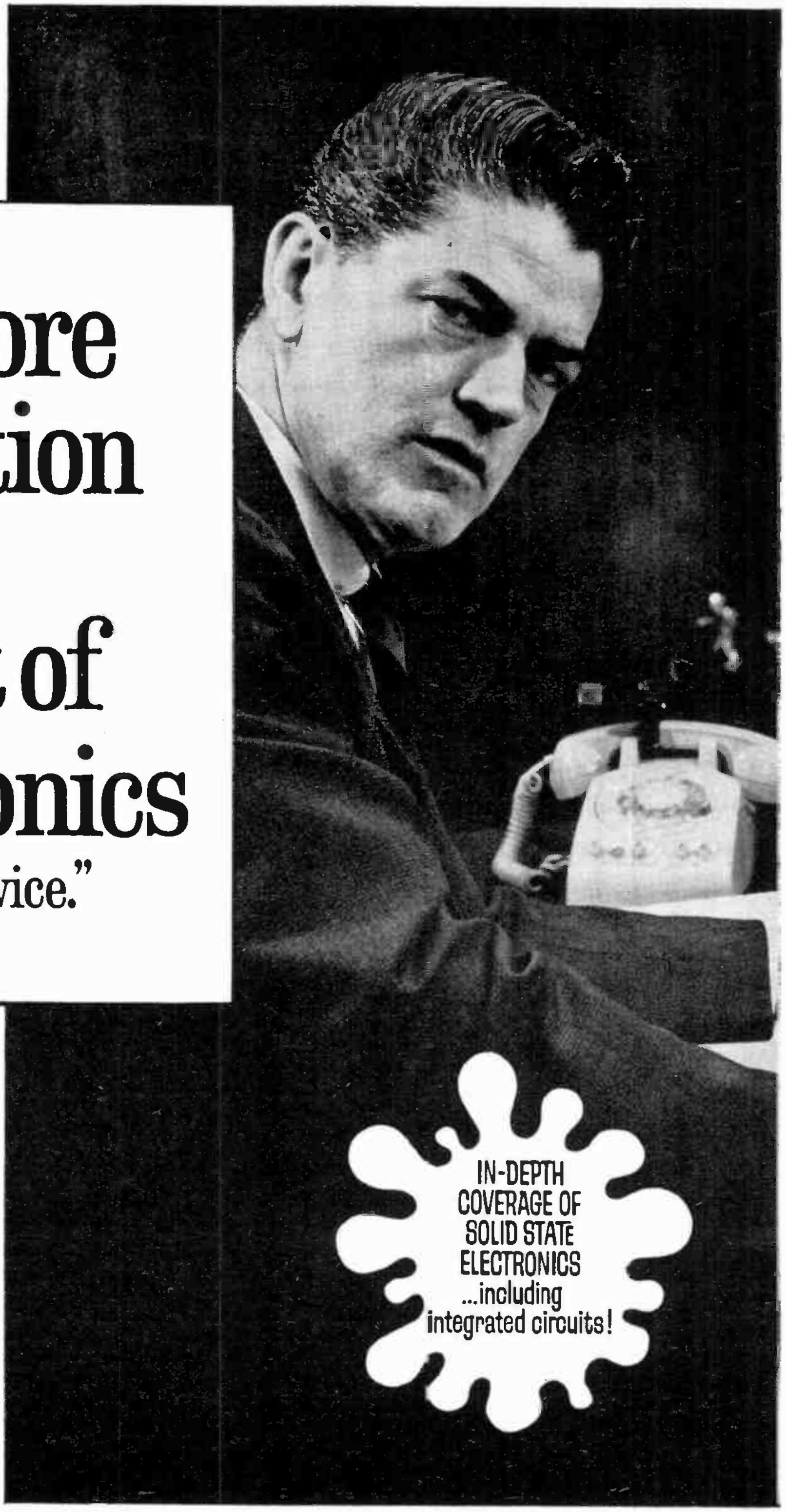


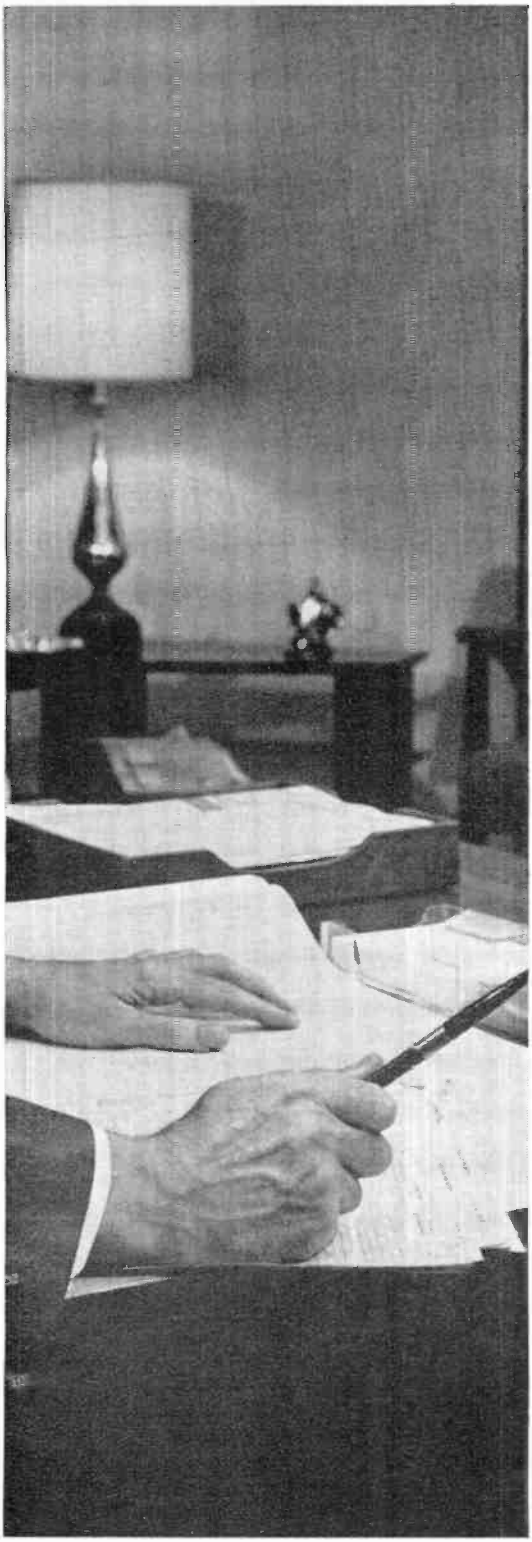
Fig. 1. The setting of R10 and resistance value of LDR1 (under various lighting levels) determine triggering time of Q1.

PARTS LIST

C1—125—µF, 20-volt electrolytic capacitor
C2—0.05-µF disc capacitor
C3—100-pF disc capacitor
C4—0.1-µF disc capacitor
C5—1.5-µF, 20-volt electrolytic capacitor
D1—15-volt, 1-watt zener diode (Motorola HEP607 or similar)
D2,D3—1-ampere, 50-volt silicon diode (Motorola HEP154 or similar)
I1—#49 panel lamp
J1—Miniature phone jack
LDR1—Light dependent resistor (Clairex CL705HL)
P1—Miniature phone plug
Q1—Programmable UJT (GE D13T1)
R1—27,000-ohm, 1-watt resistor
R2—220,000-ohm, ½-watt resistor
R3—1-megohm, ½-watt resistor
R4,R5—150,000-ohm, ½-watt resistor
R6—430-ohm, ½-watt, 5% resistor
R7—3900-ohm, ½-watt, 5% resistor
R8—470,000-ohm, ½-watt resistor
R9—56,000-ohm, ½-watt resistor
R10—25,000-ohm wirewound potentiometer (Centralab WW-253 or similar)
R11—60-ohm trimmer potentiometer (Centralab VS-60 or similar)
S1—Spst slide or toggle switch
S2—Spdt slide or toggle switch
SCR1—HEP 320 0.8A, 30V SCR
T1—Transformer: secondaries: 125 V, 15 mA: 6.3 V, 300 mA (Knight 6-K-27VF or similar)
Misc.—Lamp socket with red dome (Dialco 95-9110-0931-102 or similar), chassis (Vector Multi-Mod W20-66-46 or similar), 351 panel lamp, line cord, earphone cable, transistor socket (2), PC board terminals (18, Vector T42-1), clear plastic for cursor, etc.

"Get more education or get out of electronics ...that's my advice."





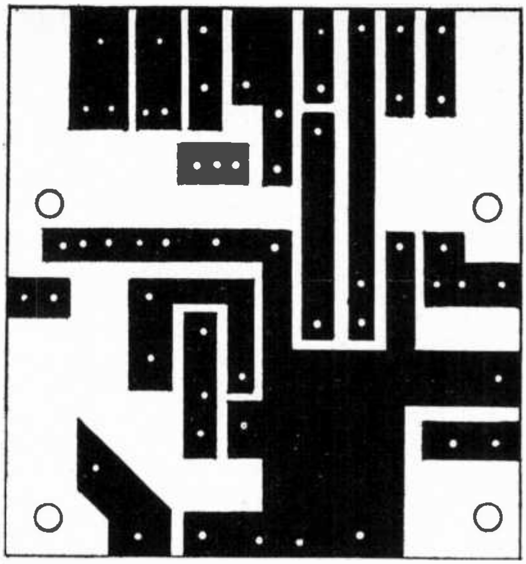
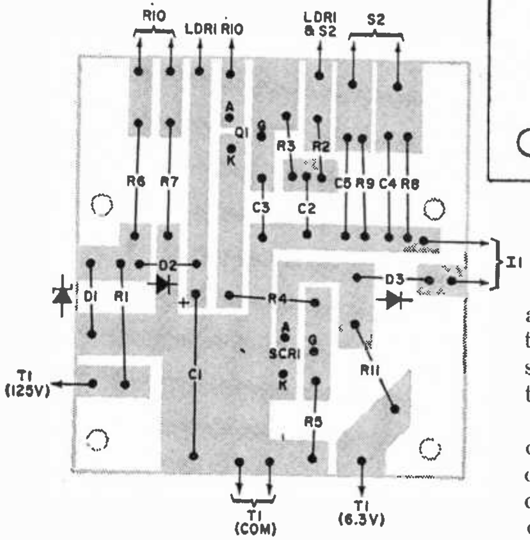


Fig. 2. Actual size printed circuit etching guide is shown at right; while below is the component location and orientation diagram.



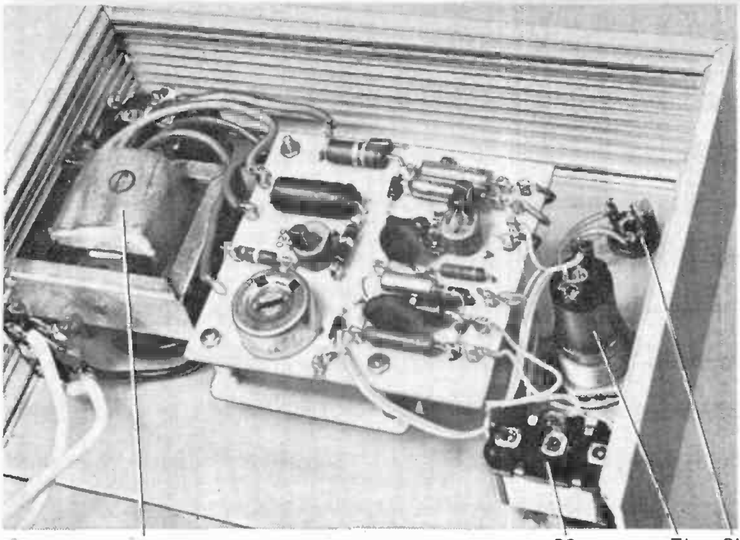
scale for high resolution readout. It should also have precise resettability and repeatability. The meter described here has a low range from 0.01 to 1 footcandle over an eight-inch scale, plus a 10X multiplier to increase the range to 10 footcandles. Light-level variations just a few percent above or below the set point of the calibrated dial cause snap action turn-on or turn-off of a panel lamp. A stabilized bridge circuit affords long-term repeatability and 100:1 light coverage per range, while a nonlinear scale provides readability to several percent at any setting.

Construction. The schematic of the enlarger lightmeter is shown in Fig. 1. The photoresistor (light dependent resistor) *LDR1*, is mounted in a thin plate-like package which is connected to the rest of the circuit by a long two-conductor cable as shown in the photos. Most of the electronic circuit is built on a printed circuit board, the foil pattern for which is shown in Fig. 2. This figure also shows the component installation and the external connections. Transistor sockets should be used to prevent thermal damage to the semiconductors during soldering.

For the prototype a 4½" × 6½" × 2" metal case was used to provide ample room for the components with enough space for a large, easy-to-read scale. Almost any type of enclosure can be used, as long as sufficient panel space is provided.

Mounted on the top panel are the calibration potentiometer *R10*, power switch *S1*, range switch *S2*, indicator lamp *I1*, and input jack *J1*. The latter should be insulated from the metal case. When all of these components have been assembled, mount the power transformer *T1* on one wall of the case; and after soldering the required leads to the PC board, mount the board on four spacers. Connect the circuit as shown in Fig. 1.

Using a piece of 1/16" thick transparent plastic, make up a cursor (or pointer) as shown in the photos to fit on the shaft of *R10*. Scratch a hairline at the center of the cursor and fill it with black ink. The knob selected for use on *R10* should preferably have a large diameter for easy handling. Cement the cursor to the knob. Prepare the upper surface of the panel for the calibration marks and with the knob temporarily installed on *R10*, make sure that the cursor can swing from limit to limit of the potentiometer. Install four rubber feet on the base of the chassis.

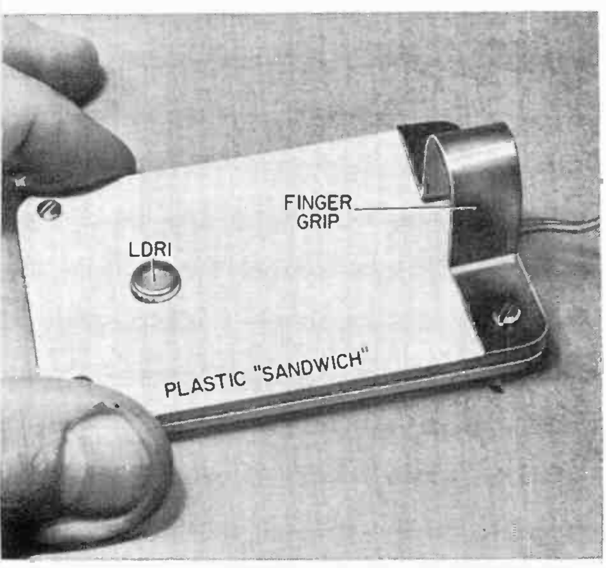


Interconnecting wires from chassis-mounted components can be soldered to appropriate points on the circuit board through use of "flea" clips.

The photoresistor is placed either within a thin plastic case or sandwiched between two pieces of thin insulation board. A slot is made in one board to provide room for the connecting cable (which can be made from old earphone cabling). A hole in the other board permits light to reach *LDR1*. Some form of finger grip should be fabricated and attached to the upper board. Use small hardware to finish off the insulation board sandwich.

Calibration. With the circuit wired as shown in Fig. 1., turn on the power. Remove *Q1* from its socket and note that indicator lamp *I1* comes on. If *I1* remains off, progressively decrease the value of *R5* to keep *SCR1* from turning on by itself. Re-insert *Q1* in its socket and with *S2* set to the X.1 position, connect a 390,000-ohm resistor in place of *LDR1*. Lamp *I1* should go on and off as *R10* is varied about its mid-position. If it does not, reverse the leads of either secondary or *T1*. If the problem still exists, progressively decrease the value of *R4* to increase the drive to *SCR1*. Remove the 390,000-ohm resistor and note that *I1* remains off at all settings of *R10*. If it does not, slightly increase the value of *R7*. Set *R11* to about 30 ohms. Then adjust to desired lamp brightness but do not exceed 2 volts across lamp.

A simple plastic "sandwich" provides a convenient means of mounting light dependent resistor LDR1.



A 0-100 dial plate can be used as a logging scale. However, it's well worth the effort to prepare a calibrated scale for maximum versatility of the meter. The calibrating procedure makes use of the inverse square law relating to light radiating from point sources. Illumination in foot-candles (FC) is equal to lamp candle power (CP) divided by the square of the distance in feet (D) from lamp to LDR location. Thus, $FC = CP/D^2$.

For the light source, use a new #51 panel lamp operated at 7.5 volts ac from a filament transformer. Use a powerstat on the primary side or a rheostat in series with the lamp on the secondary side to adjust the lamp voltage. Mount the lamp rigidly, base down, and positioned so that its filament is broadside to the LDR, facing it squarely.

Tape the mounted LDR to a wooden L bracket and mount a black card having a ½" hole several inches in front of the cell to block off most of the stray room light. Run tests at night in a large dark-walled room. At lamp-to-

THEORY OF CIRCUIT DESIGN

Photoresistor (light dependent resistor) *LDR1* and selected range resistors *R8* and *R9* form two sides of a bridge energized by filtered dc. Resistors *R6*, *R7*, and *R10* make up the remaining arms of the bridge, energized by a dc square wave developed at zener diode *D1*. The square wave resets *Q1* to off at each cycle.

When the voltage at the anode of *Q1* exceeds the voltage at the anode-gate (AG), *Q1* turns on thus energizing the gate of *SCR1*. This turns the SCR on and simultaneously turns pilot lamp *I1* off. Averaging filter *R2-C2* bypasses moderately large ac components of light present in cold light sources and the comparatively small components from incandescent sources.

As the resistance of *LDR1* takes on different values when exposed to different light levels, the turn-on (or trip point) of *Q1* occurs at different settings of potentiometer *R10*. Circuit action provides a snap action, rather than a gradual turn on, of *I1* at the trip point. Resistors *R3* and *R4* determine the bridge loading and are proportional in values so that turn-on and turn-off of *Q1* occur with minimum hysteresis or deadband on *R10*.

LDR distances of 3″, 6″, 9″, 1′, 2′, etc. to 10′, measure LDR resistance at each point with an accurate ohmmeter.

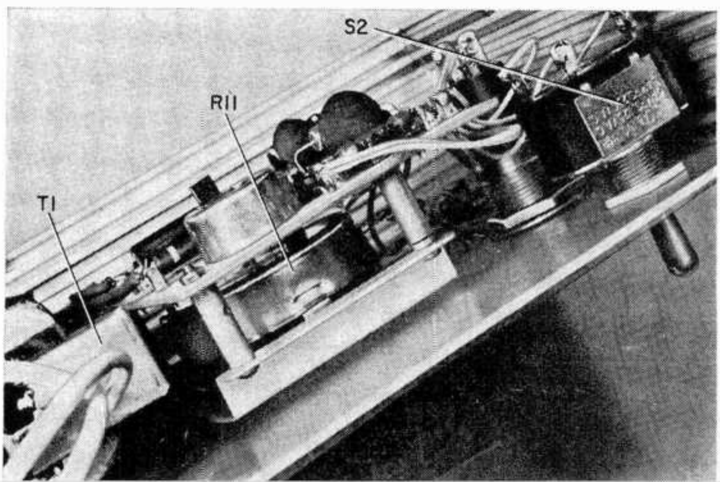
Next, using the inverse square law, calculate the illumination in footcandles—using 1.2 for the lamp's candle power. (This value is 20% higher than the rated value to allow for higher radiation broadside to the lamp filament.) Plot cell resistance vs footcandles on 1 × 1 cycle logarithmic graph paper.

From the graph, read cell resistances at 0.01, 0.02, 0.03, etc. footcandles. Using a potentiometer set to these resistance values substituted for *LDR1*, locate division marks on the panel from 0.01 to 1 FC. If the 0.01 to 1.0 range does not fit over the available range of *R10*, use a different value of resistor for *R8* to account for LDR variations. With resistors equivalent to 1 and 10 FC, use a different value of resistor for *R9* so that the high range tracks the low range with as little tracking error as possible. You may prepare a second, separate scale for the high range if desired. Scale numbers may be direct reading or they can be as shown on the prototype with X.01 and X.1 multipliers selected by *S2*.

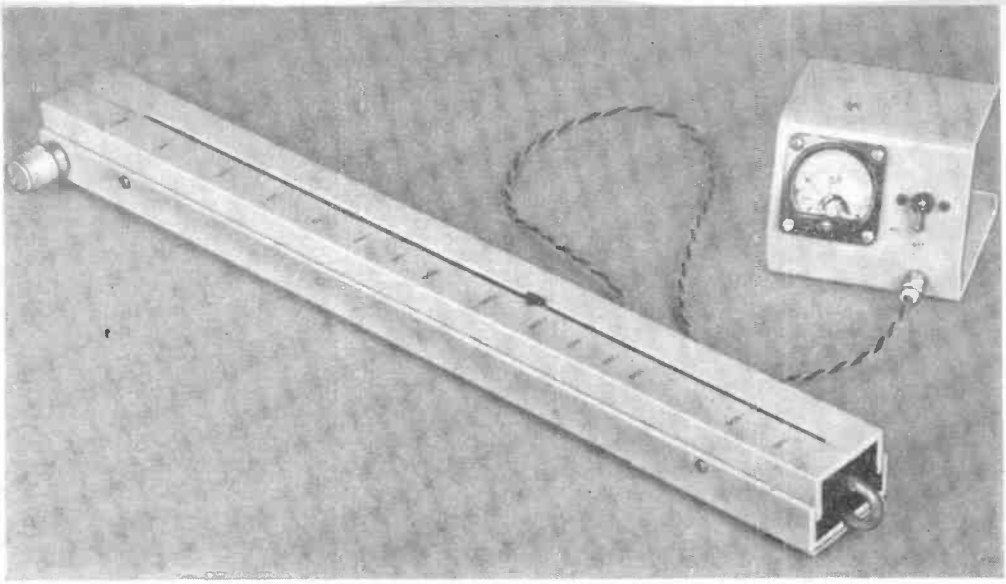
Application. When measuring light levels of a projected image, adjust *R10* CCW so that *I1* goes from off to on. Also, when adjusting light level through lens opening, decrease the aperture so that the lamp goes on at the trip point. This eliminates any stray light contribution from the panel lamp itself. All darkroom lights must be off during use of the meter.

Standardize the meter by making test runs with the various enlarging papers that you use. Make a perfect print by the usual cut-and-try procedure. Using the meter, measure and record the setting of *R10* when the lamp turns on at the lightest and darkest portions of the image, as well as at the important parts of the image. For negatives and paper of the same or similar contrast and with the same or different enlarger magnification, all you have to do is adjust the lens aperture to match the standardized settings and expose the print as before.

Since readings on the calibrated scale have a known relationship to each other, you can double the standardized readings and cut the exposure in half—and vice versa. Also, the highest and lowest readings provide an indication of the contrast on a negative, which is an aid in selecting paper contrast. For enlarging, you may prefer to read the calibrated scale as 1 to 100 on the low range and 10 to 1000 on the high to avoid use of decimals. —30—



Circuit board mounts on U bracket with aid of four spacers. Potentiometer R11 then fastens entire assembly to front panel of case via its mounting bushing.



VHF-UHF DRAIN-DIP OSCILLATOR

SPOT CHECKING IN THE 140-540 MHz SPECTRUM

A carefully machined quarter-wavelength line is substituted for a parallel-resonant LC tuned circuit in this grounded-gate FET oscillator. Mechanical calibration of the tuned line permits accurate frequency determinations between 140 and 540 MHz. The author describes a unique coupling and tuning system of interest to the experimenter.

THE "GRID-DIP" OSCILLATOR is a real godsend when it comes to checking radio-frequency circuits. Its versatility in measuring the resonant frequency of a tuned circuit, as a signal injector, and as an aid to determining the values of unknown capacitors and inductors, plus its low cost, make it an item found on many workbenches. Unfortunately, the usefulness of most inexpensive dip oscillators decreases rapidly at frequencies exceeding about 150 MHz.

The VHF-UHF "drain-dip" oscillator described in this article is designed to work at frequencies where most dip oscillators work poorly—if at all. It covers a continuous frequency range of 140 to 540 MHz. Tuning over this range is smooth and even, with only one false dip in the entire coverage.

BY A. E. McGEE, JR., K5LLI

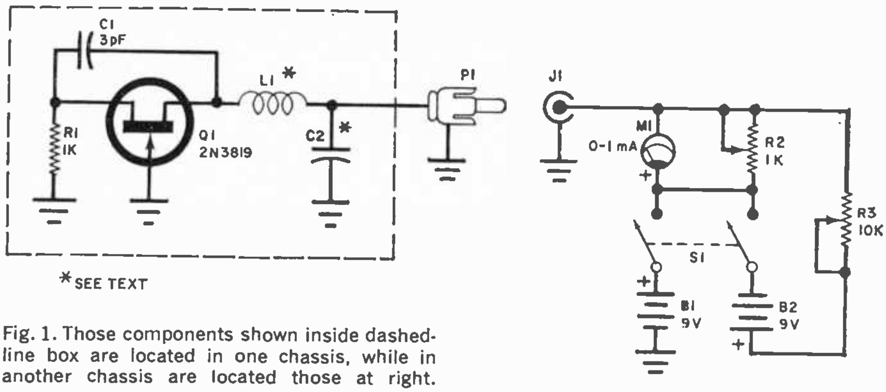


Fig. 1. Those components shown inside dashed-line box are located in one chassis, while in another chassis are located those at right.

PARTS LIST

B1, B2—9-volt battery
C1—3-pF ceramic capacitor
J1—Phono jack
L1—See text
M1—0-1-mA dc meter movement
P1—Phono plug
Q1—2N3819 or HEP802 field-effect transistor
R1—1000-ohm, ¼-watt resistor
R2—1000-ohm potentiometer
R3—10,000-ohm potentiometer
S1—Dpst slide or toggle switch
Misc.—¾" x ¾" x ⅛" aluminum angle: ⅛"-outer-diameter brass tubing; ½" faucet washer; ¼"-diameter shaft; control knob; dial cord; 1/16" aluminum stock; 0.018" galvanized steel or brass; 0.005" brass; 4-40 machine screws; hookup wire; solder; etc.

The circuit is extremely simple, and the absence of plug-in coils and a sensitivity control makes for easy operation. Most important, the drain-dip oscillator costs less than $10 to build if an inexpensive imported or surplus meter movement is used.

Theory of Circuit Design. Field-effect transistor *Q1* in Fig. 1 operates as a grounded-gate oscillator. The variable-length drain lead, *L1*, acts as a quarter-wavelength tuned line which is equivalent to a parallel-resonant LC tuned circuit. Feedback of the proper phase to sustain oscillations is provided by capacitor *C1*, which is in series with the internal source-to-gate capacitance of *Q1*. These capacitances form a voltage divider across resistor *R1*, applying a source-to-gate voltage that is in phase with the drain voltage to bring about oscillation.

Drain current varies with the strength of the oscillations and is greatest when the oscillations are the strongest When the dip oscillator and the external circuit are both tuned to the same resonant frequency, the external circuit absorbs power from the dip oscillator. This reduces the feedback and causes a reduction, or "dip," in the drain current indication on meter *M1*.

Unique construction is responsible for the simplicity of the drain-dip oscillator. Transistor *Q1*, capacitor *C1*, and resistor *R1* mount on a small circuit board assembly to which contact "fingers" are connected. This circuit board assembly is designed to move in chassis rails so that the fingers bear down on the rails and ground the source and gate circuits of *Q1*. Drain voltage is supplied by a length of copper braid (*L1*) that forms the resonant drain circuit.

When the circuit board is moved in either direction against the chassis rails, the effective length of the braid is varied by pulling it through an output coupling loop. The base of the loop is grounded for r-f by the mounting plate, which itself forms one plate of an r-f bypass capacitor. Physical movement of the board is accomplished by a tuning "dial" mechanism that connects the copper braid and a dial cord in a continuous loop around the tuning shaft pulley. The circuit board is joined to the top side of the loop, while the bottom of the loop passes freely under the circuit board assembly.

By turning the tuning knob, the circuit board moves along the chassis rails, varying the length—and, hence, the inductance—of the line between the drain lead of *Q1* and the coupling loop. Since, in the process, the inductance of the line changes, the resonant frequency of the line and, therefore, the frequency of oscillations also change.

Parts Fabrication. Machining the parts that make up the drain-dip oscillator is fairly simple. It involves cutting, filing, drilling, and thread-tapping the metal members, plus fabricating a circuit board assembly and minimal wiring. Some careful fitting together of the mechanical assembly is necessary, but in most cases tolerances are not critical; the only criterion is that the parts fit together uniformly and do not interfere with each other. In any event, any machining that might be necessary to get the parts to fit together will be simplified by the use of soft aluminum angle which can be easily cut and filed.

First, fabricate the four chassis rails from 1/8″-thick aluminum angle that is 3/4″ on the side. Dimensions and hole locations are given in Fig. 2. When cutting the angle, use a fine-tooth hacksaw and take care to prevent bending the pieces. Use a 4-40 tap for the holes to

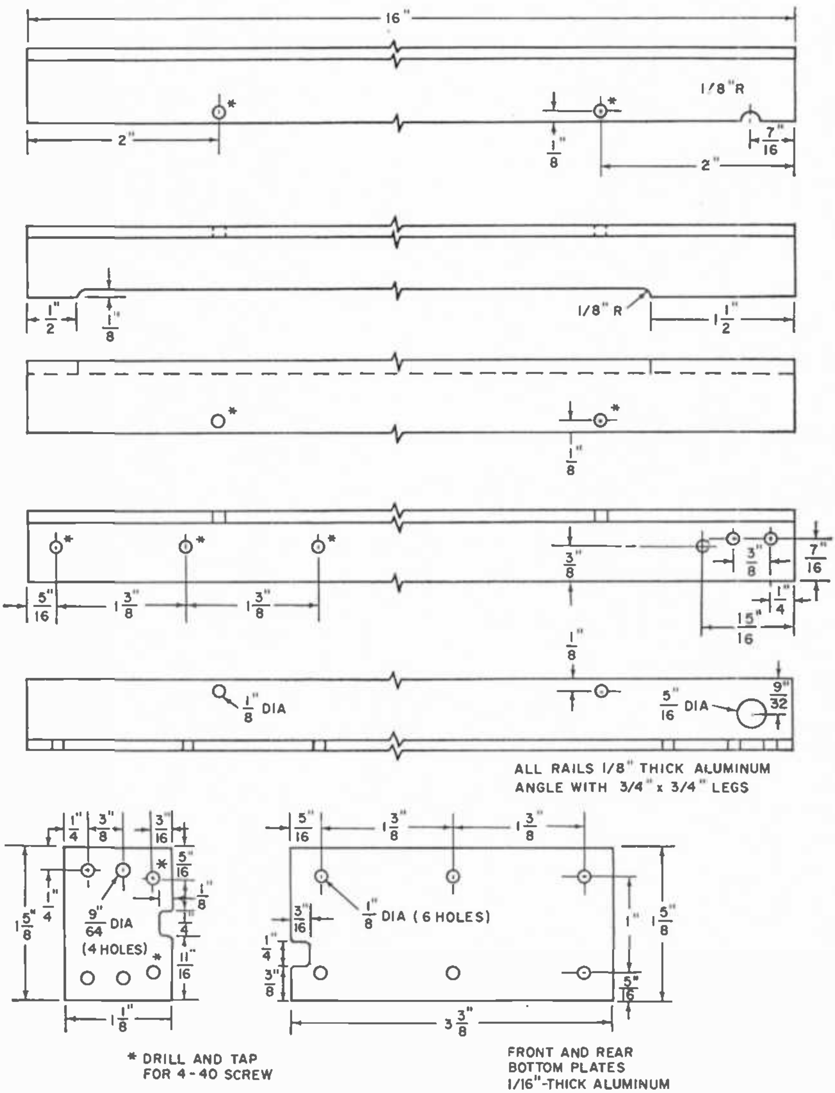


Fig. 2. Chassis rails (upper drawings) are made from 1/8″-thick by 3/4″ on the leg aluminum angle; front and rear bottom plates from 1/16″-thick aluminum stock. Drill all holes as indicated, but screw-tap only those specified.

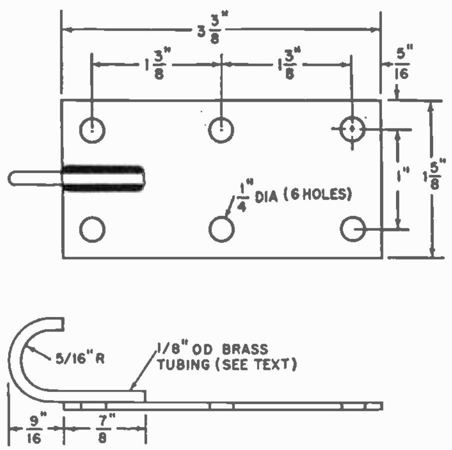


Fig. 3. The mounting plate for the output coupling loop must be fashioned from 0.018"-thick galvanized steel or brass shim stock.

be tapped as indicated. Then fabricate the front and rear bottom plates from 1/16"-thick aluminum.

The most difficult part to fabricate is the output coupling loop. This must be formed from 1/8"-inner-diameter brass tubing (available from most hobby shops or salvaged from an old and empty ballpoint pen ink cartridge). The tubing is too hard to be bent immediately. It must first be annealed by heating it until red hot and allowing it to cool to room temperature naturally; do *not* immerse the hot tubing in water or oil.

When the tubing is cool to the touch, pinch one end closed with pliers and fill the tubing with fine sand (beach sand will do nicely). Pack the sand tightly, and pinch closed the open end of the tube. Then file or cut a 1/8"-wide by 3/32"-deep groove around a length of 3/4"-diameter wood dowel to make a bending form. Place the tubing in the groove and carefully bend it to shape. Work slowly to avoid sharp bends.

Referring to Fig. 3, trim the tubing to size, removing both crimps. Empty out the sand and remove any remaining grit with a pipe cleaner. Machine the output loop mounting plate from 0.018"-thick brass or galvanized sheet steel as shown. Then solder the tubing to the plate. Be careful to prevent the solder from flowing into the open end of the tube and, through capillary action, causing an obstruction. Let the assembly cool; then slip over the curved portion of the tube a length of plastic tubing.

The drawings given in Fig. 4 show all of the dimensions and assembly instructions for the circuit board assembly. The circuit board and its base should be made from 1/16"-thick epoxy-glass board, copper-clad on one side only. After etching and drilling the circuit board, mount the components on it as shown in the

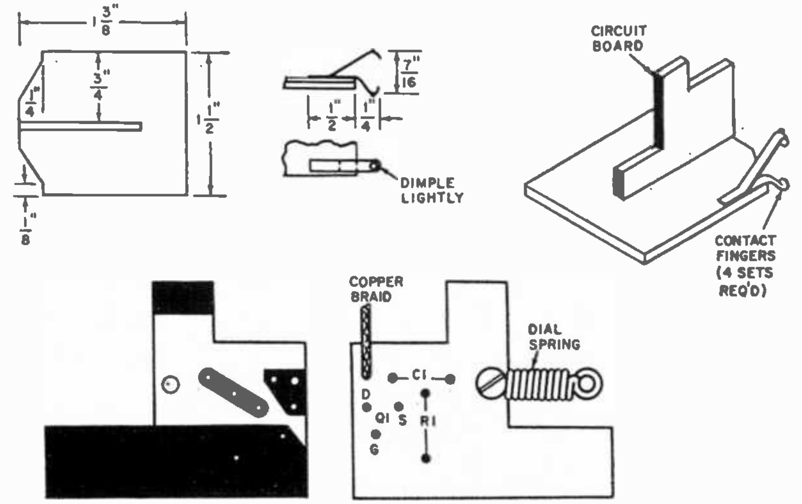


Fig. 4. Complete details for fabricating circuit board assembly are shown in this series of drawings. The contact fingers are made from 0.005"-thick springy metal. Circuit board etching guide (directly above) is actual size.

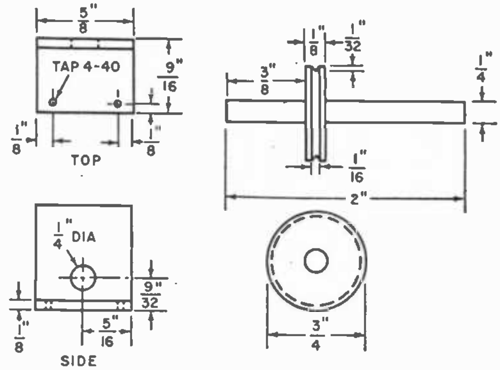


Fig. 5. Two short lengths of aluminum angle serve as supports for dial shaft. Faucet washer is cemented to shaft and grooved to make pulley.

layout drawing. Then carefully set the board over the oblong area shown on the base (see perspective drawing), and solder the two together. Bolt a dial cord spring to the board with 4-40 hardware.

The contact "fingers" must be made from thin (about 0.005") brass, beryllium-copper, or other springy metal. A piece of bronze weatherstrip is a convenient source of material. Eight fingers in all are needed. Before bending them to shape, lightly dimple each about 1/8" from one end.

Once bent to shape, the fingers should be soldered to the four square corners of the base of the assembly, about 1/64" in from the side edges to prevent the sharp edges of the fingers from dragging along the aluminum rails.

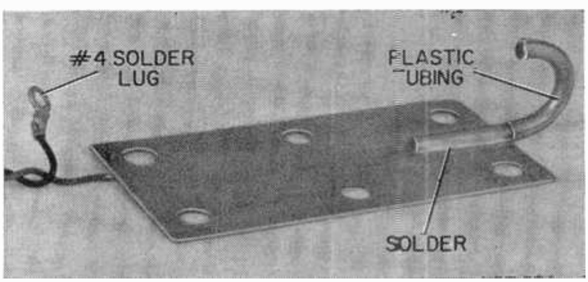
The drive pulley for the tuning mechanism can be made from 1/2"-diameter hard rubber or fiber faucet washer (see Fig. 5). The actual dimensions of this washer will be about 3/4" diameter by 1/8" thick. Carefully ream out the center hole of the washer to provide a snug fit when it is slipped over a 1/4" tuning shaft. Position the washer as shown, and bond it in place with epoxy cement. Allow the cement to cure for at least 24 hours. Meanwhile fabricate the shaft brackets from the same aluminum angle used for the chassis rails. Drill mounting holes and tap them for 4-40 machine hardware.

When the cement has cured, chuck the short end of the tuning shaft into a drill. With the drill operating, gently apply pressure from a small file against the outer rim of the washer until you have a groove that is about 1/32" deep by 1/8" wide.

The tuned drain lead is simply a length of tinned copper braid measuring approximately 1/16" wide when stretched and flattened. The exact dimension is not critical, just so the braid passes freely through the output loop tubing.

Assembling the Project. Locate the front bottom plate, the output loop assembly, and both bottom rails. Determine which will be the mating surfaces between these pieces; then cover the top side of the front bottom plate and the underside of the rails with a single layer each of Scotch® "Magic" tape. Lay the tape on evenly without overlapping the strips or leaving any exposed metal. An awl or other sharp instrument can be used to perforate the tape at the screw hole locations.

Now, set the bottom plate atop the output loop's base, properly oriented, and mark the outline of the notch in the bottom plate on the



With brass tubing soldered to mounting plate, slip piece of plastic tubing over looped section; solder piece of hookup wire with solder lug to mounting plate.

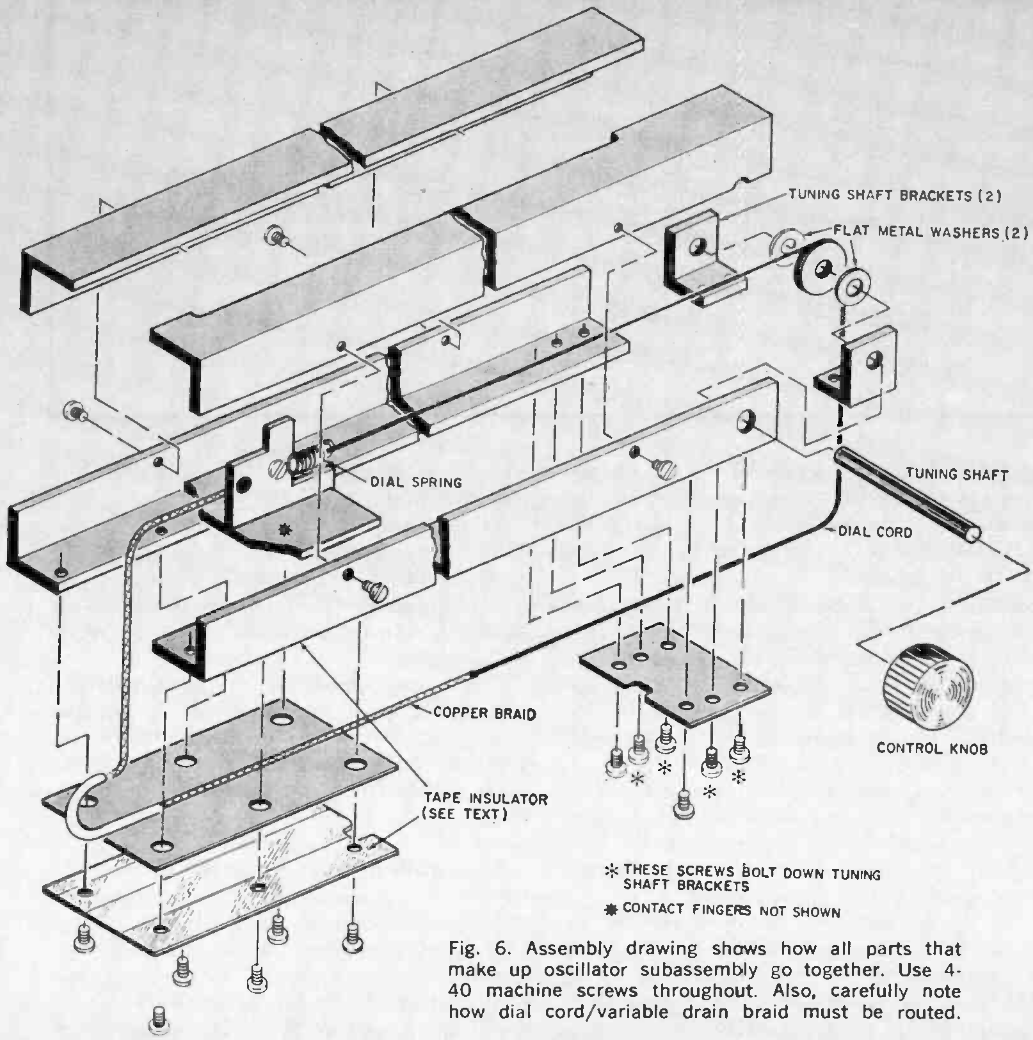
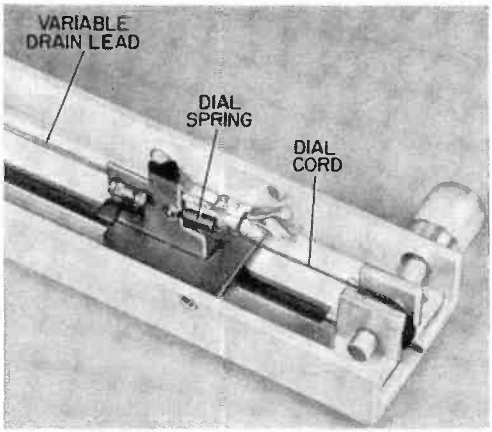
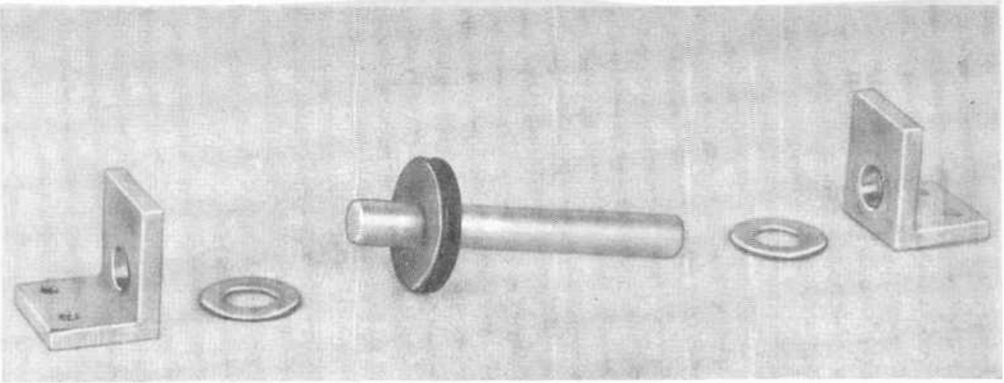


Fig. 6. Assembly drawing shows how all parts that make up oscillator subassembly go together. Use 4-40 machine screws throughout. Also, carefully note how dial cord/variable drain braid must be routed.



When properly put together, circuit board assembly should move freely in the chassis rails. Use just enough spring tension to prevent dial cord from slipping when you tune back and forth along the dial train.



Shown is correct sequence of assembling parts that make up dial tuning assembly. Flat metal washers are used to reduce friction and wear between pulley and support brackets and to prevent play between them.

loop plate. Solder one end of a 24″ length of stranded hookup wire within the outline marked. Make sure that neither the wire nor the solder goes beyond the outline.

Referring to Fig. 6, assemble the lower half of the project, making sure that the larger holes in the output loop assembly are centered over the smaller holes in the rails and bottom plate. Use 4-40 × 3/16″ machine screws. (Under one of these screws, fasten one end of another 24″ length of hookup wire, using a different color of insulation for easy identification. Twist both wires together and solder the free ends to a phono plug.)

Now, use an ohmmeter, set to the highest multiplier range, to check the insulation between the output loop assembly and all other metal parts. You should obtain a reading of infinity. Any other reading indicates that the insulation between the output loop assembly and metal chassis is defective and must be corrected immediately before proceeding.

Temporarily mount the top rails to the assembly with 4-40 × 1/4″ machine screws. Test the circuit board assembly for fit inside the rails and proper movement in both directions. If you are satisfied, disassemble the top rails. Leave the circuit board in place, and string the dial cord and variable-length drain lead braid as shown. Apply just enough dial spring tension to insure that the dial cord does not slip when the tuning knob is turned. Also at this time, make sure that the copper braid enters the coupling loop squarely; if it does not, carefully adjust the geometry of the loop tubing until it does. Rub a soft lead pencil over the copper braid to provide lubrication, and apply small amounts of light grease to the chassis rails where the contact fingers ride. Then fasten only one of the top rails in place.

Meter *M1*, batteries *B1* and *B2*, and resistors *R2* and *R3* can be assembled in any size chassis box that will conveniently accommodate them. Circuit layout is not critical.

Tuning And Use. Set *R2* for minimum resistance and temporarily disconnect *B2*. Close *S1* and adjust *R2* for about a three-quarter scale pointer deflection on *M1*. Now touch the tuned line near *Q1* with the tip of your finger. If the oscillator is operating, touching the line will cause a drop in the meter current indication. Tune the oscillator through its range; the current should remain fairly stable over most of the tuning range, gradually falling off at the high-frequency end.

If you experience trouble getting the oscillator to work properly throughout its entire range, try changing the value of *C1* slightly. (You might encounter a false dip in the meter indication at one point in the tuning range. If so, make a note of its location on the dial rail to avoid future confusion.)

Next, set *R3* for maximum resistance and reconnect *B2*. With *S1* closed and the oscil-

CALIBRATION CHART

F (MHz)	L (in.)	F (MHz)	L (in.)
140	17 5/16	320	7 19/32
150	16 5/32	340	7 1/8
160	15 5/32	360	6 3/4
170	14 9/32	380	6 3/8
180	13 15/32	400	6 1/16
190	12 3/4	420	5 25/32
200	12 1/8	440	5 1/2
220	11 1/32	460	5 9/32
240	10 3/32	480	5 1/16
260	9 11/32	500	4 27/32
280	8 21/32	520	4 21/32
300	8 3/32	540	4 15/32

For other frequencies use the formula:

$$L(\text{in.}) = \frac{2422}{F(\text{MHz})}$$

lator set near the high end of its tuning range, touch a moistened fingertip between the drain connection of *Q1* and the chassis. Oscillations should immediately cease. Still touching the drain lead, adjust *R2* so that the meter indicates zero. Remove your finger and tune the oscillator for a maximum meter indication. Adjust *R3* for full-scale pointer deflection. Repeat this procedure and readjust *R2* as necessary. Now the meter pointer will remain on-scale at any frequency setting and the meter pointer will swing between zero (no oscillations) to full-scale (strongest oscillations).

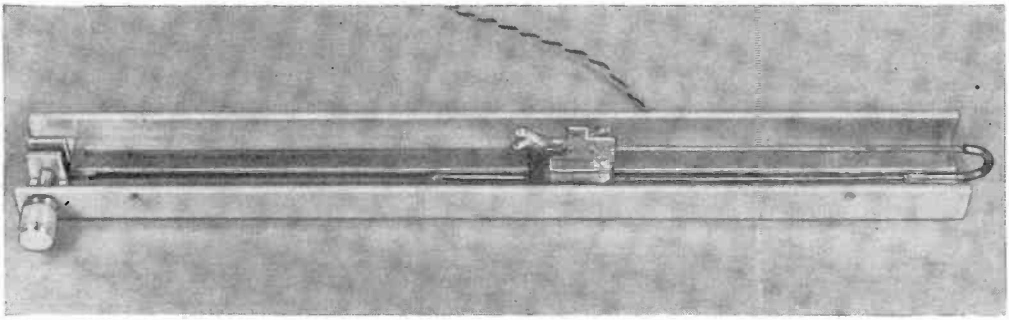
The oscillator can be calibrated easily and with reasonable accuracy by using predetermined lengths of 300-ohm twin-lead TV antenna cable as quarter-wave resonant lines with known resonant frequencies. Cut the twin-lead first to 18" long. Strip away ¼" of insulation from both conductors at one end, bend the stripped wires toward each other until they touch, and solder the wires together.

Now, starting with the longest length of twin-lead (lowest resonant frequency) indicated in the Calibration Chart, tune the drain-dip oscillator as follows: Loosely couple the drain-dip oscillator to the shorted end of the line and rotate the tuning knob on the oscillator chassis for a dip in the meter pointer deflection. The dip should be sharp and distinctive. Mark the dial rail with the frequency indicated in the Chart for the length of line used near the circuit board index.

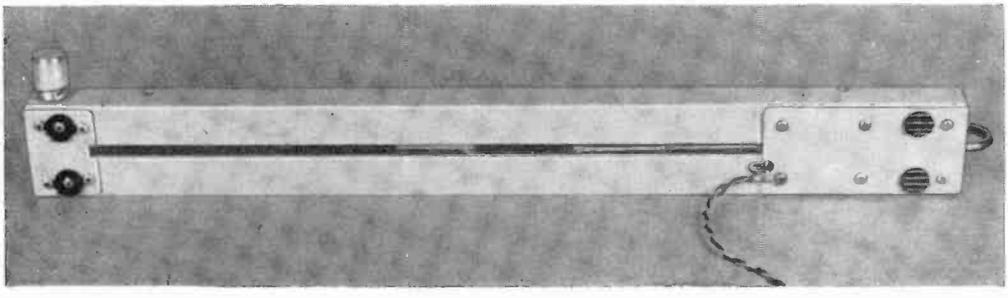
Trim the twin-lead to the next longest dimension indicated in the Chart (trim from the open end of the line only), and repeat the tuning procedure. Continue trimming and tuning for each frequency desired.

If possible, lay the twin-lead across the edges of an open cardboard box so that most of the line is in open air and well clear of metal surfaces. For greatest accuracy, the coupling between the twin-lead and output coupling loop of the drain-dip oscillator should be as loose as possible. The 140- to 180-MHz lengths of line will also give resonances at three times the marked frequency, or at ¾-wave resonances. These harmonic resonances, however, can be easily distinguished from the primary resonances by their positions away from the low-frequency end of the oscillator's dial.

If possible, the output loop should be coupled to the low-impedance or grounded end of the circuit to be measured. If the circuit is inaccessible, link coupling can be used between the circuit and the dip oscillator. But take care to avoid mistaking the link resonances with the resonances of the circuits under test. —30—



In the photo above, the oscillator subassembly is shown in the stages of final assembly, while the underside view below shows part of the power cables that goes to the bridge circuit's chassis (lower right).



A Practical Expanded Scale Milliohmmeter

MEASURING THE ALMOST UNMEASURABLE

This test instrument was developed to measure what most electronic experimenters are inclined to think of as inconsequential resistances. However, the less than 1-ohm losses are important factors in detecting hi-fi ground loops, poor contacts in high amperage circuits, corrosion, etc. The circuit is a simple, easily balanced bridge. Provision is made in the instrument for long storage and battery protection.

CONVENTIONAL home and field-type VOM's are not designed to resolve accurately resistance readings between zero and one ohm. Even the very best multimeters employ a logarithmic scale, with 10 ohms as an average center-scale reading when the range switch is in the times-one position. And you need a very sharp eye, indeed, to differentiate between readings of, say, 0.27 and 0.05 ohms on a multitap transformer.

Commercially available milliohmmeters are

BY DAVID R. CORBIN

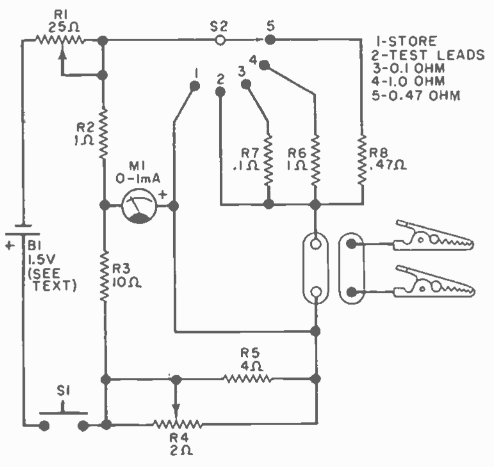


Fig. 1. Resistor R8 provides optional but very useful internal testing facility for checking calibration; S1 is momentary-action switch.

PARTS LIST

B1—Three 1.5-volt AA cells connected in parallel
M1—0-1-mA, 50-ohm meter movement (Monarch No. PMC6S or similar)
R1—25-ohm, 5-watt wire-wound potentiometer (Mallory No. VW25 or similar)
R2,R6—1-ohm, 2-watt, 5% tolerance wire-wound resistor
R3—10-ohm, 2-watt, 5% tolerance wirewound resistor
R4—2-ohm, 5-watt wirewound potentiometer (Mallory No. VW2 or similar)
R5—4-ohm, 1.5-watt, 5% tolerance wirewound resistor
R7—0.1-ohm, 2-watt, 5% tolerance wirewound resistor
R8—0.47-ohm, 2-watt, 5% tolerance wire-wound resistor (optional, see text)
S1—Spst pin-plunger momentary-action switch (Robertshaw No. 1MD1-1A)
S2—Five-position, non-shorting rotary switch (Mallory No. 3215J or similar)
Misc.—Five-way binding post pair; banana plug pair; Keystone No. 171 three-AA-cell holder; control knobs; chassis box; hookup wire; epoxy cement; solder; etc.

expensive instruments, costing $175 and more. However, with modern solid-state equipment in which biasing resistors in the 0-1-ohm range are common, a milliohmmeter is almost a must for measuring such values. By eliminating unnecessary ranges and maintaining accuracy to within practical limits, it is possible to build a milliohmmeter for less than $18.

The milliohmmeter described in this article has two very useful ranges—0-1 ohm and 0-0.1 ohm. The scale is very nearly linear (it would take very expensive and elaborate equipment to show that it is not), but is actually a tiny portion of a logarithmic curve, expanded to cover the full swing of the meter pointer.

Theory of Circuit Design. As shown in Fig. 1, the circuit of the milliohmmeter consists of a resistive bridge, one side of which is made up of the test leads (and resistance being measured). Closing *S1* causes current to flow from *B1* via *R1* to the bridge.

With *S2* in position 2 and the test leads shorted together, *R4* is adjusted to ten times the lead resistance, balancing the 1:10 ratio of the *R2-R3* side of the bridge. The meter will now indicate zero, regardless of the setting of *R1*. If the test leads are disconnected, with *S1* closed, the bridge will be heavily unbalanced in a direction such that current will flow from *R2* through the meter to *R4*, swinging the meter pointer off-scale.

For calibration purposes, *S2* must be switched to *R6* for the 1-ohm range or *R7* for the 0.1-ohm range. If *S2* is in position 3, *R7* is placed in series with the test leads, unbalancing the bridge circuit and moving the meter pointer by an amount determined by calibration potentiometer *R1*. Potentiometer *R1* is then adjusted to produce a full-scale pointer deflection.

Setting *S2* to position 2 and placing a 0.1-ohm resistor across the leads will also cause a full-scale deflection of the meter pointer (assuming that the setting of *R1* remains undisturbed). Hence, it is possible to compare the standard internal resistances of *R6* and *R7* with the values of resistance being measured and obtain direct readings in ohms.

Resistor *R5* is used to smooth the operation of *R4* and help balance the bridge. An optional feature of the circuit is *R8* which provides a useful internal resistance for checking calibration.

Construction. Assembling the milliohmmeter should present no problems, since there is nothing critical about the circuit. As shown in Fig. 2, all components, except the battery bank and its holder, mount directly to the front panel. To simplify mounting, a hard-

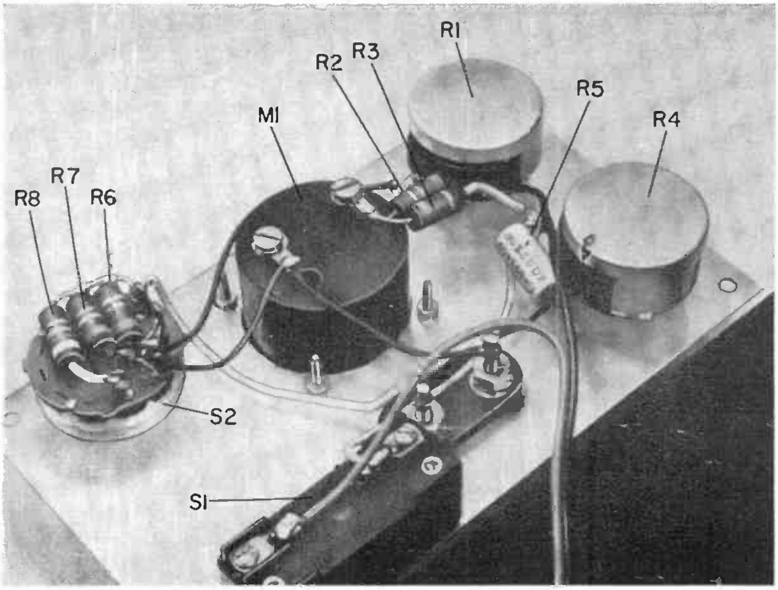
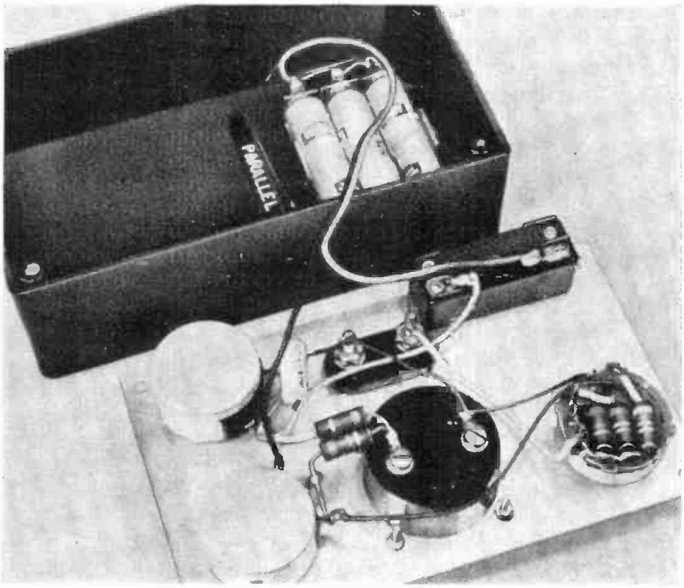


Fig. 2. The simplicity of the circuit allows all components to connect directly to the control and meter lugs.



The battery supply for the circuit is mounted in place with the aid of three AA-cell holders and machine hardware.

set epoxy cement bonding is used between the top of the housing of switch *S1* and front panel and between the battery holder bank and case. The meter movement, binding posts, function switch (*S2*), and potentiometers fasten in place with the hardware supplied.

Since there are only a few components, wiring by the point-to-point method is easy. Note, however, that the bank of three batteries that make up *B1* must be connected in *parallel* with each other. Also, when mounting the binding posts, make absolutely certain that both are insulated from the front panel.

Once the circuit is wired up as illustrated in Fig. 2, assemble the case. Now, make your test leads. Probe-type leads are useless for the milliohmmeter. What are needed for the test ends of the cables are strong spring-loaded clips that will lock solidly onto the leads of the components under test. This is necessary because in dealing with resistance measurements in the fraction of an ohm range, contact resistance becomes an important factor in accurate calibration and test readings.

It is not necessary to use any special type of test lead cable, nor are the lengths of the cables critical. The instrument is designed so that, in zero-adjust nulling and full-scale deflection calibration, the test leads become part of the bridge circuit and are "nulled out" regardless of their specific resistances. (It may seem strange that you have to consider test lead resistance, but the meter will easily demonstrate that if a null is obtained using only one lead, the meter will indicate half-scale deflection with both leads—and after calibration will give the resistance in milliohms of the lead not used in the nulling procedure!)

How To Use. First, short together the alligator clips on the test leads. It is best to clip the leads together in the same manner as they would be clipped to the leads of the component under test. This will assure good contact resistance. If you merely hold together the clips with one hand, you will find adjustments difficult to make because of the varying pressure you exert on the clips. Especially noticeable on the 0.1-ohm range will be the "jumpy" movement of the meter pointer.

Next, set *R1* to maximum resistance and *S2* to the TEST LEADS position. Depress *S1* and adjust null control *R4* for a zero meter reading. Then release *S1* and set *S2* to the desired range position. Again, depress *S1*. Now, adjust the setting of calibration control *R1* for a full-scale pointer deflection.

Release *S1*. Set *S2* to the TEST LEADS position. Your meter is now ready to measure resistance values in the range for which it was calibrated.

When storing the milliohmmeter away, set *S2* to the STORE position. This minimizes the chances of damage or off-scale readings should the PRESS-TO-TEST switch be accidentally depressed. As with any type of electronic equipment, batteries should be removed altogether for prolonged storage.

Aside from checking the values of less-than-one-ohm resistors, the milliohmmeter is a handy item to have available for other tests. It can be used to check corrosion in automotive wiring connections, a serious source of IR losses even if only a few milliohms of resistance is involved. Other uses include troubleshooting motors, generators, and starters, measuring the cold resistance of incandescent light bulbs, winding bias and motor control resistors from hookup wire, and checking for resistance in power distribution systems and ground circuits. -30-

THE PRODUCT GALLERY

Second in a New Series by "The Reviewer"

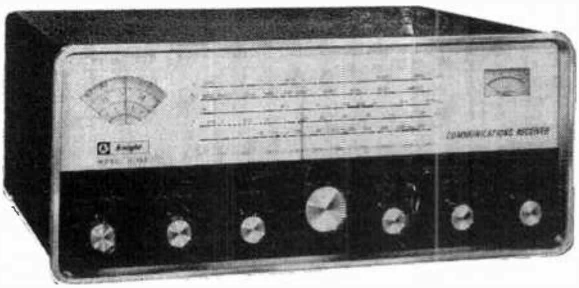
UNLIKE SOME stereo equipment, the testing of communications receivers is a well-defined art. First you make sure that alignment is on the nose and that all controls (panel and otherwise) are operating according to the parameters set forth in the instruction manual. Next, you submit the receiver to a battery of laboratory tests: selectivity, sensitivity, agc characteristic and i-f image rejection. Last, but not least, you try out the receiver on the air using a variety of antennas. Then, hopefully, you write a sensible and useful report.

In today's language, a "communications receiver" is defined as a receiver that tunes the shortwave spectrum (preferably 2 to 30 MHz), has a fair degree of sensitivity and selectivity, bandspread tuning, S-metering, bfo, product detection, noise limiting or blanking, etc. Obviously, there are many receivers (ranging up to $4500) that fit within the above definition, but sad to say, there are probably just as many (regardless of price) that fail to qualify—usually in more ways than one.

Heretofore, an SWL or ham knowledgeable about receivers could distinguish a true communications receiver on the basis of selling price, but within the past year the price parameter has collapsed. In June 1970 The Product Gallery reviewed the Heathkit Model GR-78 and although Heath calls it a General Coverage receiver, it is really a flexible, low-cost communications-style receiver. About the same time that review was being written, Knight-Kit (Allied Radio Shack) was announcing a new SWL/ham receiver that it did advertise as a communications receiver—the under $100 Model R-195.

The Knight-Kit R-195—This is a 5-band single conversion superhet tuning from about 200 to 420 kHz and 550 kHz to 30 MHz. The R-195 is another of the new breed of receivers using i-f stages employing 455-kHz ceramic filters. These filters replace l-f transformers and are fixed tuned, thus the i-f strip never needs adjustment or alignment. Three FET's are used in the R-195 front end; one in a grounded-gate r-f stage, a second FET in the mixer, and a third FET as a Hartley oscillator. Separate AM and CW/SSB detectors are used and there is a series-gate AM noise limiter, S-meter amplifier, agc rectifier, and a complementary configuration audio output stage. Although designed for 117-volt ac operation, the R-195 may be operated in an emergency from a 12-volt dc battery (about ¼-ampere drain) through a special rear skirt connection.

Assembly of the R-195 is very simple, since the receiver is delivered to the buyer with three pre-wired printed circuit boards—an r-f board, an i-f board and an audio amplifier board. The builder wires in the power supply, bandswitching, front and rear panel controls and terminals and strings the dial cord. Only the latter is of any sort of major undertaking and is notable for trying your patience and improving



The Knight-Kit R-195 is a good looking receiver, although the photo shown here, supplied by the manufacturer, differs (in bandspread scale) from the model as received and assembled by your reviewer.

your swear-word vocabulary. From opening the shipping container to turn-on, you can expect to invest between 12 and 13 hours.

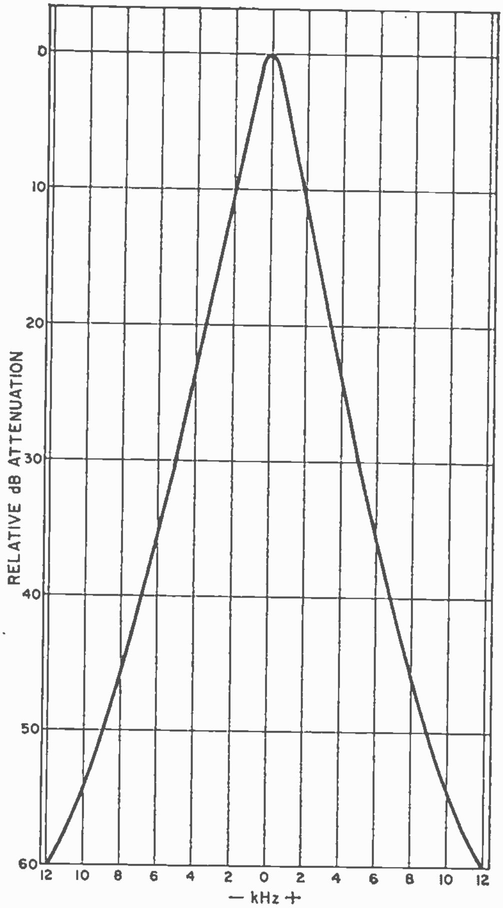
Laboratory Tests. Following the r-f alignment instructions detailed in the Construction Manual and then double-checking with test equipment, I found that the builder can obtain very good performance from the R-195 without resorting to an r-f alignment generator. However, for purposes of comparison between the manufacturer's claims and my tests, the R-195 was aligned with laboratory test gear. The sensitivity results (10 dB S+N/N) are shown at the right.

The AM sensitivity vs CW/SSB sensitivity suffers from inefficiency in the AM diode detector. At many points on the dial the AM detector is operating at a very low level and apparently departs from the linear portion of its detection (rectification) curve. Thus, efficiency is low and there is a deterioration in the AM sensitivity of weak signals.

R-195 SENSITIVITY TABLE

Band	AM (Measured)	AM (Claimed)	CW/SSB (Measured)
	(Microvolts for 10 dB S+N/N)		
A: 200-420 kHz	3.0	2.0	0.55*
B: 550-1800 kHz	1.4	1.5	0.3*
C: 1.8-4.8 MHz	1.25	1.5	0.28*
D: 4.8-12.0 MHz	3.1	2.0	0.5*
E: 11.0-30.0 MHz	4.4	1.8	1.0*

*Equal to or better than manufacturer's claim.



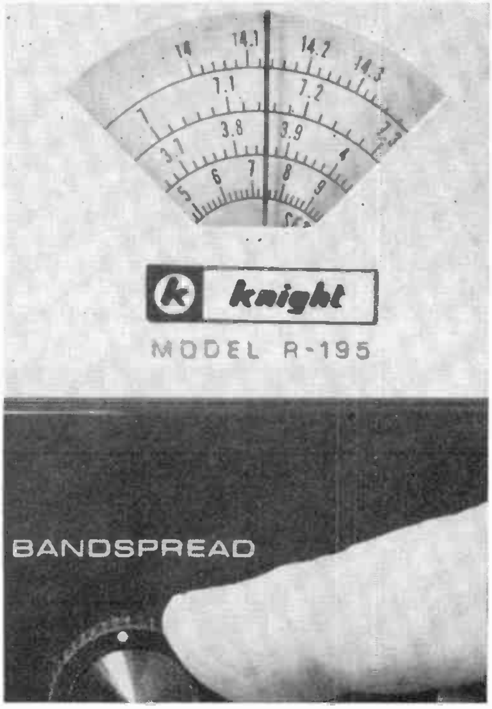
Clean symmetrical selectivity curve of the R-195 results from the use of ceramic filters in the i-f stages. Unfortunately, good selectivity cannot be used to maximum advantage due to poor bandspread.

Selectivity was measured at 3.0 kHz at 6 dB down, 10.0 kHz at 30 dB down and 24 kHz at 60 dB down. This compares with the claimed 2.5 kHz at 6 dB and 7.0 kHz at 30 dB. The S-meter readings varied from a low of 28 μV for S9 at 1800 kHz to a high of 240 μV at 28.0 MHz. A 40 dB r-f input change (10-1000 μV) resulted in a 14-dB a-f output change indicating that the agc characteristic was not too satisfactory. Overloading occurs at about 1000 μV and will produce "birdies" and intermodulation on the AM broadcast band.

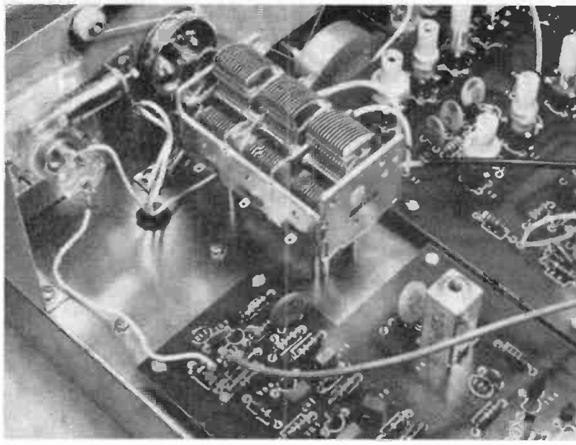
Image rejection averages 25 dB on Band A, 40 dB on Band B, 28 dB on Band C, 22 dB on Band D, and 10 dB on Band E. On the latter band the average is distorted by the very poor rejection above 22 MHz where it drops to less than 6 dB.

On The Air—As the test figures indicate, the R-195 is a sensitive receiver with reasonable selectivity, both qualities far better than the operator can use to advantage. Also on the good side of the ledger, the audio quality is excellent and more volume output is available than necessary. Frequency stability is surprisingly good for a $100 receiver and the front panel controls are nicely situated and convenient. On the negative side, I found Band A (200-420 kHz) useless in metropolitan New York due to the strong images from the AM broadcast band stations. Overall bandspreading is too tight for ease in separating stations and on Band E the antenna trimmer pulls the oscillator making the R-195 somewhat unstable on the 10-meter band. Dial calibration and the S-meter are difficult or impossible to read under some lighting conditions in your SWL/ham shack.

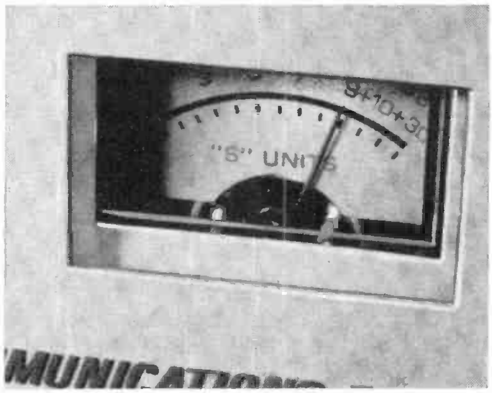
As a summary of my findings, I am convinced that the R-195 is easy and foolproof to assemble and in a dollar conscious marketplace it is an obvious bargain. What the receiver lacks in refinements are compensated for by excellence in stability, sensitivity, and selectivity.



Considering the selectivity and excellent sensitivity of the R-195, the totally inadequate main tuning and bandspread arrangements are almost criminal. Only below 4 MHz does the operator have a chance of setting up cold on a desired frequency.



The printed circuit boards (above) are supplied pre-soldered and partially pre-aligned. Builder makes the necessary interconnections, mounts the front and rear panel controls and terminals and then threads that #!*% dial cord through the hole.



Not only is the recessed S-meter difficult to photograph, it's more difficult to see when operating the receiver. The main dial tuning scale suffers from parallax problems and, on higher frequencies, it is virtually impossible to set or reset the R-195 receiver to a desired known frequency.

MY PERSONAL nomination for the least used, yet highly useful, piece of test equipment is the signal tracer. I don't think it's a matter of discrimination or thoughtlessness, it's just that most hobbyists and experimenters fail to see the value of assembling something for which they have no immediate requirement. Also, the signal tracer is not exotic as an oscilloscope or as "basic" as a VOM/VTVM, but for what the tracer lacks in glamour, it makes up in practical usefulness.

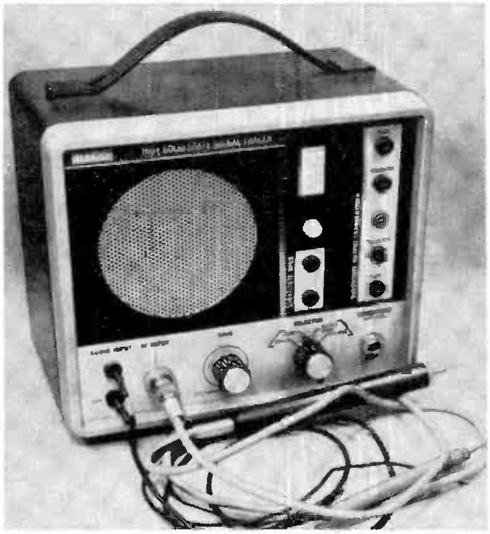
I have had some sort of signal tracer on my lab bench for the past 20 years. Its built-in audio amplifier has been used a hundred or more times and the r-f probe has repeatedly located "lost" signals in receivers ranging from the All-American 5 to the most complex and costly multi-tube communications type. Within the past six years, the tracer I've used has been the Eico Model 147A—an oldie with four vacuum tubes including a 1629 "Magic Eye" and 6 X 4 rectifier.

The Eico Model 150 Signal Tracer—Some months ago Eico obligingly sent me a new 150 Signal Tracer Kit. It is similar to the old 147A except that everything is solid state and the magic eye has been replaced by "cat's eye" meter! Assembling the kit is not a major undertaking and working at my snail's pace I had the job completed in just under 4 hours.

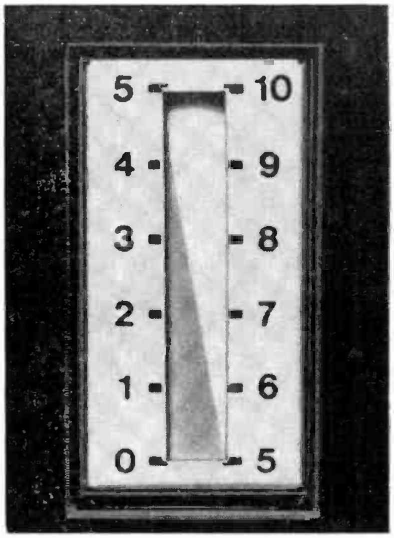
There's nothing too tricky about assembly although a few wiring instructions were confusing. For example the "Red Dot" on the speaker (p. 8, step 6) was missing as were the 10 solder lugs (p. 9, step 1), but neither of these classifies as a calamity. Of course, the GED 29A6 transistor is now a 2N5355 which might confuse some builders and there's no eyelet to bend over the shield (p. 17, step 6)—both a little startling. But Eico is getting back on the ball and the 150 worked perfectly at first turn-on.

For those interested, the 150 is basically a four-stage audio amplifier with a 400-mW output, medium gain audio amplification (60-mV drive to full output), high gain r-f amplification (1-mV drive), very low internal a.c. hum level, meter and aural output, plus provisions to use the built-in speaker separately without the amplifier. The amplifier output can also be fed to a scope or VOM.

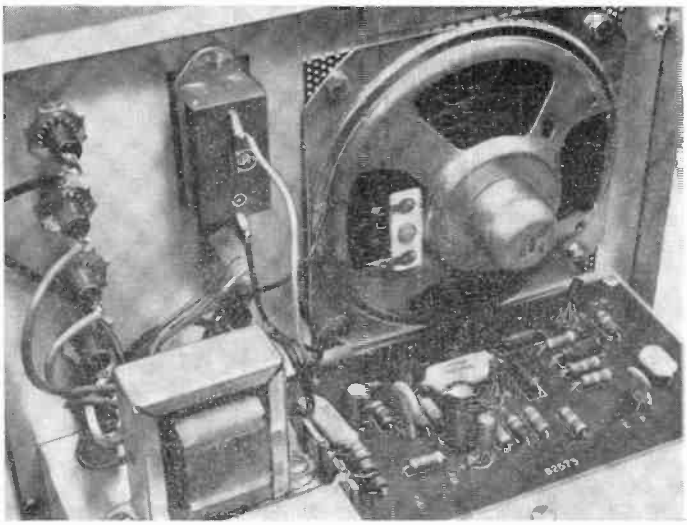
There isn't too much more I can say about the 150. I like it better in some ways than the elderly 147A, although strangely enough the first thing I missed was the calibrated wattmeter of the 147A. But this would have been a difficult addition to the 150 circuit. I have used the 150 twice in the last few weeks, once to find how much r-f was leaking out of a supposedly shielded enclosure and then as a substitute amplifier to trace out some residual hum in an HQ-215 receiver—I still haven't found the hum, but that's not the 150's fault—it did the job it was expected to do.



Signal tracer is supplied with two probes—direct for audio tests and an isolated diode rectifier for r-f tests. We dislike fragile tips and tip jacks and plan to substitute sturdy double banana jack and plug at Audio Input on our Signal Tracer.



Two hundred microampere meter on new 150 is "different." Wired to collector of the audio output stage, the speaker had to be blasted to get reading halfway up scale. It looked like cat's eye.



Behind the panel of the 150, wiring is very simple. Audio amplifier is assembled on a printed circuit board. Power transformer is at lower left.

I THINK that I have an unhealthy dislike about reviewing stereo hi-fi equipment. I seem to be more consciously aware that so much about stereo is wholly subjective. You can make laboratory measurements to your heart's content and report your findings in very explicit language, but reading in a magazine about a stereo system will never actually tell you what it really sounds like. Such word pictures can be misleading—possibly not intentionally—but subject to literal misinterpretation, nevertheless. In The Product Gallery I have made a decision (with the concurrence of the publisher and the editor) that I will only review stereo equipment that is "different" and not "run-of-the-mill."

Although such a decision might seem to limit severely stereo product reviews, I have found that there are numerous unusual products that can be reviewed in POPULAR ELECTRONICS and which the readers will find of particular interest. Some of these new products involve atypical concepts, some brilliant engineering innovations, and others represent either extraordinary performance capabilities or noteworthy dollar values. I don't intend to compete with the numerous competent analyses in my sister publication STEREO REVIEW with its strong emphasis toward the user and music lover. But, then, I don't expect STEREO REVIEW to start talking about test equipment or communications receivers either.

Stereo enthusiasts need not be told that within the past few years there have been two concurrent equipment developments for use in the home—the "compact" system and the "surround sound" reproducers. The evolutions of both developments make interesting stories—some of which appears in this issue on page 94. I think it is safe to say that the compact stereo system is here to stay and that it has brought matched-component stereo equipment into the hands of music listeners who might not otherwise feel that they had the resources or knowledge to assemble an individual component setup.

There is a tendency among stereo equipment manufacturers to combine the two above developments into the same package. The reasoning is valid, but the method as to how the combining should be accomplished and to what order of magnitude the listener should depend on surround (or reflected) sound is just coming out of its experimental stage. And, for more years than I care to recall, audio engineers have attempted somehow or other to make the hi-fi amplifier responsive to changes in the listening environment. Engineers have explained that a system should sound better if it could be made to compensate automatically for changes in room absorption, changes in the furniture arrangement, selective room resonances, etc. To my knowledge and up until now, none of these schemes ever worked in a fool-proof fashion. The "feedback" loop of information caused these systems to "hunt" or "cycle" in wild-eyed attempts to compensate for compensations.

The Electro-Voice Landmark 100. Recently I field-tested and Hirsch-Houck laboratory-tested a "different" compact stereo system that has apparently solved some part of the runaway feedback problem—the Electro-Voice Landmark 100. This compact system has introduced what it calls "Servo-Linear Motional Feedback" which it applies to its "Acoust-Array Cube Speakers."

All of this impressive lingo means that E-V has developed a new solid-state circuit to monitor the speaker cones and to instantaneously compare its movement with the signal being passed out the amplifier. If these two do not match, the feedback circuit makes a minor correction that has the effect of reducing audible distortion (particularly below 300 Hz) and slightly adjusting the amplitude responsiveness of the speakers to the listening environment.

When you open the three E-V shipping cartons containing a Landmark 100 you find a Garrard turntable/player mounted above an AM/FM/FM stereo receiver/amplifier combination in one carton. In the second carton are two relatively small speaker cubes (somewhat truncated on two edges) and in the third carton is a smoke-tinted plastic dust cover that snugly fits over the turntable/player.

Hooking up the Landmark 100 is a matter of plugging in the cables from the speaker cubes, attaching the FM dipole (if necessary), releasing the turntable hold-down bolts, and plugging in the ac power cable. In a matter of 10 minutes you are listening to stereo.

The most obvious physical "difference" in the Landmark 100 to distinguish it from other compact stereo systems are the two partially truncated "Acoust-Array" cube speakers. Each cube contains three miniature full-range speakers and one emphasizing tweeter (see photo). Each cube weighs over 10 lb and has full-range radiation from the front and from the two truncated planes. The user can position the cubes to literally aim, compress, or expand the stereo listening stage. I have no information on the division of power between the various speakers in each cube and there may not be any, but I can say that the idea of "aiming" appears to work in practice. The connecting cables between the amplifier and the cubes are 16′ long and this permits placing the cubes in seven or eight different configurations—one of which is undoubtedly suitable to your particular listening requirements.

The amplifier in the Landmark 100 is rated at 80 watts IHF music power, or 20 watts per channel continuous output with both channels being driven. There is no way to confirm or deny this fact in a laboratory test since the speakers are permanently wired into the amplifier circuit. Although in power output the Landmark 100 may not look impressive, let me say that it can be played loud enough (without apparent breakup or distortion) to drive just about any listener out of a very big room.

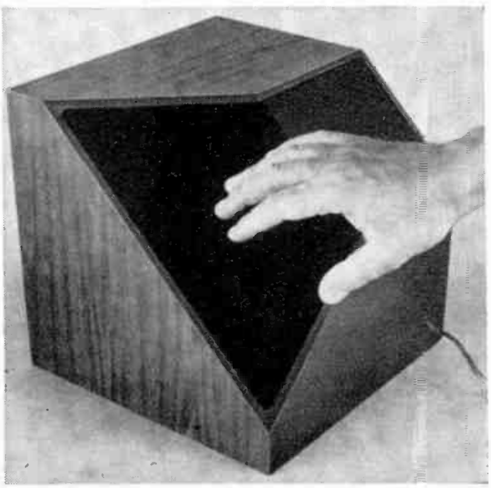
Laboratory tests on the FM tuner were a different matter and, happily, all of the tests met the manufacturer's specifications. The IHF usable sensitivity was 1.9 μV, as rated, and the FM distortion was 0.53% which the manufacturer had rated at 0.5%. The FM frequency response was very flat and is well within ±0.5 dB from 30 Hz to 15,000 Hz. Stereo separation in the FM tuner was better than the average to be expected in this price category and exceeded 35 dB from 500 Hz to 2500 Hz and was more than 20 dB from 30 Hz to 12,500 Hz.

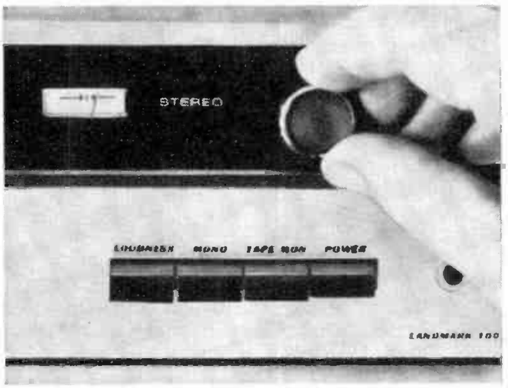
New Phono Cartridge. For what appears to be exclusive use in the Landmark 100, Electro-Voice has developed a new moving magnet cartridge, trademarked the "Stereo-V." In laboratory tests it was noted that the cartridge itself does not have particularly high compliance, but does have excellent tracking ability at middle and high

(*Continued on page* 116)

E-V Landmark 100 is a compact stereo system with 40 watts (IHF) per channel output into pair of unusual cube speakers. Motion of speaker cones is monitored to insure reduction of low end distortion through special feedback loop. Rear skirt (below) reveals simplicity of stereo setup connections.

Cube enclosure has 3 full-range speakers—one facing forward, two on the truncated surfaces. Tweeter is under fingertips. Panel controls are plain with FM carrier centering meter and automatic "Stereo" multiplex light. Earphone output jack is under thumb.





COMMUNICATIONS

SHORTWAVE LISTENING

Broadcasters Change Frequencies—The majority of the international broadcasting stations shift to winter/summer frequencies and schedules on November 1. Broadcasters make four primary schedule changes each year (March, May, September, and November). In view of the now rapidly declining sunspot cycle, shortwave listeners may expect to hear more crowding on the lower frequencies—particularly 31, 25, and 19 meters. Many of the broadcasters have abandoned 11 meters and a drastic curtailment of broadcasting on 13 meters is expected in 1971.

AMATEUR RADIO

Planet Mars QSO—*Visitors to the headquarters of the American Radio Relay League, Inc., Newington, Conn., continue to be intrigued by one of the most unusual trophies offered to ham radio operators. It is the Elser-Mathes Cup that will commemorate the "First Amateur Radio Two-Way Communications Earth and Mars." Donated by Colonel Fred Elser, W6FB/W7OX and Lt. Cmdr. Stanley Mathes, K1CY (deceased). the cup also honors Hiram Percy Maxim (founder of the ARRL), who had an intense interest in communicating with Mars and Venus. When donated to the ARRL in 1929, the idea of ham radio reaching even the moon was considered impractical, but ham-style E-M-E (earth-moon-earth) reflected communications are now almost commonplace. Maybe the first man on Mars will be a ham. If so, his trophy is all ready and waiting for him.*

BROADCAST BAND

TV Antenna for DX'ing—If you have a selective receiver and would like to try your hand at BCB DX'ing don't put up a long-wire antenna—you probably have a better antenna right at your fingertips. Don't laugh, but it's your outdoor TV antenna! Look at it this way: if you twist the two wires from the 300-ohm twinlead together and connect them to your receiver ANT input, you have a top-loaded vertical—just like a BCB transmitter. Make sure that the receiver GND goes to a very good earthy ground because at the medium wavelengths that part of the antenna system is particularly important. (Submitted by Frank H. Tooker)

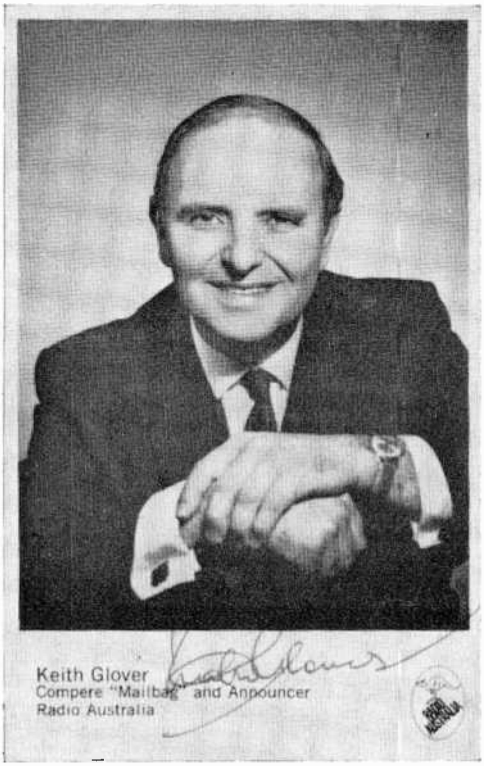
RESEARCH

A Reading from on High—*The FCC has been requested by Readex Electronics, Inc. to establish a wholly new radio service called "Industrial Telemetry." Readex wants assignments in the 216-220-MHz band for miniature low-power transmitters,* Oct. P. Elec.—No. 4

plus frequencies for a 5-watt command unit. The miniature transmitters would be installed by utility companies and connected to water, electric and gas meters. Information on customer usage would be put in digital code and the miniature transmitters interrogated by a command unit in a high-flying plane! Readex says that an area of ten thousand square miles can be covered in one flight and the readings would be recorded on tape. Big Brother and 1984 are getting closer!

AMATEUR RADIO

Novice or Technician Exams—Would-be hams in the state of Washington may take their Novice or Technician class exams at one of the following locations: Amateur Radio Supply Co., 6213 13th Ave. South, Seattle; G&C Electronics, 2502 Jefferson St., Tacoma; and HCJ Electronics, 8214 Sprague Ave., Spokane. R. E. Aspinwall, W7PV, says exams are year-round.



Due to lack of space, we omitted Keith Glover's picture from last month's interview with Richard Wood. Still looks good, though, so here it is now.

CITIZENS RADIO (CB)

Channel 11—*Now that the matter of channel 9 (exclusively for emergency traffic) has been settled, REACT National Headquarters has proposed voluntary nation-wide adoption of channel 11 for inter-licensee calling. Emphasizing that channel 9 had originally been used for intra-station and inter-station calling, a new, nationally recognized "calling" frequency must be sought. REACT says that channel 11 appears to be an agreeable choice to most clubs, REACT teams, and CB magazines. POPULAR ELECTRONICS agrees also.*

SHORTWAVE LISTENING

Clarification—*Radio Nederland's Tom Meyer has corrected some misinformation that appeared in Hank Bennett's June 1970 SWL column. First, tape recordings to Radio Nederland for verification need not be ONLY 7½ in./s; but may be any speed, any track arrangement, and even in cassettes. Also, Tom's show is not a listener's request program, although he is filing away his regular listeners' preferences (and birthdays). Musical requests are handled by Jerry and Dody Cowan's "His and Hers" on Tuesdays and "By Request" on Mondays and Fridays.*

SHORTWAVE LISTENING

Jamming It Up—The Sino-Soviet communist block countries are gradually intensifying jamming of international shortwave broadcasts. Practically all broadcasts beamed to the Soviet Union and mainland China are being jammed. On August 1, a sweep across the 19-meter band showed jamming on the following frequencies (practically a new high): 15,105; 15,115; 15,125; 15,130; 15,145; 15,170; 15,205; 15,215; 15,225; 15,260; 15,280; 15,290; 15,300; 15,340; 15,370; 15,380; 15,390; 15,440; and 15,445 MHz. Because of the splatter, this means that about 25 percent of the possible broadcasting frequencies are useless.

SHORTWAVE LISTENING

Chicom 1—Space scientists are still perplexed by the telemetry from mainland China's 380-lb satellite Chicom 1. Some specialists claim that it wasn't telemetry at all—simply the tag end of a tape recording made to sound like something important. Thousands of SWL's heard Chicom 1 on 20.009 MHz during its short life—an indication that battery power was used in this 5-plus-watt transmitter. Tape recordings mailed by SWL's to Peking have not been acknowledged—according to the latest information—much less "verified." Experts are now partially convinced that the 20.009-MHz frequency was chosen not out of respect for the ITU, but as a convenience since Peking monitors the Soviet Cosmos series on 19.995 and 20.005 MHz.

BROADCAST BAND

Mexican Stereo—Where there's a will, there's a way; and since AM broadcast-band listeners want stereo they can get it from XETRA, Tijuana, Mexico. Stereo enthusiasts are advised to get a second AM receiver and tune one receiver to the lower sideband of the 690-kHz AM signal and the other receiver to the upper sideband. Reports from southern California about the quality and stereo effects are mixed, but at least it's there for the tuning. (Submitted by Larry Sharp)

CITIZENS RADIO (CB)

Unique Noise Silencer—*Introduction of the "Noise Eliminator" Model CE-0-05 by Omega-t Systems Inc., opens exciting new possibilities in mobile operation. Intended to supplement the built-in CB transceiver noise limiter, the Omega-t solid-state (18 transistors, 1 IC and 11 diodes) device enables 100% copy of weak signals even in the midst of a traffic jam. Besides eliminating noise, the unit also acts as an r-f preselector. Basic operation (patent pending) is to take incoming signal and compare it with noise on a nearby frequency. It then makes pulses from the noise bursts and, when pulses exceed a preset level (adjustable by operator), shifts the received frequency, which effectively switches off the preselector and quiets the transceiver. Only three connections are necessary to use the unit: antenna in, antenna out, and 12-volt dc power.*

SHORTWAVE LISTENING

They Can't Do That To Us—Canadian shortwave listeners, police and fire signal buffs, feel that their Department of Communications has "flipped." In an apparent, but ill-advised, effort to stop unrestricted listening to police radio signals, the DOC has issued a new ruling that requires an SWL to have a "Private Commercial Receiving" license in order to listen to anything above 138 MHz. And, to add insult to injury, the SWL must also have permission from the stations he wants to hear in order to be granted the special license. According to reports in the Canadian magazine *Electron*, Department of Communications inspectors are not paying a great deal of attention to this new rule.

RESEARCH

Death of a Radar Echo—Try, try again, scientists are working on a "different" approach to the absorption of UHF radar signals. Laboratory tests indicate that a ballistic missile with recessed resonant antennas beneath an aerodynamically true—but transparent skin—will absorb UHF energy. If enough is absorbed, the echo return can be weakened to a point where detection at great distances is impossible. Stumbling blocks to implementing this idea concern not only mechanics of preparing missile skin, but determining Sino-Soviet radar frequencies.
(*Continued on page* 116)

STEREO SCENE

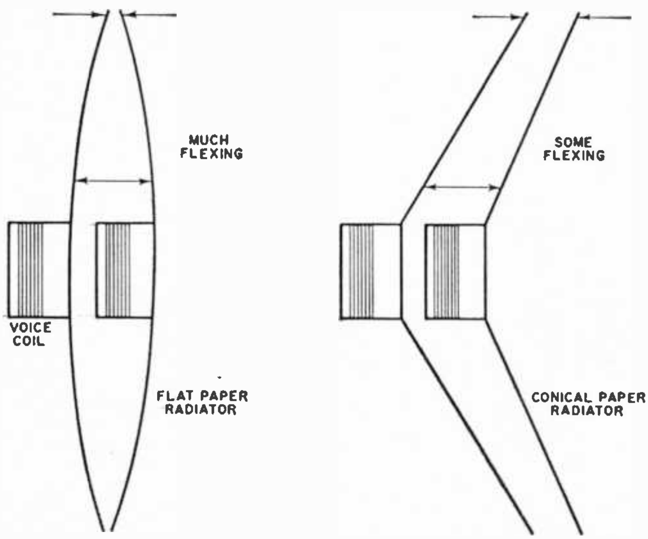
Second in a Monthly Series by J. Gordon Holt

THERE IS SOMETHING about loudspeakers that brings out the "kook" in people. Rational human beings, who would never think of designing their own amplifier or phono pickup, somehow get the idea that they have found *The Answer* to the loudspeaker problem; and the less they know about what they're doing, the more convinced they are that they are on the right track.

Perhaps this is because loudspeakers are less amenable to "instant objective analysis" than other audio components, and have gained a reputation for being arcane, occult devices, the science of which is more of an art than a science. It is only a short step from the observation that "measurements don't tell the whole story" to the conclusion that "the sound is what counts." Thus, an ardent home experimenter, blissfully ignorant of the pertinent laws of physics but with strong convictions about how things should sound, hits upon an earth-shaking idea that is so simple, so beautifully basic, that it is a wonder nobody ever thought of it before.

Produce and Reproduce. The conviction that the method by which music is produced must perforce be the correct way to reproduce music has resulted in some of the worst-sounding and oddest-looking speakers that have ever been made. One such design, that "worked like a pipe organ," used a dozen or so tubes of different lengths, bundled around one another and coupled at one end to a small loudspeaker. The inventor claimed that the loudspeaker would excite the "pipes" into resonance, just like a "majestic cathedral pipe organ." Predictably, it resonated horribly at a dozen or so different frequencies.

Not all speaker-cum-musical-instrument designers are unsophisticated hobbyists, though. The inventor of one speaker-that-worked-like-a-violin was a respected audio engineer whose idea also went awry. This device, called the Bi-Phonic Coupler, used as its radiating surface a wooden panel of "specially selected woods," to produce the "warmth and richness of a fine violin." Like almost all designs that reproduce music "the way music is produced," it added its own



A flat surface, with minimal rigidity, moves a relatively large amount in reproducing necessary sound. The stiffness of the radiator is increased significantly, without affecting the mass when surface is shaped into cone.

sonic characteristics to every sound it reproduced, including the sound of a violin.

Fortunately for us listeners, most loudspeaker designers know what they're doing. Some have access to computers that can draw a frequency response curve from a given set of design parameters. But not even the best technology can avoid occasional goofs. In fact, the only way to ensure perpetual success in loudspeaker design is to play it safe. Build a nice, conventional paper-cone speaker and try, if you can, to forget about the mathematical analyses.

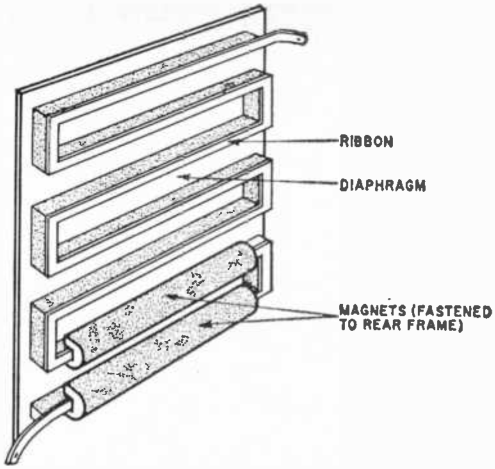
The paper-cone speaker has been the "standard" design for over 50 years, and nobody can deny that today's versions are a whale of a lot better than they were in 1920. On the other hand, nobody can deny that paper leaves much to be desired as speaker cone material.

If a loudspeaker diaphragm or cone is to reproduce a wide range of frequencies, it must embody two properties that happen to be mutually antagonistic: Large size and light weight. To reproduce bass, it must move a considerable volume of air in order to create the necessary long-wavelength air disturbances. You can do this by using a smallish radiating surface and driving the daylights out of it, or you can use a very large radiating area and just barely tickle it; but however you do it, you must move the *entire* radiating surface in order to move enough air. Since the diaphragm is pushing air, its whole surface encounters some resistance to motion, and because the driving element (usually a voice coil) is generally much smaller than the total diaphragm area, the diaphragm must be very rigid if the driven area is to carry the whole surface back and forth with it. And, almost inevitably, adequate rigidity usually means heavy weight.

On the other hand, high-frequency reproduction and the concomitant ability to start and stop rapidly on demand require that the diaphragm be free from inertia. And there, in a nutshell, is the Loudspeaker Problem.

Material's the Thing. A flat surface has minimal rigidity. Forming the flat surface into a conical shape increases the stiffness significantly without affecting the mass; but beyond that, the crucial factor becomes the material that is used. Certain kinds of paper can provide a good compromise between mass and stiffness, and can also have good internal damping characteristics to minimize resonances. But paper is always a compromise.

Experimental speaker diaphragms have been made from almost every conceivable material that looked as if it might have the right mass/stiffness ratio. Soft materials have excellent self-damping properties, but lack the necessary stiffness. Hard materials like metals have excellent stiffness properties but little internal damping, so they tend to resonate so characteristically that it is often possible to tell from their sound the material used to make the diaphragm.

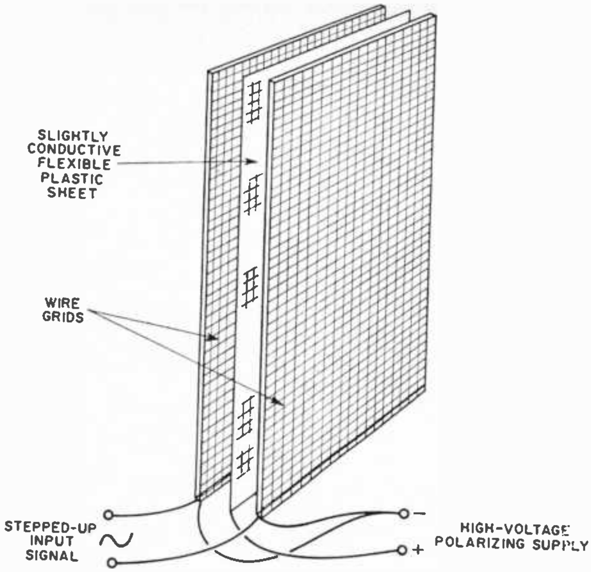


The Ge-Go "Orthophase" speaker had a long folded ribbon fastened to rear of flat diaphragm with a grooved magnet assembly interleaved with ribbon.

There *were* a couple of successful non-paper designs. The IMF speaker, with a solid foam-plastic "plug" instead of a thin cone, and the Leak "sandwich" speaker, with two metal skins and a cone of polystyrene sandwiched between two layers of damping material, sounded so much like good paper-cone speakers that they prompted some people to wonder if the Speaker Problem was not so much the paper as the cone itself.

One interesting non-cone design was the Kelly ribbon tweeter, an English product that was essentially a somewhat oversized version of a ribbon microphone, and functioned in exactly the same manner, only in reverse. Still in production (like the Leak sandwich), and popular among English hobbyists, the Kelly tweeter yields exceedingly smooth, extended highs but has limited power-handling ability. An intense cymbal crash or a transient burst of system oscillation, and the ribbon can disappear in a flash.

Unlike previous designs, the ribbon transducing element in the Kelly tweeter is also its radiating surface, and this surface is driven by the magnet assembly, so stiffness is not a consideration, even had the design been intended for low-frequency reproduction. The idea of a uniformly driven transducer element offers a promising way of driving a very large radiating area without demanding too much of it in the way of rigidity.



In push-pull electrostatic speaker, the flexible plastic sheet is either attracted or repelled by the opposing charges on the wire grids. Design must be large for good bass reproduction, but it makes good tweeter.

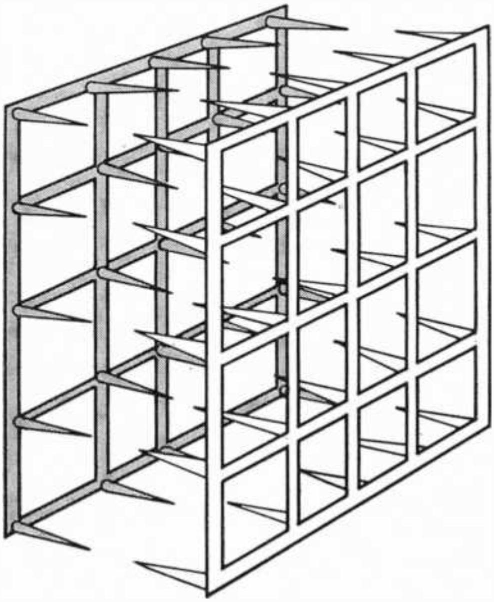
In the French Ge-Go "Orthophase" speaker, a long, folded ribbon was fastened to the rear surface of a flat foam-plastic diaphragm, and the ribbon interleaved with a grooved magnet assembly. The principle was the same as the Kelly: a ribbon microphone in reverse, but this one could move plenty of air. It sounded very good, but was costly to manufacture and, in order to yield deep bass, it had to be larger and costlier than most people were prepared to accept for something that still didn't sound remarkably better than a good paper-cone speaker system.

Meanwhile, some other designers had given up on the magnetic transducer and were investigating some entirely new actuating forces for speakers. One promising idea that was first brought to commercial refinement by England's Peter Walker was to utilize the same force that causes a lady's Nylon underwear to cling tenaciously to anything it touches in dry weather—electrostatic force.

As its name implies, static electricity is a concentration of electrons that aren't going anywhere (usually because they are on a nonconducting surface). Although they aren't moving, their negative charge exerts an attraction on any nearby object that has less of a concentration of electrons; and this attraction tends to draw the two objects together. If both objects have their respective charges spread evenly over their surfaces, the force of attraction will be uniform over their entire surface areas, and if, by design, one object happens to be a flexible plastic sheet and the other a stationary grid of wires, the sheet will move toward the grid like the theoretically perfect loudspeaker diaphragm.

The nice thing about this arrangement is that, since the moving surface is uniformly driven, it needs virtually no stiffness, which in turn means practically no resonances. And with stiffness out of the picture, the diaphragm can be extremely thin, for maximum transient response.

The electrostatic speaker was one of the



Corona-wind speaker has high-voltage charge on two elements to move air molecules between them.

non-paper designs that did sound markedly better than the cone type of speaker. The design is rather less costly than the Ge-Go to manufacture, but it still must be physically very large in order to reproduce deep bass. It makes an ideal tweeter, though.

Air is a Possibility. If an extremely lightweight diaphragm could reproduce sound so well, it seems reasonable to assume that no diaphragm at all would be better still. But without a diaphragm, how do we move air? Easy, use the air itself!

Some years ago, there were rumors of a fabulous loudspeaker design that could, literally, reproduce from dc (0 Hz) to the middle of the AM radio broadcast band. It was called the corona-wind loudspeaker, and it used the attraction between charged air molecules to draw the air back and forth through a grid-like contraption that resembled two bed springs with Yogi-style spikes between them. When a high-voltage charge was placed across the spikes, air molecules between them would become ionized and would be drawn toward one or the other set of spikes, depending on the polarity at the moment. With dc applied, there would be a steady flow of air, and with no inertial elements involved (theoretically, anyway), there should be no limit to the speaker's upper-range response.

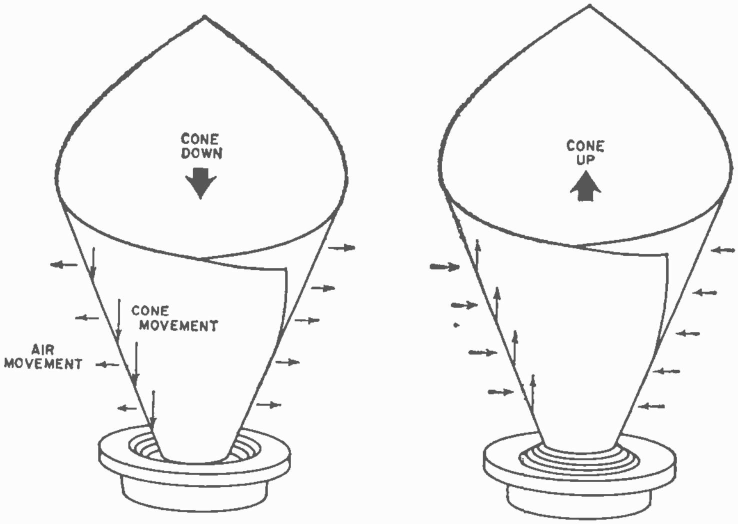
Some people who heard a prototype of the corona-wind speaker reported that it showed "promise," but wouldn't commit themselves further. Evidently, the promise was never kept, for it never got into production. Maybe the cost would have been prohibitive—like other flat-panel systems, the speaker would have had to be very large in order to plumb the lower-bass regions.

One air-pushing speaker that did get into production, though, is the so-called blue-glow tweeter developed by the French Audax company and first manufactured in the U.S. under the name Ionovac. This produces sound in the same manner as a lightning bolt—through intense heating, and consequent expansion, of the air. A high-voltage supply creates a continuous disc-shaped spark between two concentric electrodes. Audio impulses are stepped up and fed to the same electrodes, where they tend to cancel or reinforce the supply voltage, thus varying the intensity of the spark and hence the amount of heat it generates. As the spark is only about ⅛ inch in diameter, and paper-thin, it can't move much air on its own, but with the assistance of a small horn in front of it, it functions rather efficiently as a tweeter, with a virtually unlimited high-end range and unusual freedom from peaks.

The Ionovac was subsequently made by DuKane Corporation and, more recently, by Electro-Voice, and is still popular with perfectionists as a range-extending tweeter, although its tendency to wear down electrodes and generate distressing amounts of ozone has discouraged its widespread use.

Before stereo, a home hi-fi loudspeaker's beaming tendencies were mainly of academic interest to designers. If the highs collapsed off-axis, so what? The speaker just sounded a bit mellower. But along came the second channel, and suddenly speaker directionality was an important consideration. On-axis beaming causes poor center fill and limits the area in the room from which the listener can hear good stereo. The byword was 30-degree sound, and there were some interesting variations on that theme, too.

(*Continued on page* 112)



One of first omnidirectional speakers was the Hegeman lily cone tweeter aimed up at top of an open column cabinet with woofer in the bottom. The fragility of the cone was its downfall.

OPPORTUNITY AWARENESS

Thoughtful Reflections On Your Future

Seventh in a Monthly Series by David L. Heiserman

Those "Mysterious" Out-of-Town Jobs

One story after another in the periodicals tells of the shortage of electronics technicians and how employers are screaming for help. I've completed an electronics technology course, graduating with high scores, and have a commercial FCC license. But, where are the guys who wrote those articles? Where are the jobs? They are not in my area and the only places I know that have any openings are New York and Los Angeles—the last two places I'm interested in living.

● Statistics from the U.S. Department of Labor show that there is an ever-increasing shortage of trained electronics technicians. Possibly, some of the articles that you have read misinterpret these statistics and ignore the hard realities that not every single electronics manufacturer in the nation is suffering from a shortage of help all the time. There are even whole areas of the United States that have shortages one or two months a year, and a surplus of technicians the remainder.

Your situation is aggravated by the fact that you live in a town with a population under 4000 people and in the state of Idaho, which is not particularly well-known for its electronics industry. I feel that anyone taking a home study course in electronics, or a recent home study graduate in electronics technology should face up to the fact that there are plenty of towns that have absolutely no need for electronics technicians.

It may be hindsight, but anyone enrolling in a home study program should always make sure that the school has a good job placement program for its graduates. The school should also provide some sort of free resume writing service. There should also be school counsellors to help graduates prepare resumes and to be able to direct those graduates to cities where employment opportunities exist at the moment of graduation. Without the help of a school placement service, you are on your own. Since, apparently, your school did not have a job placement service, it would be well to examine the three industries that are interested in electronics technicians. These are detailed in the Table.

Kind of Industry	Kind of Business	Technicians' Jobs
Manufacturing	Aerospace Communications Computers Instrumentation Components	Assembly lead man Quality control inspector Test Research and development Repair Customer representative
Communications	Commercial broadcasting Private companies using radio equipment Government agencies using radio equipment Radio and TV Repair	Radio engineer or monitor Maintenance and troubleshooting
Research and Development	Universities Private research foundations Government research facilities	Electronic research technician Instrument maintenance and repair

From this table, make a tentative decision as to the type of a job you would like. Don't be too narrow in your selection and always bear in mind that manufacturers are looking for men with experience and you may find it necessary to lower your sights in order to gain that necessary experience for a better paying job.

Employers are not standing in dark doorways grabbing up every electronics technician that passes by. It is, however, true that some employers and manufacturers are "screaming for more help." The trick is to find those employers. There are about eight major areas in the country always looking for good electronics technicians—excluding New York City and Los Angeles. These areas are Boston, Denver, St. Louis, Baltimore/Washington, Chicago, and Houston/Dallas/Fort Worth.

If you have the opportunity to visit any of these cities, your problem is practically solved. If not, try to obtain a complete edition of one of the major Sunday newspapers containing all of the classified employment advertisements. You will invariably find at least several dozen job openings in any of the cities mentioned above.

If you can't find the Sunday newspaper, try your local library and see if they by any chance have a few of the major city telephone directories—particularly the so-called "Yellow Pages." Select some promising looking companies and send a resume to those companies. Don't hesitate to saturate a particular area.

If you don't like the idea of moving into one of the above areas, there are still several tricks left. Find a smaller town that is the site of a major state university. Not all of the large state universities are in major cities. The University of Illinois, for example, has a lot of government-sponsored research work and is in the town of Champaign—with only a population of about 50,000. Such colleges nearly always have openings for electronics technicians interested in working in various scientific projects.

For a complete listing of colleges and universities, consult the "World Almanac." And, for a listing of land grant colleges, write to the National Association of State Universities and Land Grant Colleges. Ask for their free "Fact Book." The address is: 1785 Massachusetts Ave., NW, Washington, DC 20036.

The last suggestion I can make is to attempt to find work through a competent and reputable employment agency. There is only one nation-wide employment agency that will handle clients not living in the major cities. This agency has about 400 offices and I would suggest that you write directly to the attention of: Mr. Howard Benner, International Headquarters, Snelling & Snelling, 2 Industrial Boulevard, Paoli, Pennsylvania 19301.

Job Opportunities in Australia

I have been told that the Australian Government pays the traveling costs for immigrants from the United States. Is this true? If so, what are the chances of my getting a job there in electronics? I have worked as an electronics technician for three years, and I have a diploma from a reputable home study school.

● According to Mr. K. E. Scott of the Australian Embassy in New York City, the Australian Government welcomes immigrant settlers from the United States and Europe. The Government pays about $375 (U.S. dollars) towards the fare for adults, and approximately $400 for every child under 19 years of age. This so-called "passage subsidy" is paid *after* you arrive in Australia.

To learn something about up-to-the-minute employment opportunities for electronics technicians, we consulted Mr. P. H. Cook, Secretary of the Australian Department of Labour and National Services in Melbourne.

"The unemployment rate is only a little more than one per cent of the total workforce in Australia," Secretary Cook says. "In the professional, semi-professional, and skilled electrical fields (which includes electronics) the number of unfilled vacancies exceeds the number of job seekers."

Speaking of the places where electronics technicians and engineers work, the Secretary says, "In the more heavily populated eastern States of Australia there is a strong demand for experienced electronics engineers and technical personnel. In these States, the large firms, located mainly in Melbourne and Sydney, are engaged in the production of a variety of telecommunications equipment, instrumentation and control systems, electronic componentry and radio and television receivers."

The chances of an American immigrant getting a job with the Australian Government Departments are slim, ". . . because of the requirements that applicants for such employment be British subjects."

"Employment opportunities in the other States of Australia occur less frequently, with occasional vacancies arising for specialists in communications or control systems work, and there are good prospects for instrumentation engineers in those States in which major processing plants are located.

The commercial TV field is well-established and growing. Color TV is still a novelty, but the predicted popularity of color TV will open new positions for hundreds of skilled technicians and engineers.

(*Continued on page* 114)

SOLID STATE

One Hundred Seventy-Third in a Monthly Series by Lou Garner

AMONG the predictions for 1970 in our January column, we anticipated the development of a new solid-state memory system suitable either for a computer or, possibly, an "electronic" camera. Although, quite frankly, we considered this prophecy a little on the wild side, we can now thank Bell Telephone Laboratories (Murray Hill, N.J.) for turning our prediction into a reality.

At Bell Labs, Drs. Allen Meitzler, Juan Maldonado, and David Fraser have been working with solid-state devices which can store picture images until electronically erased or changed. Imagine a reusable 35-mm slide on which an operator can electronically erase all or part of the image, add new material, and then project the new image on a standard screen.

Called "ferpics" (for ferroelectric picture) the new devices are based on the electro-optic properties of fine-grained lead zirconate-lead titanate, a ferroelectric ceramic material first announced by the Sandia Corporation.

In its basic form, the ferpic is a sandwich structure consisting of transparent electrodes, a photoconductive film and a thin plate of ferroelectric ceramic. This basic sandwich is bonded to a transparent substrate which is then flexed so as to stretch or "strain" the material. Using this "strain-biasing" technique, Bell Labs scientists were successful in changing the stored information in the basic structure.

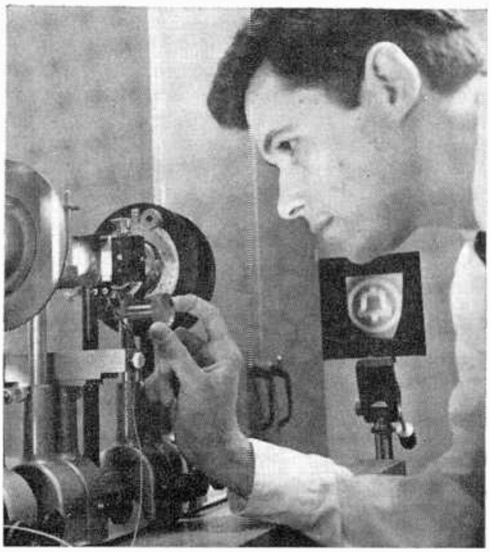
On a conventional photographic slide, the image is stored as variations in the transparency of the film. In a ferpic, on the other hand, the image is stored as a variation of the *birefringence* of the ceramic plate—that is, as a variation in the way the plate transmits polarized light.

In one mode of operation, a scanned laser beam records an image on the photoconductive film, one picture element at a time, much as a TV image is formed. A voltage applied to the transparent electrodes develops a field across the ceramic. When the field is removed, the image remains stored on the ceramic plate. The resulting image can be viewed directly by putting light polarizing sheets over it or, if prefered, the image can be projected onto a conventional screen using polarized light.

To erase the image, the entire structure is flooded with light in the presence of a reversed electric field. Afterwards, the plate is ready to store another image.

At the present stage of development, Bell Lab scientists have demonstrated that ferpic devices can store and display, with good resolution, black-and-white images that have a relatively long lifetime before fading. Present ferpics are suitable for the display of written text or figures, since such applications, although exploiting the unique image storage capabilities of the device, do not place severe demands on the speed or lifetime of the ceramic material.

Further experiments are being carried out in the hope of obtaining efficient, low-cost



Bell Laboratories' Juan Maldonado adjusts focus of image from ferpic device on small viewing screen.

Same negative made original print at top and one from the ferpic storage device (directly above).

solid-state information displays with features that are difficult to obtain in present display systems. Since the stored image can be projected, very large displays may be obtained. In addition, ferpic slides can retain images for a long time without electrical power, in contrast to other electro-optical memory systems.

Still considered laboratory devices, ferpics probably will not be available in commercial versions until at least mid or late 1971. But serious experimenters can look forward—one day—to the prospects of working with another new and exciting solid-state device.

Reader's Circuit. Sometime author and regular reader Luis Vicens (Box 1546, Wheaton, Md. 20902) writes that the new low-cost light-emitting diodes now being offered by Motorola, Hewlett Packard, and Monsanto can be used in a variety of interesting applications other than as simple replacements for conventional pilot lamp bulbs. He submitted the three basic experimental circuits illustrated in Fig. 1 as examples of how these intriguing little units can be used with other active semiconductor devices. All three circuits are suitable for breadboard tests, science fair demonstrations, or as sub-systems in complex equipment designs.

Useful in a visual metronome or as an attention-getting indicator for intrusion or process alarm systems, the blinker circuit

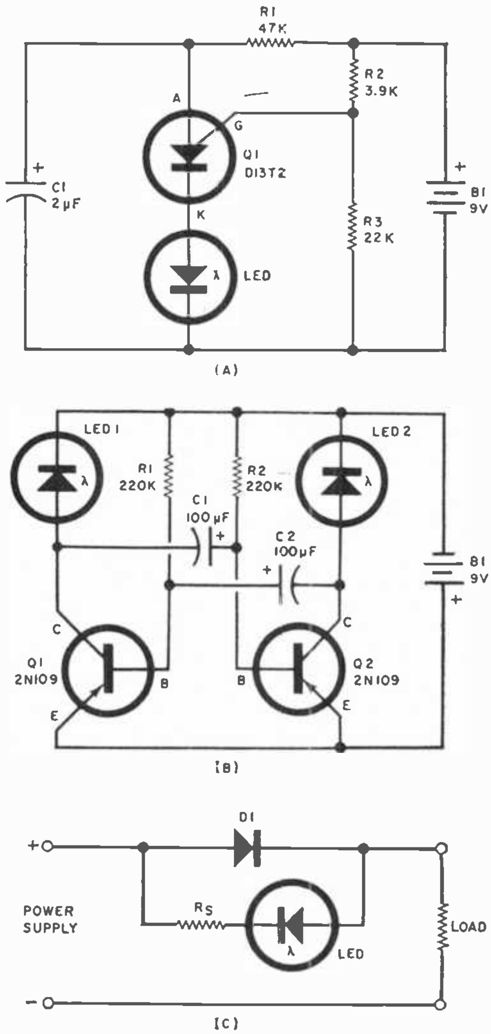


Fig. 1. Circuit (A) is relaxation oscillator blinker, (B) is dual blinker, and (C) is polarity reversal alarm, all using unusual light-emitting diodes.

shown in Fig. 1A teams an LED with a programmable unijunction transistor (PUT), *Q1*, in a simple relaxation oscillator. In operation, *C1* is charged by *B1* through *R1* until *Q1*'s breakdown (or "firing") voltage is reached, as determined by voltage divider *R2-R3*, at which time *Q1* switches to a conducting state, discharging *C1* through the LED and activating this device. The entire cycle is then repeated at a rate determined by the supply voltage, *R2-R3*'s ration and *R1-C1*'s time constant. The LED may be either a Motorola type MLED600 or Monsanto type MV50, and with the component values shown, the repetition rate is approximately 100 flashes/minute and the current drain about 0.5 mA. The flashing rate can be reduced by using a larger valued capacitor in place of *C1* and vice versa.

The alternating dual-blinker circuit given in Fig. 1B may be used alone as a simple demonstration or can be incorporated into such projects as electronic toys, games, and advertising displays. Transistors *Q1* and *Q2* are used as a conventional collector-coupled multivibrator, with their resistive collector loads replaced by LEDs. As in any multivibrator, the circuit's repetition (flashing) rate is determined by its R-C time constants.

Referring to the diagram, the LEDs are Motorola type MLED600 or Monsanto type MV50, with transistors *Q1* and *Q2* general purpose pnp types similar to RCA type 2N109.

In operation, the two LED's flash alternately about once per second with the specified component values. The flashing rate can be increased by using lower values for *C1* and *C2*, decreased by using larger valued capacitors. Assuming a symmetrical circuit (matched components), the LED's will flash alternately for equal intervals. If the planned application requires unequal flashing periods, different value coupling capacitors (*C1*, *C2*) may be used. Typically, with *C1* larger than *C2*, *LED1* remains lit for a longer period than *LED2*.

A combination dc polarity reversal alarm and protective circuit is shown in Fig. 1C. Suitable for use with mobile transmitters, receivers, p.a. systems and test instruments, the circuit will protect the equipment against catastrophic damage if the power source's dc polarity is reversed and, at the same time, will flash a warning signal for the operator. The circuit may be built in as an integral part of a new design or assembled as an outboard accessory for existing equipment.

In operation, rectifier diode *D1* is forward-biased when correct dc polarity is applied and, therefore, does not interfere with equipment performance. The LED is reverse-biased, but at a very low voltage (i.e. *D1*'s IR drop), and thus remains dark. If the supply voltage polarity is reversed, whether accidentally during hook-up or as a result of external equipment failure, *D1* is reverse-biased and, acting as a high resistance, prevents equipment damage. The LED, on the hand, is then forward-biased and activated, thus signalling the operator that there is a problem.

As in previous circuits, the LED is an MLED600 or MV50. Protection diode *D1* can be any silicon rectifier capable of handling the equipment's load current and with a PIV rating at least twice the supply voltage. Resistor Rs is a half-watt or one-watt resistor, with its value determined by Ohm's law to limit the LED's voltage and current within the device's maximum ratings. Simply subtract the LED's maximum forward voltage from the source voltage and divide by the average operating current. With a 9-volt source, for example, a 200- to 240-ohm resistor may be used.

"TA-TA!" In the past, we've occasionally featured experimental circuits using RCA devices with a "TA" prefix in their type number. An example is the TA5371B IC featured in our June 1970 "Manufacturer's Circuit." The TA designation is used by RCA to identify development devices—those in pilot, but not yet full, production or those not yet assigned a commercial, JEDEC, or EIA type number. TA type devices are *not* stocked by distributors but, as a general rule, can be obtained on special order through franchised RCA semiconductor dealers or direct from the factory.

Often, due to publishing deadlines, a standard stock type number will be assigned by RCA before a device reference appears in print but too late for a change to be made in final copy. The TA5371B IC featured in our June column, for instance, is now available as a stock RCA device and is designated CA-3062.

If you need a TA device for a special project, first check to see if it is available under a commercial stock number; if not, then the device can be obtained *only* on special order. A phone call to your local RCA component representative (check the Yellow Pages) or a letter to the factory will give you the information needed.

Manufacturer's Circuit. Although widely used and extremely popular for burglar alarm applications, the standard light-operated relay can be defeated quite easily by a clever thief. All that he needs is a flashlight to intercept the light beam and he can walk by as if on his way to a picnic. Using an invisible (infrared) beam helps some, but even this will not deter a determined and skilled intruder. One good solution to this problem is suggested by Motorola engineer John Bliss in his technical *Applications of Phototransistors in Electro-optic Systems*. John recommends the use of a modulated light beam coupled to a frequency-sensitive detector/amplifier. His complete paper, which includes a wealth of other information, is published by Motorola Semiconductor Products, Inc. (Box 20912, Phoenix, AZ 85036) as their Application Note No. AN-508. John's frequency-sensitive detector/amplifier circuit is illustrated in Fig. 2.

The modulated light beam is detected by phototransistor *Q1*, with the resulting signal applied through common-base amplifier *Q2* to FET preamplifier *Q3*. The preamp's output signal is developed across a potentiometer which serves as the system's sensitivity control. From here, the signal is capacitance coupled to two cascaded band-pass IC amplifiers. A pair of parallel-T feedback networks establish frequency selectivity. The amplifier's output is coupled to a diode detector and applied as base bias to Darlington amplifier *Q4* which, operating in a saturated state, effectively shorts out the SCR's gate bias.

In operation, any interruption in the modulated light beam will result in a loss of *Q4*'s base bias, shifting this device away from its saturated state and permitting a gate bias to be applied to the SCR. Triggered into operation, the SCR switches power to an alarm device, such as a bell, buzzer, siren, or floodlight. Once the alarm is actuated, it remains on even if the light beam is restored, until the system is reset by momentarily shorting the SCR by a spst anode-cathode switch.

The modulated light beam needed for system operation can be obtained by pulsing a LED, neon bulb, or low-power incandescent lamp. Such sources are adequate for short distances. If the installation requires a strong light beam for a long "throw," however, a pulsed laser or a high-intensity incandescent lamp modulated by a motor-driven rotary "chopper" can serve as the light source.

In practical installations, the frequencies of the two bridge-T networks are calculated by conventional techniques, making sure that they correspond to the frequency of the light-beam transistor. Lenses would be used at both the light source and detector, with infrared filters provided to obtain an invisible light beam. Naturally, accurate optical alignment of the system is essential for optimum performance.

Roll (Design) Your Own! Old-time cowboys used to pride themselves on their ability to "roll their own" cigarettes with one hand. If you use Siliconix FET's in your projects, you'll now be able to outdo the legendary cowpokes and "roll your own" circuit designs

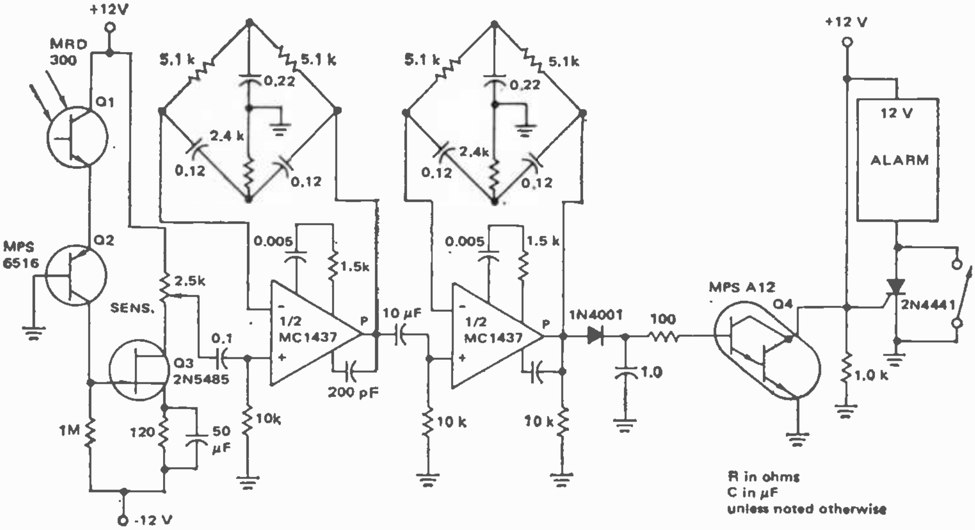
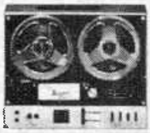
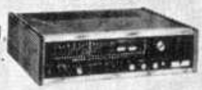


Fig. 2. Motorola-designed intrusion alarm amplifier/control circuit employs modulated light (source not shown) to foil burglars; Q1, sensitive to frequency-modulated light, is detector.

with no hands, slide rules, computers, or other calculation gadgets.

Impossible? Not really—and you don't have to be a mental giant. Recognizing that design engineers are human and, as most people, inclined to avoid heavy mental effort, Siliconix, Inc. (2201 Laurelwood Road, Santa Clara, CA 95024) is now including circuit design charts as part of their device data sheets. By using these new "full design" specification sheets, a hobbyist, experimenter, engineer or technician can develop circuit designs similar to the two-stage FET amplifier illustrated in Fig. 3 without tedious

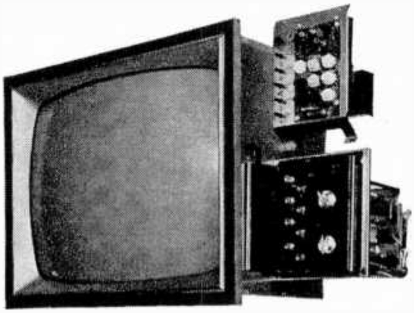




New Heathkit® Solid-State

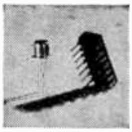
Design and performance features add up to one-of-a-kind superiority.

Over five years were spent in research and development to achieve the notably superior performance, improved convenience features, and ease of service now embodied in the new GR-270 and GR-370. They are premium quality receivers in the truest sense, and, we believe, the finest color TV's on today's market. Here's why...



Compare these features:

- Modular plug-in circuit board construction.
- MOSFET VHF tuner and 3-stage IF.
- Adjustable video peaking.
- Sound instantly, picture in seconds.
- Built-in Automatic Fine Tuning.
- Pushbutton channel advance.
- Tilt-out convergence and secondary controls.
- Hi-fi sound outputs — for amplifier.
- Virtually total self-service capability with built-in volt-ohm meter, dot generator, and comprehensive manual.
- Premium quality bonded-face etched glass picture tubes.
- Choice of 295" or 227" picture tube sizes.



Exclusive solid-state circuitry design...total of 45 transistors, 55 diodes, 2 silicon controlled rectifiers; 4 advanced Integrated Circuits containing another 46 transistors and 21 diodes; plus 2 tubes (picture and high voltage rectifier) combine to deliver performance and reliability unmatched by conventional tube sets.

Exclusive design solid-state VHF tuner uses an MOS Field Effect Transistor for greater sensitivity, lower noise, and lower cross-modulation ...gives you sharply superior color reception, especially under marginal conditions. Gold/Niborium contacts give better electrical connections and longer wear. Memory fine tuning, standard. Solid-state UHF tuner uses hot-carrier diode design for increased sensitivity.

3-stage solid-state IF has higher gain for better overall picture quality. Emitter-follower output prevents spurious signal radiation, and the entire factory-aligned assembly is completely shielded to prevent external interference.

Automatic Fine Tuning — standard on both sets. Just push a button and the assembled and aligned AFT module tunes in perfect picture and sound automatically...eliminates manual fine-tuning. Automatic between-channel defeat switch prevents tuner from locking in on stray signals between channels. AFT can be disabled for manual tuning.

VHF power tuning...scan through all VHF and one preselected UHF channel at the push of a button.

Built-in automatic degaussing keeps colors pure. Manual degaussing coil can be left plugged into the chassis and turned on from the front panel...especially useful for degaussing after the set is moved some distance.

Automatic chroma control eliminates color variations under different signal conditions.

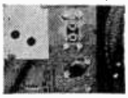
Adjustable noise limiting and gated AGC keeps pulse-type interference to a minimum, maintains signal strength at constant level.

High resolution circuitry improves picture clarity and new adjustable video peaking lets you select the degree of sharpness and apparent resolution you desire.

"Instant-On". A push of the power switch on the front panel brings your new solid-state set to life in seconds. Picture tube filaments are kept heated for instant operation, and extended tube life. "Instant-On" circuit can be defeated for normal on-off operation.

Premium quality color picture tubes. Both the 227 sq. in. GR-270 and 295 sq. in. GR-370 use the new brighter bonded-face, etched glass picture tubes for crisper, sharper, more natural color. And the new RCA HiLite Matrix tube is a low cost option for the GR-370. See below.

Adjustable tone control lets you choose the sound you prefer ...from deep, rich bass to clean, pronounced highs.

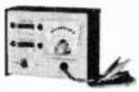


Hi-fi output permits playing the audio from the set through your stereo or hi-fi for truly lifelike reproduction. Another Heath exclusive.

Designed to be owner serviced. The new Heath solid-state color TV's are the only sets on the market that can be serviced by the owner. You actually can diagnose, trouble-shoot and maintain your own set.

Built-in dot generator and tilt-out convergence panel let you do the periodic dynamic convergence adjustments required of all color TV's for peak performance. Virtually eliminate technician service calls.

Snap-out glass epoxy circuit boards with transistor sockets add strength and durability and permit fast, easy troubleshooting and transistor replacement. Makes each circuit a module.



Built-in Volt-Ohm Meter and comprehensive manual let you check circuits for proper operation and make necessary adjustments. The manual guides you every step in using this built-in capability. Absolutely no knowledge of electronics is required.

Easy, enjoyable assembly...the Heathkit way. The seven-section manual breaks every assembly down into simple step-by-step instructions. With Heath's famous fold-out pictorials and simple, straightforward design of the sets themselves, anyone can successfully complete the assembly.

Heathkit Solid-State Modular Color TV represents a significant step into the future...with color receiver design and performance features unmatched by any commercially available set at any price! Compare the specifications. Then order yours today.

Kit GR-270, all parts including chassis, 227" picture tube, face mask, UHF & VHF tuners, AFT & 6x9" speaker, 114 lbs. **$489.95***

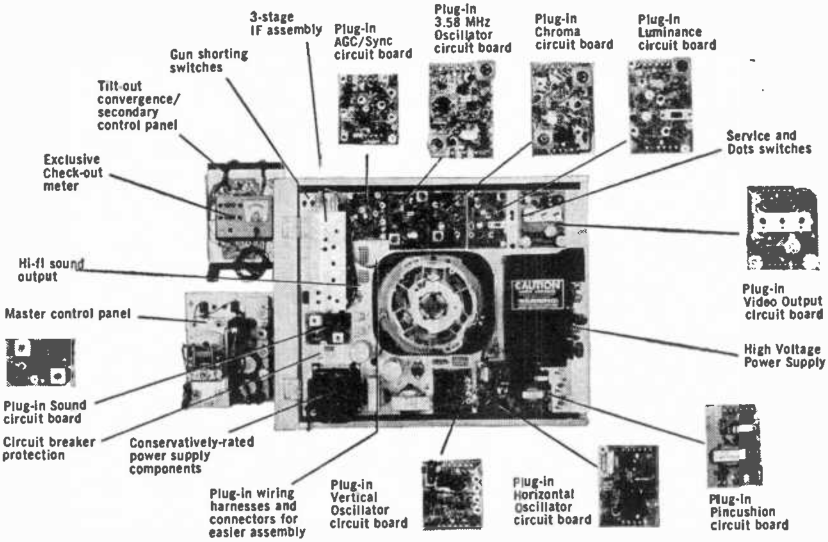
Kit GR-370, all parts including chassis, 295" picture tube, face mask, UHF & VHF tuners, AFT & 6x9" speaker, 127 lbs. **$559.95***

Kit GR-370MX, complete GR-370 with RCA matrix picture tube, 127 lbs. **$569.95***

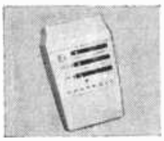
GR-270 AND GR-370 SPECIFICATIONS — PICTURE TUBE SIZE: GR-370 Approximate Viewing Area: 295 Sq. In. GR-270 Approximate Viewing Area: 227 Sq. In. **DEFLECTION:** Magnetic, 90 degrees. **FOCUS:** Electrostatic. **CONVERGENCE:** Magnetic. **ANTENNA INPUT IMPEDANCE:** VHF 300 ohm balanced or 75 ohm unbalanced. UHF: 300 ohm balanced. **TUNING RANGE:** VHF TV channels 2 through 13. UHF TV channels 14 through 83. **PICTURE IF CARRIER:** 45.75 MHz. **SOUND IF CARRIER:** 41.25 MHz. **COLOR IF SUBCARRIER:** 42.17 MHz. **SOUND IF FREQUENCY:** 4.5 MHz. **VIDEO IF BANDWIDTH:** 3.58 MHz. **HI-FI OUTPUT:** Output impedance — 1 k ohm. Frequency response — ±1 dB 30 Hz to 10 kHz. Harmonic distortion — less than 1% at 1 kHz. Output voltage — 0.3 V rms nominal. **AUDIO OUTPUT:** Output impedance — 4 ohm or 8 ohm. Output power — 2 watts. **POWER REQUIREMENTS:** 110 to 130 volts AC, 60 Hz, 240 watts. **NET WEIGHT:** GR-370, 114 lbs.; GR-270, 101 lbs.

Modular Color Television!

Exclusive Modular Design . . . Circuit Boards snap in and out in seconds for easy assembly, simple servicing



New Expedited 48-Hour No-Charge Warranty Service Plan for Solid-State TV Modules! Special service facilities have been established at the factory and all Heathkit Electronic Centers to expedite service and return of Solid-State TV circuit modules within two working days. During the 90-day warranty period, TV modules will be serviced or replaced with no charge for labor or parts. After the initial 90-day warranty period expires, TV modules will be serviced or replaced at a fixed charge of $5.00 per module for labor and parts for a period of two years from date of original kit purchase.

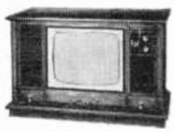


Add extra convenience and versatility to your new GR-270 or GR-370 Solid-State Color TV with this new ultrasonic remote control kit. Lets you turn the set on and off, adjust volume, change VHF channels and adjust color and tint from the comfort of your chair. Assembles and installs complete in just a few hours and the built-in meter on the receiver makes final adjustment a matter of minutes.
Kit GRA-70-6, 6 lbs. $64.95*

Choose One Of These Handsome, Factory Assembled Cabinets

3 models in 295 sq. in.

Luxurious Mediterranean Cabinet . . . factory assembled of fine furniture grade hardwoods and finished in a flawless Mediterranean pecan. Statuary bronze trim handle. 30-1/32" H x 47" W x 17¾" D. Assembled GRA-304-23, 85 lbs. $129.95*

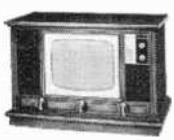


Deluxe Early American Cabinet . . . factory assembled of a special combination of hardwoods & veneers and finished in classic Salem Maple. 29-21/32" H x 37¼" W x 19¾" D. Assembled GRA-303-23, 67 lbs. $114.95*

Contemporary Walnut Cabinet . . . factory assembled of fine veneers & solids with an oil-rubbed walnut finish. 29-17/32" H x 35-13/16" W x 19⅞" D. Assembled GRA-301-23, 56 lbs. $74.95*

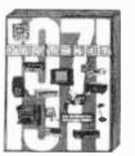
3 models in 227 sq. in.

Exciting Mediterranean Cabinet . . . assembled using fine furniture techniques and finished in stylish Mediterranean pecan. Accented with statuary bronze handle. 27-31/32" H x 41⅞" W x 19-9/16" D. Assembled GRA-202-20, 70 lbs. $114.95*



Contemporary Walnut Cabinet and Base Combination. Handsome walnut finished cabinet sits on a matching walnut base. Cabinet dimensions 20-31/32" H x 31-7/16" W x 18⅝" D. Base dimensions 7¾" H x 27¾" W x 18⅝" D. Assembled GRA-203-20 Cabinet, 45 lbs. $49.95* GRS-203-6 above cab. w/ matching base, 58 lbs. $59.95*

Handy Roll-Around Cart and Cabinet Combination. Features the GRA-203-20 walnut cabinet plus a walnut-trimmed wheeled cart with storage shelf. Assembled GRA-203-20 Cabinet, 45 lbs. .... $49.95* GRA-204-20 Roll-Around Cart, 18 lbs. ... $19.95* GRS-203-5, Cart & Cabinet Combo, 58 lbs. $59.95*



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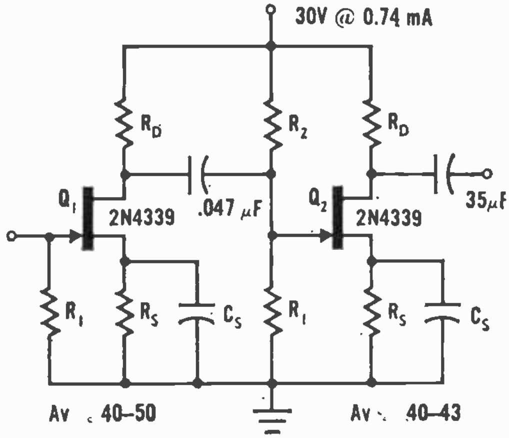
CIRCLE NO. 14 ON READER SERVICE PAGE

calculations. A portion of the design charts given for the 2N4338-41 series general purpose FET's is reproduced in the Table. This chart refers to the circuit given in Fig. 3. Note that supply voltages, current drains, component values, output voltages and even gain figures are specified.



	V_{DD}	R_S	R_1	R_2	C_S	I_{DD}	R_D	e_o max	A_v
Q1	30	1800	1M	∞	40μF	0.42mA	51k	4.5V	40-50
Q2	30	9100	1M	13M	35μF	0.32mA	43k	5.0V	40-43

Fig. 3. FET amplifier circuit was easily designed from information chart supplied with transistors.

Naturally, the Siliconix data sheets also include the customary information—maximum ratings, lead connections, electrical specifications, outline drawings, etc.

Brochures, Books & Other Tid-bits. Solid-state design is dominant in the B & K Professional Test Equipment described in Dynascan's latest catalog. Among the new semiconductor-operated instruments are a FET VOM, an RF signal generator, a sine square wave generator, a tube tester, and an improved television analyst with a solid-state sweep drive. The new 1970-71 2-color, 24-page catalog, EK-71, is available on request from the Dynascan Corporation, 1801 W. Belle Plaine Ave., Chicago, IL 60613.

Edited by your columnist, GC Electronics' new *Printed Circuit Handbook* provides step-by-step illustrated instructions for producing professional quality etched circuit boards at home or in the small industrial or school laboratory. Photographic as well as direct application techniques are covered. For your copy, contact your local parts distributor or, for information, write to GC Electronics, 400 South Wyman St., Rockford, IL 61101.

Fairchild Semiconductor is now offering an 88-page, pocket-size catalog describing its complete line of linear integrated circuits. Measuring 3½ by 6 inches, the booklet provides key information and pin diagrams for 31 linear IC products, including operational amplifiers, dual op amps, ac amplifiers, comparators, communication devices, preamps, differential amplifiers, stereo multiplex decoders, chroma demodulators, and other specialized devices. Among the new products covered are advanced IC's designed for memory interface, analog-to-digital interface, communications systems, and consumer applications. The catalog also includes a cross reference for linear applications and products, a listing of application literature available from the manufacturer, an illustrated section showing package outlines and dimensions, and a fold-out section containing an operational amplifier selection guide for both military and commercial grade products. Copies of the *Linear Integrated Circuit Condensed Catalog* can be obtained by writing to Distribution Services, Fairchild Semiconductor, Box 880A, Mountain View, CA 94040.

Responding to a suggestion made by yours truly, Monsanto has issued a valuable applications booklet covering its LED's and other opto-electronic devices. Identified as ESP 40, Vol. 1, and entitled *GaAsLite Tips*, this 48-page booklet costs 50¢. Among the projects and circuits described are a constant brightness light source, a modulated IR beam control system, silicon PIN photodiode applications, and monolithic seven segment displays. For information, write to Monsanto Electronic Special Products, 10131 Bubb Road, Cupertino, CA 95014.

The TRW Semiconductor Division (14520 Aviation Blvd., Lawndale, CA 90260) has issued a new 10-page brochure covering a series of hybrid power Darlingtons. Designated Applications Note No. 14, the paper is concerned with Class-B amplifiers, solenoid drivers, and switching or series regulators employing 10-ampere, 50-volt Darlington hybrid microcircuits in either dual or complementary configurations. —*Lou*

OUT OF TUNE

"Build a RIAA/NAB Preamplifier" (August 1970). In the schematic on page 62, the dot and notch for the IC are shown on the wrong end. The foil pattern is correct. And, with apologies to the author, his name is spelled Huffnagle.

"Build Dynamic Diode Tester" (July 1970). The value of *R1* in the Parts List on page 58 is incorrectly specified as 100 ohms. It should be 1000 ohms as shown in the schematic.

STEREO SCENE

(Continued from page 97)

Omnidirectionality. One of the first truly omnidirectional hi-fi speakers was the brainchild of Stu Hegeman, an audio inventor of enviable reputation. This system had an upturned woofer in a rectangular shaped enclosure (standing on end) with a "cage" of grille cloth at the top. Looking inside the cage, directly above the woofer, you could see a cute looking tweeter shaped like a lily and made from what appeared to be stiff paper. (The prototypes were actually handmade of ledger paper and the fine blue rules could be seen.) The bottom end of the lily was attached to a voice coil on the tweeter assembly. The lily design proved to be a very excellent high-frequency radiator and the early prototypes of this Hegeman design sounded superb, embodying a sense of depth and openness that put practically every other loudspeaker available at that time to shame. Hegeman sold the manufacturing rights of his system to Eico and it might have been a commercial success were it not for the fact that the speaker system was too fragile for interstate truck or rail shipment.

There were, and still are, other 360-degree speakers of varying quality, but one (happily discontinued) design probably established a record for disorganized thinking. Advertised as a "360-degree speaker," this little gem contained the usual upturned woofer, but instead of an omnidirectional tweeter, it had a small cone tweeter aimed horizontally that was rotated by a little electric motor like a lighthouse beacon! However, once per revolution, the rear of the tweeter was actually aimed at the listener and the woofer/tweeter phasing was reversed twice for each revolution, causing an in-out modulation that was quite upsetting to the listener. If this wasn't bad enough, the remainder of the system left the midrange fairly muddled and not one of the consumer hi-fi magazines did more than mention this system in a cursory fashion. The fact that the rotating tweeter went over like the proverbial lead balloon with the buying public is a tribute to their perspicacity.

On the other hand, the popular hi-fi press has had some nice things to say about the Bose 901 speaker system, the first of a new spate of "omnidirectional" designs. This system is based on the idea that what makes 360-degree speakers sound so spacious is the reflection of the rear radiated sound from the wall behind the system, rather than just the freedom from on-axis beaming.

The designer, Dr. Bose, is a professor of acoustics at M.I.T. and a very capable and knowledgeable audio enthusiast. He claims that much of the music reaching the listener in a concert hall consists of reflections arriving from the walls, which is of course true.

After an extended analysis of this effect, Dr. Bose concluded that a speaker system for the home should radiate about 89% of its sound from the rear of the enclosure for reflection from the surrounding walls. This expands the stereo stage and produces (in the home) a concert-hall type of listening environment.

Personally, I happen to be on the side of those who say that the speaker system should do no more than accurately reproduce full-fidelity sound. Whether you should attempt to create conditions in your home similar to a concert hall is to me quite debatable. Certainly there can be no disagreement that concert-hall reflections produce the ambience information creating the feeling that the original sounds were made in a very large "room." I feel that this ambience information should be reproduced "as is" in the home and that this should mean adding as little as possible of the listening room's "ambience" to the reproduced sound.

Those who have listened to a properly installed Bose 901 system cannot fail to be impressed by the startling sense of spaciousness it provides. The system works as claimed; however, unless it is very carefully installed, listeners begin to notice that almost every sound across the stereo stage seems to be stretched from left to right. Mono material is strung out between the speakers—a not unpleasant illusion for mono, but a contradiction and an ill omen for stereo reproduction.

You can achieve the spaciousness claimed for the Bose 901 through very careful placement of the speakers. The phase relationship between sounds emanating from the rear speakers, reflected off the walls and reinforced by the sound from the front-facing speakers appears to be quite critical.

Proper speaker placement of ordinary front-radiating systems is more critical than most listeners realize. The Bose 901 certainly expands the stereo stage, but it seems to be that, although the answer to achieving optimum stereo reproduction in the home may be closer at hand, it is still subject to critical elements that not every listener has the knowledge and provisions to overcome. —30—

INTERFACE

MORE "BUG-SHOO"

I constructed your July project by Lyman Greenlee and clipped it to my belt strap. Potentiometer *R3* was adjusted until I could no longer hear the squeal. Now, while sitting in an outdoor patio, I am the only person not getting eaten alive by mosquitoes.

M. WALDMAN
Philadelphia, Pa.

BETTER TV RECEPTION

George Monser's article on TV twinlead "transformers" gave far better results than anticipated. I live about 80 miles from channels 2, 4, and 5; and the improved matching between antenna and receiver cut down about 80% of the snow.

D. HASTING
Hemingway, S.C.

SUGGESTIONS

In line with your new editorial outlook, how about projects on a magnetometer, balanced induction metal locator, AM BCB direction finder, and full-fledged lie detector that records heart beats, etc?

J. WEGNER, JR.
Glendale, Calif.

OPPORTUNITY AWARENESS

(Continued from page 99)

Concerning other branches of modern electronics, the Secretary states, "There is also a demand for highly skilled men to install and maintain computer hardware, although Australian manufacture in this field is at present concerned mainly with software. The development of fully electronic telephone exchanges and the extension of Subscriber Trunk Dialing services throughout Australia have meant great expansion in the field of integrated circuitry. In addition, the Australian Government actively encourages the local manufacture of microelectronic devices to meet both defense requirements, and the needs of the Post Office and Civil Aviation."

OPPORTUNITIES IN AUSTRALIA

Immigration information (Eastern USA)
Australian Consulate General
636 Fifth Ave.
New York, N.Y. 10020

Immigration information (Western USA)
Australian Consulate General
1 Post St.
Crocker Plaza
San Francisco, CA 94104

Employment information
Dept. of Labour and National Service
P.O. Box 2817AA
Melbourne, Victoria 3001
Australia

Information concerning application for professional engineering status or higher education
Institution of Radio and Electronics Engineers
Science House
157 Gloucester St.
Sydney, Australia

Electronics and electrical engineers from the U.S. can apply for professional engineering status, and any technician or engineer can further his education in the excellent Australian schools. According to Secretary Cook, "Professional recognition as an engineer in Australia depends upon acceptability to the Institution of Engineers, Australia. Some employers stipulate that applicants for positions in the engineering field must have qualifications for graduate membership in the Institution."

Salaries for electronics technicians and engineers are from 3500 to 8000 U.S. dollars a year. Although these figures are low by American standards, the cost of living in Australia is somewhat lower, too. —30—

POPULAR ELECTRONICS READER SERVICE PAGE

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COMMUNICATIONS

(*Continued from page* 93)

SHORTWAVE LISTENING

Speech Scramblers—Next year we can celebrate the 70th anniversary of first attempts at electronic speech scrambling—Alexander Graham Bell tried it, but the results were unimpressive. Local and state police are increasingly concerned over the influx of VHF/UHF monitoring receivers and speech scrambling is being installed in an average of three police communications systems per month. The E. F. Johnson Co. has demonstrated a hand-held VHF transceiver with 6 possible modes of scrambling. It will sell for about $1000 per unit—not considered too high for the extra security. Scrambling can be speech inversion, band splitting, frequency modulation, analog, or time division. Band splitting was used during World War II for supposedly secure messages between Roosevelt and Churchill, but the Nazis managed to unscramble it.

CITIZENS RADIO (CB)

Canadians Get CB Reciprocity—In a sudden unexpected move, the FCC on July 24, granted CB reciprocal operating privileges to all Canadians coming into the U.S. with bona fide GRS licenses. CB'ers from the States have been able to operate in Canada for several years and a reciprocal arrangement had been advocated by numerous CB organizations. Canadians must request permission using FCC Form 410 (New Form 410-B after November 1) and should understand the FCC Part 95 CB Rules and Regulations. While in the States, Canadians use their "XM" callsigns followed by a geographical identification (city and state).

PRODUCT GALLERY

(*Continued from page* 86)

frequencies. A frequency response curve run on the cartridge alone (tracking at just under 3 grams) showed a response of ±1 dB from 40 Hz out to 20,000 Hz. The channel-to-channel separation was better than 20 dB below 12,000 Hz and was still 10 dB at 18,000 Hz.

Speaker response tests were made to confirm—through the tone burst method—that the system had excellent response at all frequencies. Hirsch-Houck Laboratory subjectively reported (and this reviewer subsequently confirmed) that the Landmark 100 has very solid and healthy-sounding bass in the 50-60 Hz region and that the audio output is smooth and free of peaking out beyond the limit of normal hearing (say, 15,000 Hz).

As compact stereo systems go, the Landmark 100 is certainly one of the more unusual designs and one of the better sounding systems that we have heard. Due to the lack of "on-axis" beaming from the small speakers that are usually supplied with compact systems, the Landmark 100 appears to give the listener the ideal mix between direct and reflected sounds and judging from the response below 300 Hz the "Servo-Linear" feedback system can really perform in almost any listening environment.

One thing that I do dislike about the Landmark 100 is the absence of FM interstation hiss suppression or squelch. Just why this has been eliminated is a mystery and I hope that the next manufacturing run has this additional minor circuit.

I apologize for not getting to the Avanti "Astro-Plane" CB antenna in this column. I sometimes think I write too much. —30—

LIBRARY

(*Continued from page* 16)

the text, and practical mathematical analyses are used to explain operation and design detail.

Published by TAB Books, Blue Ridge Summit, PA 17214. Hard cover. 352 pages. $14.95.

DICTIONARY OF ELECTRONICS AND NEUCLEONICS

by Hughes, Stephens & Brown

Since electronics and neucleonics are in many cases interrelated, a common dictionary of definitions is a useful reference book, indeed. In addition to the dictionary text of some 9000 definitions, this book contains a comprehensive list of abbreviations, acronyms, and symbols. The appendices provide fuller statements of some of the fundamental theories of the increasingly complex fields of atomic and nuclear physics, as well as numerous useful and relevant tables of data on a wide range of topics.

Published by Barnes & Noble, Inc., 105 Fifth Ave., New York, NY 10003. Hard cover. 443 pages. $14.50.

TECHNICAL CALCULUS

by H.R. Stillwell & D.H. Price

Written to meet the calculus requirements of students of engineering technology in technical institutes, junior colleges, etc, this book requires a working knowledge of trigonometry, college algebra, and logarithms. However, for the reader who may have been away from these subjects for some time, there is a brief review. The text material is elementary, with the subject matter grouped into basic categories, each of which is complete in itself. This is an excellent self-study textbook, but no answer key is provided for the review questions.

Published by Holt, Rinehart and Winston, Inc., 383 Madison Ave., New York, NY 10017. Soft cover. 251 pages. $3.95.

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by S.S. Haykin

This book presents, in a unified manner, the fundamentals of active network theory so that the student can understand fully the circuit properties of semiconductor devices and vacuum tubes and be able to deal effectively with circuit devices yet to come. Written at a level suitable for use by senior undergraduate and graduate electrical engineering students, physical explanation and meaningful examples have been included to elucidate the results obtained. Each chapter ends with a list of problems and references.

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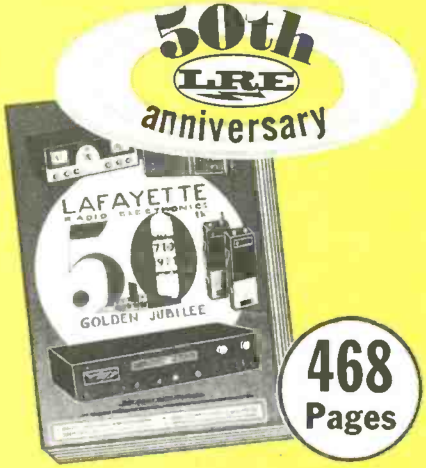

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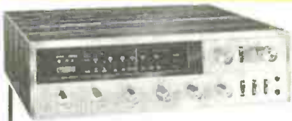

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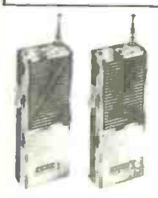

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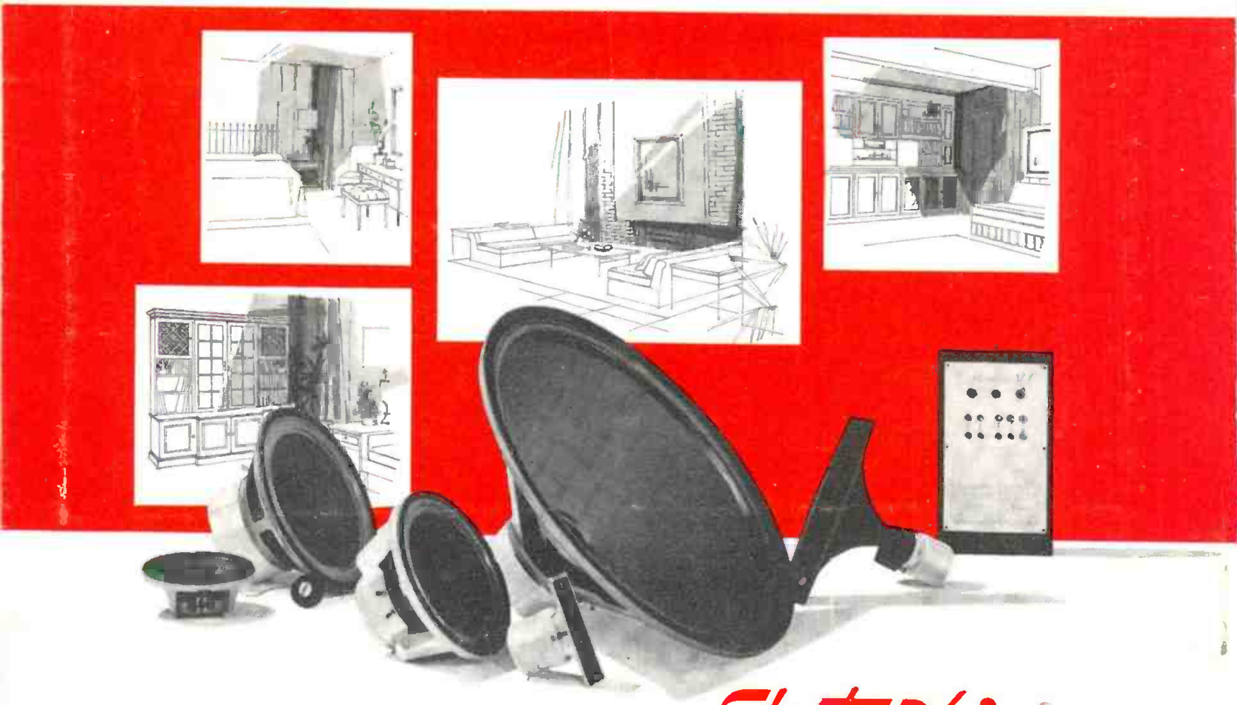

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