1971 POPULAR ELECTRONICS

ELECTRONIC EXPERIMENTER'S HANDBOOK

WINTER EDITION

$1.50

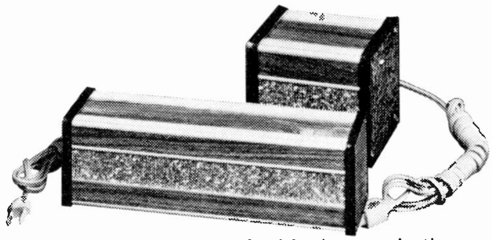
Detailed Assembly Plans

- STIMULATING COLOR ORGAN
- VERSATILE STEREO PREAMP
- HOT-ROD DWELL EXTENDER
- SIMPLIFIED RECEIVER
- HI-GAIN TV ANTENNA
- SWL FREQUENCY CHECK
- CAPACITANCE METER
- BATTERY CHARGER
- AUDIO GENERATOR
- DIGITAL CHECKOUT
- DANCING LIGHTS
- STUD/NAIL FINDER
- TRIAC TRANSFORMER

plus many others

THE "ORB"
Look Out! It's Alive!

Security takes many forms. Sometimes it's mink... sometimes it's an ultrasonic burglar detection system.



Burglary and vandalism are constant threats to your home, office or shop. With DeltAlert on the job, you have dependable and economical security.

A silent ultrasonic blanket guards 15′ to 30′ (150 to 300 square feet) of critical space in the home or business. Lights go on automatically driving away prowlers.

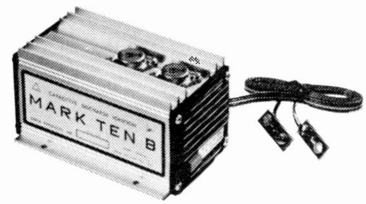
When teamed with the separate DeltaHorn, DeltAlert provides an added shock of loud ear-splitting noise... frightening off even the boldest intruder.

These sturdy units, finished in handsome walnut veneer, are maintenance free and require no expensive installation. The DeltAlert plugs right into a wall socket. The DeltaHorn plugs directly into the DeltAlert. Small, the DeltAlert is only 10⅜″w x 3¼″h x 3¼″d, and the DeltaHorn 3¼″w x 3¼″h x 3¼″d, the units blend right into your decor (and are difficult to detect).

Keep well covered with reliable DeltAlert detection and alarm protection, and order your security now.

DeltAlert Only **$69.95** ppd
DeltaHorn Only **$24.95** ppd

Security is also instant starts, dependable engine performance and fewer tune-ups. It's a CD System.



What did your last tune-up cost? More and more, tune-ups are reaching for $60 and up. Why not keep the dollars in your pocket by eliminating 2 out of 3 tune-ups? Delta's all new Mark Ten B is made especially for foreign cars and modern American engines suffering from smog control devices, rough idle and poor fuel mix. The system is completely sealed, with handy switch for instant conversion. Quick installation—no rewiring. The sooner you order, the sooner the Mark Ten B pays for itself. Mail the coupon today.

Mark Ten B Only **$59.95** ppd (12V neg. only)
Standard Mark Ten **$44.95**

"Delta Products, One of America's Finest Names In Electronics"

Please send me literature immediately: ☐
Enclosed is $ ____ ☐ Ship ppd. ☐ Ship C.O.D.
Please send:
_____ DeltAlert(s) @ $69.95 ppd
_____ DeltaHorn(s) @ $24.95 ppd
_____ Mark Ten B @ $59.95 ppd
_____ Standard Mark Ten @ $44.95

DP 70-20

Name ____________________
Address ____________________
City/State ____________________ Zip ______

DELTA **DELTA PRODUCTS, INC.**
P.O. Box 1147 EEH / Grand Junction, Colorado 81501

CIRCLE NO. 2 ON READER SERVICE CARD

WINTER EDITION

1971 POPULAR ELECTRONICS ELECTRONIC EXPERIMENTER'S HANDBOOK

A NEW APOGEE

Experimental electronics is subject to phases—probably like all other hobby interests. Six years ago the "big" interest was transistorized ignition; two years ago it became digital readouts and as you glance through this HANDBOOK you will see that audio construction projects are "in." Those readers of this HANDBOOK with long memories will recall that hi-fi and audio projects were notable favorites in the early 1960's and one must assume that hobby electronics has made a full orbit. What will the next HANDBOOK bring into focus? Maybe test equipment or communications gear—hobby favorites in the late 1950's. See the next HANDBOOK and find out for sure.

OLIVER P. FERRELL
Editor

ZIFF-DAVIS PUBLISHING COMPANY
Editorial, Circulation, and Executive Offices
One Park Avenue, New York, New York 10016
212-679-7200

Midwestern Office
The Pattis Group, 4761 West Touhy Ave.
Lincolnwood, Illinois 60646, 312-679-1100
GERALD E. WOLFE, DICK POWELL

Western Office
9025 Wilshire Boulevard, Beverly Hills, California 90211
213 CRestview 4-0265; BRadshaw 2-1161
Western Advertising Manager, BUD DEAN

Japan: James Yagi
Ishikawa Mansion #4, Sakuragaoka
Shibuya-ku, Tokyo 462-2911-3

Member Audit Bureau of Circulations

1971 ELECTRONIC EXPERIMENTER'S HANDBOOK, Winter Edition, is published by the Ziff-Davis Publishing Company, One Park Avenue, New York, New York 10016, also publishers of Popular Electronics, Electronics World, Stereo Review, Communications Handbook, Tape Recorder Annual, Stereo/Hi-Fi Directory.

Cover photo by Justin Kerr

If you can't come to the world's newest, largest and most exciting electronics department store, we'll mail the store to you!

Exclusive! Knight-Kit and Science-Fair Kits. Exciting build-your-own kits made to our own exacting standards. Stereo, CB, automotive, ham radio, science, hobby, test equipment, photography and more!

Exclusive! Realistic Life-time Tubes. Never worry about buying another tube. We guarantee ours will last as long as your set—or we replace it FREE!

Exclusive! Battery-A-Month Club. Join the Allied Radio Shack Club and receive a powerful battery every month for a full year—FREE!

Exclusive!
Quality Audio Products at Factory-Direct Savings

Allied TD-1099 3-Head Stereo Tape Deck. New one-piece head makes tape threading a snap. With case. Spectacular value! **$179.95**

Realistic STA-120 Wideband AM, FET-FM Stereo Receiver. 140 Watts. With case. **$269.95**

New Allied Radio Shack Catalog!

Thousands of electronic values!

Allied Radio and Radio Shack have joined forces to form the largest electronics distributing company in the world! This new 1971 460-page catalog offers you the best of both companies: famous-name brands, exclusive new products you'll find nowhere else (including some items you didn't even think were invented yet), and special money-saving prices that only the *combined buying power* of these two great companies could offer!

World's Largest Electronic Department Stores. Over 800 stores in 48 states. See your phone book for store nearest you.

Mail Coupon To Address Below

. . . or bring to Allied Radio Shack store for new catalog!

ALLIED RADIO SHACK
DIVISION OF TANDY CORP.

ALLIED RADIO SHACK 100 N. Western Avenue
Chicago, Illinois 60680 652

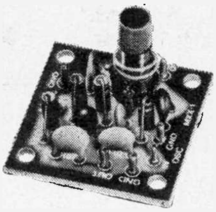
Yes! I want your big new 1971 catalog. I enclose $1 for mailing and handling (refundable with my first purchase of $1 or more).

NAME ______________________
First Middle Last

ADDRESS ______________________
Street or Route and Box No.

CITY __________ STATE __________ ZIP ☐☐☐☐☐

I enclose ☐ check ☐ money order ☐ cash



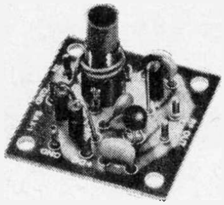
MXX-1 Transistor RF Mixer $3.50

A single tuned circuit intended for signal conversion in the 3 to 170 MHz range. Harmonics of the OX oscillator are used for injection in the 60 to 170 MHz range.

Lo Kit 3 to 20 MHz

Hi Kit 20 to 170 MHz

(Specify when ordering)



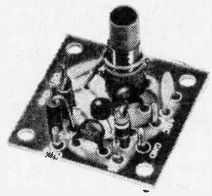
SAX-1 Transistor RF Amplifier $3.50

A small signal amplifier to drive MXX-1 mixer. Single tuned input and link output.

Lo Kit 3 to 20 MHz

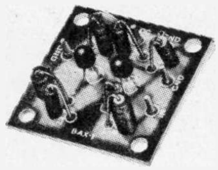
Hi Kit 20 to 170 MHz

(Specify when ordering)



PAX-1 Transistor RF Power Amplifier $3.75

A single tuned output amplifier designed to follow the OX oscillator. Outputs up to 200 mw, depending on the frequency and voltage. Amplifier can be amplitude modulated. Frequency 3,000 to 30,000 KHz.



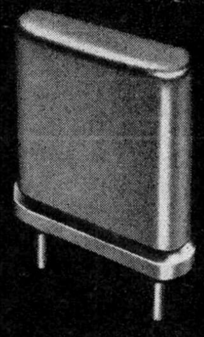
BAX-1 Broadband Amplifier $3.75

General purpose unit which may be used as a tuned or untuned amplifier in RF and audio applications 20 Hz to 150 MHz. Provides 6 to 30 db gain. Ideal for SWL, Experimenter or Amateur.

For The Experimenter!

International EX Crystal & EX Kits

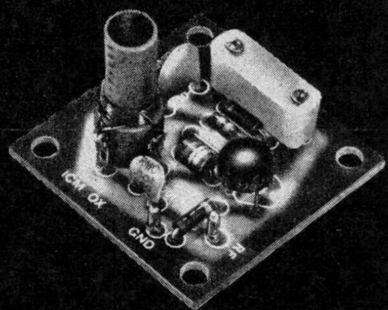
OSCILLATOR / RF MIXER / RF AMPLIFIER / POWER AMPLIFIER



Type EX Crystal

Available from 3,000 to 60,000 KHz. Supplied only in HC 6/U holder. Calibration is ±.02% when operated in International OX circuit or its equivalent. (Specify frequency)

$3.95



OX Oscillator

Crystal controlled transistor type. Lo Kit 3,000 to 19,999 KHz
Hi Kit 20,000 to 60,000 KHz
(Specify when ordering)

$2.95

Write for complete catalog.

INTERNATIONAL

CRYSTAL MFG. CO., INC.

10 NO. LEE • OKLA. CITY, OKLA. 73102

CIRCLE NO. 11 ON READER SERVICE CARD

CONTENTS

COVER FEATURE

AUDIO / STEREO

USEFUL HOUSEHOLD PROJECTS

TEST EQUIPMENT & EXPERIMENTATION

It Startles!

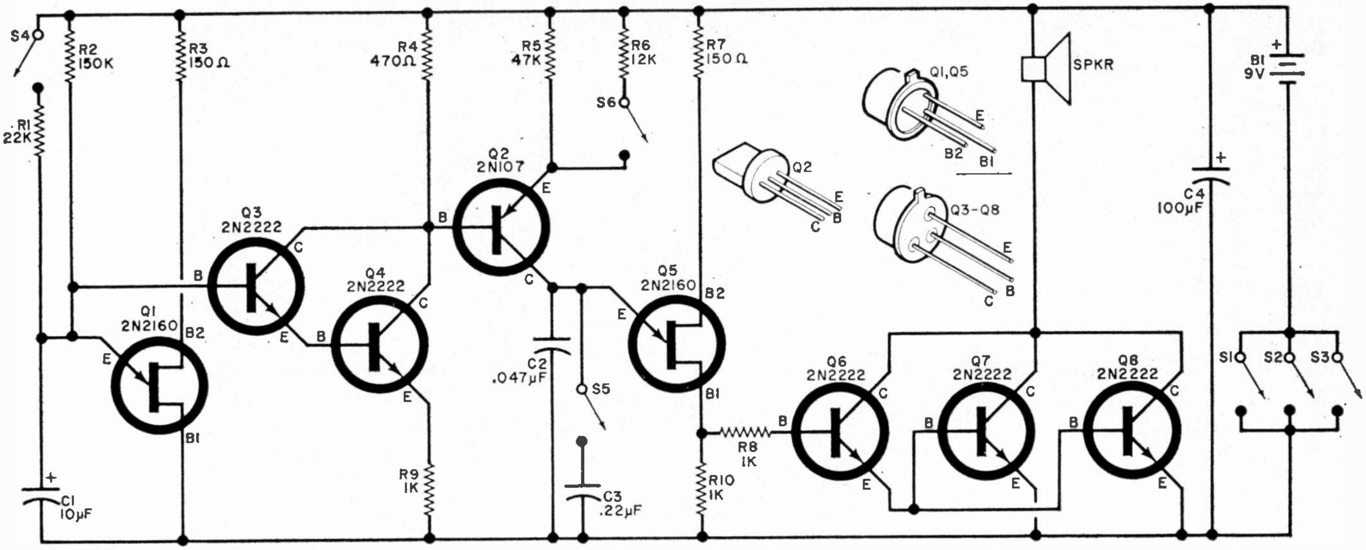
It Fascinates!

It Boggles!

COVER STORY

BY B. FISHER AND R. SHAW

HERE'S A PROJECT that's difficult to describe but we guarantee that, once you've built it, you and your friends will go ape over it. Quite simply, The Orb is a 12″ diameter plastic ball that just sits there quietly doing absolutely nothing. *However,* if it is picked up and rotated, even slightly, it emits a variety of sounds that will liven the dullest party. The sounds range from animal-like grunts to



PARTS LIST

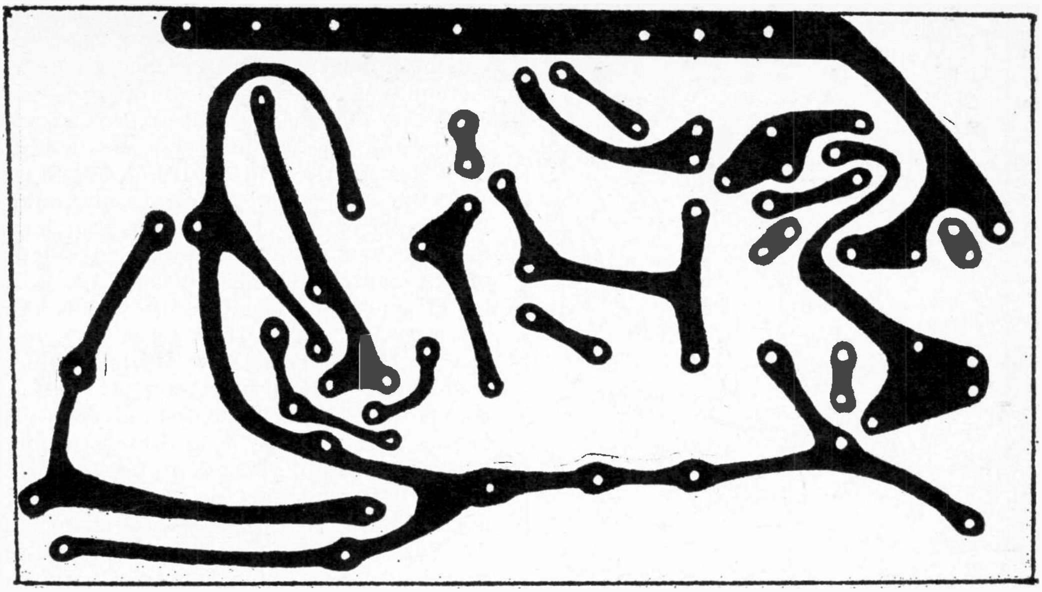
B1—9-volt battery
C1—10-μF, 10-volt electrolytic capacitor
C2—0.047-μF, 10-volt capacitor
C3—0.22-μF, 10-volt capacitor
C4—100-μF, 10-volt electrolytic capacitor
Q1, Q5—2N2160 transistor or similar
Q2—2N107 or HEP253 transistor or similar
Q3,Q4,Q6,Q7,Q8—2N2222 or HEP55 transistor or similar

R1—22,000-ohm
R2—150,000-ohm
R3,R7—150-ohm
R4—470-ohm
R5—47,000-ohm
R6—12,000-ohm
R8-R10—1000-ohm

(All resistors ½-watt 10% tolerance)

Spkr.—8-16-ohm speaker
S1-S6—S.p.s.t. mercury switch
Misc.—12" plastic ball, 12" plastic rod, 10" plastic disc, battery clip, battery connector, epoxy cement, mounting screws, etc.
Note—Electronic parts and PC board are available from Super Whoopee Ltd., 523 E. 12th St., New York, NY 10009 for $18.75. A complete kit, including ball, rod, disc, and stand, is available from the same source for $30.50. A kit of semiconductors is available from Semitronics Corp., 265 Canal St., New York, NY 10013 for $7.50 plus 50¢ postage and handling. Specify kit "Sw." A 12" plastic ball, a rod, and a disc are available for $7.50 from Engraving and Marking, 336 Canal St., New York, NY 10013. Specify "Electric Ball Kit." The ball alone is $6.25.

Fig. 1. The circuit consists of one UJT audio oscillator modifying the frequency of another. Each UJT circuit, in turn, has its basic frequency changed by operation of mercury switches which close to introduce new time constants in each oscillator.



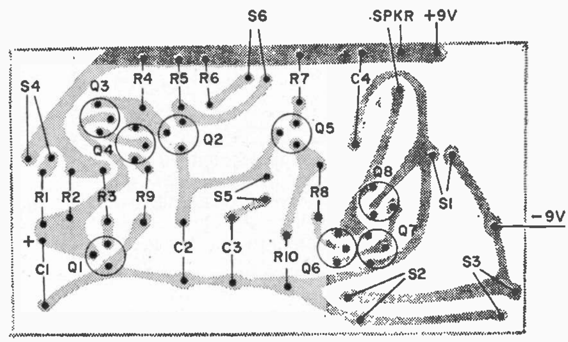


Fig. 2. After making the PC board, shown actual size above, install components as illustrated on the right. It is possible to alter the values of the UJT time constants (in the emitter circuits) so as to create a completely different set of unusual sound effects. Just be sure that there is at least one position of finished sphere where the power switches (S1,S2,S3) are turned off, removing power.

wild whistles, to outer-space screeches—with variations in between. Each sound is dependent on the attitude of The Orb and how it is rotated. The sound continues until the ball is placed in its "off" position—and trying to find this can be a lot of fun too, especially for the uninitiated.

This electronic toy is ideal for parties, as a conversation piece, and as a safe means of entertaining children. Once you start to play with it, it gets to be like potato chips—you just can't put it down.

About the Circuit. The noises emitted by The Orb are generated by two unijunction oscillators feeding a common audio amplifier (see Fig. 1). The frequencies of the oscillators are changed by switching components in and out of the circuits. The switching is performed by mercury switches which go on and off as the ball rotates.

The frequency of the first oscillator (*Q1*) is determined by *R2* and *C1*. This frequency is changed when mercury switch *S4* introduces *R1* in parallel with *R2*. The second oscillator (*Q5*) uses either *C2* or *C2* and *C3* in parallel and the emitter-collector resistance of *Q2* as the frequency-determining factors. The resistance of *Q2* is determined by the sawtooth signal generated at *Q1* and amplified by the Darlington-connected pair, *Q3* and *Q4* and is also changed by the action *S6*.

The audio amplifier consists of *Q6*, *Q7*, and *Q8* arranged to drive the low-impedance speaker.

Construction. The electronic circuit, shown in Fig. 1, is constructed on the

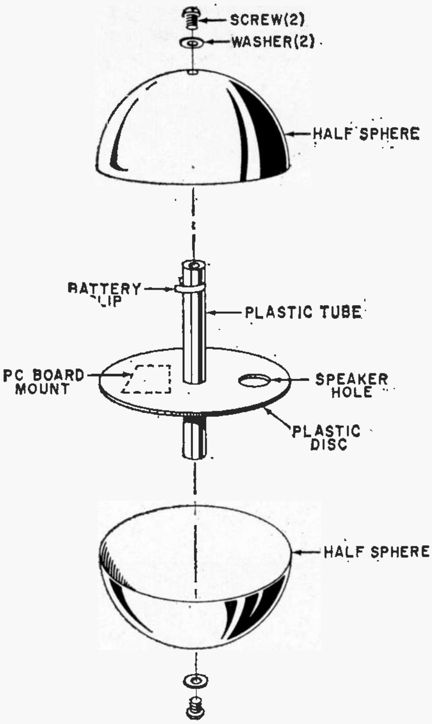


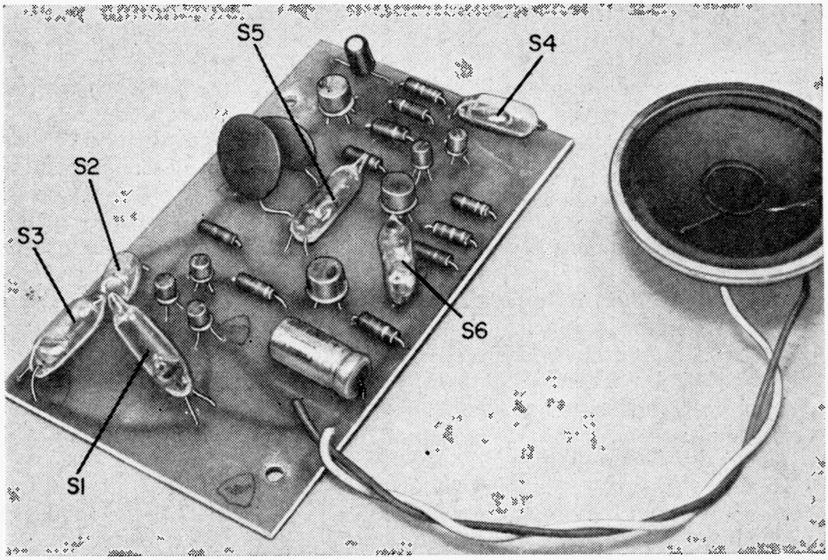
Fig. 3. The sphere is assembled on the plastic rod which has been tapped at both ends. The battery clip can fit on the plastic rod, or on the disc that supports both the PC board and speaker.

printed circuit board whose foil pattern is shown in Fig. 2, which also gives component layout. When mounting the 6 mercury switches, position *S4* and *S5* close to the board at right angles to each other and *S6* vertical to the board. Switches *S1*, *S2*, and *S3* are arranged so that the tips touch to form a pyramid. Put a spot of cement at the tip junctions to keep them in place. This arrangement of the switches insures that there will be at least one position in which the power is off. The other three switches change the sound as the ball is rotated.

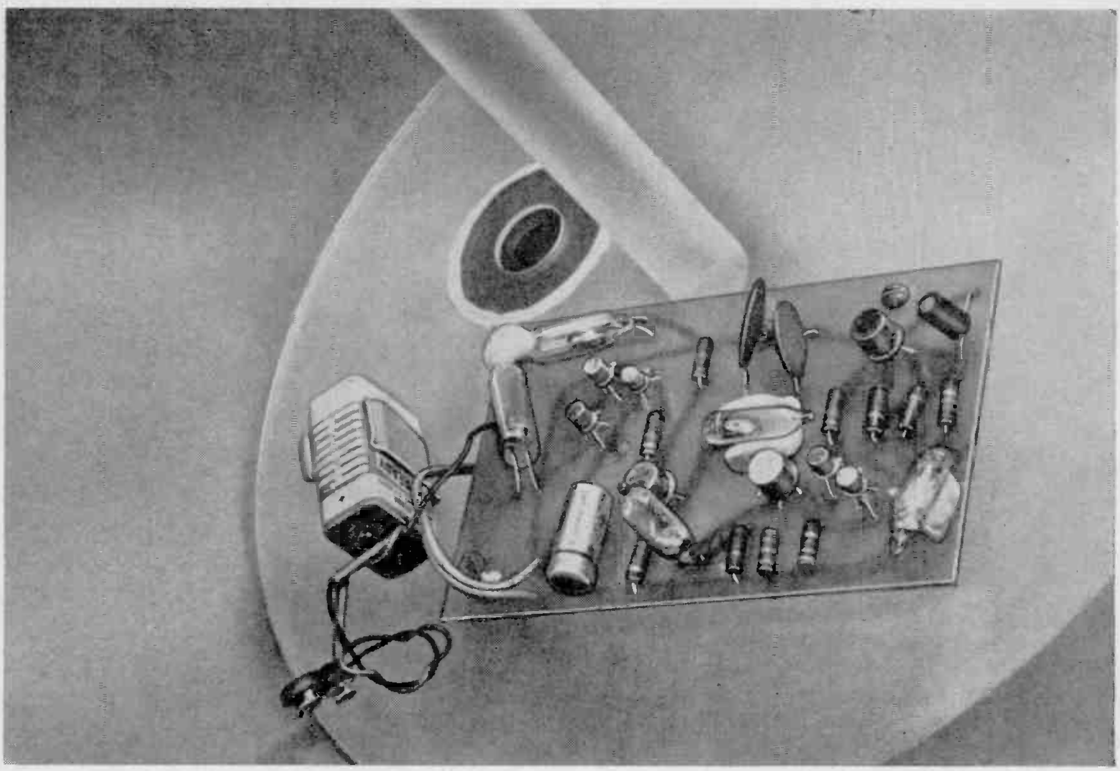
Once the board has been assembled, connect the speaker and the battery connector to it through 6- to 8-inch twisted pairs. Be sure to get the proper polarity on the battery connector. Hold the board upside down, so that the three switches *S1*, *S2*, and *S3* are off when connecting the battery to the connector. There should be no sound from the speaker with the board in this position.

The 12″ plastic ball (see Parts List) comes in two pieces which are to be held together by a 12″ piece of ¾″ or 1″ plastic rod. The latter is drilled and tapped at each end as shown in Fig. 3.

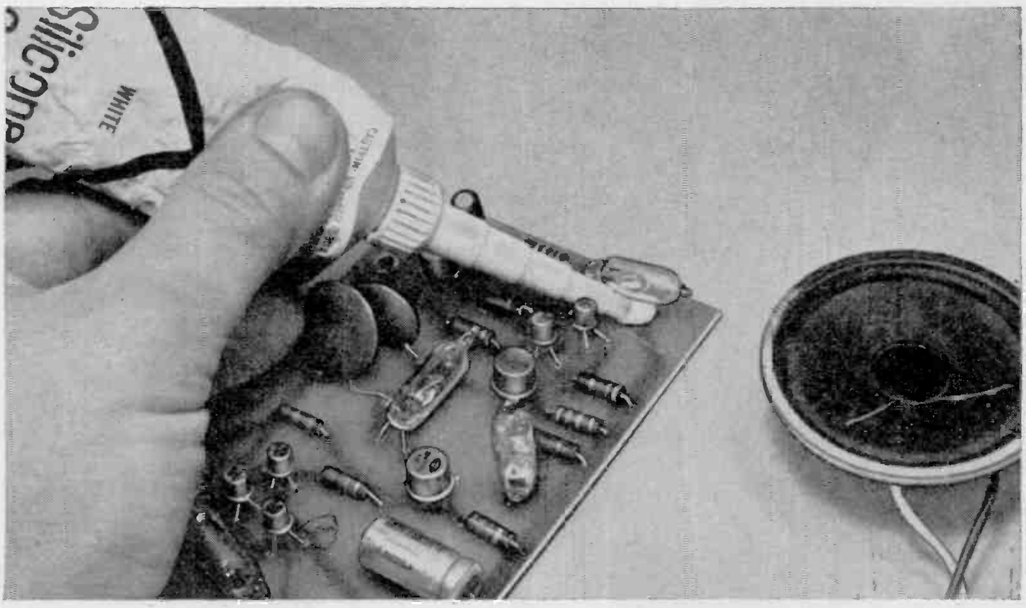
Position the plastic rod in one of the sphere halves and secure it in place using a suitable screw and washer. Make



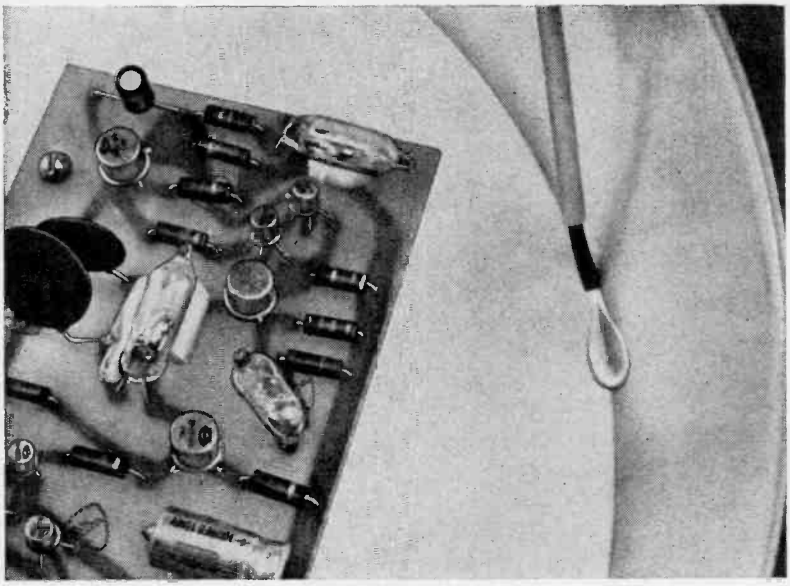
The mercury switches must be positioned as shown here. The pyramid of S1,S2, and S3 makes sure that there is at least one position where the battery is switched off. Other switches are at right angles to each other to make finished sphere position sensitive.



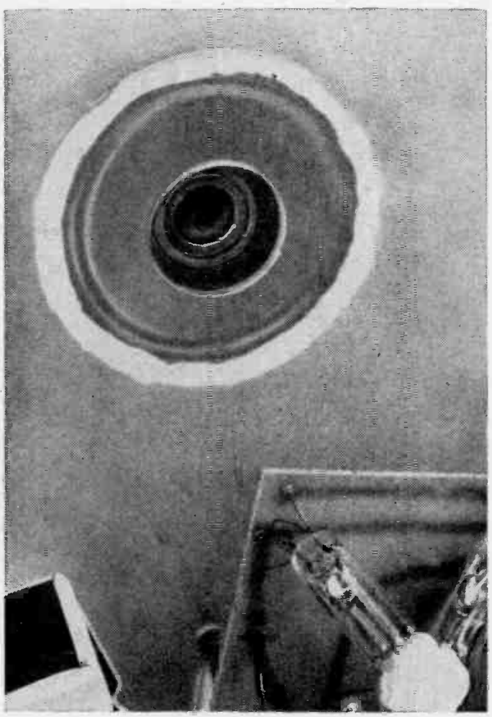
The speaker is mounted directly on large plastic disc that acts as a sounding board, thus increasing volume. The board and battery clip are secured with mounting hardware.



Once correct positioning of mercury switches has been made, they are cemented to prevent movement. Switches S4 and S5 are affixed to board, switches S1,S2, and S3 form a pyramid with their tips cemented together, while S6 is tight to chassis and vertical.



The plastic disc is secured to the sphere wall by applying several cement joints around the circle.

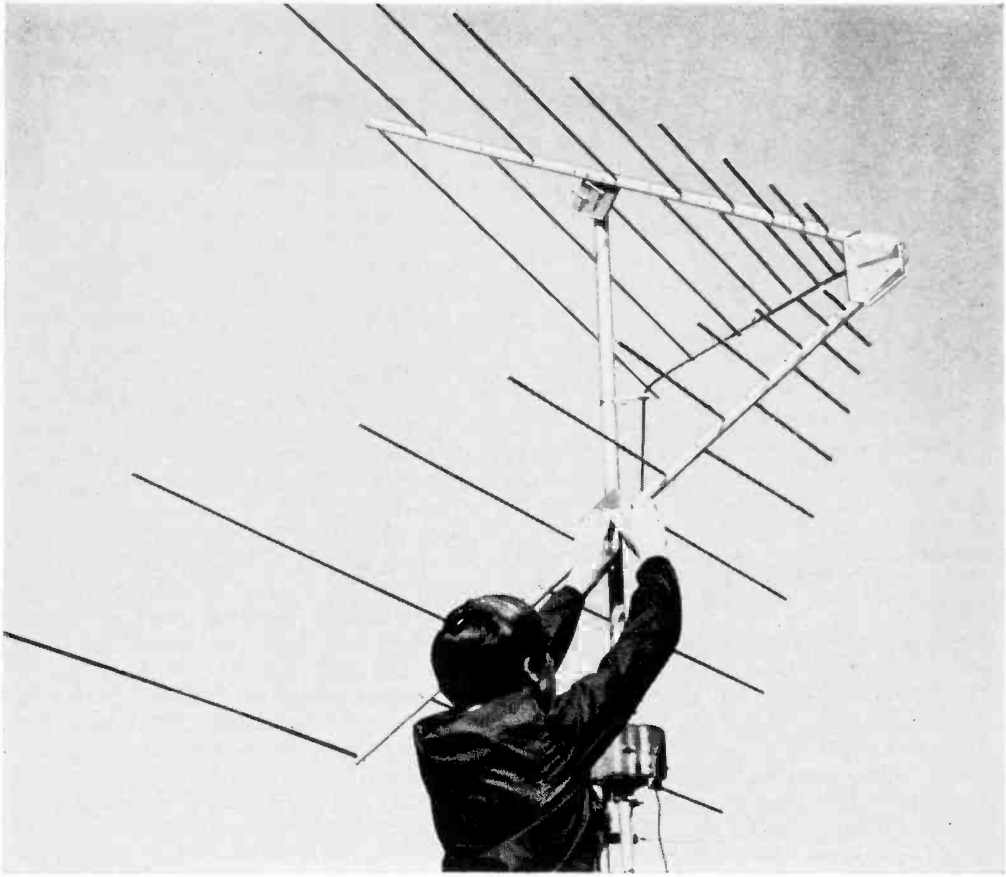


The rim of the speaker is coated with cement and concentrically fixed to its hole in plastic disc.

up a plastic disc having a diameter of approximately 10″ and drill a hole in the center just wide enough to accommodate the rod. Make another hole in the disc for the speaker. This hole should be just slightly smaller than the speaker rim so that the speaker can be cemented in place. On the other side of the disc make holes for mounting the PC board and secure it in place using suitable hardware. Make sure that both the speaker and battery connector are still wired to the board.

Lower the disc onto the plastic rod until the disc rim touches the plastic half sphere. Cement the disc in place all around its rim. Insert the battery in its clip and install the battery connector. The ball (rather half ball) is now active and will start up if moved from the stable position.

Carefully mate the other half of the ball with the first half and secure it to the rod using suitable hardware. The complete ball is now ready for use—either plain white as it comes, or you can paint it or add psychedelic stickers, as we did for the cover photo. Make sure that you know where the off position is so that you can "stop the music" when you want to. You will probably want to fashion some sort of base ring to hold the ball when not in use. —30—



BUILD THE

"PYRAMIDAL" TV/FM ANTENNA

LOW COST AND HIGH GAIN ARE FEATURED IN UNUSUAL DESIGN

BY GEORGE MONSER

THE RAPID GROWTH of color programming on the TV channels and stereo broadcasting on the FM band has generated an urgent need for an inexpensive high-gain receiving antenna. Unfortunately, most of the really good ready-to-install antennas are relatively expensive. But if you are willing to invest about $25 for materials and some four hours of your time, you can fabricate a "Pyramidal" antenna that will equal or better the performance of antennas selling for several times the cost of the materials.

The Pyramidal antenna described here is a frequency-independent (log-periodic) design. As opposed to the Yagi antenna that is "peaked up" at certain points within its band, the log-periodic antenna has an essentially constant gain over its entire band. (The Yagi, for example, has 10-13 dB of gain at the peaked frequencies—much less at all other frequencies—while the log-period-

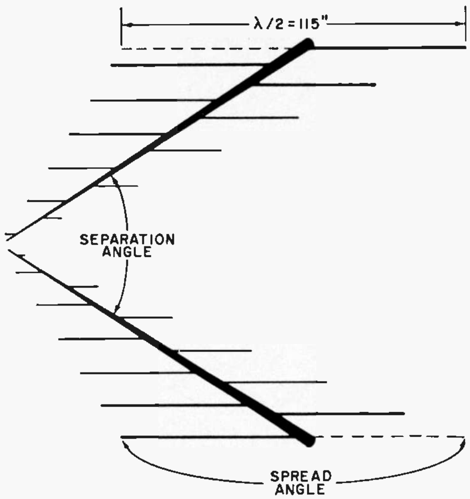


Fig. 1. Antenna gain and pickup characteristics are chiefly determined by spread and separation angles.

ic's gain curve is virtually flat at 8-12 dB over its entire band.)

The unique design of the Pyramidal antenna permits broad band coverage (VHF and UHF TV, and FM broadcast bands), using just 17 elements. The antenna also has sufficient gain to classify it as a "fringe" and "deep fringe" receiving antenna for color TV. Furthermore, the feed impedance almost perfectly matches commonly available 300-ohm lead-in, eliminating the need for expensive coaxial cable and impedance-converting Baluns.

Antenna Characteristics. The factors that have the greatest effect on the gain and performance of the Pyramidal antenna are the spread and separation angles (see Fig. 1) and, to a lesser degree, the number of elements used to cover the band. For a given separation angle, any decrease in the spread angle results in an increase in antenna gain. This increased gain, however, is accomplished only by narrowing the pickup lobe of the antenna, making aiming of the antenna more critical.

To minimize the aiming problems, yet preserve a high degree of gain, some compromise in the design of the antenna must be accepted. Hence, the spread angle is fixed at about 90° (actually closer to 86.5°) for a 60° separation angle. These figures, while they make aiming of the antenna easy, provide about 9 dB of gain—sufficient to qualify the antenna for fringe area use. The graph in Fig. 2 shows how the spread and separation angles affect gain.

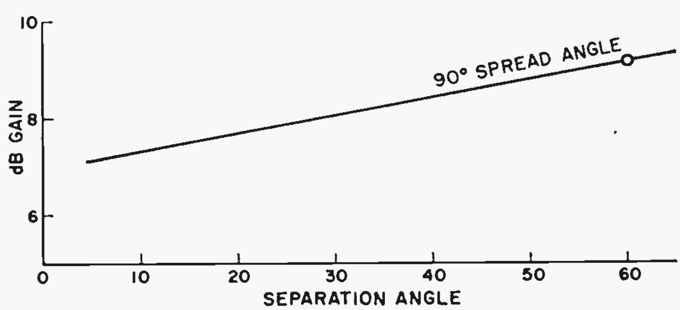
Theoretically, the longest element in the array should be cut to one-half wavelength at the lowest operating frequency. In practice, however, this is neither necessary nor desirable since the drop-off of the gain curve is so gradual. For this reason, as shown in Fig. 1, the longest element spans only 115" tip-to-tip, about one-half wavelength at 51 MHz.

Finally, for smoothness of operation over the entire band, a spacing ratio of 0.87 between elements was selected. Again, this is a compromise figure, one selected to provide smooth operation with the minimum number of elements.

Construction. Most of the materials needed for fabricating the Pyramidal antenna can be obtained from a hardware store, but you can save a few dollars by buying the tubing from a pipe outlet. The Plexiglass and NEMA G-10 epoxy-fiberglass, of course, should be bought from a plastics supplier.

Start construction by cutting the 3/8"

Fig. 2. Graph shows how 90° spread angle and 60° separation angle provide approximately 9-dB gain.



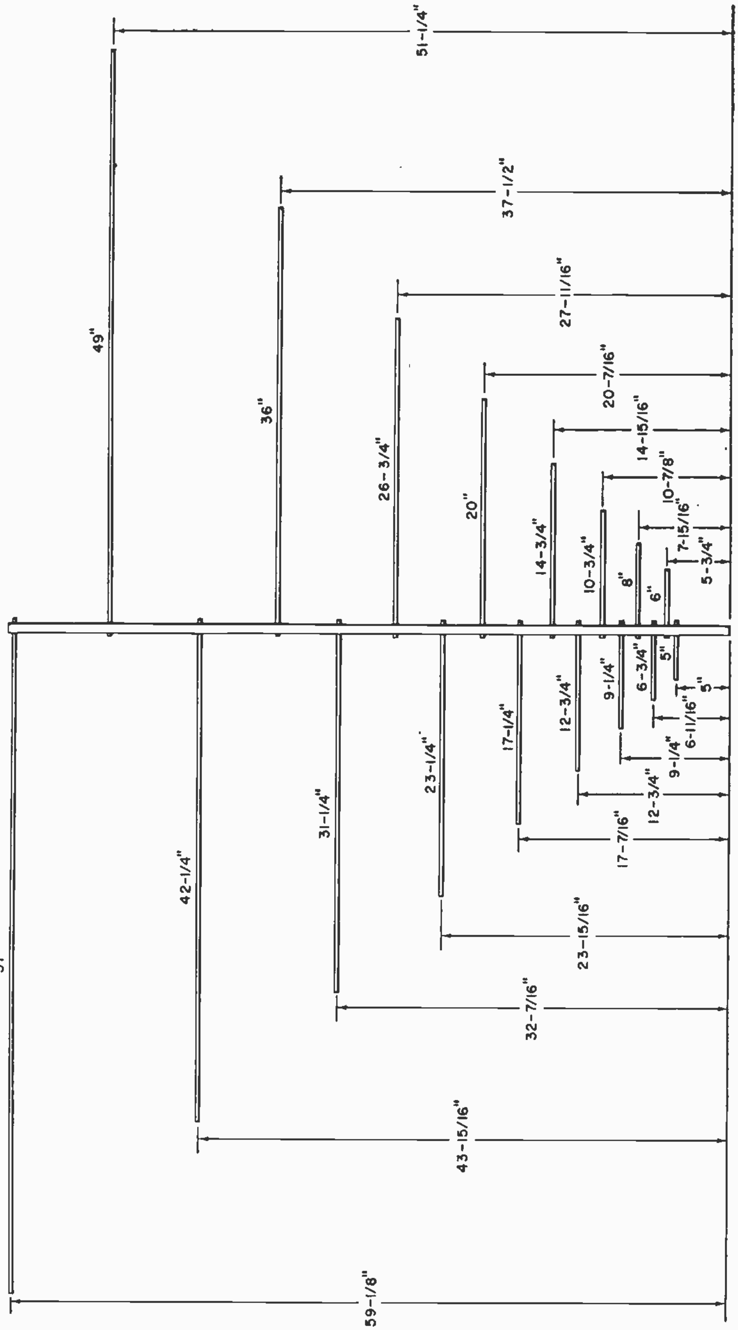


Fig. 3. Lengths given for elements (horizontal bars) are overall, include portions inside boom and projecting beyond boom on opposite side of element proper. Element hole location measurements are referenced from short element end of boom to hole centers. Double check measurements before drilling.

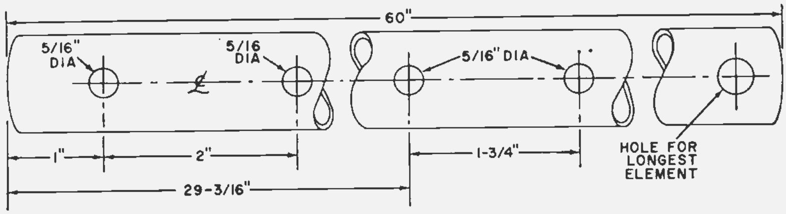


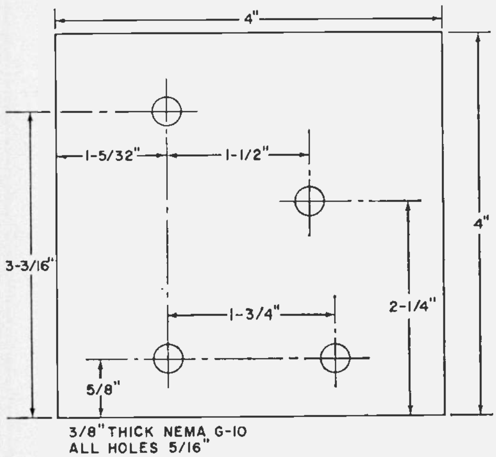
Fig. 4. Holes at left in drawing are for nose supports and at center for U-bracket supports. Reference all your measurements from short element end of boom. Outside diameter of the copper or aluminum tubing is not particularly important, so long as the builder adjusts the support tube diameter and holes to match.

seamless tubing to the lengths specified for the elements in Fig. 3; two of each length are required. Then cut the two 1"-diameter booms to 5′ lengths. Mark each of the booms with a small punch at the appropriate locations for the element holes, and drill ⅜" holes through both sides of the booms at the points indicated. Use a small rattail file or a reamer to deburr the exit holes.

Rotate each boom 90° along its axis, and repeat the hole marking procedure outlined above. Make sure these new markings are midway around the circumference of the boom between the ⅜" hole pairs. Then drill #18 holes through only one wall of the booms at these markings.

BILL OF MATERIALS

1—10′ length of 1" outer-diameter seamless aluminum TV antenna mast
2—5′ lengths of 1" outer diameter x 0.035" seamless aluminum tubing for booms
70′ of ⅜" outer diameter x 0.028" seamless aluminum or copper tubing for elements
2—U-bolt mast clamps with spacer, washers, and nuts
2—6" x 6" x ¼" pieces of Plexiglass for nose supports
2—4" x 4" x ⅜" NEMA G-10 epoxy-fiberglass (or equivalent) pieces for U-bracket support
1—Small plastic cable clamp
300-ohm twin-lead lead-in cable (see text)
Misc.—#8 x ¾" sheet metal screws; ¼-20 x 2½" machine screws, lock washers, and nuts; #8 solder lugs; 6-32 x ½" machine screw, lock washer, and nut; wood dowel or soft plastic (see text); solder; etc.



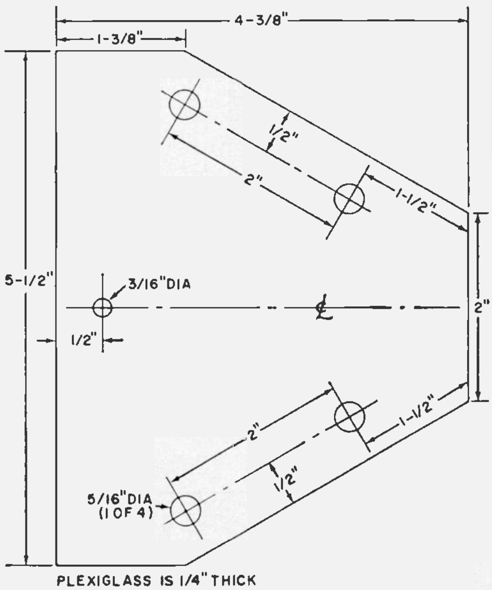
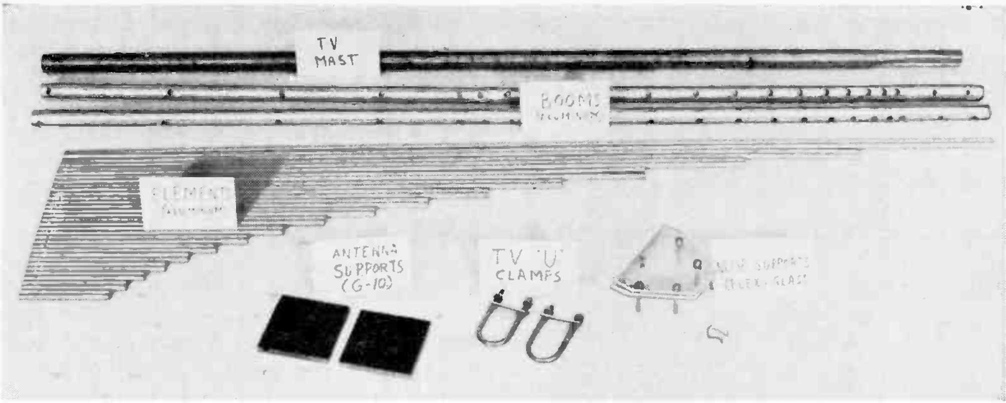


Fig. 5. Two each of the NEMA G-10 epoxy-fiberglass U-Bracket supports (above) and ¼" Plexiglass nose supports (right) are required for proper assembly of antenna.



Besides parts shown, you will need two 1" antenna mast standoffs and 300-ohm lead-in cable. For best results, choose highest quality lead-in cable available.

Next, referring to Fig. 4, drill 5/16" holes, directly in line with the 3/8" holes, through the booms for the nose and U-bracket supports. Then carefully measure 3/4" in from one end of each element. Mark your measurements with a punch, and drill through the dimples with a #28 drill. Deburr all exit holes on the elements and booms.

Now, pretap the holes in the elements with a #8 × 3/4" sheet metal screw. Insert each element into its proper hole in the boom, and use #8 × 3/4" sheet metal screws to hold them in place; note that a 1/4" stub should project from the boom on the opposite side from the element proper.

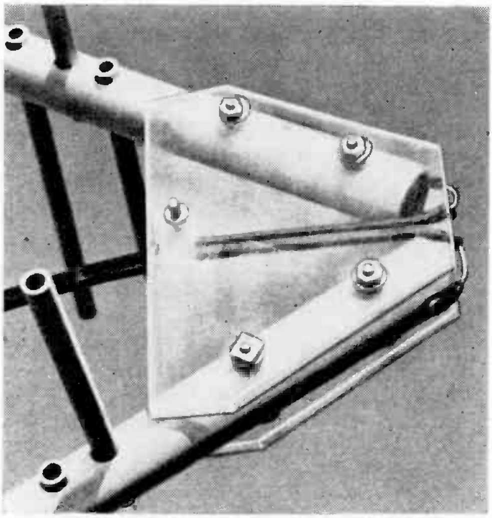


Fig. 6. The nose assembly fastens together with 1/4-20×2 1/2" hardware, cable clamp with 6-32 hardware.

Fabricate the two Plexiglass nose supports and two NEMA G-10 U-bracket support assemblies (see Fig. 5 for dimensions). Then drill a #28 hole through one wall of each boom, directly in line with the screws securing the elements in place and 1/4" from the short element ends. Pretap these holes with #8 × 3/4" sheet metal screws. Then plug both ends of each element and both booms with pieces of wood doweling or soft plastic.

Finally, prepare the required length of 300-ohm twin-lead transmission line in the following manner. At the antenna end of the lead-in, split the insulation down the center for a distance of 5". Strip away about 1/4" of insulation from each conductor, and solder a #8 solder lug to each. Then solder a spade lug to each conductor at the opposite end of the cable. (If the lead-in is to be routed through a wall or conduit, solder the spade lugs in place after the cable has been routed.)

Installation and Aiming. Take all of the antenna parts, including the mast and lead-in cable, out of doors where you will have plenty of room for final assembly. Assemble the nose pieces and element booms together as illustrated in Fig. 6. Screw down the solder lugs on the lead-in cable, and pass the cable through a small cable clamp. Bolt the clamp to one of the Plexiglass pieces with a 6-32 × 1/2" machine screw, lockwasher, and nut.

Place a plastic or rubber cap over the large-diameter end of the antenna mast section. Then fasten the mast section to the antenna as shown in Fig. 7. Be sure

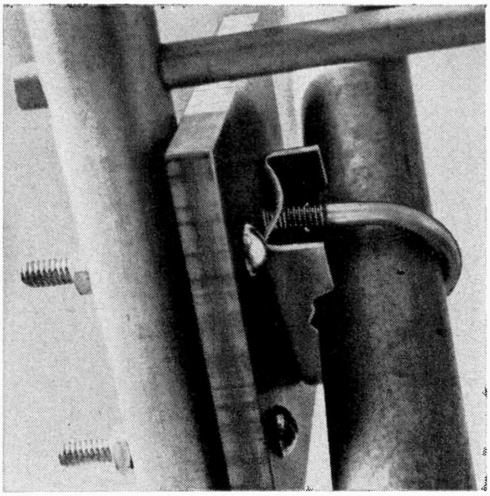


Fig. 7. To prevent antenna from shorting against mast, mount standoff between mast and NEMA board.

to use the U-bracket spacer between the epoxy-fiberglass plates and mast to prevent the antenna from shorting out against the mast through the mounting hardware.

Now, mount the antenna on your rotator by slipping the small-diameter end of the mast into the rotator ferrule. (Note: because the Pyramidal antenna is highly directional, an antenna rotator is almost an absolute must, especially in fringe reception areas.)

Route the lead-in cable to your TV receiver, or if you are simply replacing your present antenna, connect the present lead-in cable to the element booms via the sheet metal screws. Then connect the other end of the lead-in to your TV receiver. Turn on your receiver, and point the *small element end* of the antenna array at a known strong or local TV station (use the positioning control of your rotator.) Now rock the positioning control back and forth to determine the position that provides best reception. (The angular sector off the nose, or apex, of the antenna for best reception is approximately 60° wide; so the final aiming angle can be taken to encompass TV stations within the 60° spread.)

Set the channel selector to a weak-signal channel in your area and again rotate the antenna for best reception. In like manner, check for best reception on all of the VHF TV channels. If you desire, you can indicate on the rotator control dial which positions provide best reception for each channel.

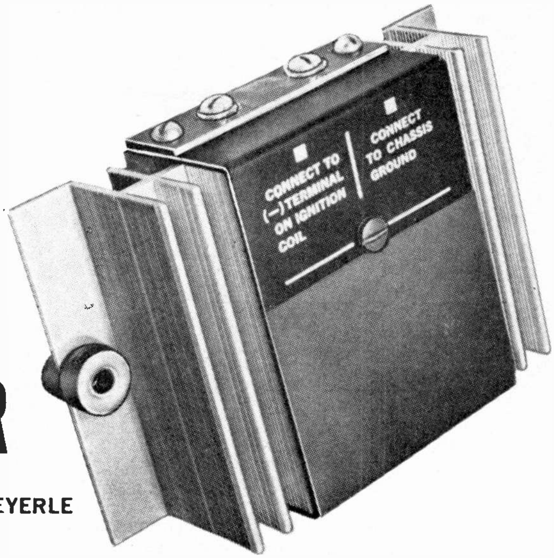
In some areas where direct-path reception is obstructed by large buildings, hills, etc., siting is best accomplished by employing "scatter" reception. To do this, point the antenna toward objects such as metal water tanks, other TV antennas, or even buildings that have an unobstructed view of the TV station.

Checking out the reception of the UHF TV channels is a little trickier than for the VHF channels. You will have to set the channel selector as near as possible to the UHF channel position desired, rock the rotator control back and forth until you have a picture, and touch up both the channel selector and positioning control as needed for best results. The same procedure applies to FM reception.

In tests in the New York-New Jersey area, the Pyramidal antenna was certainly impressive. For example, in comparison to a "standard" Yagi array of seven VHF TV elements and 14 UHF TV elements, the Pyramidal antenna was better on channels 5 through 13, and literally tremendous on FM. There was also a slight to modest improvement in UHF TV reception.

For its price, size, and ease of construction, the Pyramidal is very likely the best antenna you can use for touchy color TV and stereo FM reception. So, if you are in the market for a good high-gain receiving antenna—whether for VHF TV, UHF TV, or FM broadcast—look no further, the Pyramidal is it! —30—

Build a DWELL EXTENDER



BY GEORGE MEYERLE

ELECTRONIC ASSIST TO YOUR IGNITION SYSTEM

MANY SCHEMES have been proposed in the last ten years for improving electronically the efficiency of the ignition system of the internal combustion (automobile, boat, etc.) engine. Such proposals, whose basic purpose is to improve overall performance and reduce fuel consumption, are all based on the principle of increasing the spark energy at high engine speeds (see p 23). Many of these spark improvement systems have value—whether they are simple switching transistors or elaborate, relatively complex capacitive-discharge circuits. Unfortunately, they also have varying disadvantages of some type.

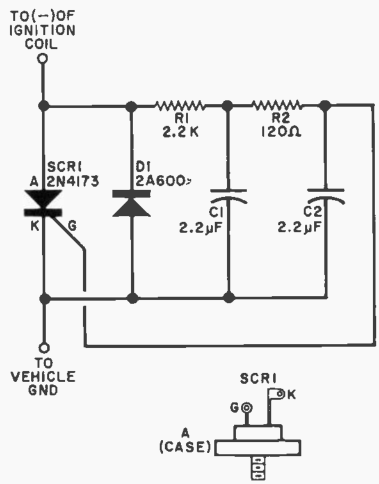
The "Dwell Extender" described here increases spark energy at high engine speeds by lengthening the dwell time electronically and requires only two connections to the existing system. The patented circuit, shown in Fig. 1, can be used in any car or boat with a negative ground. It can be installed or removed in a matter of minutes and is applicable to any number of cylinders, provided a coil-and-breaker-point system is used. It cannot be used on engines having a magneto ignition or a positive-ground.

What can be expected of this unusual system? Truthfully, not very much if you have a new car that is properly tuned up and if you don't drive at high speeds. However, if your car has a lot of mileage on it and you want additional "zoom" for passing or accelerating on a hill, the Dwell Extender can provide an improvement in your car's performance.

The use of this system in your car will also save you some gasoline due to more efficient burning; and you will find that problems resulting from worn points are reduced since they no longer play such an important part in the ignition system. Spark plugs will last longer too.

Construction. It is important that you use the silicon controlled rectifier (SCR1) called for in the Parts List. It is capable of withstanding the temperature extremes existing near the engine and it can take the reverse voltages that occur when the points open. Similarly, the capacitors must be of the solid tantalum type which can withstand the temperature extremes.

The components are actually mounted



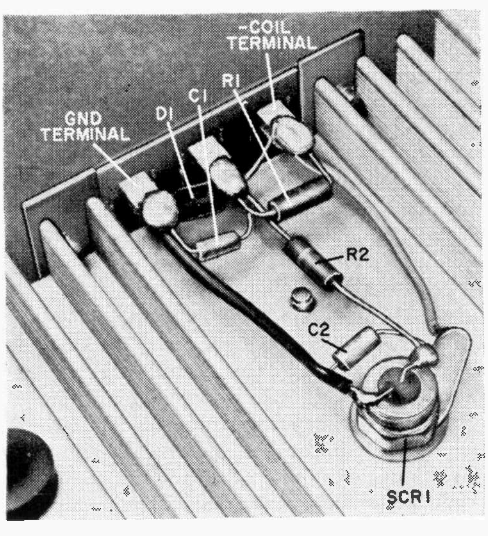
PARTS LIST

C1, C2—2.2-μF. solid tantalum capacitor (Sprague 164D or similar)
D1—2-ampere, 600-volt PIV rectifier diode (Solitron Devices 2A600)
R1—2200-ohm, ½-watt resistor
R2—120-ohm, ½-watt resistor
SCR1—Silicon controlled rectifier (Motorola 2N4173)
Misc.—SCR mounting hardware (Motorola MH475 or similar); heat sink (Wakefield 400 or similar); three-lug screw-type terminal strip; metal for U-brackets; length of #14 twin-conductor cable; two crimp-on lugs; rubber grommets (2); mounting hardware; etc.
Note—A pre-tested SCR with mounting hardware at $4.50; a pre-tested diode at 30¢; and two tantalum capacitors at 60¢ each are available from Metrotec Industries, 1405 Old Northern Blvd., Roslyn, N.Y. 11576. Also available from the same source are: a gold anodized heat sink with covers, shock mounts, and terminal strip at $3.95; a complete kit of parts at $9.50; and a finished, wired unit encapsulated in a heavy-duty cylindrical heat sink at $19.95, all postpaid. The unit has a 2-year guarantee. Patented, Foreign and U.S.A.

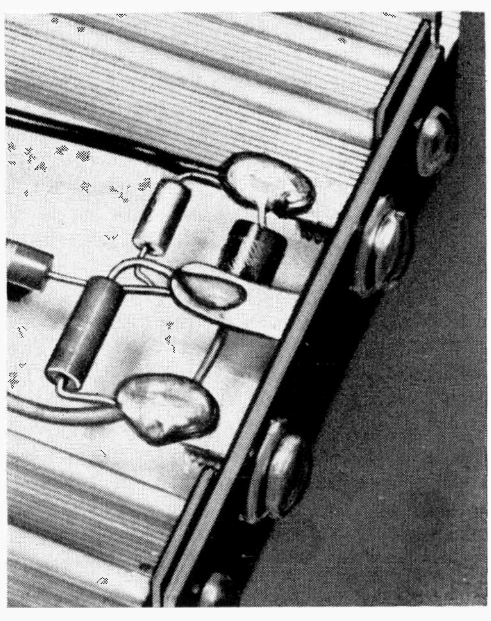
Fig. 1. Be sure to use the components specified so that the finished device can withstand both engine-space heat and any switching transients.

on the heat sink (or similar) prescribed in the Parts List. Drill a hole in the center of the heat sink for *SCR1*. Mount the SCR with an insulating (mica) washer around the stud on each side of the heat sink and a soldering lug making contact with the case of the SCR on the wiring side of the heat sink. You may also have to use some type of insulating tubing around the stud where it passes through the heat sink to avoid any contact between the two. When you have the SCR mounted, use an ohmmeter to check that there is no contact between the case (anode) of the SCR and the heat sink.

Fig. 2. Install the SCR so that it is completely insulated from the metal heat sink. Mount a large solder lug between the case and insulator to make the anode contact. All wiring is point to point.



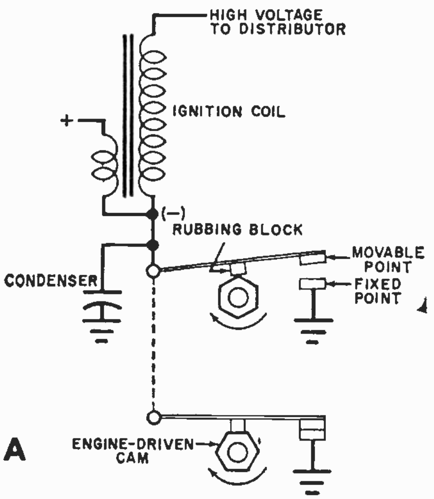
The three-screw terminal is mounted on a U-shaped cover that snaps over the heat sink. Remove center screw and cover the outside hole with a piece of tape. The lug is used as a wiring support only.



SPARK ENERGY

The efficiency of an internal combustion engine depends, in the final analysis, on the mixture of gasoline and air that is introduced into the cylinder and the successful ignition of that mixture by an electrically induced spark. If we assume that the carburetor is doing its job of providing the proper fuel mixture, then obtaining the right spark energy to fire it is the best way to improve efficiency.

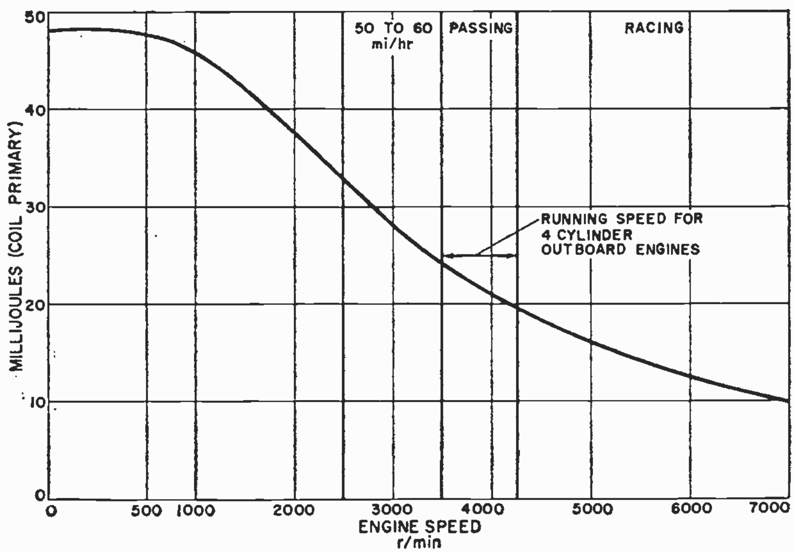
To provide a spark, the majority (about 98%) of conventional engines use the Kettering system, which was developed about 50 years ago (see Fig. A). In this system, battery current is allowed to pass through the primary of an autotransformer (ignition coil) when the breaker points are closed. The opening and closing of the points are timed by an engine-driven cam that is designed to open the points whenever a spark is required by a cylinder. When the points are closed, the current flowing through the coil builds up a magnetic field which saturates the coil. When the points open, the current flow stops and the magnetic field collapses. As the field collapses, the magnetic lines of force cut the turns on the other portion of the autotransformer, inducing a very high back e.m.f. This voltage is applied through the distributor to the appropriate cylinder to ignite the gas-air mixture. The time that the points remain closed is called the dwell time and is specified in degrees of dwell for the particular engine.



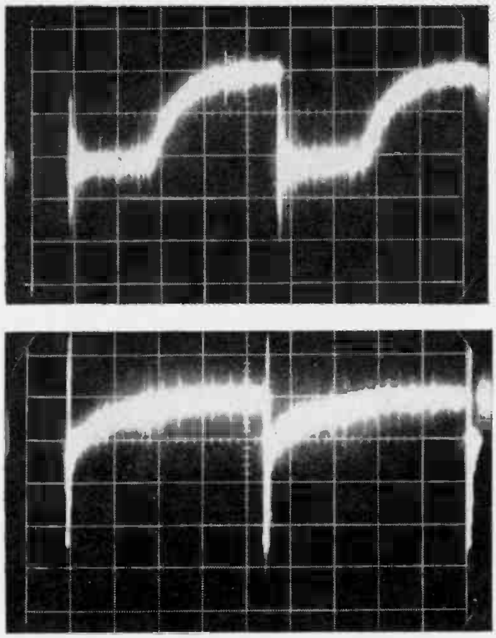
A

An ignition system of this type always works (unless something is drastically wrong) but it does have disadvantages, which result primarily in the loss of performance at high engine speeds. This is because, as the engine speeds up, the amount of time that the points remain closed is proportionally reduced. When the engine speed reaches two thousand r/min or more, the points are closed for such a short time that the magnetic field within the ignition coil does not build up to maximum. This results in a much lower "thinner" spark voltage for ignition. As a result the energy in the coil primary drops dramatically as shown in Fig. B. Because the higher engine speeds are used in accelerating and passing, "sluggishness" is noted in many engines when this situation occurs. Since the fuel doesn't burn properly, the condition also wastes gasoline and the spark plugs get fouled up, causing an even further drop in performance.

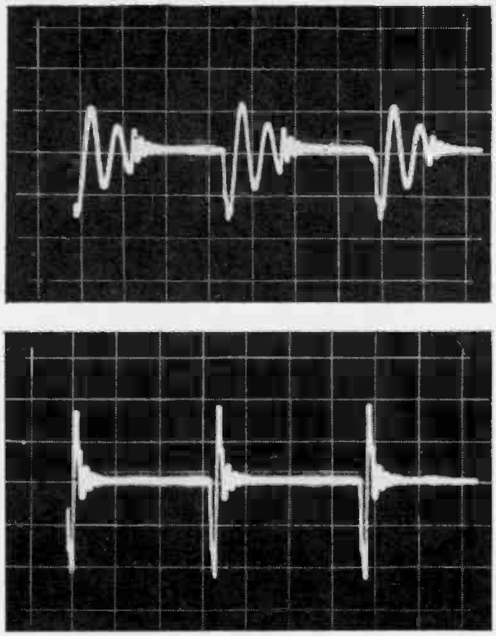
The purpose of most ignition-improvement systems is to overcome the "droop" in spark energy at high engine speeds.



B



Primary current in the ignition coil without (top) and with (bottom) the Dwell Extender. Calibration is 5 ms per division horizontal, and 2.5 amperes per division vertical. Note the longer time that ignition coil current flows using Dwell Extender.



Secondary voltage of the ignition coil without (top) and with (bottom) the Dwell Extender. Calibration is 1 ms per division horizontal and 10 kV per division vertical. Note the reduced ringing and the higher voltage using the Dwell Extender.

Prepare a U-shaped metal cover to fit over the top of the heat sink and project down over the two sides. Cut out one end of the cover so that a three-lug terminal strip can be mounted on it as shown in Fig. 2. The two outer lugs serve as wiring connections for the internal components and for connection of the external leads. The center lug is used as a standoff insulator for internal wiring which is point-to-point.

Once the circuit is complete, spray the interior with a non-corrosive lacquer to provide protection against moisture. Make another U-shaped cover to fit over the bottom of the heat sink and cover the electronic components.

Drill holes in the ends of the heat sink for mounting and insert rubber grommets in the holes to provide protection against shock and vibration.

Clearly identify the two external connections. Mark them "CHASSIS GROUND" and "(—) TERMINAL OF IGNITION COIL."

Installation. Select a suitable mounting spot for the Dwell Extender—away from the heat of the engine and radiator. The location can be on the sheetmetal wheel covering, the firewall, or even inside the car (or boat). Make sure that rain or snow (or spray if used on a boat) cannot reach the device. A maximum of six feet of wire can be used to connect the circuit to the ignition coil.

(*Continued on page* 38)

HOW IT WORKS

When the points are closed, the Dwell Extender is shorted out so that the SCR is non-conducting. During this time, the current through the coil (through the closed points) builds up the magnetic field. When the points open, the back e.m.f. from the collapsing field around the coil creates a voltage high enough to fire the spark plug. However, the instant that the points open, the positive voltage from the battery is applied directly to the anode of the SCR and, through an *RC* network, to its gate. About 100 microseconds after the points open, the positive pulse reaches the gate, firing the SCR. This closes the points electrically. Shortly afterward, they close mechanically.

The result is that the coil is being charged for almost the entire duty cycle except for the 100 microseconds to allow for spark to occur. The magnetic field built up in the coil is thus stronger and a much larger spark is available at the distributor. In fact, the spark energy is almost doubled at high engine speeds. Diode *D1* bypasses the negative spike that occurs when the points open.

MINI-SIX ADD-ON

Try new dispersion technique for better stereo

BY DAVID B. WEEMS

SINCE high fidelity first came on the scene, some critical listeners have complained that most music systems produce sound that appears to come through a hole in the wall. The advent of stereo gave us two openings for music and added the phrase "hole in the middle" to the hi-fi vocabulary.

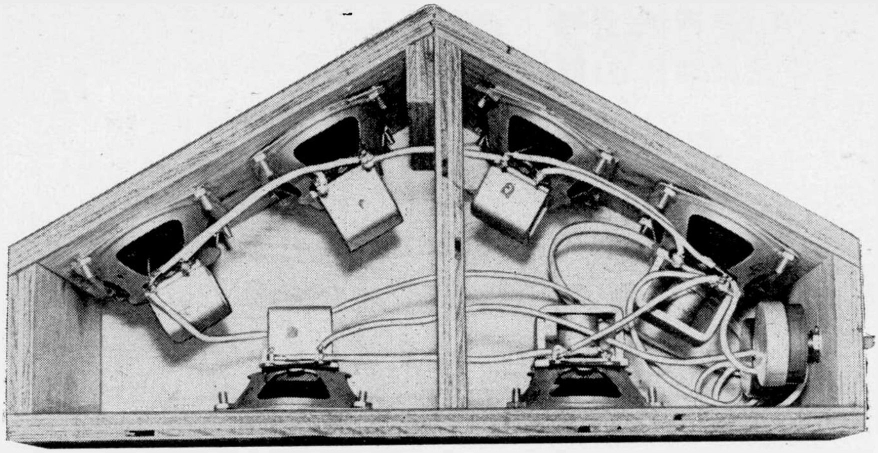
As good as they are, loudspeakers still sound more like loudspeakers than musical instruments. One reason for this is that the sound reaching the listener at a live performance is rich in both direct and reflected sound waves. But in the optimum listening position for most stereo systems, the predominant effect is produced by direct sound waves.

The directivity of loudspeakers gives a satisfactory left-to-right perspective in locating individual voices or musical instruments. However, there is a tendency to aim the sound in only one direction—particularly the high frequencies—often in stereo compressing the sources into two separate "points."

Dealing With The Problem. Several approaches have been tried to eliminate the "point source." Some of the earlier ones were: adding a center channel to stereo systems; removing the back of the speaker enclosure to gain reflections

The Author

While Dave Weems was getting his Bachelor of Science degree at the University of California at Los Angeles, he worked as research assistant in a physics laboratory which was next door to an acoustics lab. That was when he started building amplifiers and speaker systems. He has taught mathematics, physics, and chemistry and is now a free-lance consultant and writer on the design of speaker systems.



Four speakers (top) are mounted on angled baffles facing back. The other two speakers face the front. Individual L-pad controls for two sets of speakers are mounted on side.

from the rear; using speaker columns to produce a line source for wider horizontal distributions and reflections; and developing nondirectional tweeters.

A new approach, described by some enthusiasts as "revolutionary" is offered by the Bose Model 901 speaker system. This system contains nine 4″ loudspeakers—eight of them located on baffles that are mounted on angles at the rear of the small enclosure. A single speaker faces forward. The purpose of this rather unorthodox arrangement is to produce 89% reflected and 11% direct sound waves. The Bose Corporation claims that this is the optimum ratio for the reproduction of recorded sound.

Each of the nine speakers in the Bose system handles the full range of frequencies without crossover networks. A solid-state "active equalizer" is used to tailor the response to that preferred by the listener as well as to compensate for the inherent base rolloff caused by the small enclosure.

Even if you are a critical listener, you will notice that the "character" of the sound produced by the Bose system does not change as much as you might expect it to as you move about the listening room. And the feeling of spaciousness adds a depth of sound not evident with conventional speaker systems.

A minor drawback of this unique speaker system is the necessity of locating the Model 901 about 12″ away from the wall to obtain the proper reflection pattern. There is also the question of the reflecting surface itself. If it is smooth you can confidently expect the reflected sound content to approach the optimum of 89% . But a rough surface or the presence of even a small amount of drapery or other sound absorbing material could alter this ratio. The exact percentage of reflected sound might not be critical, but listening rooms present a wide variety of acoustical environments.

Taking the above into consideration, it is desirable to provide a means for varying the direct/reflected sound ratio produced by the speaker system. This would allow the listener to optimize the ratio to his particular listening room and personal tastes.

The "Mini-Six," the add-on speaker system described here, is designed to be adjusted to the environment. Utilizing the reflected sound principle employed in the Bose 901, it permits the listener to vary the ratio of direct/indirect sound to match his room acoustics.

The Mini-Six, unlike the Bose system, is not a full-range speaker system; rather, it is an add-on for existing hi-fi speaker systems, the latter being used only to reproduce the bass range. This strategem minimizes material cost and satisfies limited space requirements.

The add-on consists of 3″ × 5″ replacement-type 8-ohm oval speakers selling for about a dollar apiece. Each has a magnet weight of 1.47 ounces. Four of the speakers are mounted on angled boards facing the rear of the enclosure, and two face the front.

The rear speakers are connected in parallel-series to maintain a normal 8-ohm impedance, while the front speakers are wired in series to provide a 16-ohm impedance. The two sets of speakers are then wired in parallel to provide a total impedance between 5 and 6 ohms.

The front speakers would normally dissipate 33% of the power with this hookup. However, a 16-ohm L-pad controls the output to any desired level up to about 33% of the total sound.

While the low-frequency response of the replacement-type speakers is limited by their small size and high cone resonance (over 200 Hz), their performance in the high-frequency range is fairly good. When used as designed to reproduce the midrange and high-frequencies from 300 Hz up, the sound reproduction does not betray the low cost of the speakers.

A simple home-made crossover network permits you to utilize your present speaker system as a woofer. Because the crossover point is at 300 Hz, the position of the big speaker system is not critical. And the addition of an 8-ohm L-pad allows you to match the output of the Mini-Six to that of your woofer.

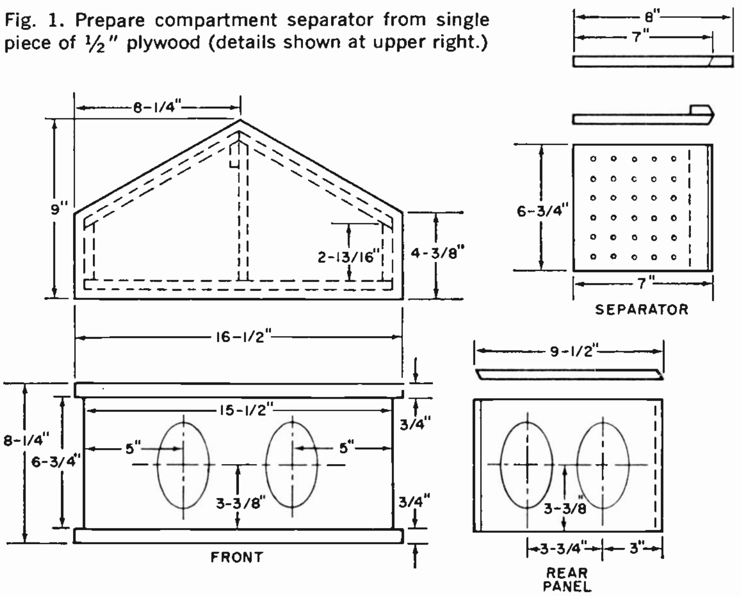
Construction. Although building the Mini-Six (Fig. 1) appears to be an exercise in making 60° miter cuts, construction is quite simple. A table saw or an adjustable portable rotary saw, set for 30°, will do the job easily. If you elect to use a sabre saw for the cutting operations, be very careful to keep the cuts straight and go very slowly. Always make a few practice passes at the cutting angle through some scrap ½″-thick plywood.

Now, referring to Fig. 1, prepare each of the eight major pieces that make up the enclosure according to the dimensions provided. The center panel that separates the two interior chambers of the enclosure (see drawing at upper right) should be cut from a 6¾″ × 8″ piece of ½″ plywood. The excess strip (illustrated) can then be reversed and secured to the center panel with glue and screws, forming a double angled surface to accommodate the rear panels. Then drill about 30 ¼″-diameter holes on 1″ center-to-center squares through the panel.

Rub chalk around the gasket of one speaker. Then firmly press the speaker onto a piece of heavy cardboard to obtain a pattern for the speaker cutouts. Cut the cardboard along the *inner* outline. Then punch a small hole through the center of the pattern.

Place the pattern over each of the

Fig. 1. Prepare compartment separator from single piece of ½″ plywood (details shown at upper right.)



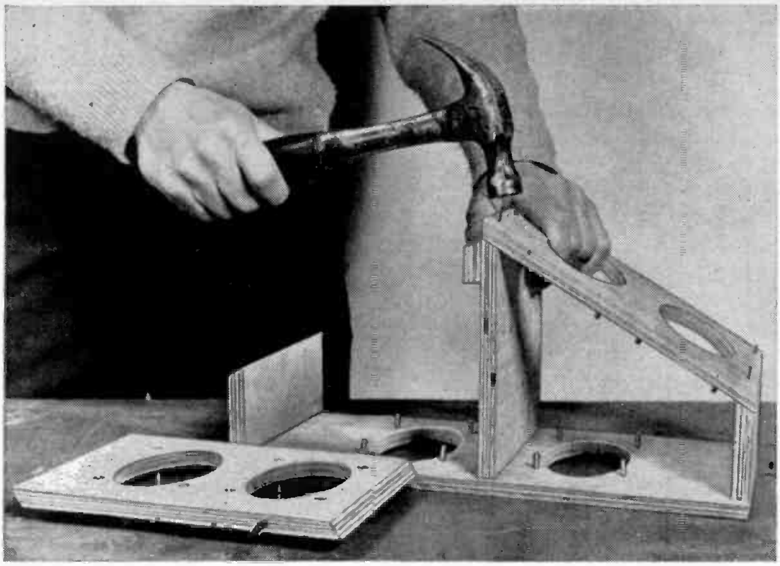


Fig. 2. Except for top plate, all parts should be joined using wood glue and finish nails.

speaker locations on the front and rear panels of the enclosure to make the outlines for the speaker cutouts. Then cut the outline holes. Set a speaker over each cutout and mark the positions of the speaker mounting holes. Now drill a 3⁄16" hole through the front and rear enclosure panels at each marked location. Mount the bolts, and check the speakers for proper fit.

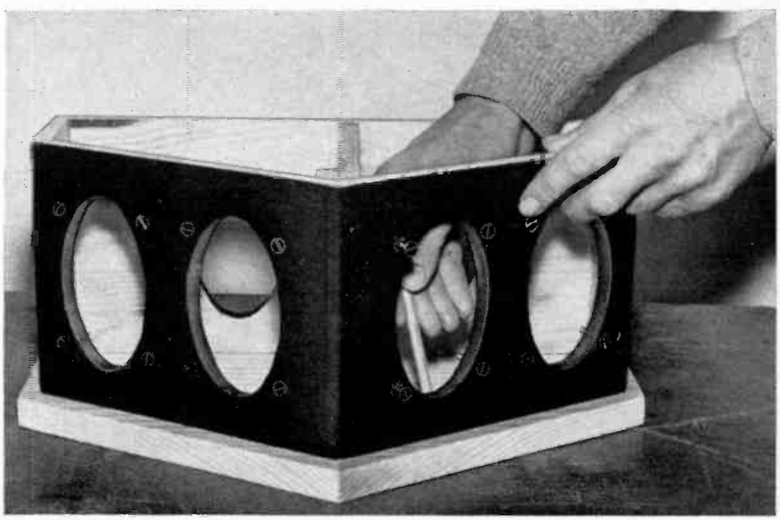
Anchor the sides and center panel to the enclosure front plate with glue and screws. Then attach the rear panels with glue and finishing nails as shown in Fig. 2. Apply a coat or two of flat black paint to all exterior surfaces and the insides of the speaker cutouts. Allow the paint to dry.

Next, invert the enclosure shell onto the inverted top panel. Carefully center the shell; then mark the outline of the interior shell surfaces on the top panel (see Fig. 3). Again, carefully center the bottom panel over the enclosure shell, and glue and nail the bottom panel to the shell.

Prepare 3⁄4" × 3⁄4" pine cleats to fit the *inside* of the shell outline on the top panel at the front and rear, and glue and screw together as in Fig. 4. Locate and drill holes through the front and two rear panels to permit screws to be driven through the shell and into the cleats to hold down the top panel. Stain and finish the top and bottom panels.

The screw-type terminal strip mounts on the bottom of the enclosure, centered near the side on which you plan to install

Fig. 3. To locate positions of top cleats, invert top plate, center enclosure shell on it, and strike pencil lines along edges of inner walls of shell.



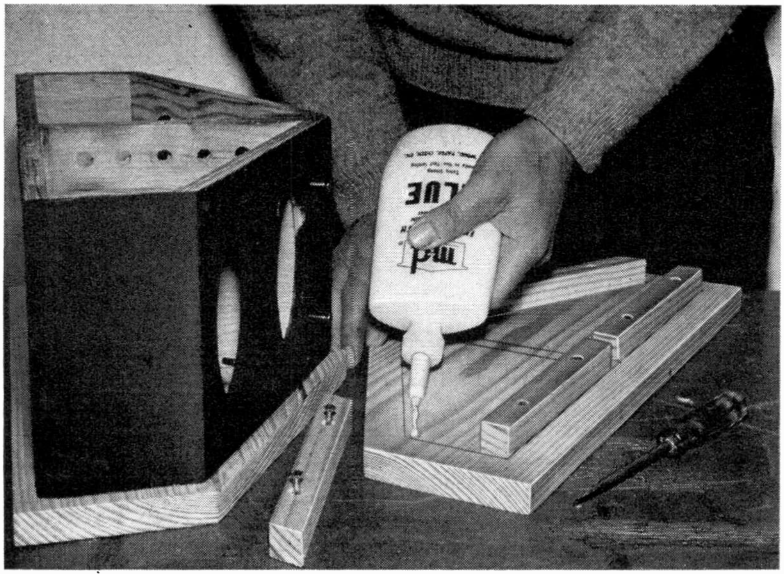


Fig. 4. Fasten cleats along only front and rear locator lines on top plate. Leave appropriate breaks in cleat to accommodate the chamber vertical separator.

the L-pads. First, drill two ¼″ holes through the enclosure bottom panel, removing enough wood to accommodate both the solder lugs and screw ends of the terminal strip. Next, solder one conductor of a 15″ length of zip cord to each solder lug on the terminal strip. Then mount the terminal strip on the outside surface of the bottom panel with glue and screws.

Invert the enclosure and attach to the bottom panel three rubber bumpers. These bumpers should be large enough to provide adequate clearance for the speaker wires and screw connections at the terminal strip when the Mini-Six is placed on a flat surface right side up.

Wiring and Testing. Set the LP8 L-pad down with the shaft pointing away from you and the solder lugs pointing downward. The lugs in this orientation are numbered 1, 2, and 3, left to right. (This same orientation and numbering procedure also applies to the LP-16 control.)

Solder a 10″ wire and one of the terminal strip conductors to lug 1; a 16″ and a 7″ wire to lug 2; and the remaining terminal strip conductor to lug 3.

Now place before you the LP16 control. Connect and solder a 5″ wire to lug 1 and an 11″ wire to lug 2.

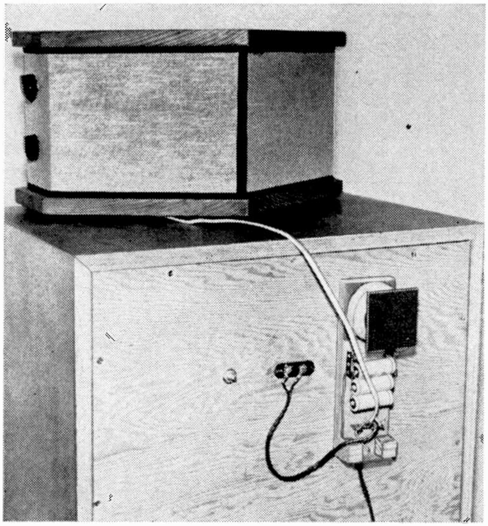
Drill the holes for and mount the two controls, locating the LP16 at the top. Connect and solder the loose end of the 7″ wire from lug 2 of the LP8 pad to lug 3 of the LP16 control. The remaining loose wire ends will be connected later, after the speakers are mounted inside the enclosure.

Carefully unpack the speakers and determine the voice coil polarity of each with a 1.5-volt battery. To determine the polarity, momentarily touch the contacts of the battery across each pair of speaker terminals, and observe the direction of cone movement at the moment of contact. If the cone moves outward, mark the terminal adjacent to the positive pole of the battery with a permanent identifying mark (red dot or scribed plus sign). Inward movement of the cone indicates that the terminal adjacent to the negative pole of the battery should be marked.

Now install the speakers on the front and rear mounting boards, pointing the solder terminals on the speakers toward the top of the enclosure. (If all speakers are the same brand name and model number, all identifying marks will likely be either on the left or the right, greatly simplifying wiring.) Note that you will have to remove the four mounting bolts nearest the chamber separator panel before mounting the speakers on the rear panels of the enclosure.

When you tighten the mounting hardware, do not apply excessive force or you will deform the speaker baskets.

Finish wiring the Mini-Six according to Fig. 5. After wiring is completed,



System crossover network mounts on rear of woofer enclosure; connecting wires are routed as desired.

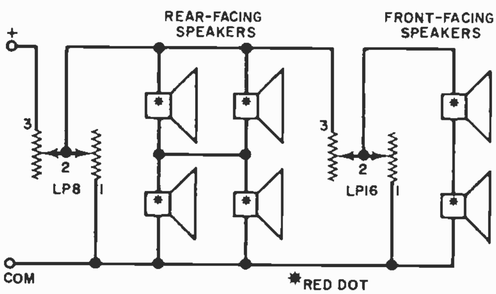


Fig. 5. Combination of series and parallel-series is used to obtain 4-8 ohms impedance.

BILL OF MATERIALS

6—5" x 3" replacement-type 8-ohm speakers
1—8-ohm L-pad (Calrad LP8, or similar)
1—16-ohm L-pad (Calrad LP16, or similar)
1—100-μF nonpolarized capacitor (see text)
1—1-lb spool #18 magnet wire
1—Two-terminal screw-type terminal strip
1—15½" x 6¾" piece of ½" plywood for front panel
2—9½" x 6¾" pieces of ½" plywood, edges cut at 60° angle, for sides
2—6¾" x 2 13/16" pieces of ½" plywood, one edge cut at 60° angle, for compartment separator panel
1—6¾" x 1¼" piece of ½" plywood for separator panel (see text)
2—16½" x 9" pieces of ¾" clear pine shelving for top and bottom
1—36" length of ¾"-square pine for cleats
8—1¼" x #8 flathead wood screws to anchor cleats to top of enclosure
2 doz—1" x #8 flathead wood screws
2 doz—1" x 3/16" flathead stove bolts for speaker mounting
Misc.—Grille cloth; three-penny finishing nails; wood glue; nuts for stove bolts; wire; solder; etc.

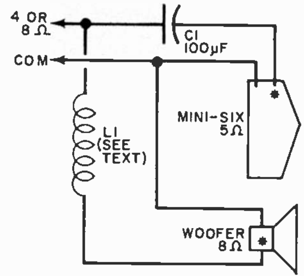
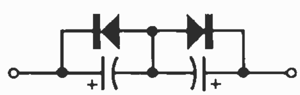


Fig. 6. Homemade crossover network must be connected between Mini-Six and woofer as shown.

DIODES "DE-POLARIZE" POLARIZED CAPACITORS

A low-cost method of obtaining the equivalent of a high-capacity non-polarized capacitor was recently suggested by Don Purland in a recent issue of "Electronic Design" magazine. As shown in the diagram, two polarized capacitors, each twice the desired value and connected back-to-back, cancel out the polarizing effect. But to prevent an undesirable reverse voltage appearing across either capacitor (even though each is "protected" by the other), connect a silicon diode in reverse polarity across each capacitor.



The capacitors in this arrangement will never "see" the reversed voltage since the diode shorts out the capacitor that is connected into the circuit backwards.

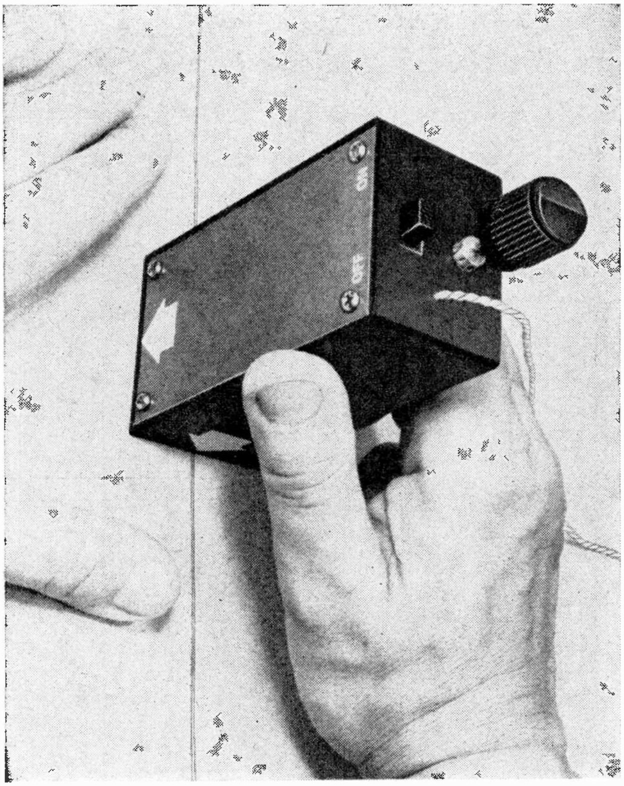
Although untested at this writing, the suggestion seemingly has great merit since it permits the use of cheaper capacitors of more common values.

check the polarity of the system by the same method used for the individual speakers, and identify the positive screw terminal with a permanent mark. Check that all cones move in a common direction.

Connect the Mini-Six to the 4- or 8-ohm output of your amplifier to check for "buzzes" and "rattles." A sweep-frequency test record is ideal here, but you can substitute a variety of music programs in a pinch. If you detect a buzz or rattle, locate the speaker causing it and loosen or tighten the mounting hardware until the problem clears up.

Now check the LP8 and LP16 controls

(*Continued on page* 38)



Carpenter's Mate

TINY METAL LOCATOR FOR TINY METAL

BY JOHN S. SIMONTON, JR.

THOSE LITTLE magnetic gadgets that carpenters use to locate studs work fine if you're looking for ferrous nails. They won't do the job, though, for a boat owner trying to avoid sanding and sawing the brass hardware used on his craft.

If you have this problem, you can save some of the time you're spending developing a sailor's vocabulary and some of the money you use replacing chewed up saw blades by building the "Carpenter's Mate." It locates ferrous or non-ferrous metals quickly and easily.

The Carpenter's Mate, not much bigger than a pack of cigarettes, works just the same as larger types of metal locators except that it has a very restricted range and better resolution (pin-point accuracy). By using a small search coil (mounted inside the plastic case) maximum range has been reduced to about 2 inches while resolution is increased so that even a small wire brad—detected head on—can be spotted. The Carpenter's Mate slips easily into your shirt pocket and can be put into operation as fast as you can turn it on.

Construction. The circuit of the Carpenter's Mate is shown in Fig. 1. Layout is critical and since radio frequencies are involved, good wiring practice should be followed and all leads should be as short as possible. A circuit board simplifies the construction. You can make your own using Fig. 2 as a guide or you can buy one.

Parts placement on the board is shown in Fig. 3. The leads of *Q1* and *Q2* are bent so that the flat sides of their bodies can be placed adjacent to one another and glued together. This helps to maintain the two transistors at the same temperature to stabilize the relative frequencies of the two oscillators.

The sensing coil, *L1*, is made by modifying a standard J.W. Miller #6300 or equivalent High-Q variable inductor. Make the modification by removing the tuning slug and carefully cutting the threaded brass tuning screw off flush with the ferrite core material. Then carefully unsolder the lead wires from the terminals on the side of the coil and use a sharp knife to cut the form so that the coil winding is centered between the ends

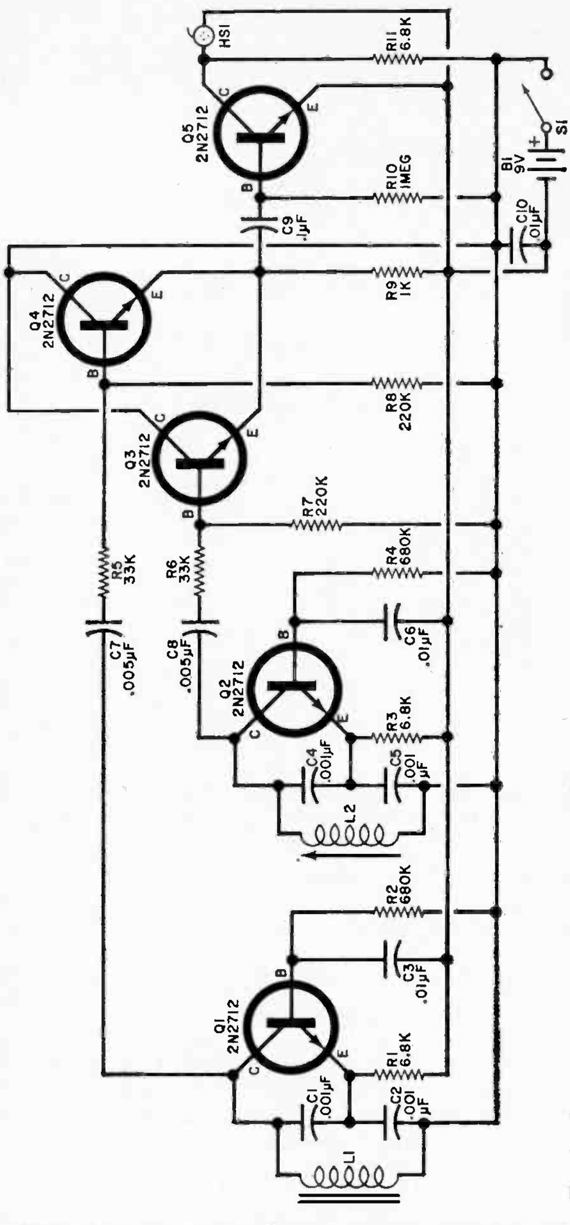


Fig. 1. The two r.f. oscillators (Q1 and Q2) mix in the two emitter followers (Q3 and Q4) and produce an audible sound that is a function of their frequency difference. This difference occurs when L1 is brought close to a piece of metal.

PARTS LIST

B1—9-volt transistor battery
C1,C2,C4,C5—0.001-µF ceramic disc capacitor
C3,C6,C10—0.01-µF capacitor
C7,C8—0.005-µF capacitor
C9—0.1-µF capacitor
HS1—High-impedance earphone
L1, L2—High-Q Ferrite Antenna Coil (J.W. Miller #6300 or similar)
Q1-Q5—2N2712 transistor
R1,R3,R11—6800-ohm
R2,R4—680,000-ohm
R5,R6—33,000-ohm
R7,R8—220,000-ohm
R9—1000-ohm
R10—1-megohm
All resistors ½-watt
Misc.—Plastic case 1⅝" x 4" x 2⅛" with metal cover, battery connector, battery clip, wire, solder, epoxy cement.
Note—The following are available from PAIA Electronics, P.O. Box 14359, Oklahoma City, Okla. 73114: etched and drilled PC board, $2.00; complete kit of parts including cement, $9.95; postpaid in continental U.S.A. Okla. residents, add 3% sales tax.

of the form. Slide the ferrite slug back into the coil and center it before securing it in place with a dab of cement.

The completed unit is housed in a 1⅝" × 4" × 2⅛" plastic utility box (see Fig. 4). To prevent tone changes associated with touching exposed metal hardware, all internal components, including *L1, S1,* and the PC board are glued in place with epoxy cement. Clean all mating surfaces thoroughly with steel wool before gluing. Blow away all steel-wool debris to avoid shorts. Drill a hole for *S1* at one end of the box and glue it in place. Then drill a hole on the same end for the mounting clip of *L2* and snap it into place. Drill a small hole near these two to pass the earphone cord. Make a knot at the inside end of the cord to prevent it from being pulled through.

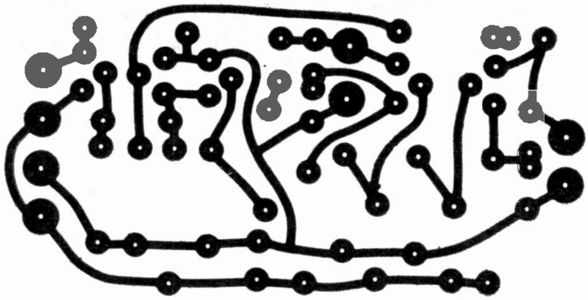


Fig. 2. Actual-size foil pattern to be used in making the PC board.

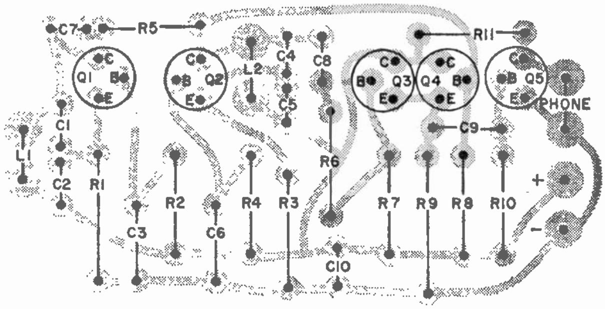
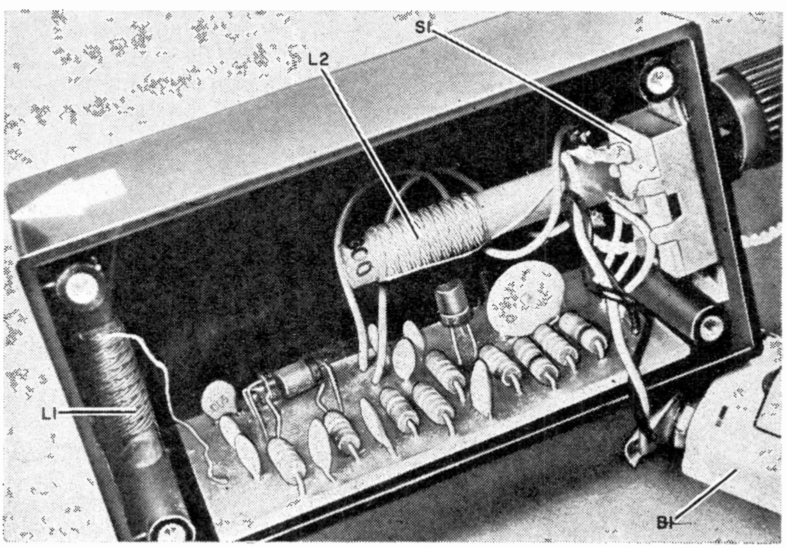


Fig. 3. Other than transistors, component polarities are not critical.

Mount *L1* at the center of the undrilled end of the box, using epoxy cement. Before mounting, make sure that the leads are long enough to reach the terminals on the PC board. If they are not, either unwind a little wire from the coil or solder on short extensions. Before mounting the PC board, connect up the circuit and put a small knob on the protruding shaft of *L2*. Turn on the power and adjust *L2* until a whistle is heard in the earphone. Once you hear this whistle,

Fig. 4. The entire instrument is easily mounted in a small plastic box. Place arrowheads to indicate the center of the search coil. All parts mount with epoxy.



you know that the circuit is operating. Turn off the power and cement the board in place using a drop of cement at each corner.

When attaching the battery clip to the cover, place it slightly off center to keep it from interfering with the circuit board components when the cover is in place.

Operation. Hold the unit clear of any metal, turn it on, and insert the earphone in your ear. Withdraw the core from *L2* by turning its adjusting screw knob counterclockwise. As the slug passes through the coil, you will hear a rising and falling tone. While any position of the slug which produces a tone may be used as an operating point, the most desirable setting can be found in the following manner. Start with the slug screwed out about an inch. At approximately this point, a tone considerably louder than the others will be heard. Continue to withdraw the core until a null is reached. Slightly before this null point is the best position for locating non-ferrous metals. In this case, the presence of a non-ferrous metal causes a slight increase in the oscillator frequency, causing the signal to go toward the null point. For detection of ferrous materials, withdraw the slug so that the tone is slightly beyond the null point. The presence of a ferrous object then decreases the oscillator frequency, again bringing the tone down to the null. By positioning the slug on either side of the null, it is possible to identify either ferrous or non-ferrous materials. If you leave the slug so that a relatively low audio frequency is heard, the frequency will go up or down depending on the metal detected.

To get some practice using the Carpenter's Mate, use a test surface which you know contains a piece of brass hardware. With the case held so that the side adjacent to the sensing coil is pressed lightly against the test surface, move the device over the area. The tone will decrease noticeably when the sensing coil is directly over the brass. With the proper adjustment of *L2*, the null point will be reached when the metal is detected.

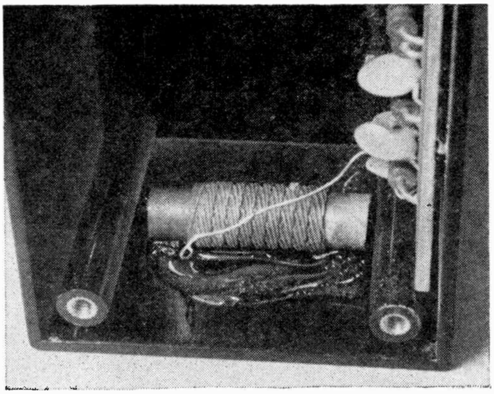
Four clearly visible arrows can be drawn or pasted on the sides of the box at the *L1* end so that scribe marks can be made on the test surface to locate the detected metal under the center of the coil. If the coil is exactly centered in the end of the box, the arrows should be centered on the sides. It is possible to orient *L1* so that it butts against the end of the box. In this case, the sensitive area is greatly reduced permitting more accuracy in location. However, with this arrangement there is always the chance that the coil will be dislodged when the instrument is moved about. —30—

HOW IT WORKS

Transistors *Q1* and *Q2* and their associated components form two independent Colpitts oscillators. The outputs of these oscillators are combined in the mixer composed of *Q3* and *Q4* and the resulting signal appears across the common load resistor *R9*. Since the mixer is nonlinear, the output signal contains the two original frequencies and also the sum and difference of the two. However, only the difference signal is within the range of human hearing. This signal is amplified by *Q5* and used to drive the high-impedance crystal earphone.

When a metallic object (either ferrous or non-ferrous) comes close enough to *L1* to intercept and distort the magnetic field surrounding the coil, there is a change in the effective inductance of the coil. This causes a change in the frequency of the "sense" oscillator *(Q1)*. This relatively small change in the frequency of the oscillator can be heard as a significant change in the tone in the earphone.

To minimize "pulling" of the oscillators and the tendency of the two to lock on to the same frequency, the "local" oscillator *(Q2)* is adjusted to run at about twice the frequency of the "sense" oscillator.



Coil L1 should be mounted with epoxy cement on the blank end of the box in exact orientation shown.

Free

World's Largest Electronic Kit Catalog

over 300 kits for every interest...save up to 50%

Join the millions who have discovered that they can *build* a better product than they can buy . . . have fun . . . & enjoy substantial savings in the process. No special skills are required to assemble Heathkit electronics...just follow our simple step-by-step instructions. Send for your free Heathkit catalog now...and discover the fun & satisfaction of building the best.

- NEW Solid-State Color TV
- Deluxe Tube-Type Color TV
- Stereo/Hi-Fi Components
- Transistor Organs
- Home Equipment
- Shortwave Radios
- Amateur Radio Equipment
- Musical Instrument Amplifiers
- Automotive Electronics
- Marine Electronics
- Trail Bikes
- Test & Lab Equipment
- Home Study Courses
- Scientific Instrumentation
- Radio Control Electronics

SEND FOR YOUR FREE COPY TODAY!

HEATHKIT
a Schlumberger company

HEATH COMPANY, Dept. 110
Benton Harbor, Michigan 49022
Please send FREE Heathkit Catalog

Name ________________

Address ________________

City ________ State ________ Zip ________

CL-390

CIRCLE NO. 9 ON READER SERVICE CARD

MINI-SIX

(*Continued from page* 30)

for proper operation. Rotating the LP8 clockwise should increase the total volume of sound; clockwise rotation of the LP16 should increase the sound level coming from the two front speakers only.

Final Assembly. Disconnect the amplifier, and fill the enclosure with small cut-up pieces of fiberglass batting. Then cement felt or weather stripping to the top edges of the shell to provide a proper sealing gasket for the enclosure. Set the top panel in place and screw it down.

Starting and ending at the apex of the rear panels, wrap the sides of the enclosure with grille cloth. Cover the exposed edges with ¼″-wide velvet ribbon or other finishing material.

If you do not have a suitable crossover network, a simple coil-capacitor arrangement as shown in Fig. 6 will suffice. Capacitor *C1* is a 100-μF *non*polarized type (if you cannot obtain this value, parallel-connect three 33-μF, 25-volt nonpolarized capacitors). The coil, *L1*, is homemade, consisting of 1 pound of #18 magnet wire (about 500 turns) wound on a 1″-diameter by 1½″-long coilform made of wood doweling and Masonite. When connecting the Mini-Six to your present speaker system, disconnect the LC network in the system.

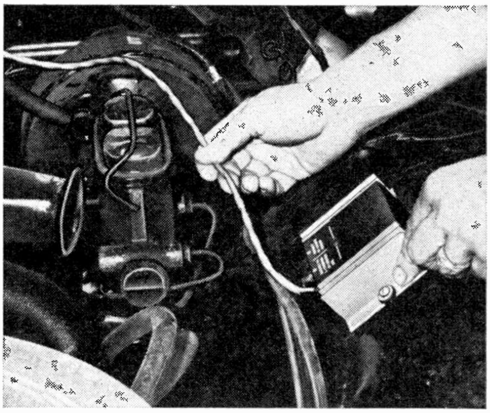
When using the Mini-Six, place it so that the apex of the enclosure is about 12″ from the reflecting surface. Now, set the LP8 control so that a proper balance is obtained between the bass speaker and the Mini-Six. Then have someone adjust the setting of the LP16 as you move about the room. This control is properly set when a minimum change in the high-frequency response of the system can be detected as you cross the listening area. (For the stereo version, set each Mini-Six system independently.)

As you listen to the composite speaker system in different locations in your listening room, you will come to realize that your favorite listening chair is not so special any more. The big change you will notice is that the Mini-Six adds a feeling of depth and spaciousness that was missing before. —30—

DWELL EXTENDER

(*Continued from page* 24)

Identify the connections on the ignition coil. There are usually three wires: one (large diameter coming from the insulated top of the coil) carries the high voltage to the distributor; one goes to the ignition switch and may be marked (+) or "BATT"; and the third goes to the distributor (where the points are) and is marked (−) or "DIST." This last connection is the one you want. Loosen the nut that secures this lead to the coil and insert the lead from the proper terminal on the Dwell Extender. Do not remove any existing wires. Tighten the nut, making sure that all of the leads are making good contact with the coil terminals. Locate a convenient ground screw or nut. Loosen it and insert the ground lead from the Dwell Extender. Retighten the screw or nut.



Mount the Dwell Extender in relatively cool place (in this case on sheet-metal wheel housing) using suitable mounting hardware and shock-absorbing rubber grommets at two heat-sink mounting holes. The two-wire connecting cable can use same mounting hardware as the conventional engine wiring system.

Use #18 insulated wire to make these electrical connections. A spade lug can be soldered to each wire to make it easier to connect to the proper points.

When new points are installed or you want to check dwell time, disconnect the Dwell Extender by removing the one wire to the ignition coil. Once the dwell has been checked or reset, reconnect the Dwell Extender lead. —30—

PSYCHEDELIA 1

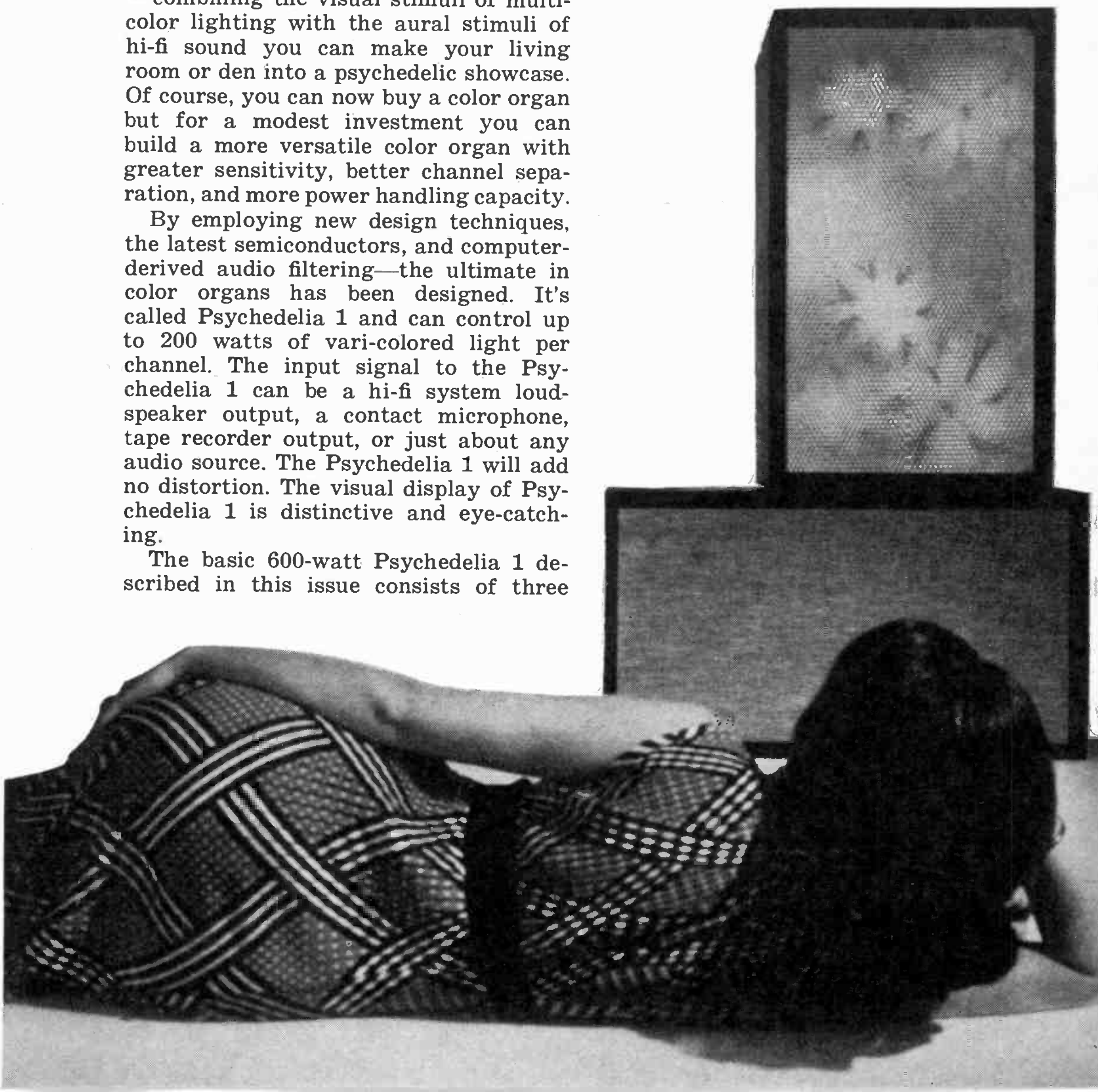
Color Organ Designed for the 70's Opens New Vistas in Display of Sound

BY DON LANCASTER

THIS IS the day of the color organ. By combining the visual stimuli of multi-color lighting with the aural stimuli of hi-fi sound you can make your living room or den into a psychedelic showcase. Of course, you can now buy a color organ but for a modest investment you can build a more versatile color organ with greater sensitivity, better channel separation, and more power handling capacity.

By employing new design techniques, the latest semiconductors, and computer-derived audio filtering—the ultimate in color organs has been designed. It's called Psychedelia 1 and can control up to 200 watts of vari-colored light per channel. The input signal to the Psychedelia 1 can be a hi-fi system loudspeaker output, a contact microphone, tape recorder output, or just about any audio source. The Psychedelia 1 will add no distortion. The visual display of Psychedelia 1 is distinctive and eye-catching.

The basic 600-watt Psychedelia 1 described in this issue consists of three



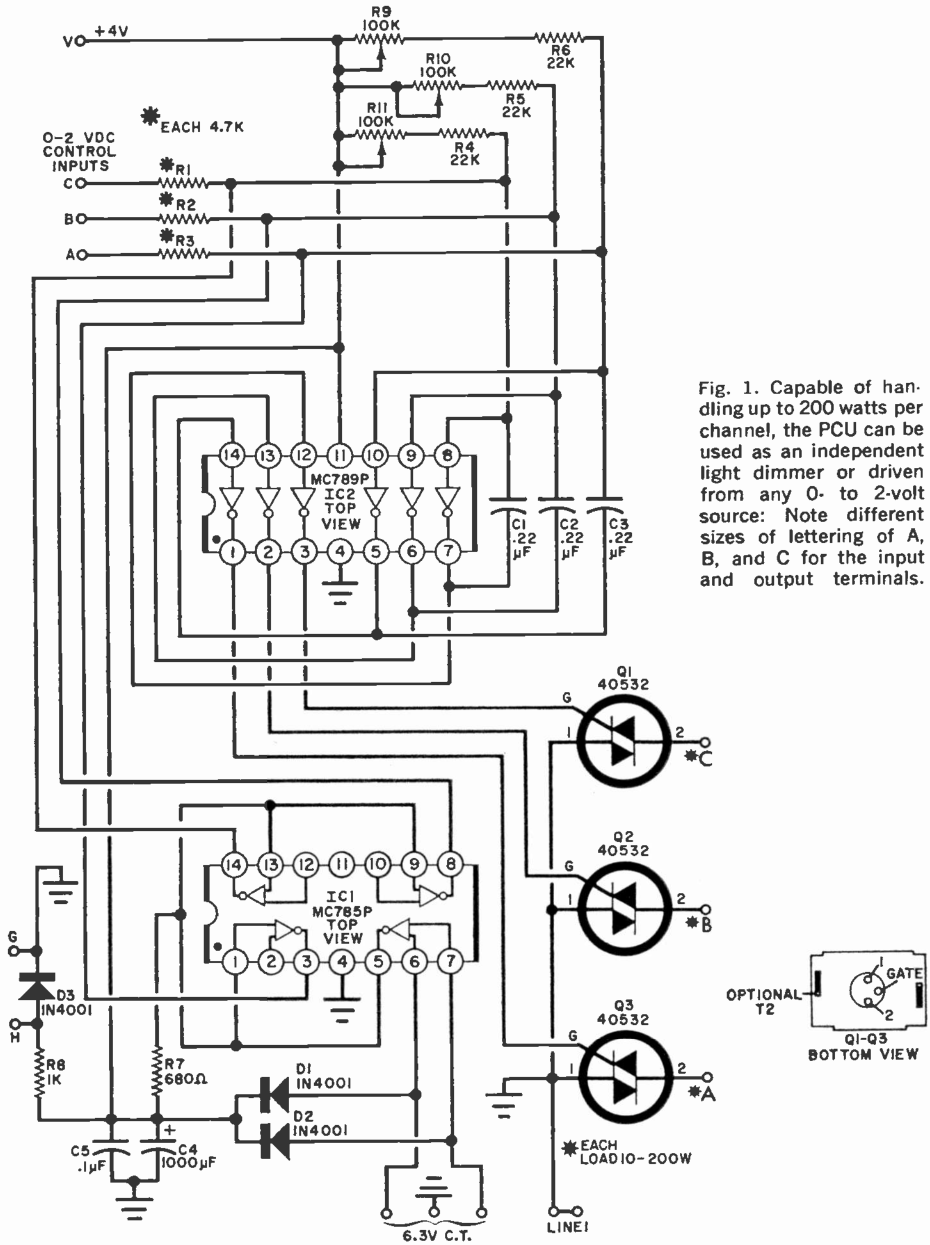


Fig. 1. Capable of handling up to 200 watts per channel, the PCU can be used as an independent light dimmer or driven from any 0- to 2-volt source: Note different sizes of lettering of A, B, and C for the input and output terminals.

PARTS LIST POWER CONTROL UNIT

C1-C3—0.22-µF, 50-volt Mylar capacitor (see text)
C4—1000-µF, 5-volt electrolytic capacitor
C5—0.1-µF, disc ceramic capacitor
D1-D3—30-volt, 500-mA silicon power diode (1N4001 or similar)
IC1—MRTL quad two-input expander (Motorola MC785P)
IC2—MRTL hex inverter (Motorola MC789P)
Q1-Q3—Triac (RCA 40532, no substitute)
R1-R3—4700-ohm, ¼-watt resistor
R4-R6—22,000-ohm, ¼-watt resistor
R7—680-ohm, ¼-watt resistor
R8—1000-ohm, ¼-watt resistor
R9-R11—100,000-ohm trimmer potentiometer (CTS U-201 or similar)
Misc.—Male quick-disconnect PC terminals (Keystone #1256 or #1257 or similar, 3 required); mounting hardware; solder; etc.
Note—The following are available from Southwest Technical Products, Box 16297, San Antonio, Texas, 78216: etched and drilled PC board, #501, $2.80; complete kit of all parts, #501-K, $13.90; postpaid in U.S.A. Individual parts and assembled and tested units are also available.

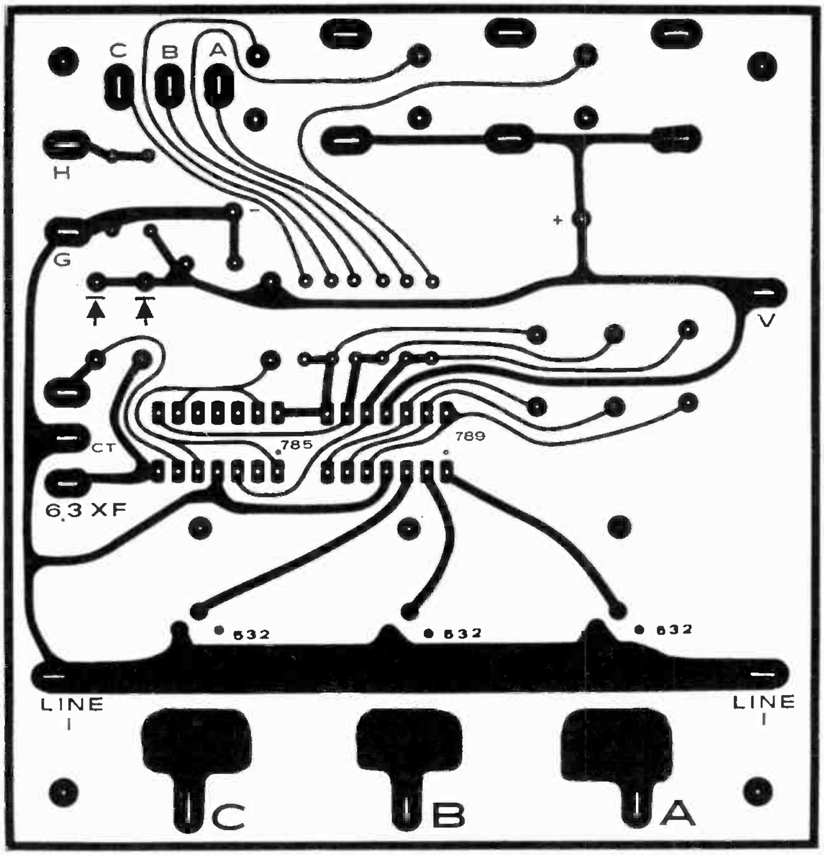
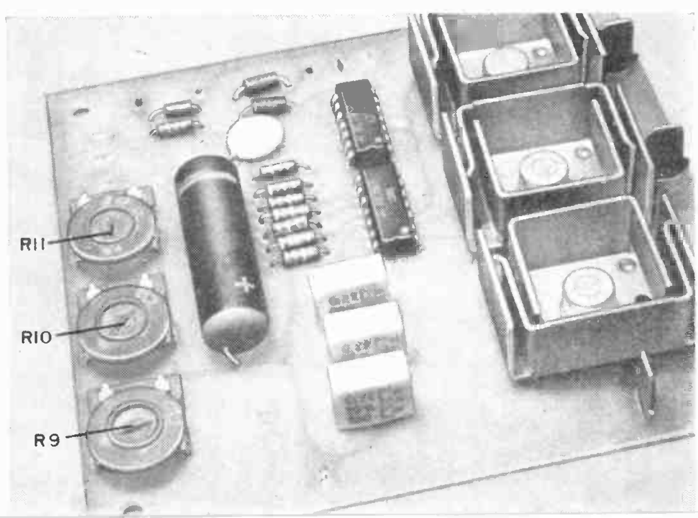


Fig. 2. This foil pattern for the PCU PC board is actual-size and can be reproduced.

elements: a power control unit (PCU), a quality filter unit (QFU), and a holographic bookshelf display. This is all you need for a "starter" system.

Power Control Unit. This is a three-channel (200 watt per channel) full-wave proportional (or strobe) a.c. power controller. It uses three triacs and two IC's in a unique, recently designed circuit. It has continuous gate drive for the triacs, eliminating channel-to-channel interaction; it is very sensitive and requires only 0-2 volts d.c. for operation; and it is mechanically simple. The triacs have their own built-in heat sinks and require no insulation or mounting hardware. Three background control po-



The three background controls should be screwdriver adjusted. The three triac heat sinks may be "hot" or ground, depending on polarity of line.

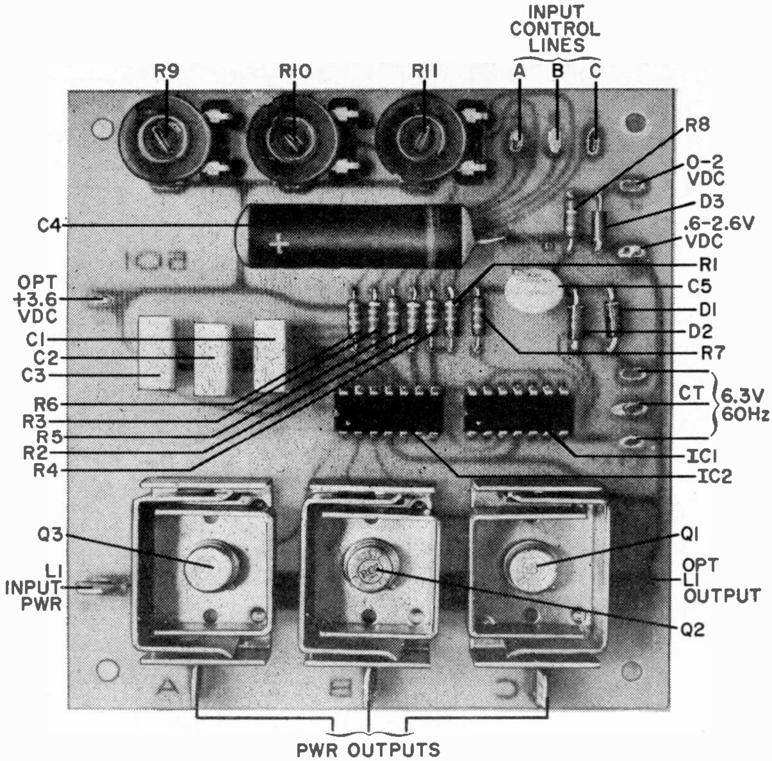
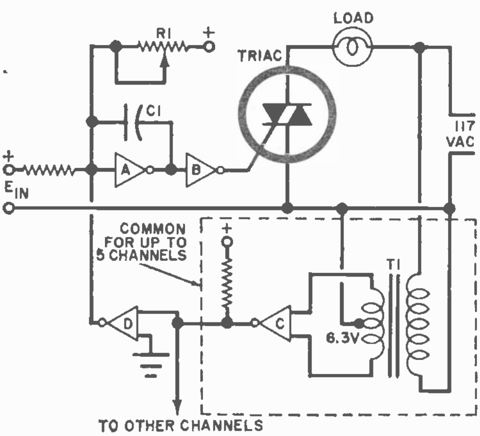


Fig. 3. To install the components, follow the arrangement shown here. Soldered-in, slip-on power terminals are to be used for the output.

HOW IT WORKS
POWER CONTROL UNIT



As shown in the simplified schematic, in the Power Control Unit, Inverter A is a single *npn* gain stage which, with capacitor *C1* forms a ramp generator. The amplitude of the ramp is at a maximum each time the reference or a.c. line voltage passes through zero. The build-up and decay of the ramp are determined, as we shall see, by other elements in the circuit.

Inverter B operates whenever the ramp voltage drops below 0.6 volt. Above 0.6 volt, the inverter holds the triac in the nonconducting state and below 0.6 volt, the triac is conducting. In this way, the triac gate is either clamped to ground or to a positive voltage so that the possibility of gate interactions is eliminated. Inverter B also isolates the loading effect of the triac from the ramp generator.

The triac acts as a series switch between the supply and the load, automatically turning off when the a.c. line passes through zero. Once it is off, the triac stays off until the ramp voltage drops below 0.6 and the inverter supplies a gate signal. The decay time of the ramp voltage is determined by the size of the input control voltage E_{in} and the resultant input current. The higher the input, the faster the ramp decays and the sooner the triac turns on during each cycle. Thus more power is supplied to the load and the light is brighter.

The ramp generator is reset each time the supply goes through zero by a synchronizing signal provided by transformer *T1* and gate expander *C*. Each time the supply passes through zero, a 0.5-millisecond positive pulse drives expander D to recharge capacitor *C1* and return the ramp to its initial positive value. Only one synchronizer circuit is required for 5 or less channels.

Background control is obtained by applying a constant d.c. level in parallel with the input through potentiometer *R1*.

Strobe or on-off operation of the Psychedelia 1 can be obtained by decreasing the background control to a minimum. This produces an abrupt switching action.

tentiometers permit the user to preset the "off" level of the display lamps.

The schematic of the PCU is shown in Fig. 1. The unit is assembled on a fiberglass PC board using the foil pattern shown actual-size in Fig. 2. Once the board has been made or purchased, mount the components as shown in Fig. 3. Observe the notch, dot, and lead code on the semiconductors and polarity markings on the electrolytic capacitors. The case lead (*T2*) on each triac may be cut short since the *T2* connection is made when the heat sink is soldered in place on the board. The triacs come with an integral heat sink and require no insulation from the board. Install quick-disconnect male terminals at the triac outputs, which are marked **A, B,** and **C** beside each heat sink.

Quality Filter Unit (QFU). This circuit takes a relatively low-level audio input, divides it into three isolated frequency bands, and provides three proportional control voltages for the PCU. The QFU is considerably more complex than most color organ filters, but it gives the finest filtering ever offered for a lighting display. Usual filter problems involving display washout, multiple-channel tracking, input loading, distortion, requirements for high input levels, nonlinearity and limited dynamic range have been eliminated.

Among the unique features of the QFU are active filters with very steep slopes and narrow guard bands between channels, and the use of an averaging detector.

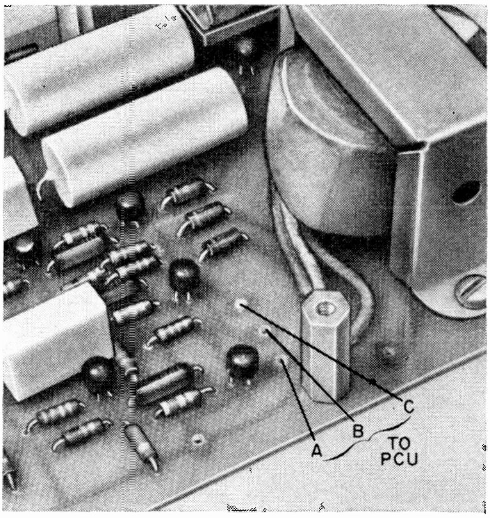
An averaging detector responds to the average value of a signal for a few milliseconds instead of instantaneous peak values. This makes the display less susceptible to radical input variations and eliminates threshold nonlinearity.

The filters are a combination of transistors and passive components called a "two-pole Tschebyscheff." They would require two high-Q, load-isolated inductors per channel if conventional parts were used.

Guard bands are "holes" between the filter responses. These no-response areas between the channels eliminate multiple-channel tracking on a single loud passage or a dominant instrument. Because of the high harmonic content of most music, the guard bands lose very little of the music. Usually there is *too much* "information" in most music for a psychedelic light display to handle. If a little of the music information is thrown away, the display action is much livelier and is without washout or multiple tracking.

Since transistors are used for the filters in the QFU, they also provide gain. The result is excellent sensitivity, no noticeable loading of the input circuit, and no noticeable distortion since the input impedance is resistive at all frequencies of interest.

Resistor *R44* (see Fig. 4) provides input protection and also serves as a sensitivity adjustment. For normal audio listening levels with a 5- to 20-watt amplifier, use the 47-ohm resistor specified. For lower power levels, *R44* can be reduced to 12 ohms, 1 watt. For high-power systems, increase *R44* to at least 100 ohms, 10 watts. The resistor should be the largest ohmic value that still gives acceptable sensitivity to minimum-volume passages.



Holes marked A, B, and C on QFU provide outputs to PCU. The single spacer shown here is one of four used to attach PCU and QFU boards together.

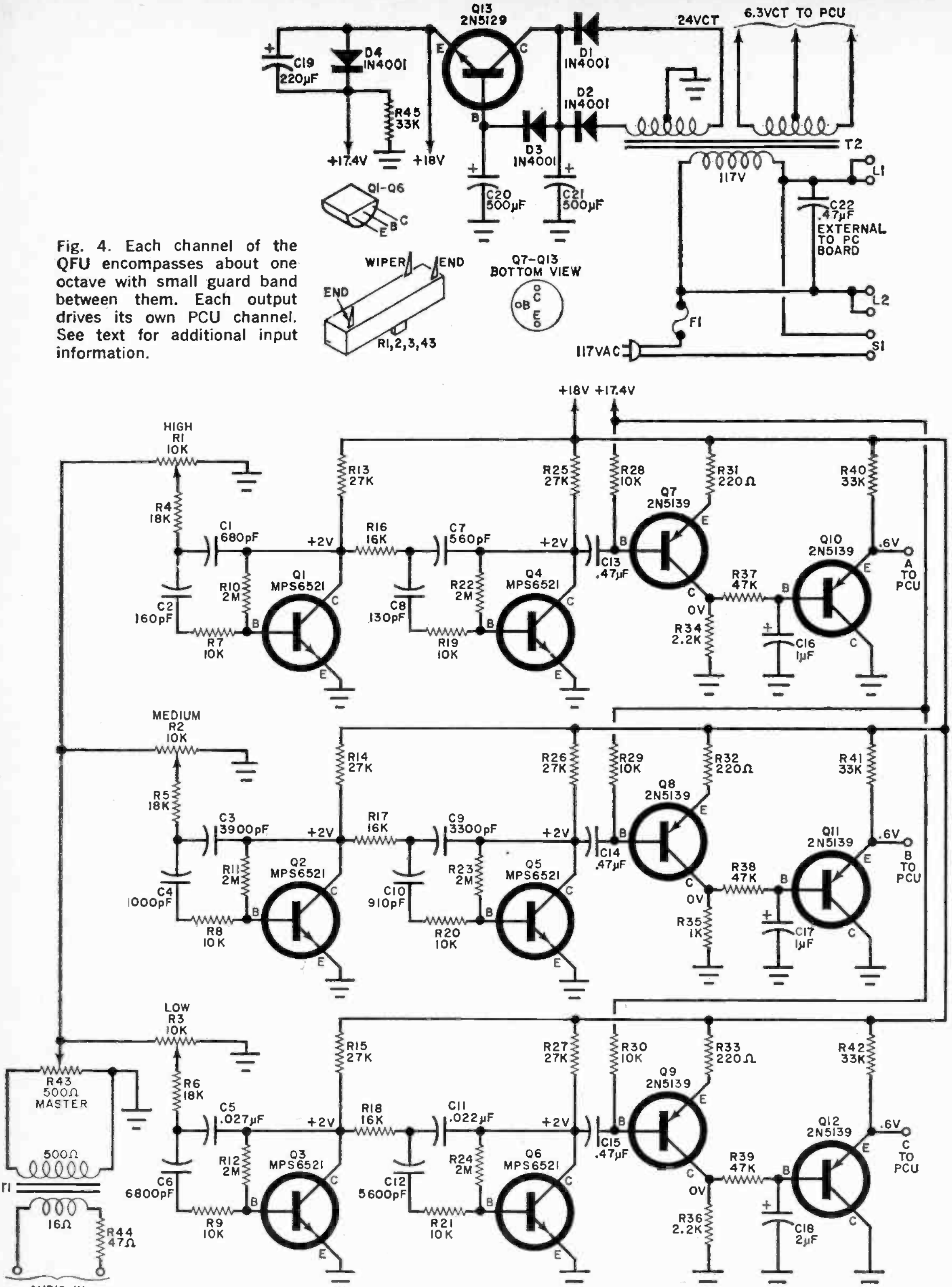
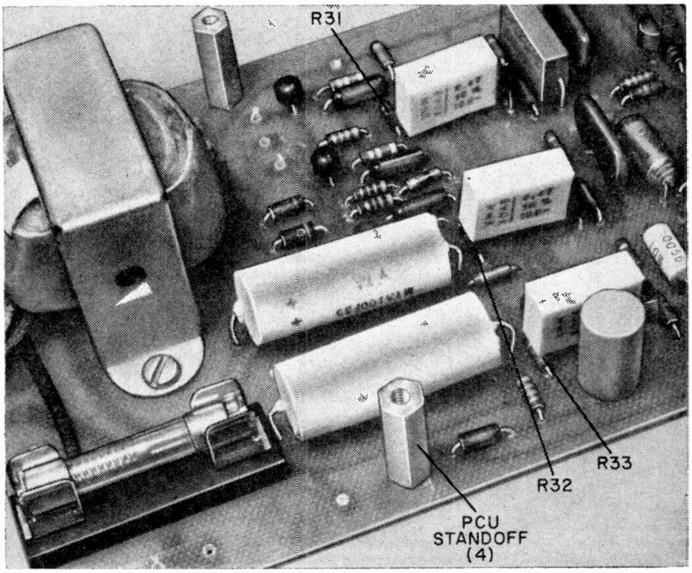


Fig. 4. Each channel of the QFU encompasses about one octave with small guard band between them. Each output drives its own PCU channel. See text for additional input information.

PARTS LIST
QUALITY FILTER UNIT (QFU)

C1—680-pF, 5% mica or polystyrene capacitor
C2—160-pF, 5% mica or Mylar capacitor
C3—3900-pF, 5% Mylar or polystyrene capacitor
C4—1000-pF, 5% Mylar or polystyrene capacitor
C5—0.027-µF, 5% Mylar or polystyrene capacitor
C6—6800-pF, 5% Mylar or polystyrene capacitor
C7—560-pF, 5% Mylar or polystyrene capacitor
C8—130-pF, 5% Mylar or polystyrene capacitor
C9—3300-pF, 5% Mylar or polystyrene capacitor
C10—910-pF, 5% mica or polystyrene capacitor
C11—0.022-µF, 5% Mylar or polystyrene capacitor
C12—5600-pF, 5% Mylar or polystyrene capacitor
C13-C15—0.47-µF Mylar capacitor (do not substitute an electrolytic)
C16,C17—1-µF, 6-volt tantalum or electrolytic capacitor
C18—2-µF, 6-volt tantalum or electrolytic capacitor
C19—220-µF, 6-volt electrolytic capacitor
C20,C21—500-µF, 20-volt electrolytic capacitor
C22—.47-µF, 600-volt high-quality Mylar capacitor
D1-D4—1-ampere, 50-PIV silicon power diode (1N4001 or similar)
F1—Fuse to suit load, clip mounted to board
Q1-Q6—Transistor (Motorola MPS6521, no substitute)
Q7-Q12—Transistor (National 2N5139)
Q13—Transistor (National 2N5129)
R1-R3—10,000-ohm, color-coded slide potentiometer, one each red, blue, and green (Southwest Technical #S-10K-R, S-10K-B and S-10K-G or similar rotary equivalent or stack pole slide-trol)
R4-R6—18,000-ohm, 5%
R7-R9,R19-R21—10,000-ohm, 5%
R10-R12,R22-R24—2-megohm
R13-R15,R25-R27—27,000-ohm
R16-R18—16,000-ohm
R28-R30—10,000-ohm
R31-R33—220-ohm
R34,R36—2200-ohm
R35—1000-ohm
R37-R39—47,000-ohm
R40-R42,R45—33,000-ohm
(All resistors ¼-watt)
R43—500-ohm, white-coded slide potentiometer (Southwest Technical S-500-W or similar rotary equivalent or stackpole slide-trol)
R44—47-ohm, 2-watt resistor
S1—S.p.s.t. switch
T1—Input transformer: 8- or 16-ohm primary, 500-ohm secondary, 5 watts, 500-volt winding-to-winding insulation. (Knight 54F1423, Southwest Technical PSY-T1 or similar)
T2—Power transformer: secondaries, 24 VCT at 100 mA and 6.3 VCT at 100 mA (Southwest Technical PSY-T2 or two separate filament transformers such as Knight 54F1416 (6.3 VCT) and 54F710 (24 VCT) or similar)
Misc.—Fuse mount; male quick-disconnect terminals (15); transformer rivets or hardware; mounting hardware; spacers for PCU; clamp for C22; solder; etc.
Note—The following are available from Southwest Technical Products, Box 16297, San Antonio, Texas 78216: etched and drilled PC board, #502, $5.50; complete kit of all parts, #502-K, $29.50; postpaid in U.S.A. Individual parts and assembled and tested units are also available.



The three resistors called out here cannot be seen in the top view as they are hidden by the three capacitors. Also shown are two of the four spacers that join the PCU to the QFU.

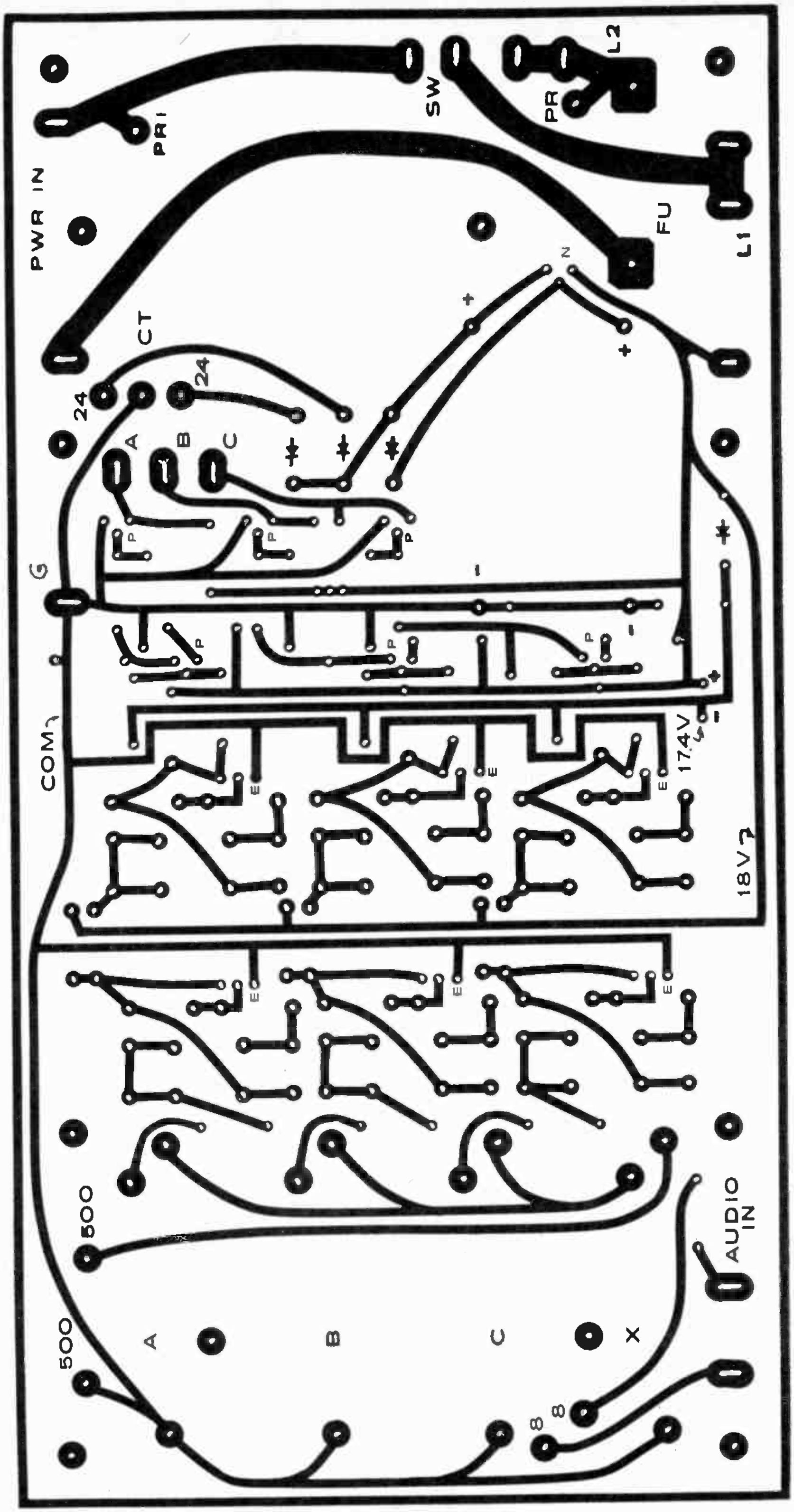


Fig. 5. You can copy this actual-size foil pattern for the QFU PC board or buy the boardreadymade.

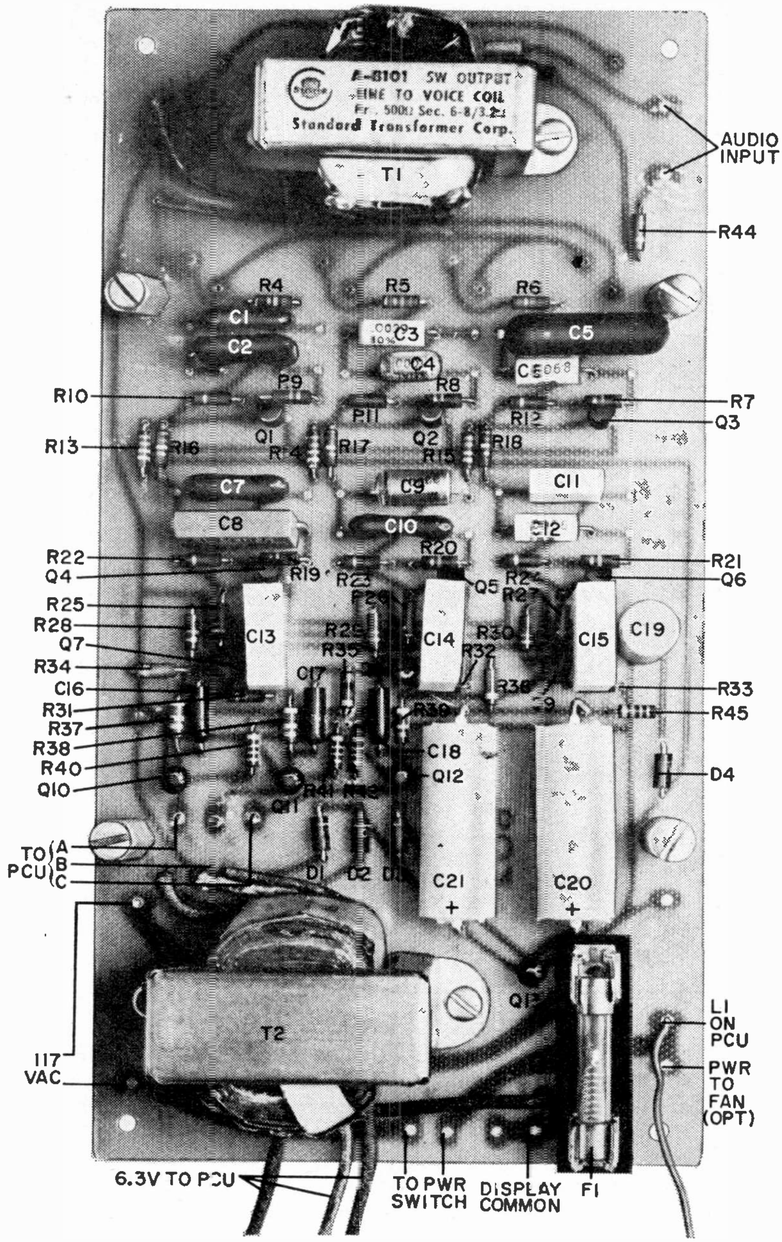


Fig. 6. Component installation on QFU PC board. Also shown are connections made to the board.

Construction of the QFU. The schematic of the QFU is shown in Fig. 4 and an actual-size foil pattern for the PC board is in Fig. 5. Components are installed on both sides of the PC board. The units on the foil side are shown in Fig. 6. Install the four slide potentiometers with the blue at *R1*, green at *R2*, red at *R3*, and white at *R43*. The components on the other side of the board are shown in Fig. 7. Transformers *T1* and *T2* are pop-riveted or bolted in place on the component side of the board. Except for the three leads to the 6.3-volt winding of *T2*, all transformer leads terminate on the *PC* board.

Do not be disturbed by what appear to be extra holes near the active filter capacitors. These holes permit the use of capacitors of different physical sizes at each stage. Use the holes that fit the capacitors you have. If you alter the PC

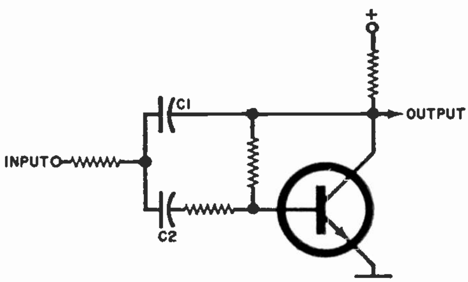
HOW IT WORKS
QUALITY FILTER UNIT

The heart of the QFU is an active filter with the basic configuration shown in the schematic. The transistor must have very high gain for proper operation. This circuit produces a single resonant peak such as that shown at B. Two of the filter stages are cascaded for each channel and the responses are slightly staggered to produce a steep-skirted, flat-topped, octave-wide response such as that at C.

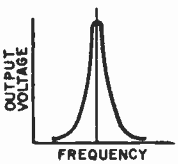
The values of capacitors *C1* and*C2* determine both the Q of the circuit and the center frequency. The capacitors used in the Psychedelia 1 were selected to produce the response shown at D. To experiment or add more channels, divide each capacitor value by the ratio of old to new center frequencies. For example, the low channel shown covers 50 to 100 Hz. To change it to cover 100 to 200 Hz, each capacitor value would be divided by 2. Do not change the ratios between capacitor values or the Q and bandpass values will be changed.

The output of each cascaded filter is applied to a detector transistor biased so that it is almost, but not quite, conducting. A negative-going audio signal turns the detector on, and vice versa. This type of detector produces some gain with a very low threshold offset. The detected signal is smoothed by an RC filter and coupled to the PCU through an emitter follower. The medium-frequency channel detector has half the gain of the others (*R35* is lower in value than either *R34* or *R36*). This compensates for the greater amount of medium frequencies than either high or low in most music.

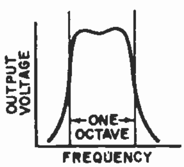
D.c. supply is obtained from a regulated supply powered by transformer *T2*. Dynamic regulator *Q13* insures excellent low-frequency bypassing. Transformer *T2* also provides 6.3 volts, center-tapped for the PCU. To prevent coupling hum in the low channel, *T1* and *T2* must be located at least 5½" apart.



(A)

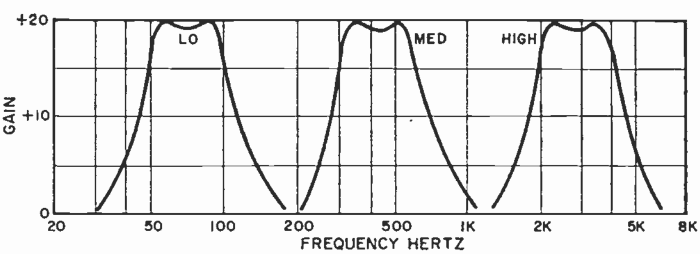


(B)



(C)

(D)



board layout, be sure that *T1* and *T2* are at least 5½" apart and that *T1* is at least 10" away from any other source of a.c. hum (motors, power transformers, etc.). Do not substitute for transistors *Q1* through *Q6* and use only polystyrene, Mylar, or mica capacitors for the filter elements. Above all, do not delete *T1* since it provides power-line isolation as well as impedance matching for the audio input.

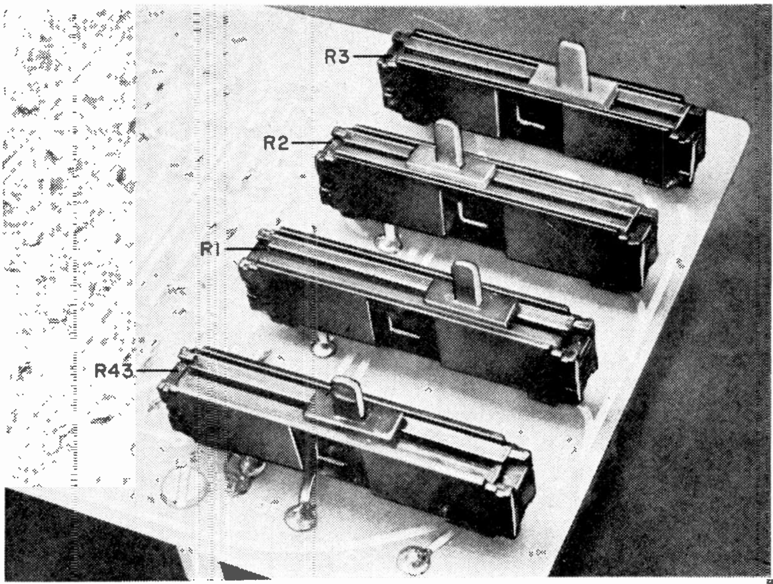
Capacitor *C22* is a noise reducing filter and can be mounted wherever convenient off the PC board. It must be a high-quality, 600-volt Mylar type.

Assembly. The PCU board can be mounted directly above the QFU board to form a control console. Use 1" spacers at each of the four corners of the PCU and mount the PCU on the four holes of the larger QFU board as shown in Fig. 8. Note how the two boards are aligned—component side of the QFU facing the foil side of the PCU with the triacs adjacent to *T1*. Short spacers can be used to mount the combined board on the front panel of the console you select. Only the four level potentiometers are exposed.

Make the board-to-board connections as shown in Fig. 9. For testing, connect three 25- to 40-watt lamps to the system as shown in Fig. 9. These are not the lamps used in the final display. They are for testing only.

Caution is advised from here on since portions of the PCU are referenced to ground and severe shock can be experienced if you touch certain leads.

Fig. 7. The three color-level and the master-level slide potentiometers are mounted on the foil side of the QFU PC board.



With the primary a.c. power turned on but no audio applied, the three lamps may or may not glow. Adjustment of the three background controls on the bottom of the PCU (*R9*, *R10*, and *R11*) should cause the respective lamps to vary in brightness from out to almost fully lit. Set the three controls so that the lamps barely glow.

With the audio input coupled to the speaker leads of a hi-fi or other power amplifier, turn up the volume to the source. Slide control *R43* is the master gain control and can be set at about ¾ of the way up. Adjustment of each of the channel slide potentiometers will cause the respective lights to glow in proportion to the amount of power in that frequency range. Check each control for smooth operation.

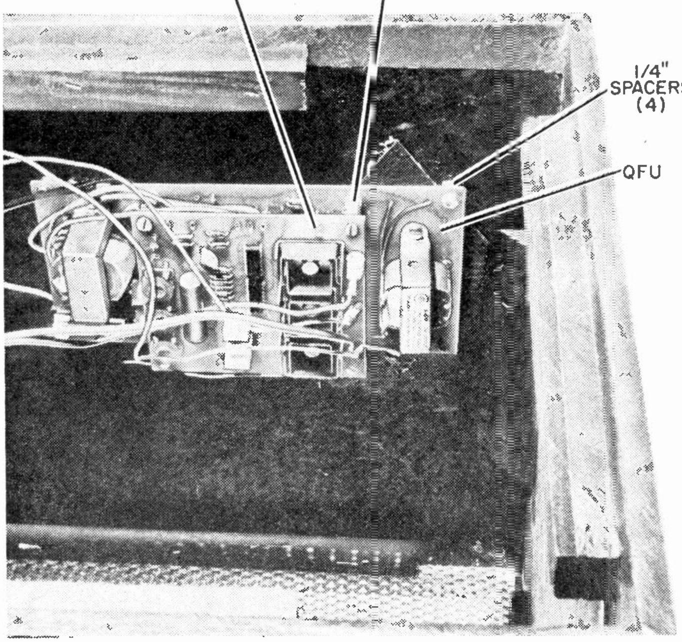


Fig. 8. Four 1" spacers are used to assemble the PCU and QFU boards together. Then use smaller spacers to mount the two of them on the top of the cabinet with the four sliders accessible through a cut slot.

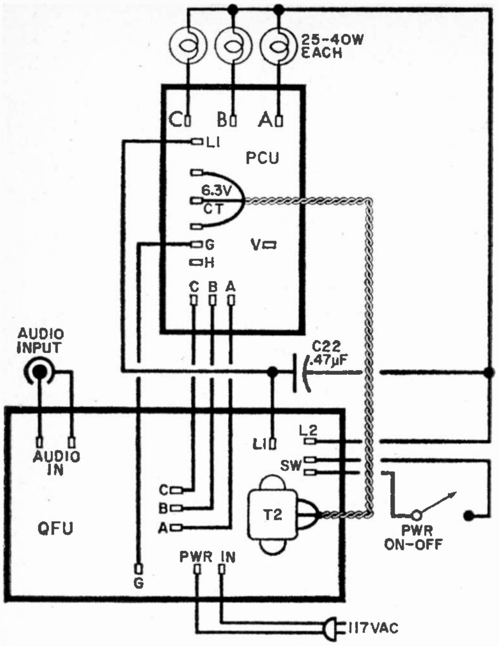


Fig. 9. Interconnection of the complete system.

If noise is created in the audio system, install capacitor *C22* as shown in Fig. 9. Some localized interference may be heard on the AM broadcast band, particularly if long display cables are used.

Holographic Bookshelf Display (HBD). A suggested display unit for the Psychedelia 1 is shown in the photos. It is 15″ × 16″ × 24″ with a durable vinyl covering and an attractive holographic imaging system. The HBD can be built as an integral unit with internal QFU and PCU units or it can be built separately for remote control. A maximum of four HBD's can be powered by one QFU/PCU combination.

Keys to successful display in the HBD are the holographic imaging panel and the lamp placement. The imaging panel is a rigid transparent plastic sheet with hexagonal lenses made up of individual wedge-shaped elements. If you look at a single colored lamp through the panel you see a six-petaled flower. The bulb diameter and the spacing of the bulb from the plastic sheet govern the size, shape, and petal details of the flowers.

Constructing the Display. The imaging panel is a light diffuser for fluorescent lighting usually suspended from the ceiling ("T-Bar" or "Grid Lume"). You can buy it at your local hardware or building supplier in an 18″ × 24″ sheet.

The HBD case is a box made of 4 particle board panels ½″ thick. You can buy the panels already prepared as mentioned in the Parts List or you can buy the material and have it cut (or cut it yourself) according to the details given in Fig. 10. Cleats are added to the panels to strengthen the corners and provide a means of attaching the rear panel. The panels are assembled around the imaging panel using nails and glue.

The interior of the cabinet may be painted all flat black or black on the sides and white on the rear panel. A solid black background accentuates the flower pattern produced by the lamps; while painting the rear panel gloss white increases the light output slightly but does not mute or blend the patterns.

WHEN USING 150-WATT SPOTLIGHTS

For protection of IC2, 100-ohm ½-watt resistors should be inserted in the leads from pins 1,2, and 3 of IC2 and the appropriate gate ("G") of Q1, Q2, and Q3, respectively. Cut the leads on the PC board and solder the resistors across the open bridges.

SIX- OR TWELVE-CHANNEL OPERATION.

You can operate the six lamps in the Psychedelia 1 individually by using two PCU units and two QFU's. However, the capacitors in the QFU must be changed to the values given below.

	QFU #1	QFU #2
C1	1200 pF	470 pF
C2	270 pF	110 pF
C3	5600 pF	2200 pF
C4	1500 pF	620 pF
C5	0.047 μF	0.015 μF
C6	0.012 μF	4200 pF
C7	910 pF	390 pF
C8	220 pF	62 pF
C9	4700 pF	2000 pF
C10	1300 pF	560 pF
C11	0.039μF	0.012 μF
C12	0.01 μF	3300 pF

All capacitors are 5% mica, Mylar or polystyrene types.

You can use only one bulb per channel in one display unit or you can use two units side-by-side with three channels in each. For a super-duper 12-channel stereo display, use 4 PCU's and 4 QFU's.

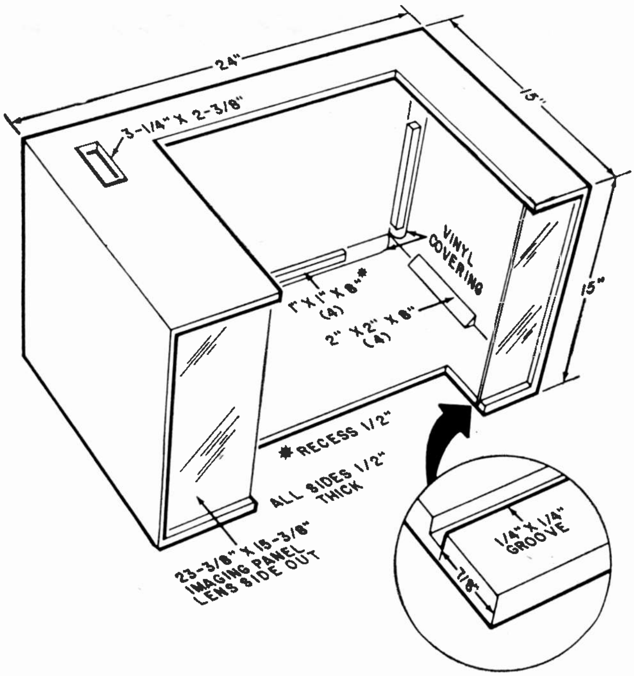


Fig. 10. General construction details of a display cabinet. Any other dimensions can be used. The controls are accessible through a small cutout in the top of the cabinet. Display can be viewed either horizontally or vertically.

If a built-in PCU and QFU are used, a suitable access hole should be added to one side. The rear panel supports the lamps and optional fan, and is shown in photos. The five 2″ × 3″ posts on the inside of the rear panel range in height from ¾″ to 8½″. They support the sockets for the lamps and should be spaced in a random manner to give the most pleasing pattern.

The Edison lamp sockets are mounted with wood screws on the posts with a sixth socket attached to the rear panel itself. The higher wattage bulbs go to the rear. The prototype uses 7½- and 25-watt red bulbs for the low frequencies, two 25-watt green bulbs for the medium frequencies, and 7½- and 40-watt blue bulbs for the highs. You can experiment to obtain what you think are the most dramatic effects.

Wiring. Using 16- or 18-gauge wire, parallel the two similarly colored lamps for each channel. Connect one side of each pair to each other and then to ter-

CABINET BILL OF MATERIALS

Lumber
2—24″ x 15″ pieces of ½″ particle board
2—15″ x 15″ pieces of ½″ particle board
1—22⅞″ x 14⅞″ piece of ½″ particle board
4—2″ x 2″ x 8″ triangular pine molding
4—1″ x 1″ x 8″ pine
1—4″ x 3″ x ¾″ pine
1—¾″
1—3½″
1—4½″ } 3″ x 2″ pine
1—7½″
1—8½″

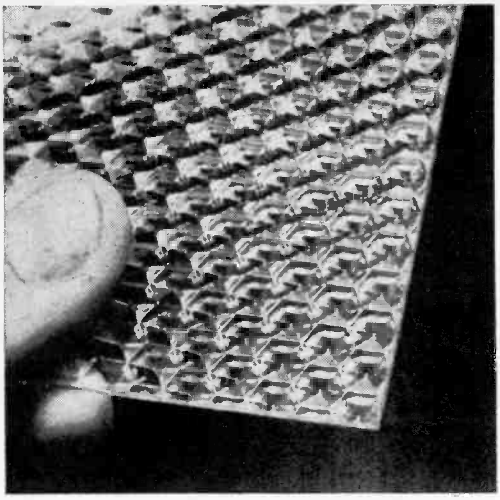
Electrical
6—Edison cleat sockets for 117-volt lamps
2—40-watt, 117-volt lamps, one red, one blue
2—25-watt, 117-volt lamps, both green
2—7½-watt, 117-volt lamps, one red, one blue
1—Cooling fan, whisper type, 55 CFM (optional)
1—6-pin female chassis mounting socket, polarized (Cinch-Jones S-306-AB or similar)
1—6-pin male plug, polarized (Cinch-Jones P-306-AB or similar)
3—Quick disconnect female terminals

Integral Master Unit
1—Line cord and strain relief
1—Phono jack
1—Rocker switch (6 amperes, 117-volts)

Slave Unit
1—6-pin female chassis mounting socket, polarized (Cinch-Jones S-306-AB or similar)

Misc.—23⅜″ x 15⅜″ panel of "T-Bar" or "Grid Lume" (for imaging panel); cloth-back upholstery vinyl 21″ x 84″; vinyl glue; wood glue; nails; no-skid feet (4); paint; wood screws.

Note—An assembled cabinet, less lamps and not wired, is available from Southwest Technical Products, Box 16297, San Antonio, Texas 78216 for $26.50. Item is shipped express or truck, collect only. Specify type of shipment desired.

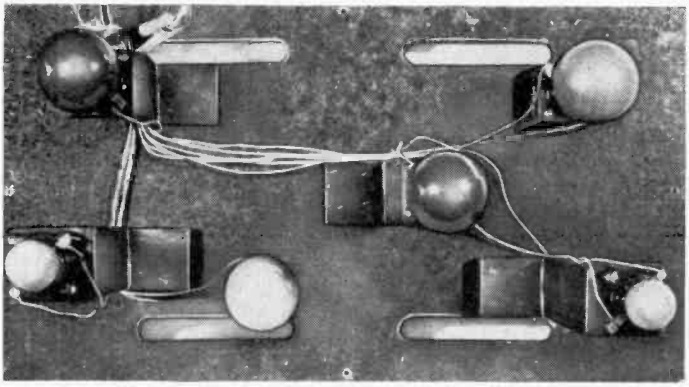


The imaging panel is made up of hexagonal lenses that make each lamp appear as a flower.

minate *L2* on the QFU board. Connect the other sides of the pairs to female quick-disconnect terminals to mate with the male terminals at **A, B,** and **C** on the PCU board.

The colors that you put on the respective channels is up to you. Once the system is operating, you can change the colors by switching the quick-disconnect terminals around. Be sure that primary power is turned off before touching these terminals. The system doesn't require any warm-up time, so there is no need to rush.

Connect a suitable length of shielded audio cable between the input bracket audio jack and the QFU board. Connect capacitor *C22* (Fig. 9) between the *L1* and *L2* terminals of the QFU boards to reduce switching noise.



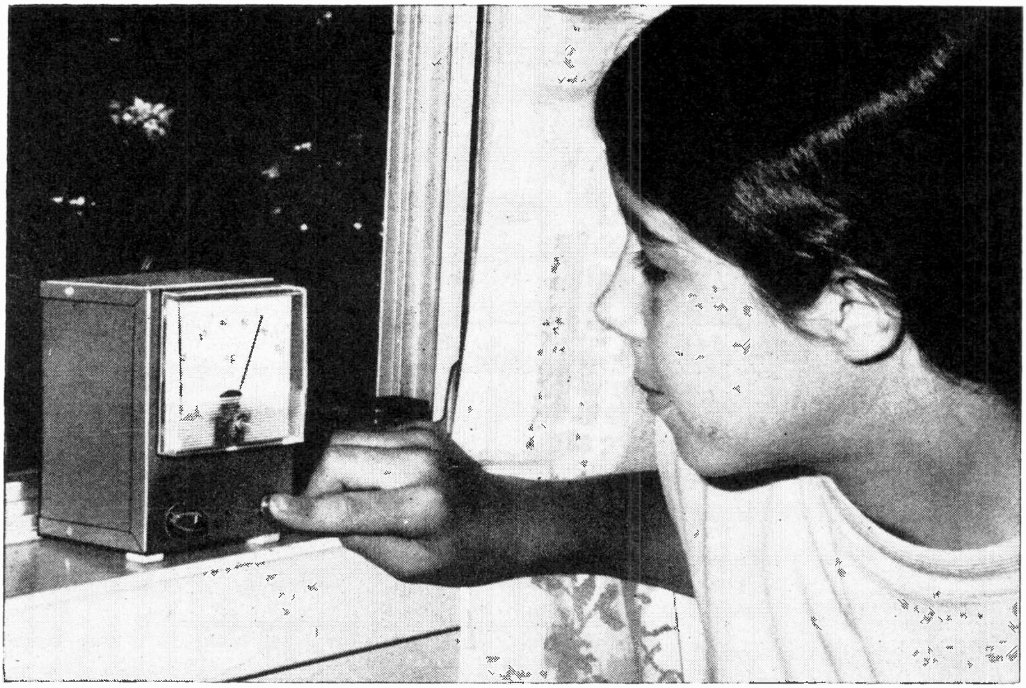
The lamps are arranged in any random pattern around the rear panel. Secure wiring to hold it in place and avoid shorts.

Three different lamp heights are used as shown here. The stands are made from wood.

Final Assembly. When the wiring is completed and checked, mount the electronics assembly to the cutout on the inside of the display cabinet so that the slide potentiometers are accessible from the outside. Use spacers at the four holes on the corners of the QFU board to support the assembly. The power on-off switch can be mounted anywhere that is convenient.

Connect the audio input cable and turn on the power. Set the amplifier to a reasonable listening level. (Make sure that *R44* has been selected to match the audio system as explained previously.) The white slide potentiometer controls the master level, while the three colored slide potentiometers can be adjusted to obtain the desired interplay of colors. The display is best viewed directly from the front. The cabinet can be mounted either horizontally or vertically. —30—

Indoor/Outdoor



All-Electronic Thermometer

HELP SAVE MERCURY METAL—GO ELECTRONIC!

BY C.P. TROEMEL

UNLESS YOU happen to live "up in Central Park" or "in the Chicago Loop" the temperature reports that come over the radio are not really enough to prepare you for what you will find when you step out your front door. So everyone wants an outdoor thermometer. Unfortunately, just hanging a standard thermometer outside a window is not always the best solution—either you can't see it or it's in a protected spot that doesn't give true indications. Similarly, if you use the conventional outdoor-indoor bulb-type thermometer with remote sensing, you must locate the bulb in the best place you can and then carefully bring a long copper capillary tube into the house through a window frame or wall.

It is possible, however, to have an outdoor-indoor electronic thermometer that is accurate, easy to build, and easy to install. The sensing element in this thermometer is a resistor (Sensistor®) with a positive temperature coefficient—that is, its resistance increases linearly as the surrounding temperature increases. The connection between the sensor and the temperature readout is made with flexible twin-conductor cable (zip cord, 300-ohm twin-lead, etc.) so that the sensor can be in any location, inside or out.

Construction. The circuit of the thermometer is basically a simple resistance bridge as shown in Fig. 1. Any number of sensing units may be used and you can locate them anywhere you like. Two (one indoors and one outdoors) are shown in Fig. 1. Use a multi-contact selector switch for *S1* to choose the sensor

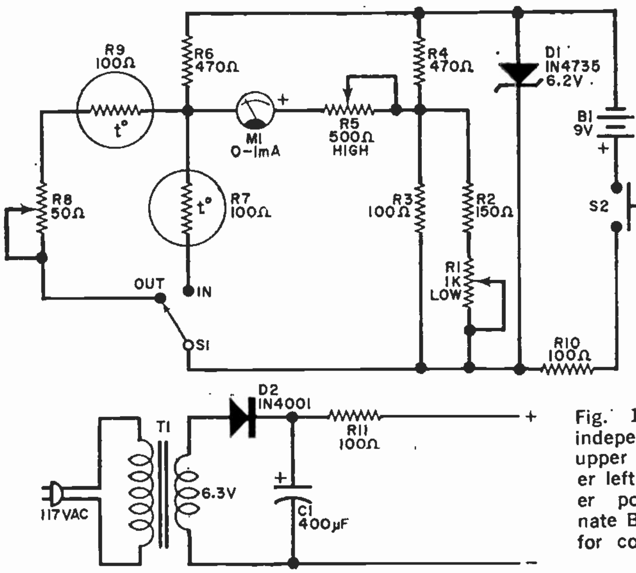


Fig. 1. Entire circuit of line-independent thermometer is shown upper left. Power supply at lower left can be connected in proper polarity across D1 (eliminate B1, R10, and S2) to provide for constant a.c. line operation.

PARTS LIST

B1—9-volt battery
C1—400-μF, 15-volt electrolytic capacitor
D1—1N4735, 6.2-volt, 1-watt zener diode
D2—1N4001 diode
M1—0-1-mA meter, 100 ohms maximum resistance. (If a more sensitive meter is used, increase the value of R5.)
R1—1000-ohm potentiometer
R2—150-ohm, ½-watt resistor
R3—100-ohm, ½-watt resistor
R4,R6—470-ohm, ½-watt resistor (must be closely matched)
R5—500-ohm potentiometer
*R7,R9—100-ohm Sensistor (Texas Instruments TM¼)**
R8—50-ohm miniature potentiometer
R10,R11—100-ohm, ½-watt resistor
S1—S.p.d.t. switch (see text)
S2—S.p.s.t., normally open pushbutton switch
T1—Filament transformer, 6.3-volt secondary
Misc.—5" x 4" x 3" metal enclosure, rubber grommet, aluminum for L-bracket, elastic band, knob, terminal strips, lengths of twin-conductor cable, mounting hardware, etc.
**Available from Newark Electronics Corp., 500 N. Pulaski Rd., Chicago, Illinois 60624, Cat. No. 12F055, $4.*

you want to read. If the thermometer is to be located in a fixed position in the house, you can use the line-operated power supply shown in the schematic. If you want a thermometer free of power lines, use the internal battery. In either case, the zener diode, *D1*, must be in the circuit.

If you use a battery, you will need pushbutton switch *S2* to turn on the thermometer to make a reading. If you use the line-operated supply, the meter will indicate temperature at all times. Current drain is only about 20 mA so there is no harm in having it on constantly.

The first step in assembling the thermometer is to modify the meter scale to read degrees Fahrenheit. Gently remove the plastic cover from the meter face. The original 0-1-mA scale division markers can be used. Remove the old numerals using a typewriter eraser. Then, using Datak press-on lettering (available at most art stores), renumber the scale divisions as shown in Fig. 2, making the 32°F (freezing) mark red if desired. Replace the face cover.

The thermometer is assembled in a 5″ × 4″ × 3″ metal cabinet. The meter and switches *S1* and *S2* (if they are used) are mounted on the front panel. After the meter is installed, make sure that the needle rests on the zero mark. If it does not, adjust the meter zero screw at the axis of the meter movement.

The high- and low-range calibration potentiometers (*R5* and *R1*, respectively) are mounted on a small L-bracket on the bottom of the chassis (see Fig. 3). An elastic band is wrapped around the L-bracket to hold the battery behind the potentiometers. If used, remote-sen-

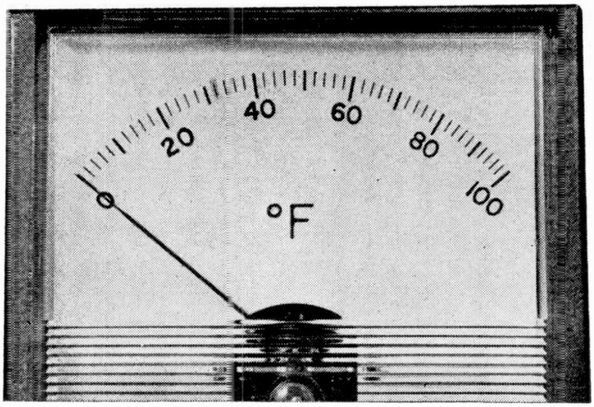
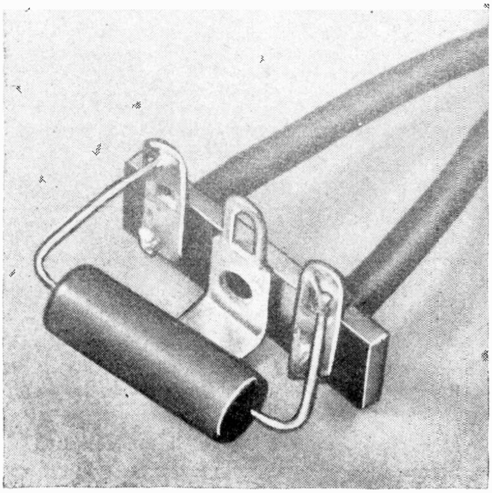


Fig. 2. Use the original scale markings, but renumber scale to indicate between 0 and 100; affix °F marking under scale.

sor trimming potentiometer *R8* is mounted on a two-lug terminal strip (neither lug grounded) fastened to the front panel under one of the meter mounting nuts. A three- or four-lug terminal strip can be mounted under the other meter mounting screw to serve as a connector for the sensor cables.

Drill a hole in the top of the chassis for the sensor cables. Put a rubber grommet on the hole to protect the cables. Then wire the circuit point-to-point following Fig. 1. Check that *R4* and *R6* are within a few per cent of each other in resistance values. At the same time, measure the resistance of both sensors, being careful not to heat them with your fingers. Use the higher valued sensor for the indoor unit (*R7*).

Since the sensors are encapsulated, they are not affected by rain, snow, etc. A good way to mount the sensors is to put them on small two-lug terminal strips which can be attached to almost any surface. Lengths of conventional twin-conductor cable (such as 300-ohm TV twin lead) can be used to connect the sensors to the thermometer. Be careful not to get more than a few ohms of resistance in the sensor circuit. Assume that most wire has a resistance of about ½ ohm per 100 feet (one wire, one way). Calibration is performed with the sensors actually connected to the necessary lead lengths.



Three-lug terminal strip provides most convenient method of connecting a sensing resistor to cable.

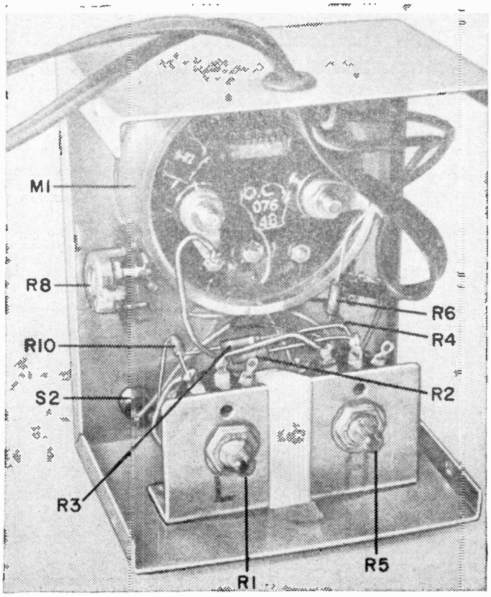
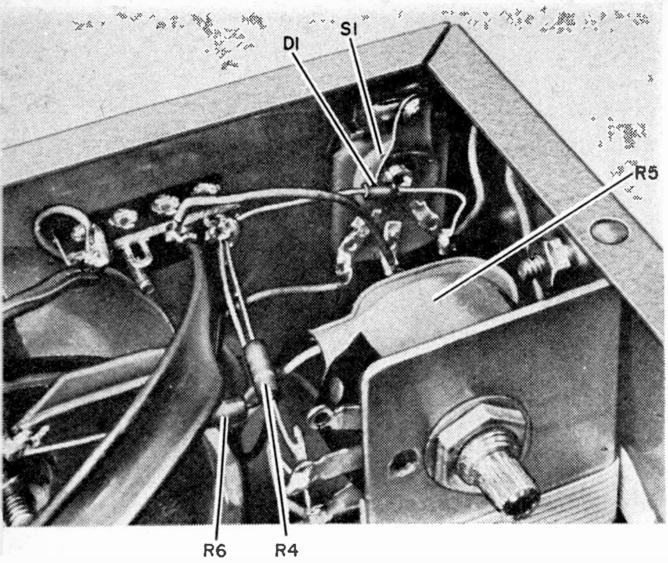


Fig. 3. Wiring is point-to-point. An elastic band secures B1 against the rear surfaces of R1 and R5.



Selector switch S1 (at top) is for two-sensor operation. If more sensors are used, substitute a switch with the appropriate number of positions.

Calibration. To calibrate the thermometer, you will need an accurate bulb thermometer covering the range from 0° to 100°F. With *S1* in the indoor position and the indoor sensor connected to the length of cable that will actually be used, wrap a small piece of wire around the sensor and the bulb thermometer to hold them in close thermal contact, making sure you can see the bulb-thermometer scale graduations.

Place the sensor-thermometer combination in a cold environment that is as close to 0°F as possible (refrigerator freezer) and allow the temperature to stabilize for 10 or 15 minutes. Turn on the electronic thermometer and compare its indication with the temperature as indicated by the bulb thermometer. Adjust *R1* until the meter agrees with the bulb thermometer. Remove the sensor and thermometer from the cold area and allow them to come up to room temperature.

Now place the sensor-thermometer combination in a hot environment that is as close to 100°F as possible (kitchen oven) and allow the temperature to stabilize again. Adjust *R5* until the meter indicates the same temperature as the bulb thermometer. Repeat the low- and high-temperature adjustments until the controls do not have to be touched up. If the low-temperature adjustment is made at exactly 0°F, the high-temperature adjustment need only be done once. Put a drop of glue on both potentiometer shafts to keep them from being moved accidentally. If you prefer maximum accuracy at some specific temperature, seek an environment that is exact-

HOW IT WORKS

The positive temperature coefficient resistor used as a sensor for the electronic thermometer is actually a semiconductor (silicon) device whose resistance versus temperature curve is extremely linear. Unlike the conventional thermistor, its resistance increases in proportion to an increase in temperature.

As shown in the schematic, the sensor forms one arm of a conventional Wheatstone bridge that is made to balance at 0°F. The resistance of the parallel combination of *R3* and *R1* plus *R2* is made to equal the resistance of *R7* at that temperature. In this condition, there is no voltage drop across the bridge so that no current flows and the meter indicates zero.

When the ambient temperature surrounding *R7* rises, the resistance of *R7* increases in proportion. This unbalances the bridge so that the voltage at the junction of *R6* and *R7* is higher than at the junction of *R4* and *R3*. Current then flows through the milliammeter, whose meter face has been calibrated in degrees Fahrenheit. If the ambient temperature surrounding *R7* decreases, its resistance decreases, less current flows through the meter and the needle drops. The circuit is designed so that zero current through the meter is 0°F—however, as pointed out in the text, any other temperature can be used.

Potentiometer *R1* is used to adjust the low (0°F) end of the meter scale, while potentiometer *R5* adjusts the high (100°F) end.

The power supply is regulated to prevent input-voltage variations from affecting the thermometer calibration.

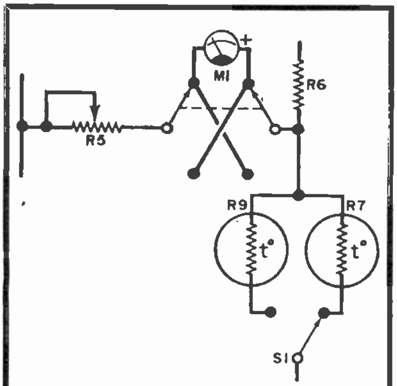
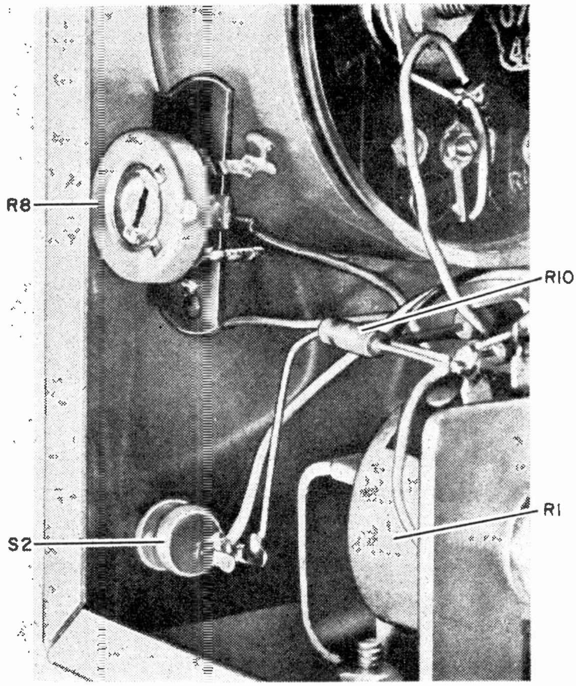
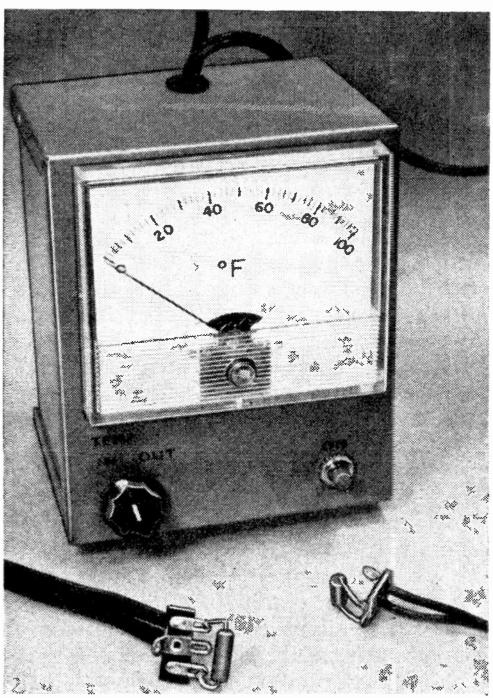


Fig. 4. With the installation of a polarity-reversing switch as shown, the thermometer can be used to indicate temperatures down below 0°F.



Potentiometer R8 should be mounted on a two-lug, ungrounded terminal strip. Terminal strip is held under the meter corner hardware.



Power line (if used) and sensor cables should enter top of the cabinet through grommet-lined hole.

ly the temperature that you want (as indicated on the bulb thermometer) and adjust either the high or low control to get the correct indication on the meter.

Once the thermometer has been calibrated for the indoor sensor, connect the outdoor sensor to its required length of cable and repeat the low-temperature calibration, using *R8* to make the necessary adjustment. Calibration of the outdoor sensor for the high end is not possible now but the accuracy will not be greatly affected.

Modifications. If you want to measure below 0°F, build the meter-reversal circuit shown in Fig. 4 and calibrate the thermometer accordingly. To measure above 100°F, change the meter scale markings and calibrate using the desired temperatures. If the meter cannot be brought on scale, increase the value of *R5*.

To add more sensors, change selector switch *S1* accordingly and connect the sensors just as *R8* and *R9* are in Fig. 1. The added trimmer potentiometers are mounted in the cabinet and adjusted as described above for *R8*. —30—

SIMPLICITY+ DWELL METER

BY JACK SADDLER

Build automotive accessory using HEP components

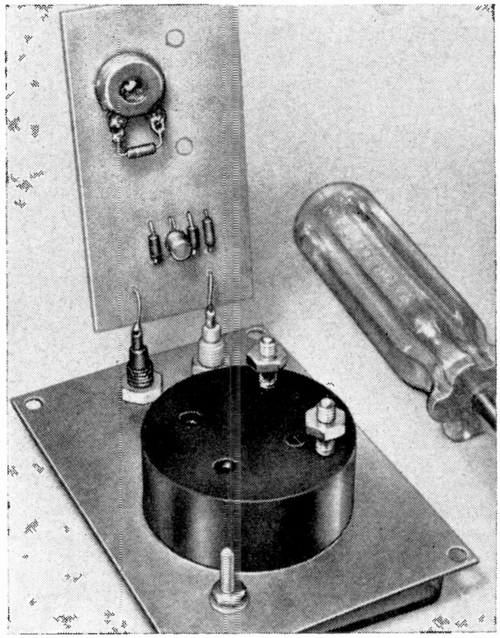
The high-compression engines used in modern cars and boats perform well only when they are properly tuned. They must be checked regularly to make sure that they are tuned up. One of the most important measurements that is made in the process of tuning up an engine is the checking of the dwell time of the distributor cam-point system.

Now, for less than the cost of one commercial engine tune-up, you can build an accurate dwell meter to check your engine's performance. The dwell meter can be used, as is, for 4-, 6-, or 8-cylinder engines with 6-, 12-, or 24-volt batteries (negative ground) and either conventional, transistor, or capacitor-discharge ignition systems. The meter is protected against voltage transients or accidental reverse voltages.

What Is Dwell? As the engine-driven distributor cam rotates, it opens and closes the points. When the points are closed, battery current flows through the primary of the ignition coil and builds up a magnetic field. When the points are open, the current through the coil is interrupted and the magnetic field collapses. Since the ignition coil is a large-ratio auto-transformer, the collapsing magnetic field induces a very high voltage at the upper end. It is this voltage that fires the spark plugs. The dwell time is the interval during which the points are closed and the magnetic field builds up. If the dwell is too short (for the engine under consideration), the magnetic field built up is not strong enough to produce a very high voltage and the plugs do not fire properly. If the dwell time is too long, too much current is drawn through the coil (and any transistors associated with the ignition system), which may result in damage to these components. Engine manufacturers specify the correct dwell setting for each type of engine. This information is given in the applicable engine manual.

As the engine is used, the constant wear on the distributor cam blunts the relatively sharp corners on the cam and causes the points to remain closed longer. If this abrasion process is allowed to continue, the cam will finally get so bad that the opening of the points is affected. Mis-

The author mounted his circuit on a PC board, then mounted the PC board to the meter terminals. Solid or flexible wire connections can be made between PC board and the two banana jacks J1 and J2 on the panel.



firing and sluggish performance result. Thus measuring and maintaining the proper dwell time is essential to good engine efficiency.

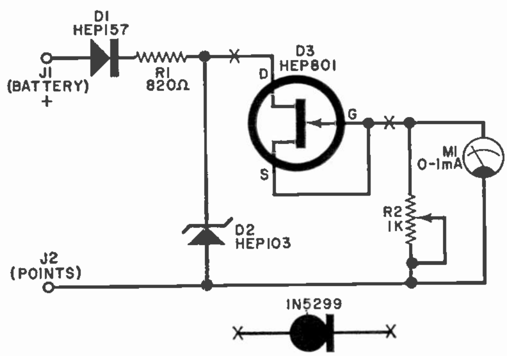
Dwell time is adjusted and corrected by installing new points in the distributor and setting them to the correct gap as specified by the manufacturer. Dwell

METER CALIBRATION TABLE

To convert 0-1-mA meter readings to dwell angle.

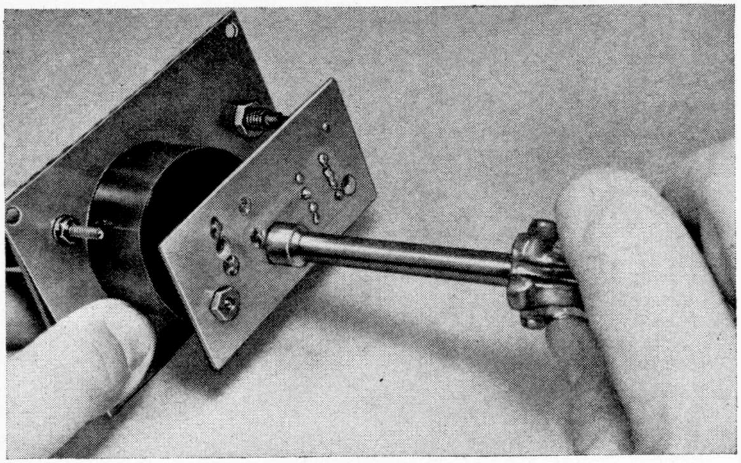
Original scale	0	0.2	0.4	0.6	0.8	1.0
4-cylinder	0	18	36	54	72	90
6-cylinder	0	12	24	36	48	60
8-cylinder	0	9	18	27	36	45

Strapping the Source to the Gate in the FET converts it to a constant-current diode. The strange-looking 1N5299 symbol is that of a constant-current diode that can be used to replace the FET. Either device can be used in the circuit.



PARTS LIST

D1—Silicon diode 1N4004 or Motorola HEP157
D2—6.2-volt, 500-mW zener diode 1N5234 or Motorola HEP103
D3—Field-effect transistor 2N5458 or Motorola HEP801; or current-regulator diode 1N5299
J1, J2—Banana plug or binding post (one red, one black)
M1—0-1-mA meter (Allied 52A7209, 52A7214, or similar)
R1—820-ohm, 5%, ½-watt resistor
R2—1000-ohm potentiometer (Mallory MTC-4 or similar)
Misc.—Mounting cabinet, rub-on numbers, mounting hardware, etc.
Note—A printed circuit board is available for $0.75 from Project Supply Co., P.O. Box 555, Tempe, Ariz. 85281. A meter is available for $5.95 and a complete kit including case and modified meter for $10.25 from the same source.



Once the circuit is assembled, secure it to the meter screw terminals. Electrical connections to the meter are made via printed circuit wiring. Drill a small hole through the PC board to provide screwdriver access to R2.

is also affected by point-to-point wear and since this wear may not be even, measuring the physical gap is not always a good indication of dwell. For this reason, most engine mechanics use some form of dwell meter to make sure that everything is working properly.

Construction. Once you have decided on the meter to be used, its scale must be altered to indicate dwell time (actually measured in degrees) rather than amperes. To do this, gently remove the meter cover to expose the scale—taking care not to damage the needle. In many cases, it is possible to remove the old numbers by rubbing with an eraser having a very fine grit. Using the table as a guide, substitute the dwell angle numbers for the original markings. If you expect to use the meter with only one type of engine you can use just one scale although the scales for 4-, 6-, and 8-cylinder engines are given in the table.

The easiest way to apply the new numbers is with commercially available rub-on lettering. Remove fingerprints or any other smudges on the meter face using alcohol applied with a fine, lint-free cloth. After meter calibration, gently replace the protective cover.

The author built the circuit on a small printed circuit board that mounts directly on the meter terminals. Parts placement is not critical, however, so any other form of construction may be used.

HOW IT WORKS

Silicon diode *D1* prevents damage to the remainder of the circuit from either accidental reversal of the input leads or the large negative-going voltage spikes present on the distributor points. In case either condition occurs, the diode does not conduct.

Zener diode *D2*, in conjunction with resistor *R1*, clips the input voltage to a fixed level to prevent damage to the meter and diode *D3*. The zener voltage is not critical. A 6.2-volt unit was used here because it is readily available.

Diode *D3* is unique. Essentially, it is a constant-current semiconductor device. You can use either a field-effect transistor with its gate connected to its source or a constant-current diode. In either case, it acts as a resistance whose value automatically increases with voltage, thus maintaining an almost constant current through the device.

Meter *M1* indicates the average current flowing through the circuit and it is calibrated by variable potentiometer *R2*.

Operation. Connect *J1* to the positive terminal of the battery and *J2* to the chassis of the vehicle. The meter will deflect upscale. Adjust potentiometer *R2* to get an exact full-scale deflection. The device is now calibrated.

To use, connect *J1* to the positive terminal of the battery and *J2* to the ungrounded distributor point. When the engine is running, the meter will indicate the dwell angle or dwell time of the points. This should be compared with the suggested dwell angle for the engine. If necessary, adjust the point gap in accordance with the manufacturer's instructions until the correct dwell is obtained. —30—

TIGERS THAT ROAR

BUILD 40- TO 100-WATT POWER AMPLIFIERS THAT MATCH FET STEREO PREAMP

BY DAN MEYER

THE HI-FI buff's search for the "perfect" amplifier is never ending. New components (particularly semiconductors) and new circuit wrinkles are announced almost daily to spur him on—in the hope that, sooner or later, something close to perfection will be achieved.

Presented here are two new audio power amplifiers ("Tiger" and "Super Tiger") which use the latest advancement in power transistors and up-to-the-minute circuit design. Try one of them and see if you don't think perfection is obtainable.

The two amplifiers are quite similar except that the Tiger delivers 35 watts r.m.s. (40 watts IHF) and the Super Tiger 80 watts r.m.s. (100 watts IHF). Specifications are shown in the table.

Construction (Tiger). The 40-watt IHF Tiger amplifier (schematic shown in Fig. 1) is assembled on a printed circuit board (foil pattern shown in Fig. 2). Mount the components on the board using the layout shown in Fig. 3. Be sure to use heat-sink grease between the two output transistors (*Q1* and *Q4*) and their heat sinks. Special clamps are called for in the Parts List to attach diode *D1* to the *Q1* heat sink and *D2* to the *Q4* heat sink. Be very careful in connecting the diodes into the circuit—proper polarities must be obtained or the transistors can be ruined. The red dot on the diode case indicates the cathode. Transistor heat sink is Staver V3-5 or similar and diode clamp is RCA SA-2100 or similar.

Two amplifiers must be made if you want a stereo version of the Tiger. Installation of the circuit boards in a cabinet is left to your discretion. The photographs show the author's approach to the packaging. The two boards are mounted on spacers. The bulky power transformer and associated rectifier components are mounted near the rear apron and the filter capacitors are on the front apron. The amplifier shown in the photos is the Tiger, but the same construction can be used for Super Tiger.

Only four external connections are required for the amplifier; two phono connectors for the inputs and a pair of jacks for the loudspeaker connections; or, if desired, a barrier strip or any other

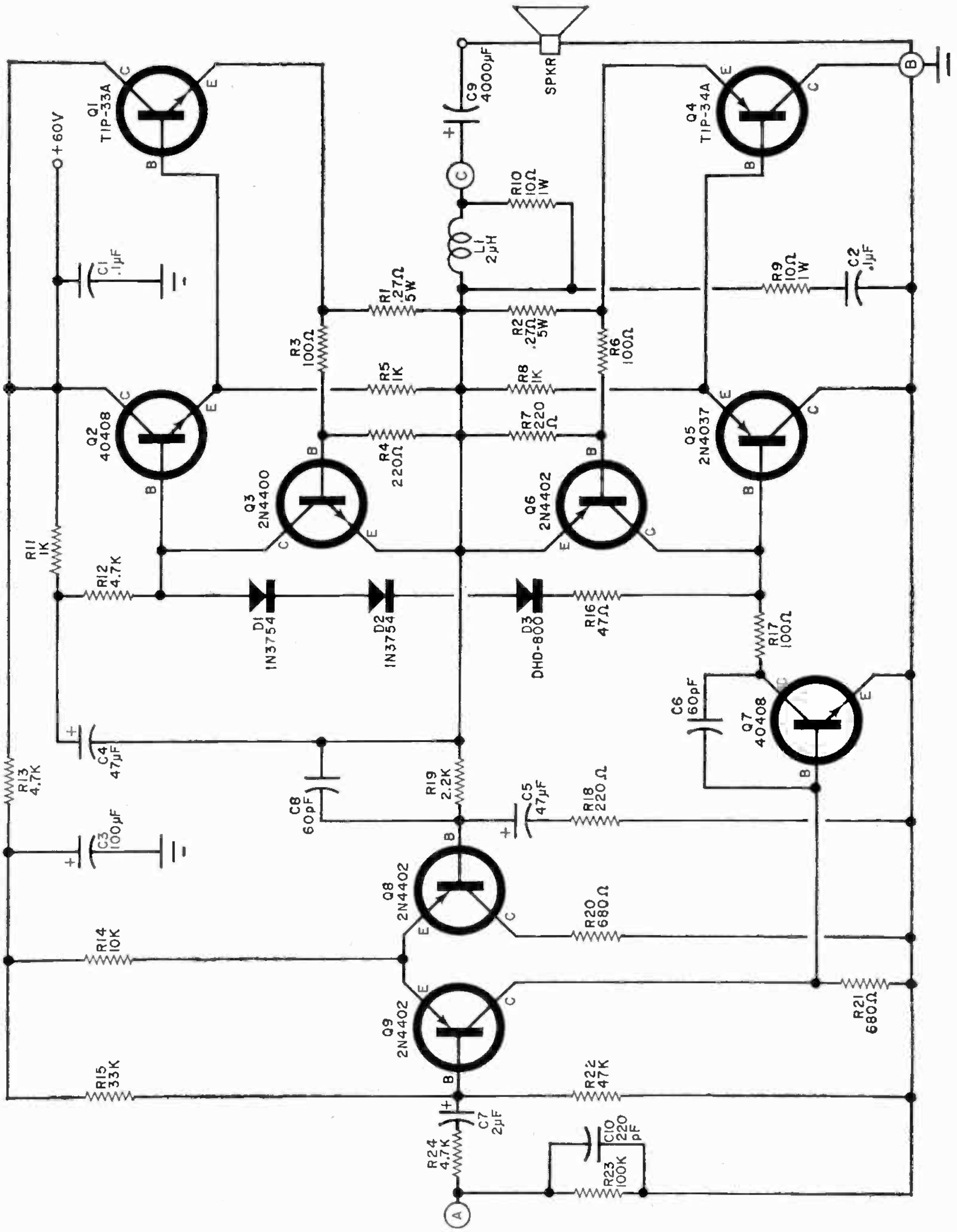


Fig. 1. The Tiger amplifier takes advantage of the latest semiconductors to produce a clean power amplifier that will compete with many commercially available power amplifiers costing many times as much.

PARTS LIST

C1,C2—0.1-μF capacitor
C3—100-μF, 50-volt capacitor
C4,C5—47-μF, 50-volt capacitor
C6, C8—60-pF capacitor
C7—2.2-μF, 50-volt capacitor
C9—4000-μF, 50-volt capacitor
C10—220 pF, ceramic capacitor
D1,D2—1N3754 diode
D3—Silicon diode (General Electric DHD-800)
L1—Three turns of #20 or #24 magnet wire on ½-inch diameter—approximately 2 μH
Q1—Transistor (Texas Instruments TIP-33A)
Q2,Q7—Transistor (Motorola SS-1123, MM3005 or 40408)
Q3—Transistor 2N4400
Q4—Transistor (Texas Instruments TIP-34A)
Q5—Transistor (Motorola SS-1122, MM4005, or 2N4037)
Q6,Q8,Q9—Transistor (Motorola 2N4402)
R1,R2—0.27-ohm, 5-watt resistor
R3,R6,R17—100-ohm
R4,R7—220-ohm
R5,R8,R11—1000-ohm
R12,R13,R24—4700-ohm
R14—10,000-ohm
R15—33,000-ohm
R16—47-ohm
R18—220-ohm
R19—2200-ohm
R20,R21—680-ohm
R22—47,000-ohm
R23—100,000-ohm
(R3 through R23: All resistors ½-watt)
R9,R10—10-ohm, 1-watt resistor
Misc.—Input jacks, output jacks, spacers, hardware, lug strips, heat sinks, clips, wire, solder, etc.
Note—The following are available from Southwest Technical Products Corp., 219 W. Rhapsody, San Antonio, Texas 78216: Etched and drilled printed circuit board (#160) $3.10 postpaid; kit for amplifier (board and components for one channel) (#160C) $16.50 postpaid; complete stereo kit with punched chassis, $50.00, plus shipping, 9 lb.

AMPLIFIER SPECIFICATIONS

"The Tiger"

Power output: 35 watts r.m.s., 40 watts IHF per channel
Distortion: Less than 0.5% total harmonic at 30 watts output and 1.0 kHz
Sensitivity: 1.0 volts for full output
Input impedance: 20,000 ohms
Output impedance: Less than 0.1 ohm; damping factor of approximately 20 with 8-ohm speaker
Hum and noise: More than 80 dB below 1-watt output
Frequency response: 10 Hz to 100 kHz (−3 dB points at full output)
Power supply: 60 volts at 2 amperes

"The Super Tiger"

Characteristics same as above except:
Power output: 75 watts r.m.s., 100 watts IHF per channel
Sensitivity: 1.25 volts for full output
Power supply: 80 volts at 3 amperes

HOW IT WORKS

The input stage of the amplifier is a differential amplifier consisting of *Q8* and *Q9*. A circuit like this has an almost constant total current flow through the two transistors due to the large resistance of the common-emitter resistor *R14*. The current divides between the two transistors, and, if the base voltages are equal, the collector currents are equal. If the base voltages are unequal, the voltages across the collector resistors are unequal but the total current does not change. A voltage divider consisting of *R14* and *R22* sets the base voltage of *Q9* and a d.c. voltage from the output stage is applied to the base of *Q8*. Any variation between the two base voltages results in a collector current change in both transistors. The differential input is connected so that shifts in output tend to correct the output shift (negative feedback) making the amplifier circuit automatically self-balancing. The emitters of *Q1* and *Q2* remain at half of the supply voltage no matter what shifts occur in transistor gain due to temperature, etc.

The ratio of *R19* to *R18* controls the amount of a.c. negative feedback and the overall gain of the circuit. Capacitor *C5* controls the low-frequency roll-off point.

Transistor *Q7* provides a voltage amplifier stage in a conventional common emitter arrangement. The collector load, *R11* and *R12* is a bootstrap circuit which provides the amplifier with a constant current even at full positive half-cycle output. Capacitor *C6* produces the required high-frequency roll-off above 100 kHz.

Transistors *Q3* and *Q6* and resistors *R3, R4, R6,* and *R7* limit the current in the output stage. This prevents the output transistors from conducting more than their rated current and being damaged if the output connection is accidentally shorted to ground.

Output current flows through *R1* or *R2* (depending on the half cycle) and if this current becomes too high, the voltage across *R1* or *R2* causes the associated transistor to start to conduct. This clamps the driving voltage so that it cannot get any higher. The peak output-transistor current is thus limited.

The output stage consists of two transistor pairs, Q1-Q2 and Q4-Q5 operated as class B amplifiers. They provide the required current gain and match the low-impedance speaker load. Diodes *D1, D2,* and *D3* and resistor *R16* provide a small "on" bias to prevent crossover distortion. Two of the diodes (*D1* and *D2*) are mounted directly on the transistor heat sinks so that the bias voltage shifts with changes in the base-emitter voltages of the transistors as they heat up under use.

The network consisting of *L1, R10, R9* and *C2* is required to insure high-frequency stability under all possible loading conditions.

type of dual connector can be used for the speaker connections. Mount the fuseholder and pass the a.c. line out through a rubber grommet. D.c. voltage for powering an external preamplifier may also be supplied to a barrier strip located on rear apron of chassis.

The power supply for the Tiger is shown in Fig. 4. It is a conventional high-current bridge rectifier with filter to supply 60 volts d.c. for the amplifier. When wiring the power supply to the

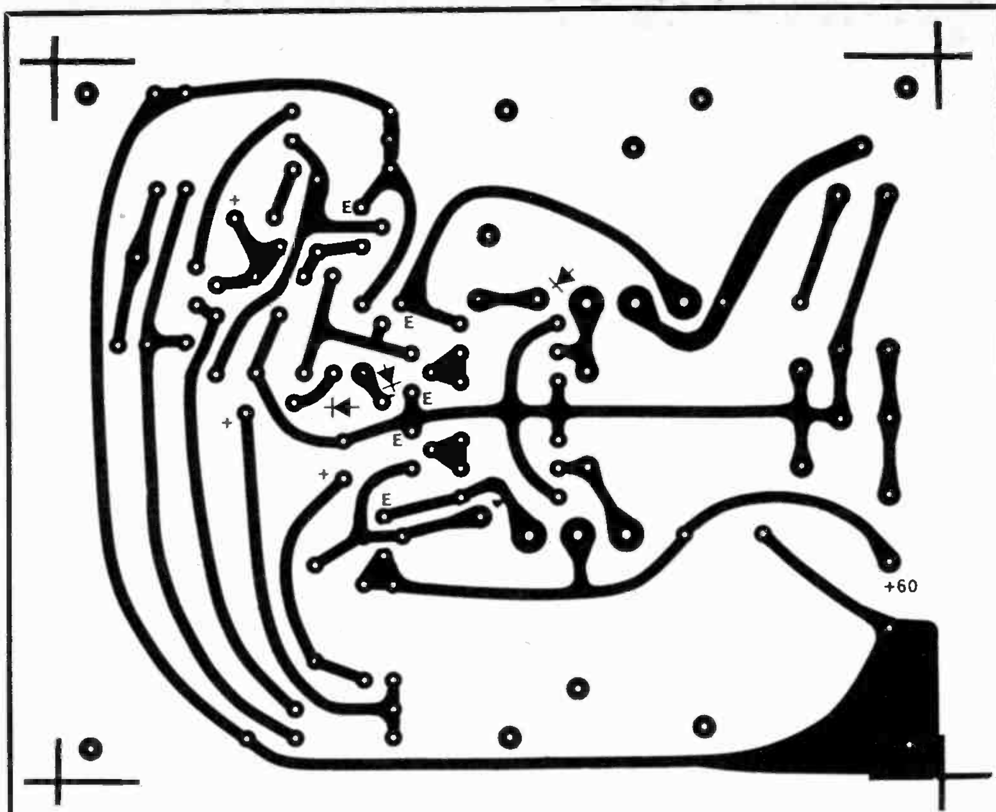
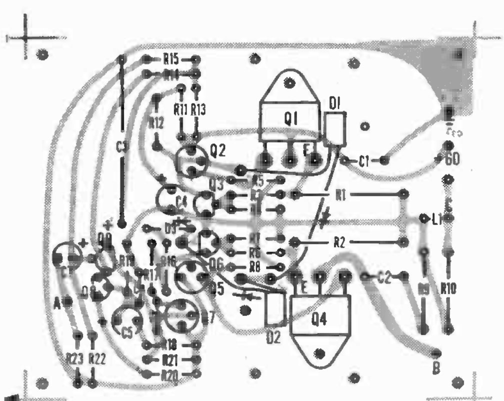


Fig. 2. Actual-size printed circuit board foil pattern for the Tiger. You can duplicate this board or purchase one etched and drilled (see Parts List).

Fig. 3. Component installation. The two holes near the power transistors (Q1,Q4) are mounting holes for the heat sinks. The associated diodes are then clamped to their respective transistor heat sinks.



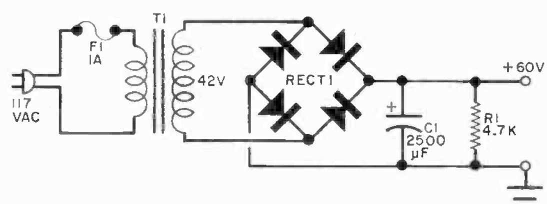
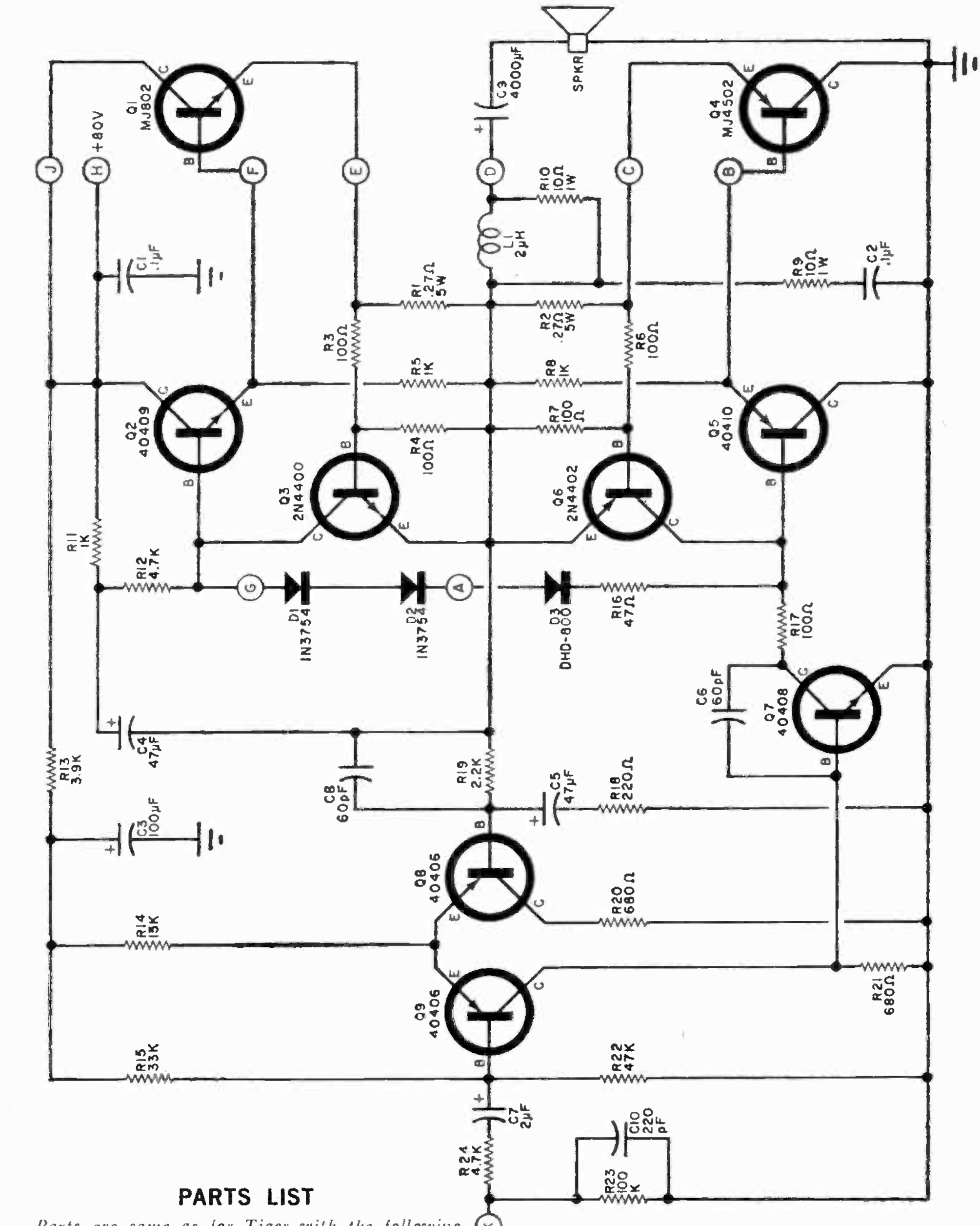


Fig. 4. Power supply for the tiger. It can be wired point-to-point with the components installed within the chassis.

PARTS LIST

C1—2500-µF, 75-volt electrolytic capacitor
F1—1-ampere fuse and fuseholder
R1—4700-ohm, 1-watt resistor
RECT1—2-ampere bridge rectifier
T1—Power transformer, secondary 42 V at 2 A (SW Tech P-5600 or similar)
Misc.—S.p.s.t. power on-off switch (optional), power on neon indicator assembly (optional).



PARTS LIST

Parts are same as for Tiger with the following exceptions:

C3—100-µF, 100-volt capacitor
Q1—Transistor (Motorola MJ802)
Q2—Transistor (RCA 40409)
Q4—Transistor (Motorola MJ4502)
Q5—Transistor (RCA 40410)
Q7—Transistor (RCA 40408)
Q8,Q9—Transistor (RCA 40406)

R4,R7—100-ohm
R13—3900-ohm
R14—15,000-ohm
R18—220-ohm
} *All resistors ½-watt*

Note—The following are available from Southwest Technical Products Corp., 219 W. Rhapsody, San Antonio, Texas 78216: Etched and drilled printed circuit board (#160SB) $2.80 postpaid; kit for amplifier (board and components for one channel) (#160SC) $22.00 postpaid; complete stereo kit with punched chassis, $70.00, plus shipping, 14 lb.

Fig. 5. The Super Tiger has same basic circuit as the Tiger, with high-power transistors in the output and a different circuit board.

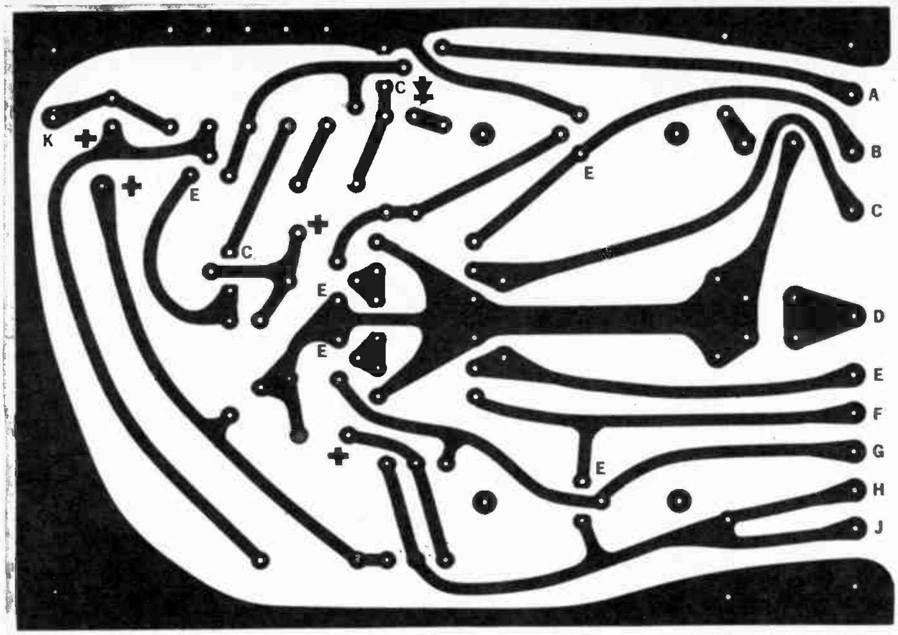


Fig. 6. Foil pattern for the Super Tiger. Like the Tiger PC board, this one is also available etched and drilled (see Parts List for Fig. 5).

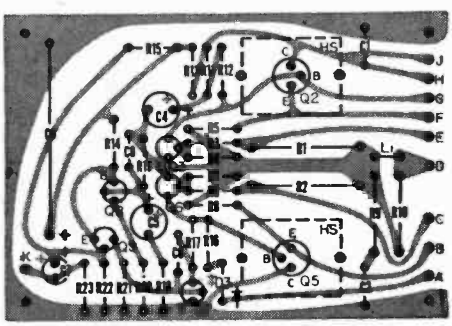
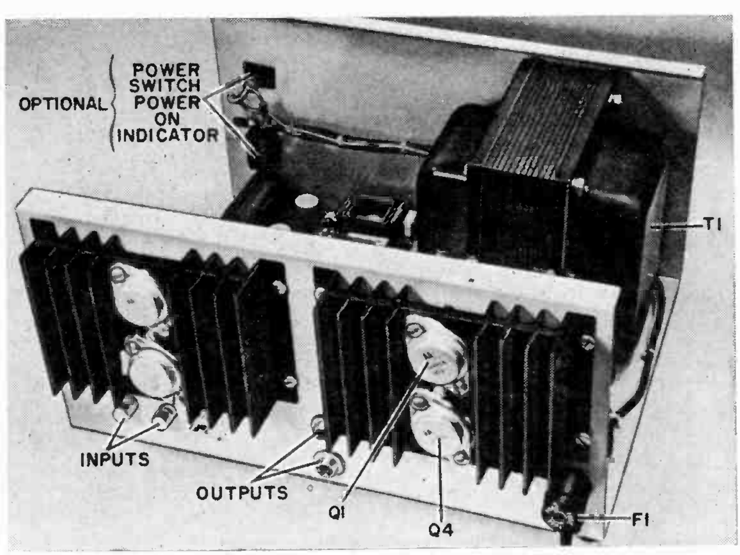


Fig. 7. Component installation for the Super Tiger. Note the location of the two transistor heat sinks (dashed line boxes) that mount on the PC boards.

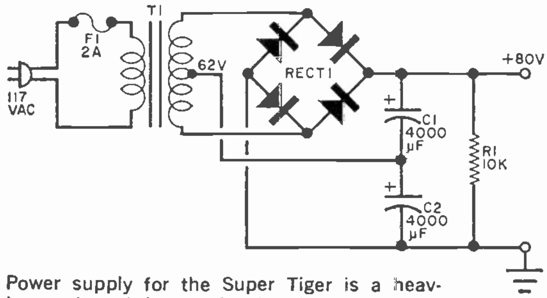
amplifier, note that there are two ground contacts on the PC board: one marked "B" and the other marked with the ground symbol. The former is the output grounding contact and should be connected directly to the loudspeaker jack along with the signal lead. Use at least a #18 wire for this connection. The other



The Super Tiger arranged for stereo. The optional power switch and indicator can be mounted on the front panel. The speaker outputs are terminated in phone jacks, although a barrier strip can be used.

PARTS LIST

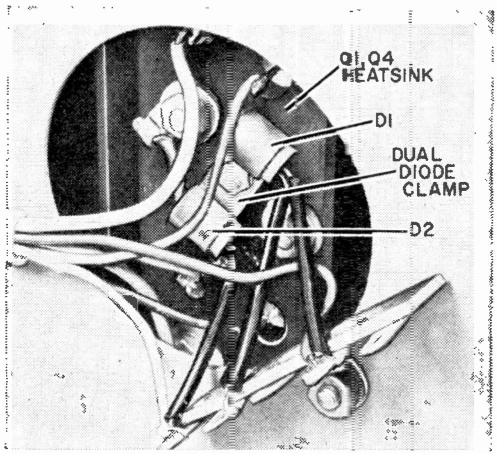
C1, C2—4000-μF, 50-volt electrolytic capacitor
F1—2-ampere fuse and fuseholder
R1—10,000-ohm, 1-watt resistor
RECT1—4-ampere bridge rectifier
T1—Power transformer, secondary 62 V at 3 A (SW Tech P-3154 or similar)
Misc.—S.p.s.t. power on-off switch (optional), power on neon indicator assembly (optional).



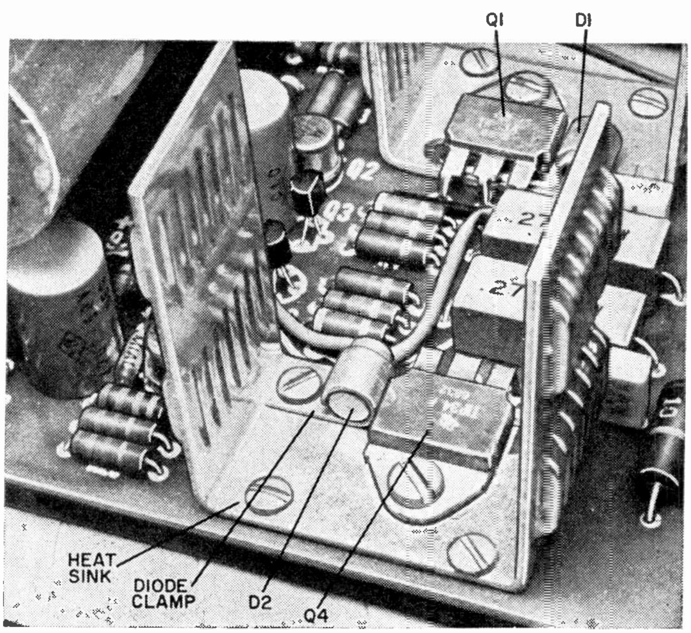
Power supply for the Super Tiger is a heavier version of the one for the Tiger. The Super Tiger takes higher voltage and more current.

ground should be connected to the chassis in the conventional manner. Do not depend on the mounting spacers for a ground connection.

Construction (Super Tiger). The 100-watt IHF Super Tiger amplifier is electrically similar to the Tiger except that the heavy-duty output transistors are mounted off the PC board on independent heat sinks. The circuit is shown in Fig. 5 and the foil pattern for the printed circuit board is shown in Fig. 6. Once the board is made, or purchased, mount the components as illustrated in Fig. 7. Note that diodes *D1* and *D2* are on the transistor heat sinks separate from the board and their connections to the board are made through lettered terminals on the

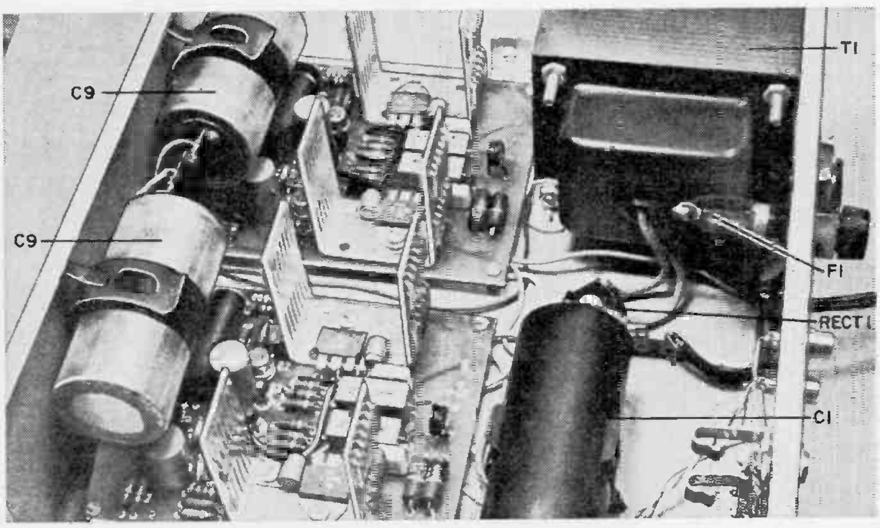


Method of mounting the diodes on power transistor heat sink. When mounting the heat sink, make sure that there is a large hole in the chassis wall so that you can readily mount the diode clamp in place.

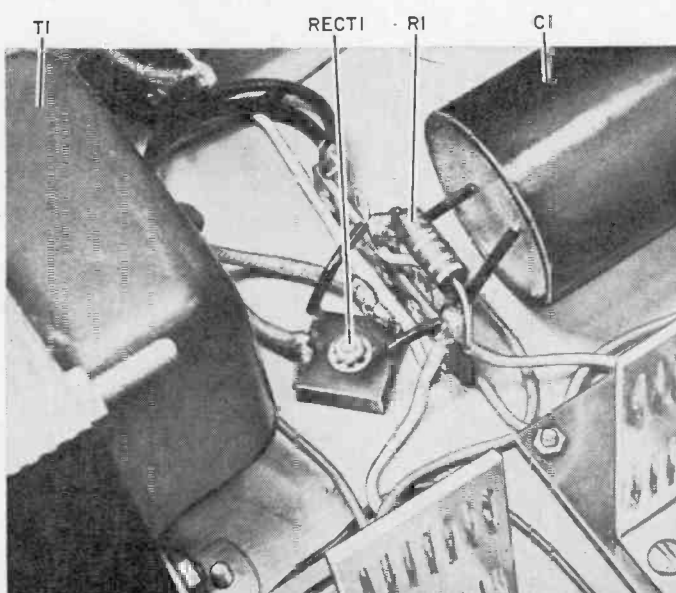


General view of one channel of the Tiger amplifier. Note how diodes are clamped to sinks.

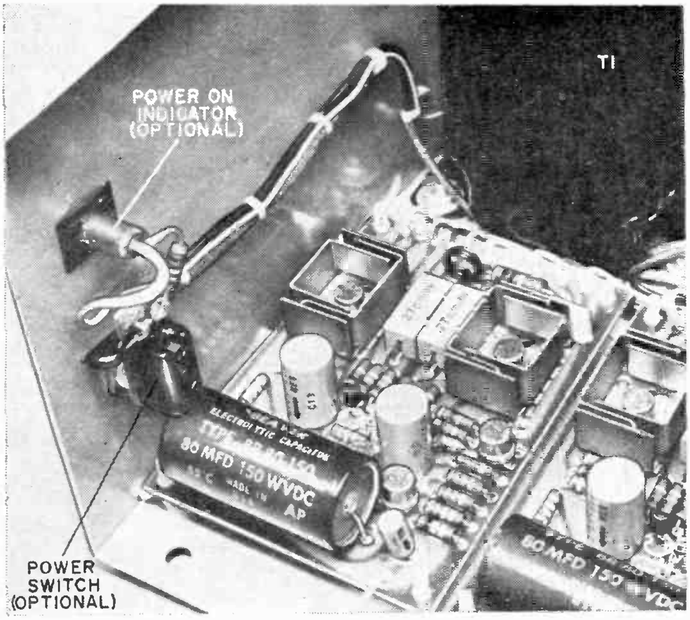
Either Tiger or Super Tiger makes excellent companion for the stereo preamp featured on page 85. The power amplifier also supplies d.c. power for stereo preamplifier.



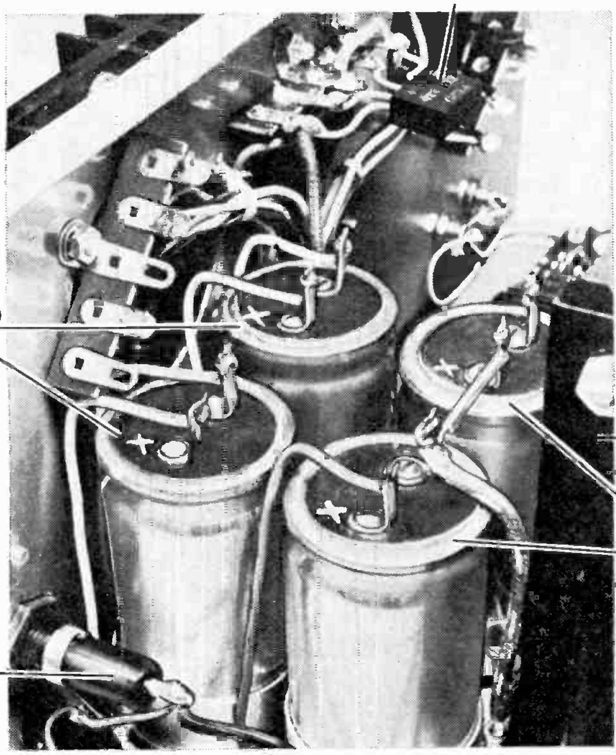
Tiger power amplifier wired for stereo (2 channels). One power supply handles both channels. Two output capacitors are mounted on the rear apron.



Close up of the power supply. Rectifier module is bolted to chassis and connections are made to a terminal strip.



Internal view of Super Tiger amplifier showing placement of optional power-on switch and indicator lamp. The heavy power transistors are mounted on opposite wall of chassis.



Due to their physical size, the power supply filter capacitors and output coupling capacitors are put directly on the chassis. The rectifier module is mounted on terminal strip held by heat sink bolt.

board. Be sure to observe the correct polarities for all diodes.

The actual physical arrangement of the boards (two for a stereo system) in an enclosure is at the builder's discretion. The bulky power transformer and filter capacitors are mounted separately from the boards.

The circuit for the power supply for the Super Tiger is shown in Fig. 8. It is a heavy-duty bridge rectifier with associated filter and bleeder circuit. The output to the amplifier is 80 volts.

(Continued on page 110)

SQUARING WITH AN IC

A SQUARE-WAVE GENERATOR THAT'S HIGH ON QUALITY, LOW IN COST

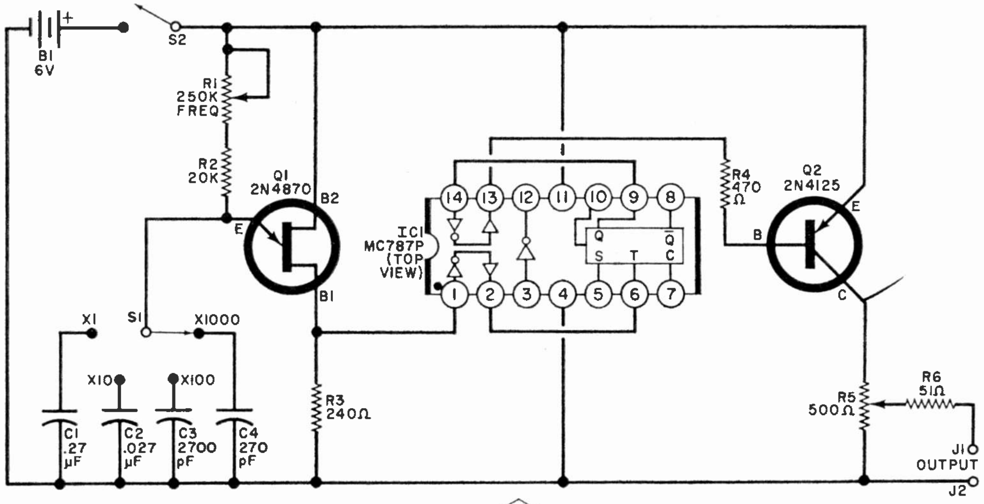
BY PHILIP E. HARMS

A SQUARE-WAVE generator is an invaluable tool for the electronics enthusiast—whether his primary interest is in radio or audio frequencies. The generator can be used as a scope trace calibrator, a driving source for digital pulse circuits or, most important, as a test instrument in checking both broadband and audio amplifiers.

Unlike a sine-wave generator, whose frequency must be capable of being set precisely and continuously across a particular band, the square-wave generator can be used to "wring out" an amplifier from about 1/10th of the fundamental of the square wave to 10 times this frequency. There are many excellent discussions in the reference books of the procedure for using a square-wave generator to check an amplifier. In simple terms, however, amplifier response characteristics can be determined rapidly by applying the square wave to the input and examining the output on an oscilloscope. The output risetime is determined by the amplifier high-frequency limits, while the square-wave tilt indicates the low-frequency cutoff.

Although there are many ways to build a square-wave generator, the availability of multi-purpose integrated circuits and UJT's makes possible the design of a simple, yet highly efficient circuit, that far surpasses most generators using vacuum tubes or standard transistors. Specifications for this new generator are given in the table.

Construction. The circuit for the square-wave generator is shown in Fig. 1. The author built the unit in a 3″ × 4″ × 5″ aluminum box, which was sufficient



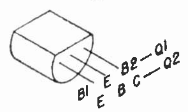


Fig. 1. Sharp spikes, generated by the UJT, are shaped and used to trigger the flip-flop. Its output is a sharp square wave at half the frequency of original.

PARTS LIST

B1—Four C or D cells
C1—0.27-μF, 10% capacitor
C2—0.027-μF, 10% capacitor
C3—0.0027-μF, 10% capacitor
C4—270-pF, 10% capacitor
IC1—Integrated circuit (Motorola MC787P)
J1,J2—Banana jack (one black, one red)
Q1—Unijunction transistor (Motorola 2N4870)
Q2—Transistor (Motorola 2N4125)
R1—250,000-ohm, linear taper potentiometer (with S2)
R2—20,000-ohm, ¼-watt resistor (see text)
R3—240-ohm, ¼-watt resistor
R4—470-ohm, ¼-watt resistor
R5—500-ohm, linear taper potentiometer
R6—51-ohm, ¼-watt resistor
S1—Single-pole, four-position rotary switch (Mallory 3234J or similar)
S2—S.p.s.t. switch (on R1)
Misc.—3" x 4" x 5" aluminum box, perf board 2¾" x 3", PC board terminals or flea clips (5), transistor sockets (2, optional), IC socket (14-pin in-line, optional), battery holder, battery clip, knobs (3), mounting hardware, etc.

to hold the perf board, the controls, and a battery holder. Wiring is not critical, although wire no smaller than #22 AWG should be used to insure a good signal path between components.

As shown in Fig. 2, the author built the electronic portion on a perf board using sockets to mount the IC and the transistors. Although the sockets are not absolutely necessary, they are advantageous to protect the semiconductors from heat during soldering. If you do not use sockets, be very careful when soldering the IC and the transistors, using a heat sink (such as long-nose pliers) between the end of the lead being soldered and the body of the device. Neat, point-to-point wiring is used on the perf board, with clips used as take-off terminals on the board.

The remainder of the components are mounted on the front panel of the chassis as shown in the photos. The battery holder is mounted on the rear of the cover.

Design Considerations. Since the characteristics of the UJT may vary as

SPECIFICATIONS

Frequency: 5 Hz to 50 kHz
Amplitude: 0 to 6 volts, variable
Risetime: less than 40 nanoseconds
Falltime: less than 250 nanoseconds
Overshoot: less than 10%
Undershoot: negligible
Non-symmetry: less than 200 nanoseconds, all ranges
Output impedance: 51 ohms, short-circuit protected
Power supply: four C cells, current drain 50 mA

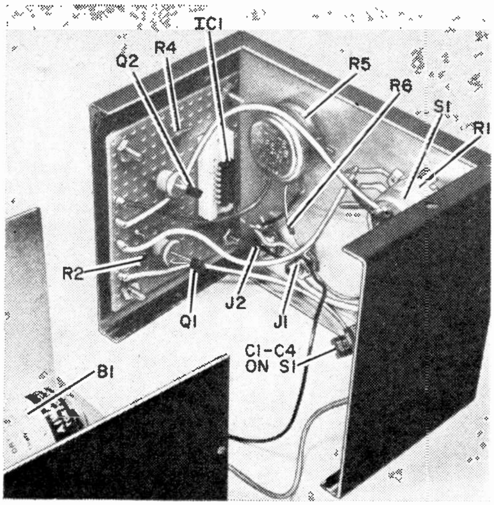
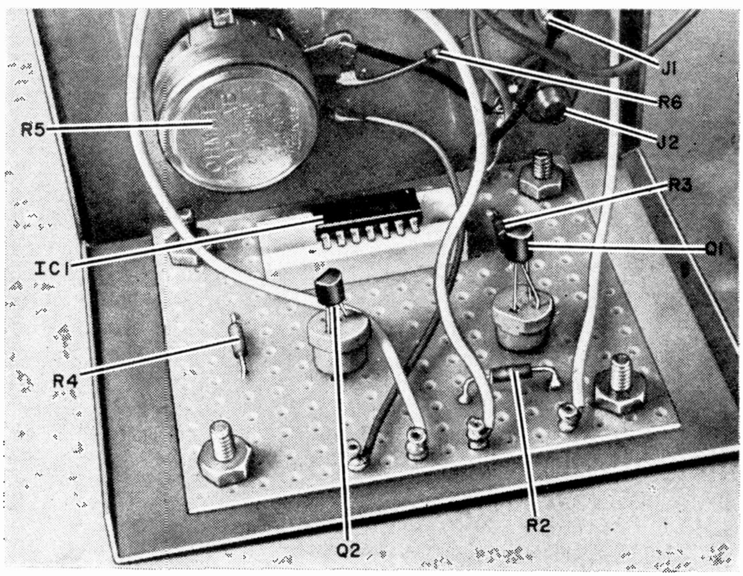


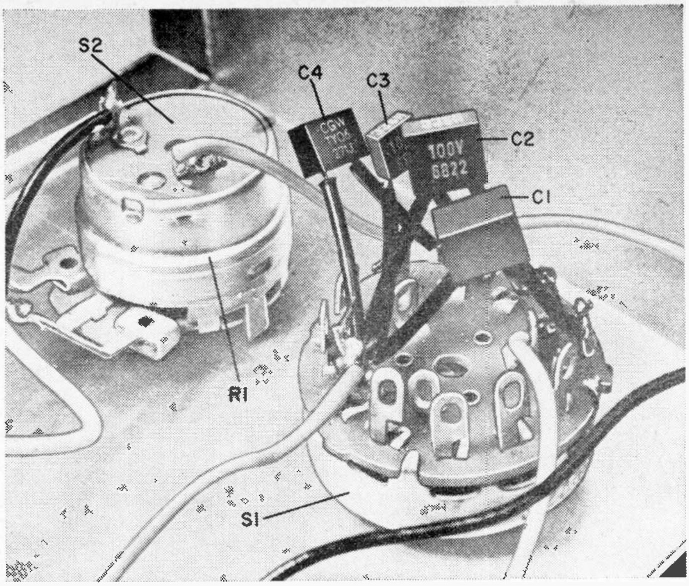
Fig. 2. The entire generator can be mounted in a small aluminum chassis as shown at the left. The four C or D cells are mounted in a holder affixed to the rear of the chassis half. The bulk of the circuit can be constructed on perf board (as shown below) or you can make a printed circuit board. The use of semiconductor sockets prevents heat damage to the semiconductors when installing but is an optional feature of design.



much as 10%, it is difficult to pick components that will result in a frequency range of exactly 5 Hz to 50 kHz. Capacitors *C1* through *C4* influence over-all accuracy; but for most applications, precise frequency increments are not required. If necessary, one, or all, of the timing capacitors can be "juggled" (parallel or series connections) to achieve exact decade intervals. For realistic results, capacitors with 10% tolerances should be used.

Resistor *R2* has a composite value which should give excellent results on all ranges. For exact calibration, *R2* can be replaced by four separate resistors, selected by using vacant terminals on *S1*. To calibrate these resistors, set *R1* for maximum resistance. Then assuming, for example, that *S1* is on X10, trim the value of *C2* (increasing the capacitance decreases the frequency, and vice versa) to achieve a frequency about 5% above 50 Hz. This is done to allow for slight changes in the value of *R2* in the next step.

Rotate *R1* to its minimum resistance. Select the value of *R2* that will give the correct upper frequency (500 Hz). The value of *R2* will be approximately 20,000



The four timing (octave) capacitors are mounted directly on the selector switch. The closer the capacitors are matched, and the better their tolerance, the more accurate the octave ranges are.

HOW IT WORKS

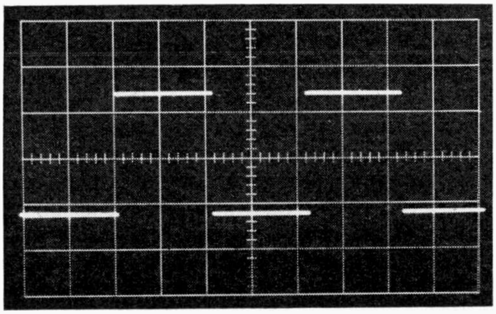
The frequency source for the square-wave generator is a unijunction transistor oscillator (*Q1*) whose frequency is determined by the resistors and capacitors in its emitter circuit. A sharp pulse at the selected frequency is developed across *R3* which drives the inverter-buffer in *IC1*. The IC contains one JK flip-flop, two inverter-buffers, and a single (unused in this case) inverter.

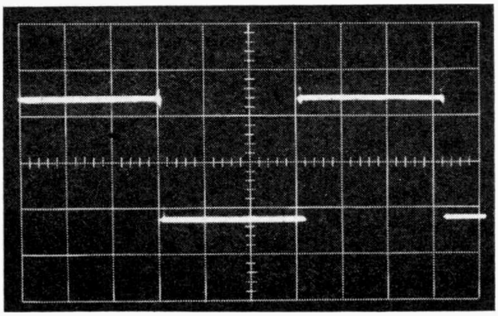
The inverter-buffer squares up the pulse generated in the UJT, and the pulse then triggers the flip-flop. The output waveform of the flip-flop is at half the UJT frequency and is sharply square on both transitions. The second buffer isolates the flip-flop and inverts the output. Transistor *Q2* acts as an amplifier isolator to provide an isolated output through *R5*. This potentiometer provides amplitude adjustment and *R6* protects the output circuit against short circuits.

ohms. Once the proper upper frequency has been obtained, increase the resistance of *R1* to maximum again and check that the 50-Hz point is correct.

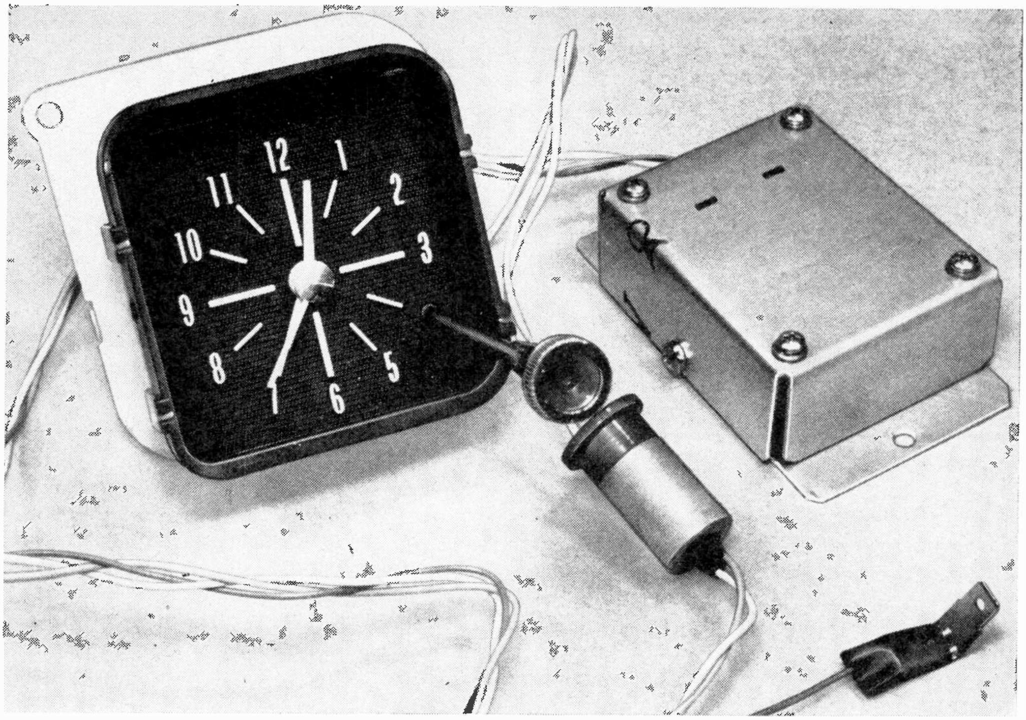
Each range can be calibrated similarly; and each is independent of the others if separate resistors are used for *R2*. The generator should never be operated without a series resistor (*R2*) in the UJT emitter circuit or the UJT may be damaged.

Because of the self-contained power supply, the generator output leads can be reversed to produce a negative-going signal. A battery can be used in series with the square-wave output to "bias" the output if desired. –30–





The output waveshape for both low and middle frequencies is shown at the left. Note the almost perfect square wave. For high frequencies, the output (right) is a good square wave with a little overshoot.



New Life for your AUTO CLOCK

ELECTRONIC DRIVE IMPROVES REWIND

BY ART KUBICZ

WHILE THE LIFE of the average automobile can be as much as ten years, the clocks in them rarely last more than a year or two. This is a strange circumstance since automobile clocks are generally quite well-made timepieces. Most of them have self-correcting mechanisms and, when properly set, their accuracy is very good.

Why, then, do they fail so quickly? The answer can usually be found in the electrical system that is used to rewind the clock automatically. (Most automobile clocks are mechanical time-pieces similar in design and construction to standard wind-up clocks used in the home.) By using an electronic driver such as the one described here, as an auxiliary to the regular rewind circuit, the life of almost any auto "electric" clock can be greatly extended.

Cause of Failure. Details of the winding mechanism of the typical automobile clock are shown in Fig. 1. The mainspring force that operates the clock is supplied through a small flywheel. Mounted on the flywheel is a spring brush and rewind contact. The brush bypasses the rewind current around the flywheel bearings and gears to prevent damage, while the rewind contact energizes the electromagnet which rewinds the mainspring.

As the mainspring runs down, the flywheel rotates freely until the rewind contact touches the electromagnet contact. At this time, the electromagnet circuit closes and kicks the flywheel around

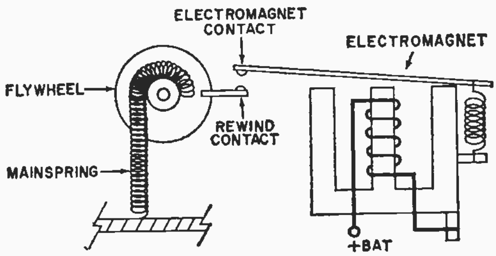


Fig. 1. Sudden collapse of electromagnetic field when contacts open causes arcing across contacts that results in early failure of rewind mechanism.

PARTS LIST

D1—50-volt, 10-ampere silicon diode
Q1—2N3773 transistor (see text)
Q2—2N2907 transistor (see text)
R1—10,000-ohm, ½-watt resistor
R2—1000-ohm, ½-watt resistor
R3—100-ohm, ½-watt resistor
1—2 ¾" x 2⅛" x 1⅝" metal utility box
Misc.—Circuit board material; solid and stranded hookup wire; metal spacers (4); rubber grommets (2); #6 machine hardware; solder; etc.

about a half turn through the contact arms. The contacts remain closed until the armature of the electromagnet closes fully; after that, the momentum keeps the flywheel turning, opening the electrical contacts and winding the mainspring until the flywheel stops. A simple one-way clutch disengages the flywheel gear during the rewind pulse.

Looking at the electrical operation of the rewind circuit, you can see that the contacts are normally open so that no current flows. But during rewind, the current rises almost linearly due to the inductance and resistance of the electromagnet winding, taking about 1 millisecond to reach full potential. For the next 4 milliseconds (see Fig. 2), the current remains at its maximum value. Then the contacts open the circuit, abruptly stopping the flow of current in about 0.2 milliseconds flat! This is the focal point of the problem.

The collapsing field of the electromagnet causes a very high voltage surge

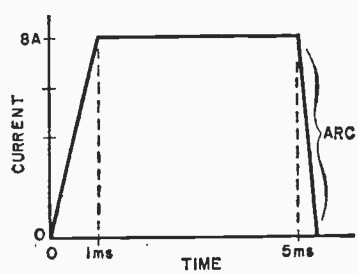


Fig. 2. Opening contacts causes sudden collapse of electromagnetic field that generates high-voltage arcing across contacts.

which arcs across the opening contacts, and the arc is maintained until the considerable amount of stored energy in the coil is exhausted. This arcing severely chars the contacts.

Aside from arcing, there is another aspect of the problem. The contacts must, when they are closed, handle a considerable amount of current, more peak current than they are designed to handle and still provide long life. With the high current, soft composition of the contacts, and lack of arc suppression, an early clock failure is guaranteed. (Consider that the engine ignition points handle about the same peak current, are larger, have arc suppression, and are made of extremely hard tungsten. They are expected to be replaced every few thousand miles.)

Solving the Problem. Two things can be done to eliminate or drastically reduce the possibility of clock failure: provide arc suppression and reduce contact current. The simple circuit shown in Fig. 3 is designed to do just that. Diode *D1* across the coil provides arc suppression.

The current reduction circuit consists of transistor stages *Q1* and *Q2*. Resistors *R1* and *R2* control the collector-to-base leakage at the high temperatures encountered in automobiles, and *R3* determines the maximum contact current. Since transistor current gain is considerably reduced at low temperatures, two transistors are used to maintain enough total current gain under these conditions. There is little else to be said about the circuit except that if it is to be used in cars with positive grounds, reverse the

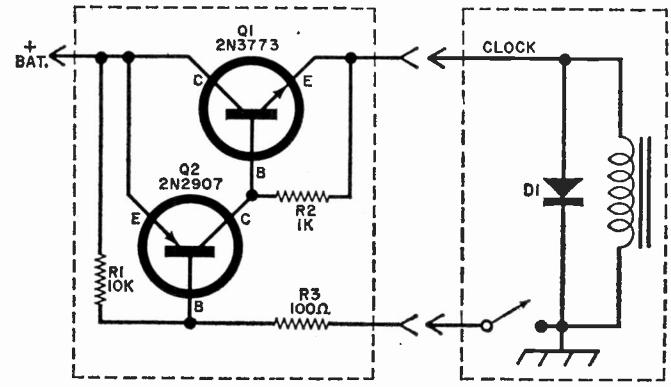


Fig. 3. Connected between battery and clock, this simple circuit provides arc suppression and limits contact current.

amplifier components from left to right, substitute pnp transistors, and reverse the polarity of the diode.

Construction. Remove the clock from your car's dashboard and open it. Now, whether or not the clock has been working, carefully clean and polish the electromagnet contacts. Use a contact burnisher, or use a point file and polish with a piece of high rag content paper. Disconnect the wire going to the electromagnet contact from the coil. Then solder the diode directly across the coil.

Connect a short wire from the contact side of the coil and diode to a convenient point on the clock frame, and a length of stranded hookup wire to the electromagnet contact, tying it securely to the frame. Make this latter wire long enough to reach the current amplifier module.

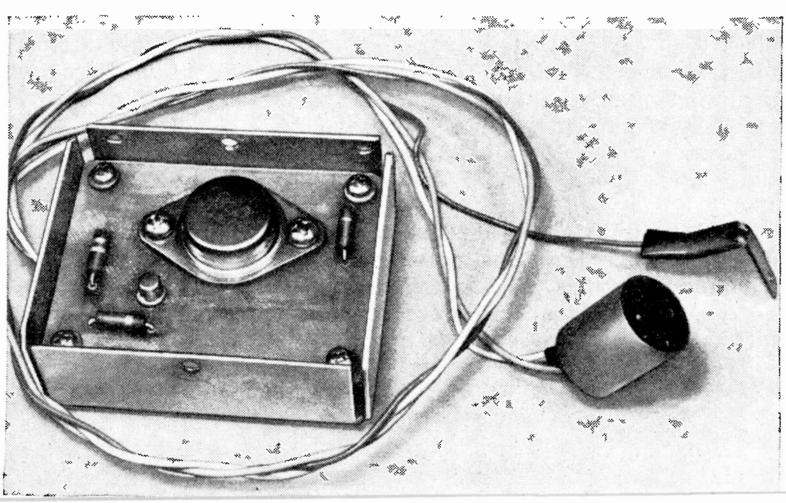
Now, drill a small hole in the back of the clock case and line it with an appropriate size rubber grommet. Blow out the clock mechanism to remove any dust. Then pass the stranded wire through the grommet and assemble the clock case. Install another stranded wire with a lug to the terminal on the clock; use a different color insulation. Twist together the two stranded wires.

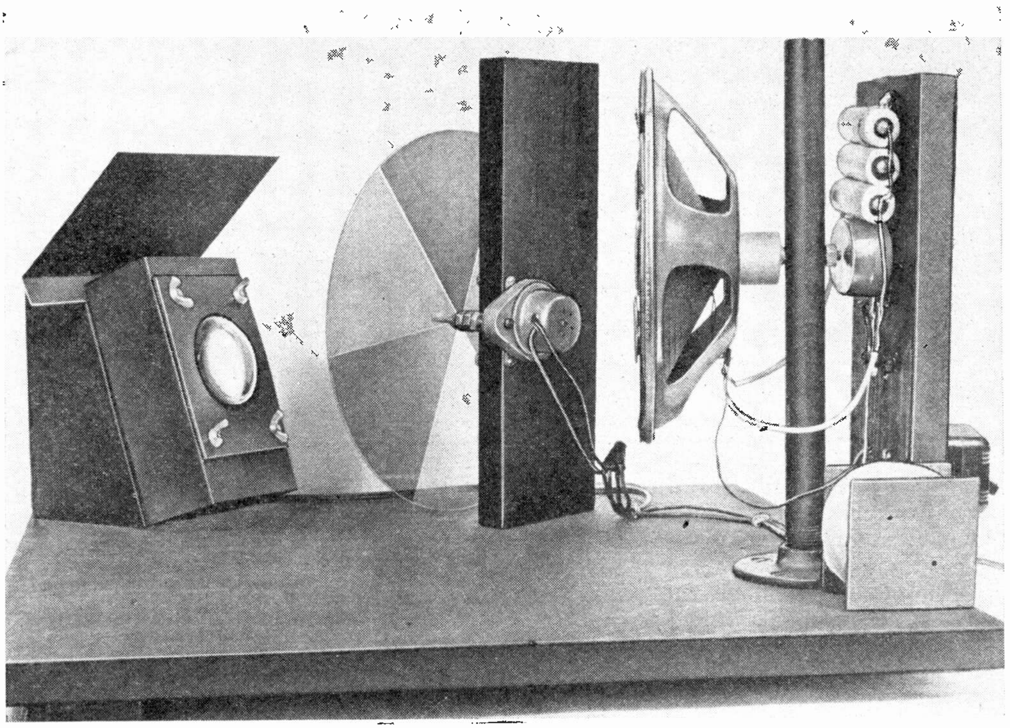
Assemble the amplifier. Any convenient method can be used, since the circuit is very simple. A small printed circuit board was used in the original prototype (see Fig. 4), but you can use perforated phenolic board.

Mount the circuit board, with the aid of four ⅜″ spacers, inside a 2¾″ × 2⅛″ × 1⅝″ metal utility box. Interconnect the clock and amplifier with appropriate connectors, and mount them in and under the dashboard, respectively.

One final word. The components used in the amplifier circuit are not critical. The ones designated were readily available and used, but other transistors could have been used. If you make substitutions, just make sure that *Q1* is rated for at least 8 amperes, and *Q2* for at least 0.5 ampere. —30—

Fig. 4. Simple circuit can be mounted on piece of phenolic board or on homemade printed circuit board.





BUILD A MusicVision® Light Display SYSTEM

BY DAVID B. WEEMS

QUITE A FEW PEOPLE believe that light accompaniment to music listening will prove to be as important to audio as was the second channel that made possible the directed-sound stereo concept. Audio alone can be pleasurable, but if you can also see light whose patterns, colors, and intensities change with the pitch, tempo, and volume of the music, you can more than double your pleasure. This is the whole idea behind the "MusicVision® Light Display System."

The MusicVision system is designed around a kit of the same name, made by Edmund Scientific Company and the heart of the system is a "motiondizer." The latter consists of a set of front-surface mirrors that mount on a flexible latex membrane. The membrane is stretched across the front of a loudspeaker so that it oscillates whenever the speaker cone is made to oscillate. Light from a projection lamp source passes through a slowly revolving color wheel onto the mirrors which, in turn, reflect the colored light beams onto a wall or any other flat, fairly large area surface.

As the speaker cone oscillates from the driving signal, the mirrors bounce around and cause the reflected spots of light to gyrate, tracing random patterns. (Only when no signal is applied to the speaker are the spots of light discrete; when a signal is applied, the spots trace continuous, unbroken lines of light.) The hanging mirrors, particularly if they are small, trace light patterns of great mo-

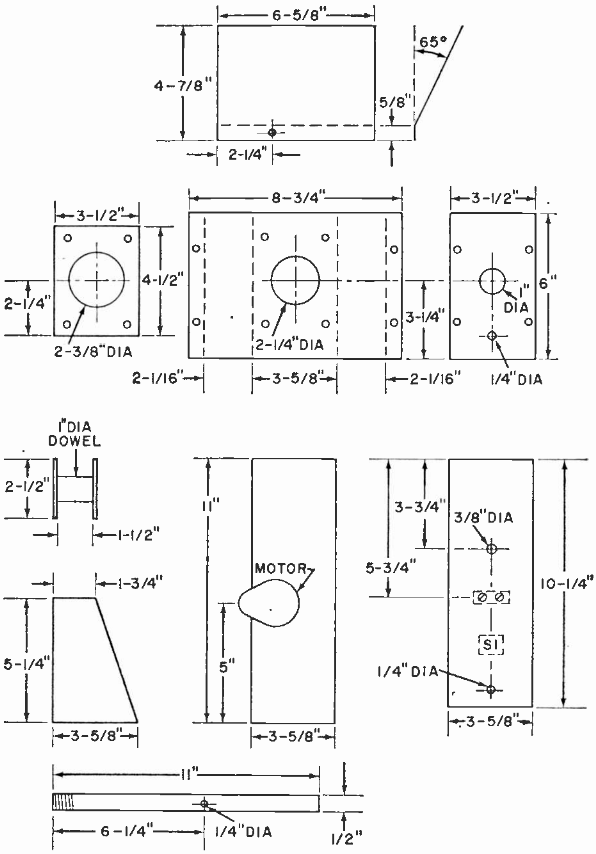
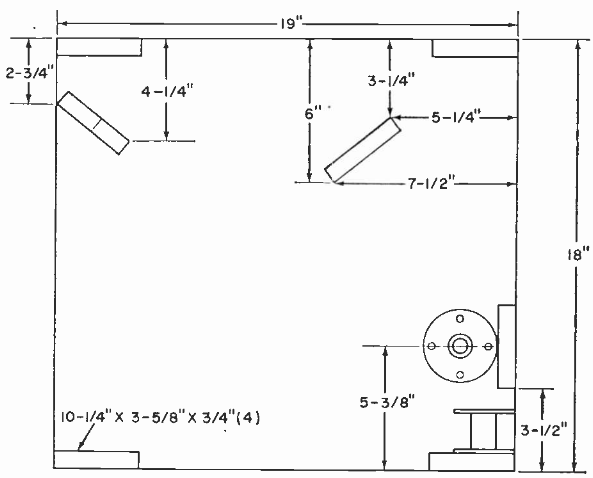


Fig. 1. With exception of lamp housing (top) and speaker support pipe (directly above), all parts are made from pine, plywood, or Masonite. In layout diagram (right) cage supports at four corners are joined by pine crossbars along top. Position parts exactly as shown.



tion and large irregularity. So, for a lot of action, three or more mirrors should be of the hanging kind.

Construction. All of the dimensioning information for the fabrication of the various parts that make up the Music-Vision is given in Fig. 1. At the upper left of the figure are shown the instructions for preparing the lamp housing. Machine the parts for this housing from sheet metal. (The light baffle can be made from the same sheet metal or from a "tin shingle," available from most lumber yards.)

Bend the housing to shape; then temporarily set the lamp panel over the housing shell and drill mating mounting holes. Remove and set aside the lamp panel. Turn over the lamp housing, set down the condenser lens retainer (made from Masonite), and drill the mating mounting holes. Temporarily set aside the housing and retainer.

Plug the lamp into its socket and locate the assembly on the lamp panel so that the lamp's filament is centered over the 1"-diameter cutout. Mark off and drill the mounting holes for the lamp socket flange. In like manner, mark off and drill the mounting holes for the reflector after making certain that the center of the concave surface of the reflector is centered over the cutout.

Now, before assembling the lamp housing, apply a coat or two of flat black paint to all surfaces. (The paint aids in the absorption and radiation of the heat given off by the light source.) This done, mount the lamp socket, as in Fig. 2, with sheet metal screws. Flip over the lamp panel, and mount the reflector exactly ½" away from the panel with machine hardware. Then mount the lamp panel to the housing with sheet metal screws

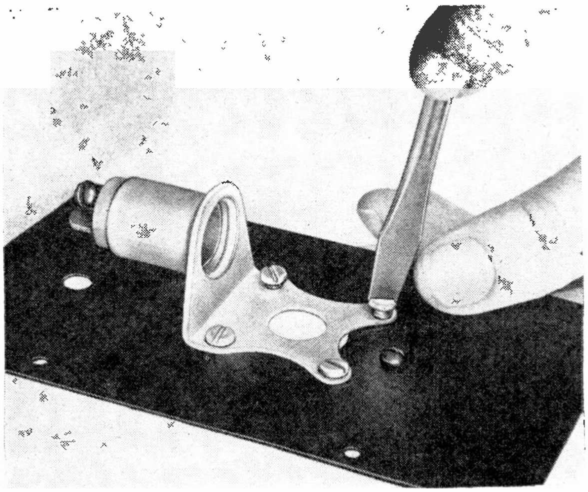


Fig. 2. Sheet metal screws fasten lamp socket to the rear plate of the paint-blackened lamp housing.

BILL OF MATERIALS

1—9¾" length of ½" inner diameter pipe, one end threaded, for speaker support
1—Floor flange for pipe
1—41½" x 19" piece of expanded aluminum
1—8¾" x 6" piece of 26-gauge or larger sheet metal for lamp housing (see text)
1—6" x 3½" piece of 26-gauge or larger sheet metal for lamp panel
1—6⅝" x 4⅞" piece of 30-gauge sheet metal for light baffle
1—19" x 18" piece of ¾" fir plywood for enclosure base
1—18" x 11¾" piece of ¼" pegboard for enclosure back
1—11" x 3⅝" piece of ¾" pine for motor mounting
1—10¼" x 3⅝" piece of ¾" pine for control panel
1—5¼" x 3⅝" piece of ¾" pine for light box mounting
4—10¼" x 3⅝" piece of ¾" pine for frame sides
2—18" x 3⅝" piece of ¾" pine for frame crosspieces
1—4½" x 3½" piece of ¼" Masonite for condenser lens retainer
*1—"Motiondizer" kit and accessories**
1—8-ohm L-pad
1—65-µF nonpolarized capacitor
1—lb. #18 enameled magnet wire
1—Two-lug screw-type terminal strip
1—Surface switch
10' length of lamp cord with a.c. plug
2—Wire nuts
1—fuse holder and ½-ampere fuse (see text)
2—doz ⅜" x #6 sheet metal screws for mounting light source box and cover
1—1¼" x ¼" flathead bolt and hex nut for speaker mounting
2—6-32 x 1" machine screws
6—6-32 x ¾" machine screws
6—6-32 machine nuts
6—#6 lockwashers
4—Wing nuts
4—#12 x ¼" flathead wood screws for flange mounting
18—#8 x 1¼" flathead wood screws for mounting pine uprights and enclosure feet
10—#8 x ¾" flathead wood screws for mounting enclosure back
Misc.—Flat black enamel undercoater; white glue; hard-set and clear epoxy bonding cements; bobbin for L1 (2 pieces of 2½"-square by ⅛"-¼"-thick Masonite and a 1½"-long by 1"-diameter wood dowel); wire nuts (2); two-lug screw-type terminal strip; etc.
**"MusicVision"® motiondizer kit, No. 71,009 ($22.50); filament-type projector lamp, No. 727 ($2.50); lamp socket, No. 74 (35¢); and plano-convex light condenser lens, No. 1142 ($1.50) are available postpaid in U.S. from Edmund Scientific Co., 555 EDSCORP Bldg., Barrington, NJ 08007.*

(see Fig. 3). Temporarily set aside the lamp housing assembly.

Referring back to Fig. 1, dimension and cut all the wood pieces that make up the enclosure, supports, and mounting members. Note also that the construction plans show the exact location and orientation of each part on the base. Using glue and wood screws, mount the lamp housing support at the upper left of the base. Then set the lamp housing against the support and outline its base on the board. Remove the lamp housing, and within the outline drawn on the base plate, drill ten ½″-diameter vent holes. Flip over the base plate and attach with flathead wood screws and glue two 18″ × 1½″ pieces of ¾″ pine to serve as feet for the project. Then, over these feet, glue strips of felt to protect furniture surfaces. Anchor the lamp housing and light baffle with a single screw (see Fig. 4).

Drill ⅛″ holes at each location where wood members are to mount to the base plate and 1⁄16″ screw-starter holes into the wood members themselves. Fasten the members in their appropriate locations with screws and glue.

Next, fabricate the speaker support from a length of 1″ inner diameter pipe (one end threaded) and a floor flange. Drill a ¼″-diameter hole through the pipe 6¼″ from the flange end with the flange in place. Then mount the flange to

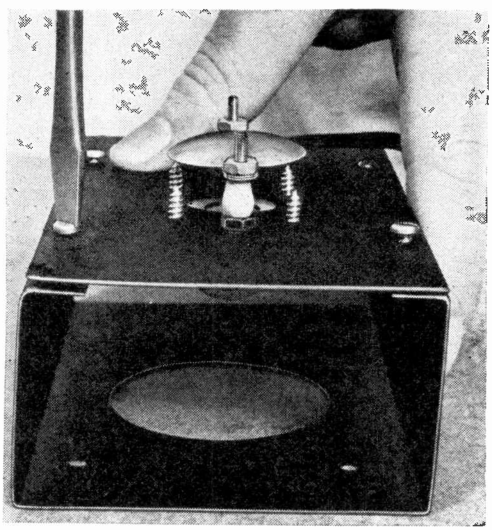


Fig. 3. Space lamp reflector exactly ½″ away from rear panel, using spacers and #6 machine hardware.

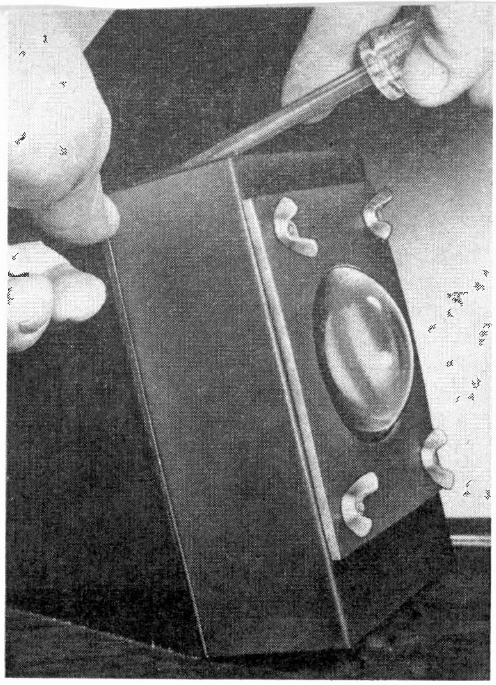


Fig. 4. Single screw anchors light baffle and lamp housing after vent holes are drilled through base.

the base plate with #12 × ¾″ flathead wood screws, and screw in the pipe.

Apply as many coats of flat black paint to *all* surfaces as are necessary to give a smooth, even finish. Meanwhile, assemble the bobbin for *L1*, using ⅛″-¼″-thick Masonite for the spool ends and a 1″-diameter wood dowel for the spool axis. Fasten these parts together with glue and wood screws or finishing nails. Then wind onto the spool one pound of #18 enameled magnet wire. Scrape the ends of the wire and solder to them 12″-long wire leads. Wrap a layer or two of tape over the windings, and cement the assembly to the base plate with epoxy after the paint dries.

Mount the terminal strip, *R1, C1,* and *S1* on the control panel. Then fasten the motor to the motor board as shown in Fig. 5. Note: Hex nuts can be added to the motor extension bolt to serve as spacers for the color wheel.

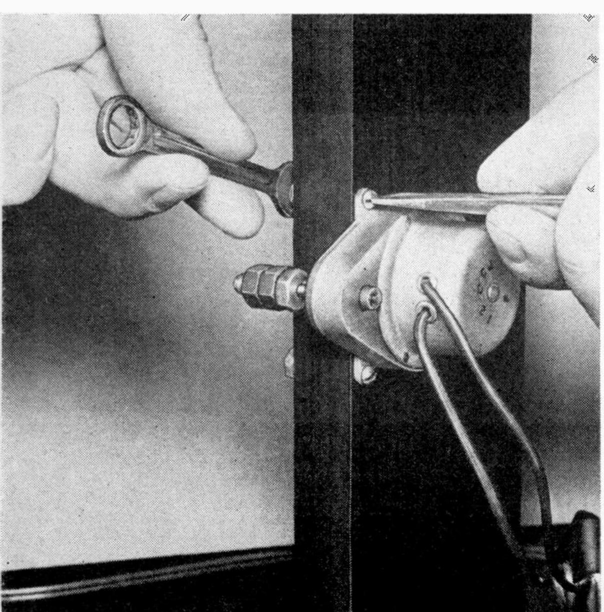
Buff the flat area of the loudspeaker's magnet assembly and the head of a 1¼″ × ¼″ bolt with emery cloth. Then attach the head of the bolt to the magnet housing with a hard-set epoxy bond. Allow at least 24 hours for the epoxy to set. At the end of this time, you can mount the speaker to the pipe support by passing the bolt through the holes in the pipe and fastening it with an appropriate hex nut. Avoid over tightening the bolt to prevent the epoxy bond from parting.

Stretch over the speaker front the latex membrane supplied with the motiondizer kit (see instructions provided with kit), and affix to it the mirrors. The kit contains three large and four small mirrors. The large mirrors are designed to hang, while the small ones are designed for direct mounting. If you prefer more action from your project, you can convert one or more of the small mirrors into the hanging types by fastening to the edges 2″ lengths of nylon cord with clear epoxy.

The only step left in construction is to wire the circuits together according to the schematic diagrams provided in Fig. 6, after which the black-painted expanded aluminum sides and top and peg-board rear plate can be attached. (The front of the project is the direction in which the front of the speaker is facing.)

In Use. Carefully check all wiring, and inspect the mechanical assembly. If all is in order, flip *S1* to ON and observe the projection lamp and color wheel. The first should glow brightly, while the latter should slowly turn. The color wheel turns at a rather slow rate; so do not be alarmed if it appears to be moving sluggishly.

Fig. 5. Bolt motor to support with machine hardware. Hex nuts can be used as motor shaft spacer.



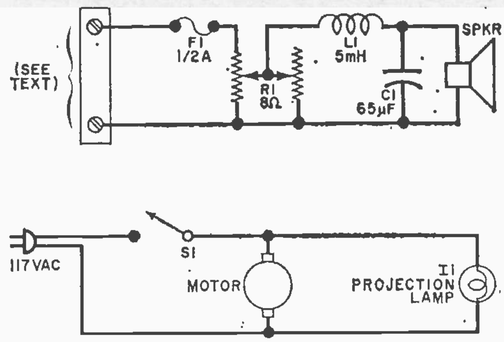


Fig. 6. Separate circuits are used for audio (top) and lamp/motor (immediately above) drive systems.

Now, check the alignment. The lamp beam should pass unobstructedly through the color wheel and onto the speaker-mounted mirrors. From here, the light should pass out through the front of the project. It may be necessary to add shims and possibly longer screws under the flange to allow the mirrors to hang free of the membrane.

When checking the light pattern exiting from the front of the project, make sure that the proper reflecting surfaces of the mirrors are doing the projecting. The instructions provided with the motiondizer kit explain how to determine the proper mirror surfaces to use.

The inductor/capacitor arrangement to the speaker cuts off the higher audio frequencies and reduces the unwanted audio output. Only the lower audio frequencies passed to the speaker agitate the mirrors enough to produce a series of wild patterns. L-pad *R1* is used as a volume/amplitude control for setting the degree of agitation desired.

The impedance of the speaker circuit will vary slightly with the setting of the L-pad and the frequency applied to the circuit. With the component values specified in the Bill of Materials, there should be no problems when using the system with most amplifiers, provided the speaker circuit is connected to the amplifier via an 8-ohm center-channel output or through a separate amplifier driven by the tape output. In the former case always include the fuse; in the latter, the fuse can be left out if the separate amplifier does not exceed 25 watts output power. -30-

BUILD THE FET PREAMP

NEW DESIGN FOR LOW NOISE AND MINIMUM DISTORTION

BY DAN MEYER

CONSTRUCTION projects and kits for making high-fidelity audio preamplifiers come in many shapes and sizes. Most of them give very good results but none has the quality of the "FET Preamp" described here. Much of the excellent performance obtainable from this preamp is due to the use of silicon field-effect transistors in the amplifier stages. These transistors operate at impedance levels similar to those in vacuum-tube circuits but they have much lower noise and far less distortion than either tubes or conventional junction transistors.

The sensitivity and output impedance of the FET Preamp are suitable for use with almost any power amplifier and full power output can be obtained from any low-level magnetic-cartridge signal source.

A high-power audio amplifier, specifically designed for use with this preamp, is described elsewhere in this issue of the EXPERIMENTER'S HANDBOOK.

Six pushbutton switches are used to select the desired input, while there are rocker switches for control of volume-loudness, high- and low-frequency filtering and the 117-volt power supply. A front-panel tape output jack and a microphone input jack are also provided. With the exception of some exotic details, such as phase reversal, every possible useful function has been included in the preamplifier, whose schematic is shown in Fig. 1.

Construction. For a stereo system, two preamplifiers are required. Each is assembled on a printed circuit board whose actual-size foil pattern is shown in Fig. 2. Once the board has been fabricated (or purchased), mount the components as shown in Fig. 3, being careful to ob-

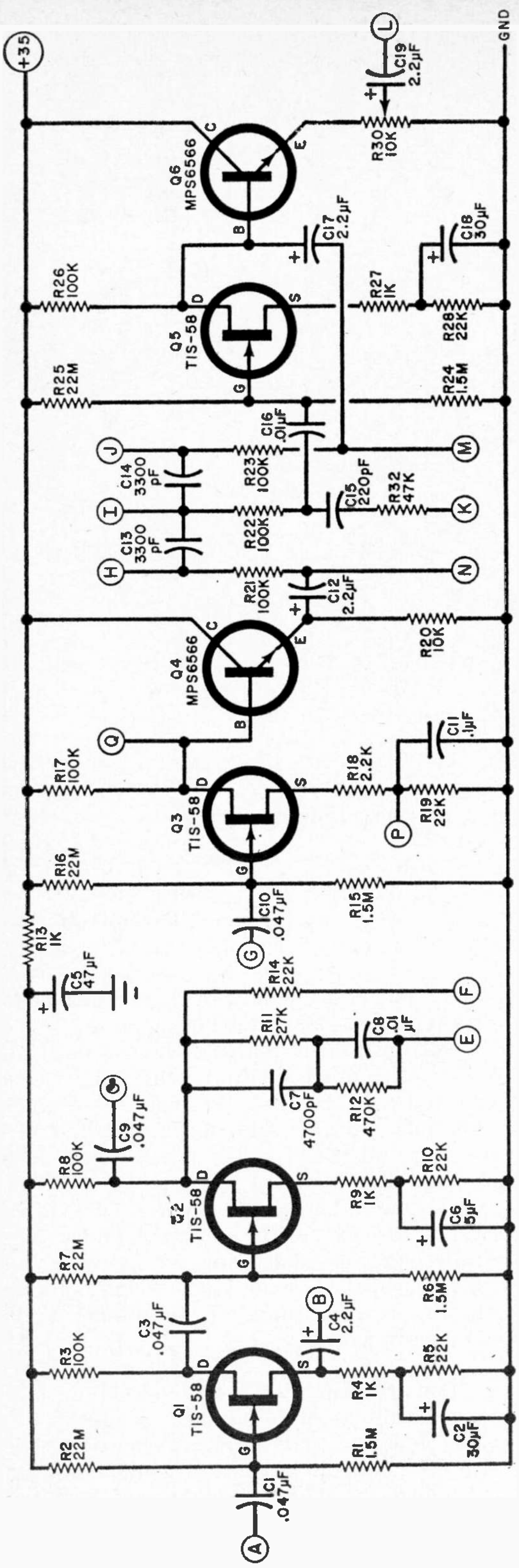


Fig. 1. Four of six semiconductors are low-noise FET amplifiers, and two conventional junction transistors are used as interstage emitter followers.

serve the polarities of the electrolytic capacitors and the identifying flats on the semiconductors. When the boards are assembled, put them aside and prepare the chassis.

Although the author used a metal U-shaped chassis 9″ × 7″ × 2¾″ (with a suitable wooden cover), any other arrangement can be used. In any case, mount the 12-circuit phono jack assembly (or 12 single phono jacks) on the rear apron of the chassis. Label one set of six jacks "Channel 1" and the other set of six "Channel 2." Also mount a pair of phono jacks for the outputs on the rear apron, along with two conventional 117-volt power sockets and two through-the-chassis strain reliefs (one for the a.c. line and the other for the d.c. supply to the preamp).

The front of the chassis can be prepared as shown in the photos. On the left side, cut a slot large enough to fit the four rocker switches. Mount the switches on a support such as that shown in Fig. 4 so that the four switches can be operated easily from the front.

PARTS LIST

C1,C3,C9,C10—0.047-µF capacitor
C2,C18—30-µF, 6-volt electrolytic capacitor
C4,C12,C17,C19—2.2-µF, 50-V electrolytic capacitor
C5—47-µF, 50-V electrolytic capacitor
C6—5-µF, 15-V electrolytic capacitor
C7—4700-pF capacitor
C11—0.1-µF, 12-V capacitor
C13,C14—3300-pF capacitor
C15—220-pF capacitor
C8,C16—0.01-µF, low voltage capacitor
Q1,Q2,Q3,Q5—Field effect transistor (Texas Instruments TIS58)
Q4,Q6—Transistor (Motorola MPS6566)
R1,R6,R15,R24—1.5-megohm
R2,R7,R16,R25—22-megohm
R3,R8,R17,R21,R22,R23,R26—100,000-ohm
R4,R9,R13,R27—1000-ohm
R5,R10,R14,R19,R28, 22,000-ohm
R11—27,000-ohm
R12—470,000-ohm
R18—2200-ohm
R20—10,000-ohm
(all resistors ½-watt)
R30—10,000-ohm PC trimmer potentiometer
R32—47,000-ohm
Note—A printed circuit board (#156) is available from Southwest Technical Products Corp., 219 W. Rhapsody, San Antonio, TX 78216 for $2.40. postpaid. A complete kit of parts including punched cabinet for stereo version (#156-C) is available from the same source for $42.50 plus postage for four pounds.

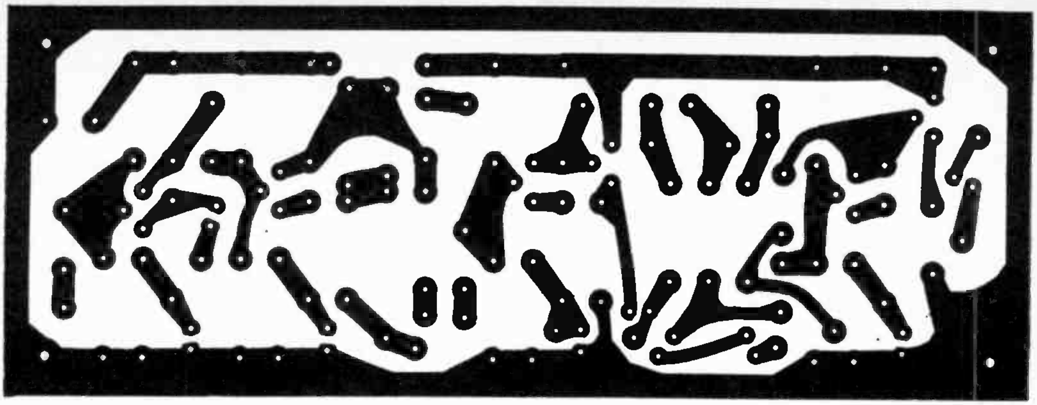


Fig. 2. Actual-size foil pattern for the preamplifier. A pair of boards would be required for stereo.

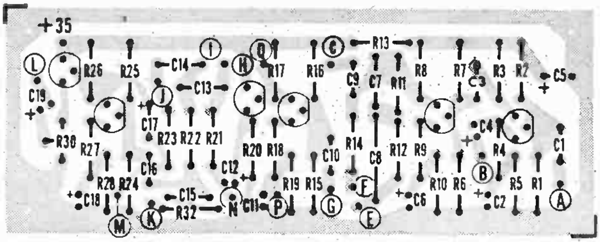
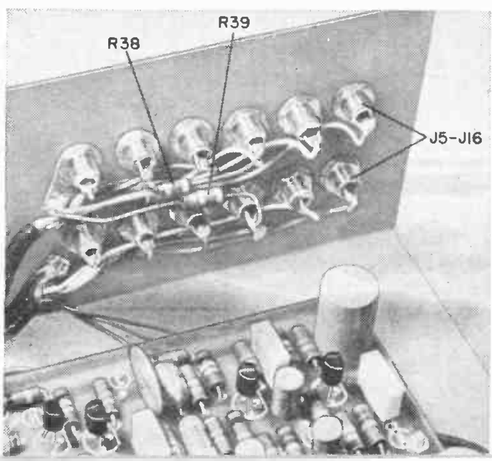


Fig. 3. After making (or buying) the PC board, install the components as shown here, taking care to observe the polarity of semiconductors and electrolytics.

Cut a long slot at the bottom of the front panel for the six pushbutton switches. The switch assembly is held on by a pair of mounting screws from the bottom of the chassis. Next to the pushbuttons, install a pair of phone jacks (one for the microphone input and one for the tape output). The three variable controls, BASS (*R34*), TREBLE (*R35*), and VOLUME (*R33*) are mounted above the pushbutton switches.

In the photographs, the top rocker switch is labeled STEREO-MONO. In the author's final design, however, this switch was used for LOUDNESS-VOLUME and a s.p.s.t. switch was added to the tandem volume controls for the stereo-mono selection. The selection is made by pulling out the shaft of the volume control. In this discussion, the top rocker switch is the LOUDNESS-VOLUME control, *S1*. The second rocker switch from the top is the HI cut switch (*S2*); the third is the LO cut switch (*S3*); and the bottom one is the main a.c. on-off switch (*S5*). The chassis com-

View of rear apron showing mounting details of the 12 input jacks and the location of the two resistors used to load each of the phonograph inputs.



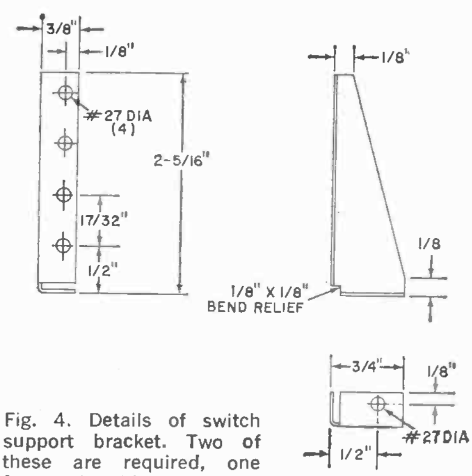


Fig. 4. Details of switch support bracket. Two of these are required, one for each side mounting.

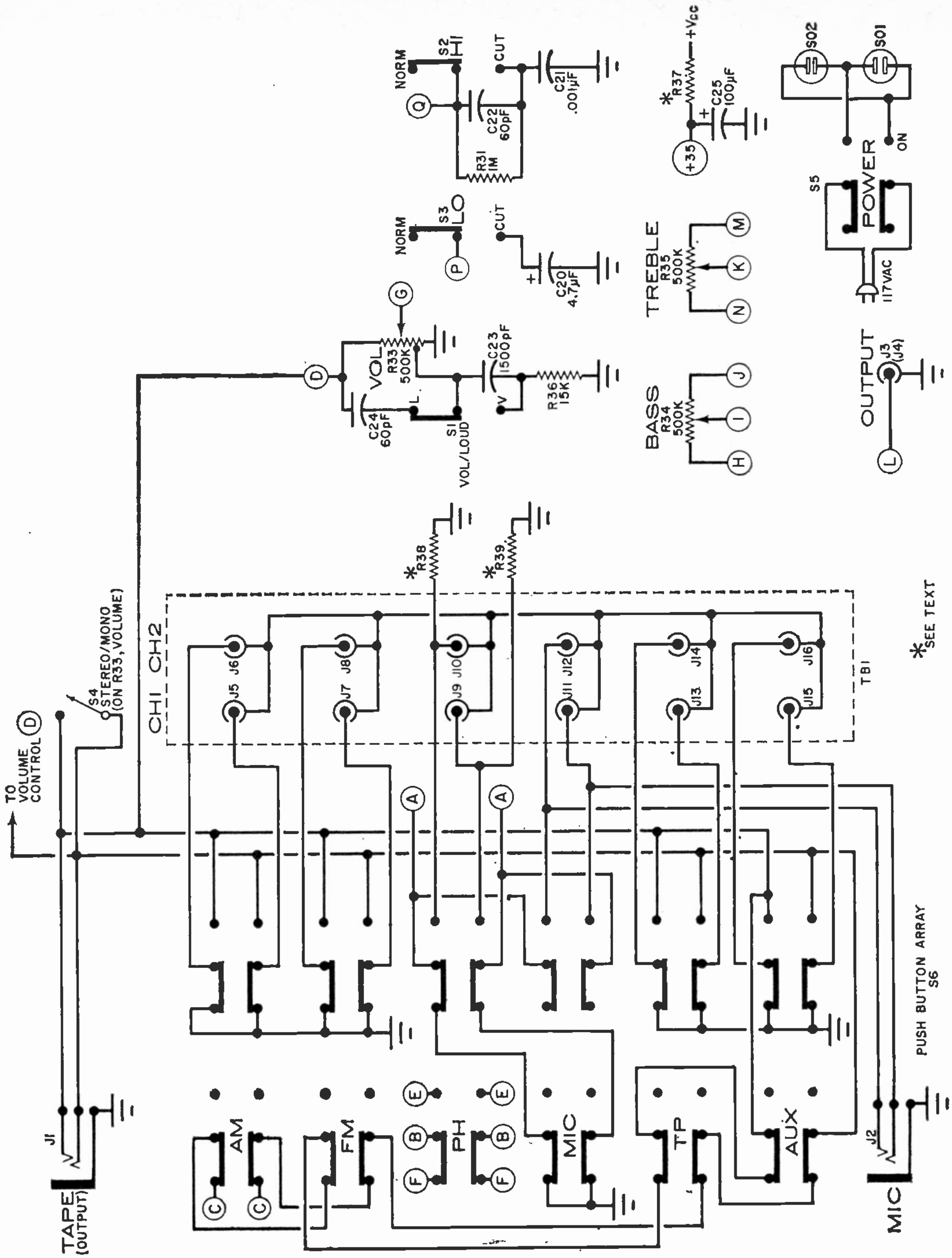
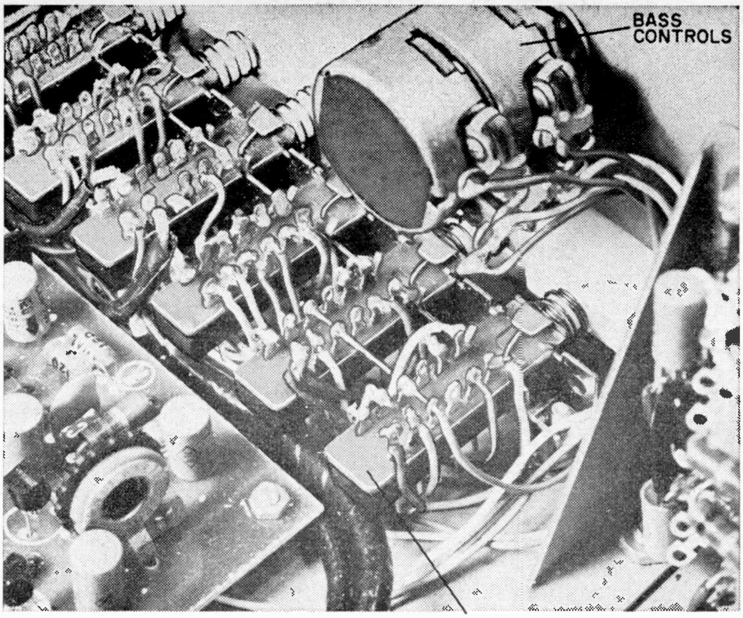


Fig. 5. Wiring of the front and rear panel components. The lettered circles are wired to similar lettered terminals on the boards. The small, individual circuits at the top are the isolated component connections.



Details of one corner of the preamp. Shown here are the tandem bass controls. a portion of pushbutton array S6, and one rocker switch support bracket.

ponents are wired to the boards as shown in Fig. 5.

Mount capacitors *C23* and *C24* and resistor *R36* between the proper terminals on *S1*; and mount *C21*, *C22*, and *R31* on the proper terminals of *S2*. Connect *C20* between *S3* and ground. (The components and connections given in this paragraph must be repeated for each channel of a stereo system.)

Resistors *R38* and *R39* must be connected between the magnetic cartridge input jacks and ground. The values of these resistors should be as recommended by the cartridge manufacturer. Although many values are specified by the various manufacturers, 47,000 ohms is the most common.

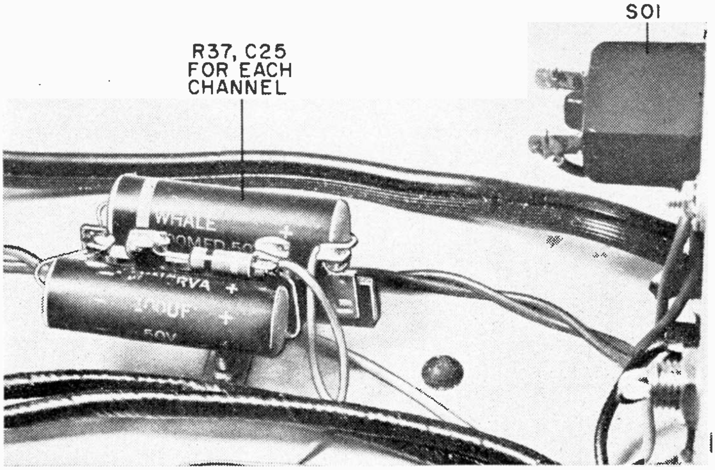
Once all chassis components are mounted, connect the various lettered terminals on the PC boards (see Fig. 5) to their respective controls in neat wire bundles. Mount each PC board on four standoffs, one at each corner.

PARTS LIST

*C20—4.7-μF, low-voltage electrolytic capacitor**
*C21—0.001-μF capacitor**
*C22,C24—60-pF capacitor**
*C23—1500-pF capacitor**
C25—100-μF, 50-volt electrolytic capacitor
J1,J2—3-circuit phone jack
J3,J4—Phono jack
J5—12-circuit phono jack assembly
R31—1-megohm, ½-watt resistor
R33—500,000-ohm tapped potentiometer, tapped 100K from end (tandem)*
R34,R35—500,000-ohm potentiometer (tandem)*
*R36—15,000-ohm, ½-watt resistor**
R37,R38,R39—See text
S1,S2,S3,S5—D.p.d.t. rocker switches
S4—S.p.s.t. switch (on R33)
S6—Six button pushbutton switch assembly, each 4 p.d.t.
SO1,SO2—Chassis-mounting 117-volt a.c. outlets
Misc.—Line cord, strain reliefs (2), spacers, mounting hardware, knobs (3), rubber feet (4), wire, solder, etc.
**Two required for stereo version.*

PREAMPLIFIER SPECIFICATIONS

Frequency response: 10 Hz to 100 kHz (−1 dB point)
Distortion: THD @1-V output, less than 0.15% from 15 Hz to 50 kHz.
Hum and noise: Phono and mic., −65 dB below full output; other inputs, −70 dB below full output.
Sensitivity: Phono and mic., 2 mV for 1-V output; other inputs, 0.1V for 1-V output.
Input impedance: Phono, 47,000 ohms (see text); other, 500,000 ohms.
Input before clipping: Phono and mic., 0.1V; other inputs, 10 V.
Maximum output: 5V r.m.s.
Output impedance: less than 1000 ohms.
Channel separation: Greater than 40 dB at 1000 Hz.
High filter: 3 dB down at 10 kHz.
Low filter: 3 dB down at 70 Hz.
Treble control range: ±15 dB at 10 kHz.
Bass control range: ±15 dB at 50 Hz.



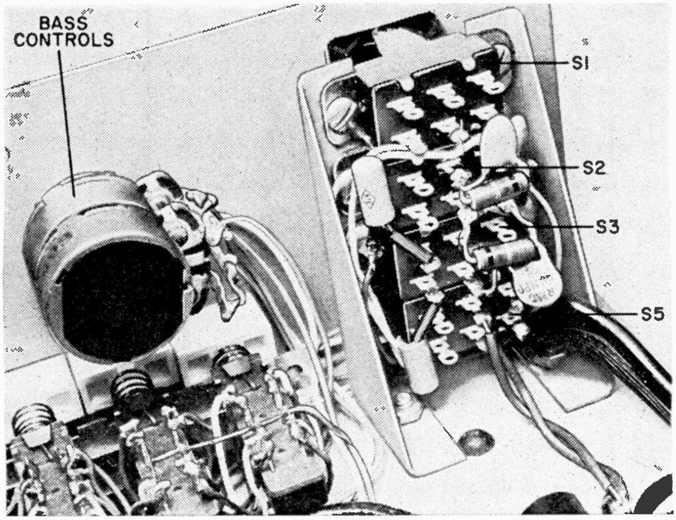
To reduce the interchannel coupling, a separate voltage-dropping network, R37 and C25, is used for each of the stereo channels.

Pass the 117-volt line cord through its strain relief and connect it to switch *S5* and to the power outlets. Line voltage for the power amplifier is taken from one of these outlets; the other can be used for a record player or tape recorder.

D.c. power for the preamplifier should be obtained from a well-filtered 35-volt source. Provisions for this supply are made in the companion power amplifier described on page 61 of this issue. If the external power source is higher than 35 volts, resistor *R37* must be used to drop the voltage. To determine the value to use for *R37*, divide the difference between the voltage you have and 35 by 0.006. For example, if the source is 50 volts, the resistance is 50 — 35, or 15, divided by 0.006, or 2500 ohms. You can use the nearest standard resistance value (2200 or 2700 in the example) at ½ watt. Mount *R37* with its companion filter capacitor *C25* on a multi-lug terminal strip in an open section of the chassis.

Recheck all wiring.

Testing. Connect the two rear-apron output jacks (*J3* and *J4*) to the inputs of the power amplifier, and connect the desired inputs to the two channels of the preamp. Turn on the power to the preamp. (The 117-volt line cord on the power amplifier can be plugged into *S01* or *S02* and switched on and off with *S5* on the preamp.) Check that approxi-



The overall rocker switch support bracket assembly. Components are mounted on switches.

HOW IT WORKS

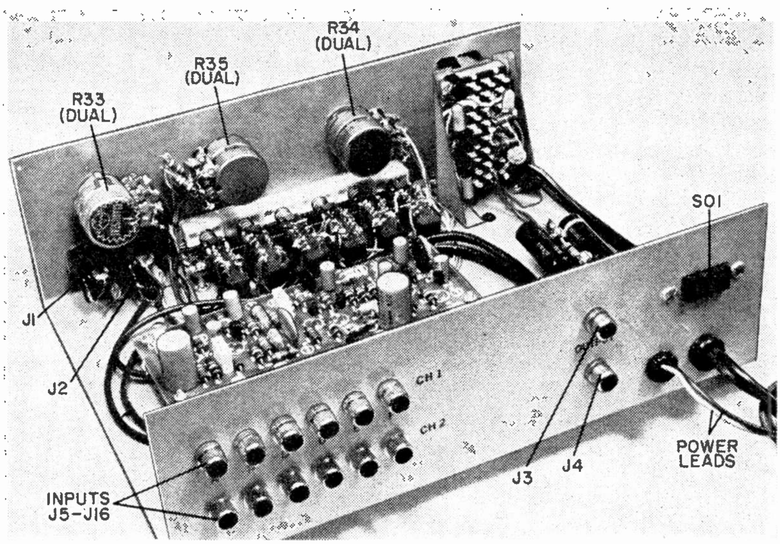
Input selection is made by a series of pushbuttons, each operating a four-pole, double-throw switch. When a button is "out," the input that the particular button controls is grounded to prevent cross talk from the unused inputs. Pushing "in" any of the four high-level pushbuttons breaks the connection between the first two stages of the preamp and the volume control, and feeds the selected high-level input directly to the volume control. This approach keeps the distortion as low as possible. (In some preamps, the high-level inputs are reduced resistively and all signals are amplified by the complete preamp.) In this preamp, only the microphone and phono input are amplified by the first two stages. In the phono position, the preamp feedback network is switched in and changes the amplifier curve from essentially flat to the required RIAA curve.

The four FET amplifier stages are similar. A common-source circuit having a large-valued source resistor and positive gate bias results in a consistent and stable amplifier. The first two stages (*Q1* and *Q2*) use the RIAA equalization network needed for magnetic phono input. Amplifier *Q2* feeds the volume control (*R33*), which is followed by a FET amplifier (*Q3*) to provide a low-impedance driving source for the tone controls.

The tone-control circuit (between *Q4* and *Q5*) is a low-distortion Baxendall-type circuit. This feedback type of tone control utilizes the most desirable variable turnover point characteristic. The controls give bass or treble boost or cut when offset from the normally flat center position. The tone control network, including *Q5*, has unity gain and is followed by emitter follower *Q6*. The low output impedance permits the use of a reasonably long cable between the preamp and its associated power amplifier with reduced attenuation and noise pickup. The low output impedance also insures that the preamp will be able to drive transistor amplifiers with the lowest input impedance. The most desirable situation in an audio system is to have a low impedance driving a higher impedance. This is not efficient as far as power transfer is concerned, but it does result in the lowest possible distortion.

The output level is adjusted by a trimmer potentiometer (*R30*) on each channel to allow balancing without the use of concentric, or clutch-coupled, controls. It also allows exact match for the power amplifier being used.

The high-frequency filter bypasses the highs to ground at the drain of *Q3*, while the low-frequency filter changes the *Q3* source network. The stereo-mono switch is coupled to the volume control which makes it possible to switch to either stereo or mono merely by pulling out the volume control. The loudness compensation switch changes the circuit of the volume control to boost the bass and treble at low volume levels.



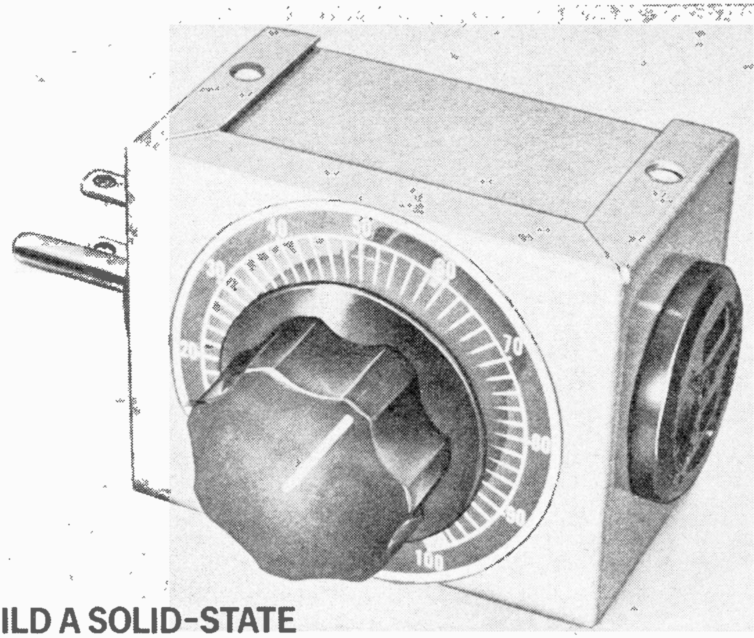
Though two are called for, the author mounted only one power outlet (SO1) on rear apron. The preamp controls primary power fed to main amplifier through this outlet, and takes d.c. from the amplifier.

mately 35 volts is present at the +35 terminal on each PC board. Using a high-impedance voltmeter, check that the drain voltage at each FET is between 12 and 18 volts. If any wide variation is found, check the circuit for possible errors in component values.

Depress the appropriate input pushbutton and operate the VOLUME, BASS, and TREBLE controls as desired. If you want loudness compensation instead of linear volume action, operate the LOUDNESS-VOLUME rocker switch.

Place the system in MONO (by operating the volume control shaft) and adjust *R30* in each channel to get the same output from each. This is the only balance adjustment that needs to be made.

If there is excessive hum in the system, the preamplifier may be too near a power transformer or a.c. motor. Proper orientation reduces interference. —30—



BUILD A SOLID-STATE

VARIABLE TRANSFORMER

USE A TRIAC FOR SMALL SIZE AND LOW COST

BY ROBERT C. ARP, JR.

A VOLTAGE-LEVEL control for a.c. is one of the most useful electronic devices you can have around the house. It can serve as a speed control for motor-driven appliances; a heat control for soldering irons; or an incandescent light dimmer.

An ordinary variable autotransformer is commonly used as a voltage-level control. However, such transformers are expensive, bulky, and not very portable. A solid-state circuit, built around a triac, eliminates these objections. It costs about $8 in parts, fits into the smallest metal utility box, and weighs only a few ounces.

Aptly called a "Solid-State Variable Transformer," the voltage-level control described in the following pages does everything a conventional variable transformer can and does it more efficiently. There are no hysteresis losses, IR losses are at a minimum, and it operates cool.

Construction. Keep foremost in your mind that the Solid-State Variable Transformer is used to control potentially hazardous a.c. line voltages. Do not substitute parts for those specified in the Parts List. Take extra care when wiring the circuit and do not attempt to power the circuit until after you perform the ohmmeter checkout given in the last section of this article.

Begin construction by machining the utility box to provide mounting holes for *R1*, *P1*, and *SO1* as shown in Figs. 2 and 3. Note that all mounting holes are to be centered in the respective sides of the box.

The quickest and neatest method of making the cutouts for *P1* and *SO1* is to punch them out with a Greenlee No. 732 keyed radio chassis punch (orient the

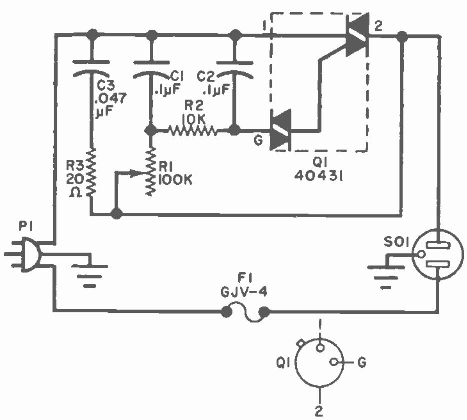


Fig. 1. Triac Q1 actually consists of four-layer diode at G and triac between 1 and 2.

PARTS LIST

C1, C2—0.1-µF, 200-volt tubular capacitor
C3—0.047-µF, 200-volt tubular capacitor
F1—Buss No. GJV-4 fuse
P1—Three-line a.c. plug (Amphenol No. 160-11)
Q1—Triac (RCA 40431)
R1—100,000-ohm, ½-watt linear taper potentiometer
R2—10,000-ohm, ½-watt resistor
R3—20-ohm, ½-watt resistor
SO1—Three-line a.c. receptacle (Amphenol No. 160-10)
1—Bud No. CU-2100-A metal utility box
Misc.—Ohmite Type 5000 dial plate (optional); control knob for R1; 2-each three-lug terminal strips (H.H. Smith No. 830, or similar); 1½"-long x ¼"-diameter heat-shrinkable tubing for F1; hookup wire; solder; etc.

keys toward the bottom of the box). However, if you do not have access to a chassis punch, simply cut out a $1\frac{11}{64}$"-diameter hole at each of the proper locations. Apply a liberal bead of epoxy cement around the entire perimeter of *P1* and *SO1*. Then insert the plug and receptacle into their respective cutouts, orienting the rounded prong and hole toward the top of the utility box, and snap into place the retainer rings.

After allowing sufficient time for the epoxy cement to set, drill a ⅜"-diameter hole through the top of the box for mounting control *R1*. Then, before setting *R1* in place, wrap one turn of 16-gauge solid bare wire around the mounting threads of the control, leaving 2" leads at each end. Insert *R1* into its mounting hole, slip on the optional dial plate, fasten down the control, and fasten down the panel knob.

Now, locate the ends of the solid wire previously wrapped around *R1*. Connect the ends of this wire to the green-coded contacts on *P1* and *SO1*. Snip away any excess wire and the *right* lug of *R1*.

Temporarily remove the silver-coded screw from *P1*, and use this screw to mount a three-lug terminal strip on the rear of the plug. In like manner, use the brass-coded screw on *SO1* to mount an identical terminal strip on the rear of the receptacle.

Slip the 1½" length of shrinkable plas-

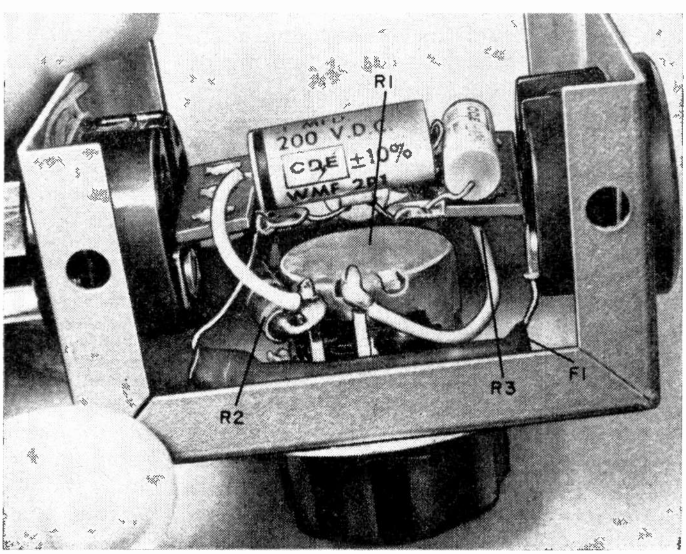
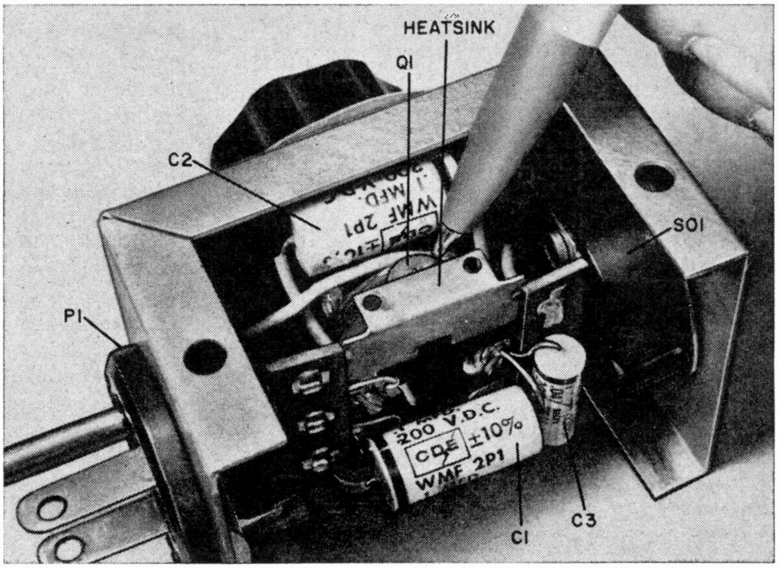


Fig. 2. Lug 3 at right of R1 is not used and should be removed to eliminate possibility of short circuits. Also, two terminal strips mount directly on rear of receptacle and plug.

Fig. 3. Once Q1 is properly soldered to heatsink according to directions, set heatsink tabs onto lugs of terminal strip; solder in place.



tic tubing over the fuse, centering it over the body of the fuse, and apply heat until the tubing shrinks snugly around the fuse. Connect one lead of the fuse to the silver-coded contact of *SO1*, the other lead to the solder lug common to the silver-coded contact on *P1*.

Solder one lead of *R2* to the left lug of *R1* and the other lead to the center lug of the terminal strip mounted on *P1*. Slip a 1¼" length of plastic insulation over each lead of *C2*. Leaving just ¼" of bare lead exposed, clip off the excess lead lengths. Now, referring to Fig. 3, place *C2* against the top of the utility box, just above *R1*, and solder one lead to the center lug on the left terminal strip and the other lead to the center lug of the right terminal strip.

Solder a 2" length of insulated hookup wire from the center lug of *R1* to the lug common to the brass-coded screw on the *SO1* terminal strip. Then connect *R3* between the two outer lugs, and *C3* from the center lug to the outer lug (near the silver-coded contact of *SO1*) of this same terminal strip.

Connect another 2" length of insulated hookup wire from the brass-coded screw on *P1* to the center lug on the *SO1* terminal strip. Cut one lead of *C1* to 1" in length, the other lead to 1¼" in length. Then slip a 1" length of plastic insulation over the 1¼" lead, and connect this lead to the left lug on *R1*. Solder the remaining lead of *C1* to the center lug of the *SO1* terminal strip.

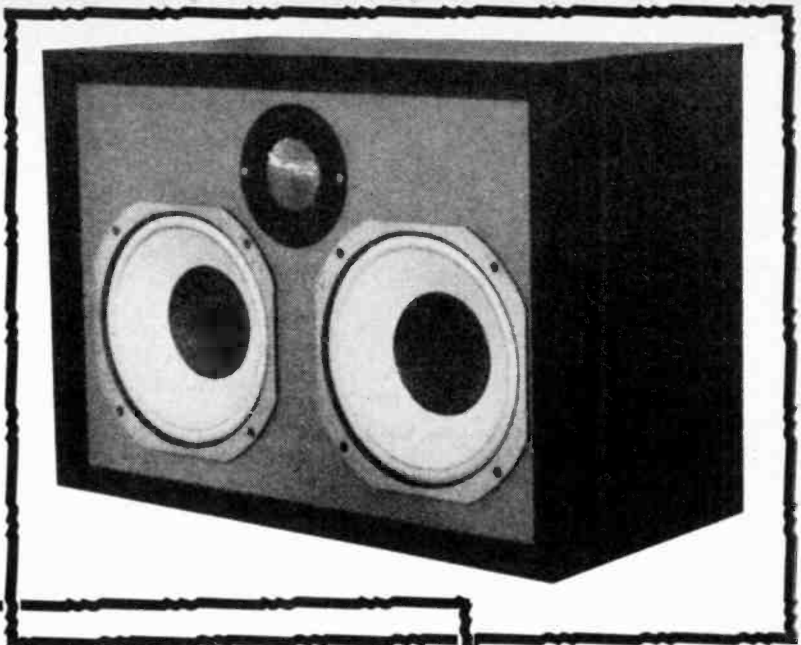
Place the solder circle that comes with the triac in the heatsink (sometimes referred to as a heat spreader). Then force the triac between the tab and rear wall of the heatsink, being careful to prevent the Gate and No. 1 lead of the triac from touching the heatsink. Solder the case (terminal 2) of the triac to the heatsink.

Now, liberally tin with solder the upper lugs of both terminal strips (see Fig. 3), place the triac assembly on these lugs as shown, and heat the heatsink to solder the triac assembly firmly in place. Finally, solder lead No. 1 from the triac to the center lug of the *SO1* terminal strip, and the Gate lead to the center lug on the *P1* terminal strip. Check to make sure that neither lead is touching the heatsink, case of *R1*, or each other.

Final Check and Use. Before powering the Solid-State Variable Transformer, check out the circuit with an ohmmeter as follows. With *R1* set for minimum resistance, and the ohmmeter's range switch set to X100K, touch the probes of the ohmmeter to the brass-coded screws on *SO1* and *P1*. Initially, there should be a well-defined deflection of the meter pointer toward the low resistance end of the scale. Thereafter, the pointer should slowly drift back toward the infinity index of the meter scale.

Now, touch the probes to the green-

(*Continued on page* 116)



THE TIE BOOKSHELF SPEAKER

ECONOMY
INTERMEDIATE
TOP-OF-THE-LINE

Build the Optional Component System

BY HERMAN F. JOHNSON

THE TROUBLE with most instructions for constructing bookshelf speaker systems is plain old tradition. For example, tradition (or convention) calls for plywood as the work medium with cleats and wood screws to give structural strength and miter cuts to obtain "finished" edges. In reality, however, these so-called time-saving and economical practices can be stumbling blocks for the once-in-a-while woodworker.

Cleats actually reduce the volume in a small enclosure, require extra time to install, and run up the cost of materials. Plywood, far from being an easy medium with which to work, is fraught with disadvantages—such as opposing grains, hidden flaws, and different types of lumber. Most important, few hobbyists have the proper cutting tools or adequate experience to turn out precise 45° miter cuts—and just try to get a lumberyard to do it for you!

So what do you do to eliminate these objections to conventional practices? First, toss out cleat supports and substitute the tongue-and-groove method of support (see Fig. 1). In so doing, you

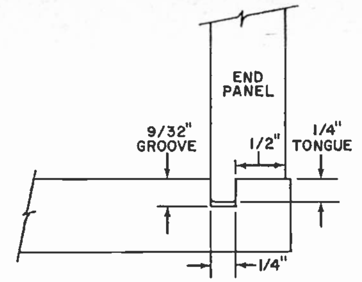


Fig. 1. Tongue-and-groove joint is self-supporting; with glue, is self-fastening.

eliminate the need for screws and cut down on assembly time. Next, use easy-to-work-with prefinished particle board shelving to eliminate the need for miter cuts and still get a neat appearance. Finally, use front-mounting speakers or adapt speakers so that they can be front mounting, and you can build a permanently sealed, "unitized" enclosure.

In following this procedure, the only tool you need (other than a common screwdriver) is a power router. Power routers are available for $35 and up. However, if you prefer not to buy one, most hardware stores will rent you one.

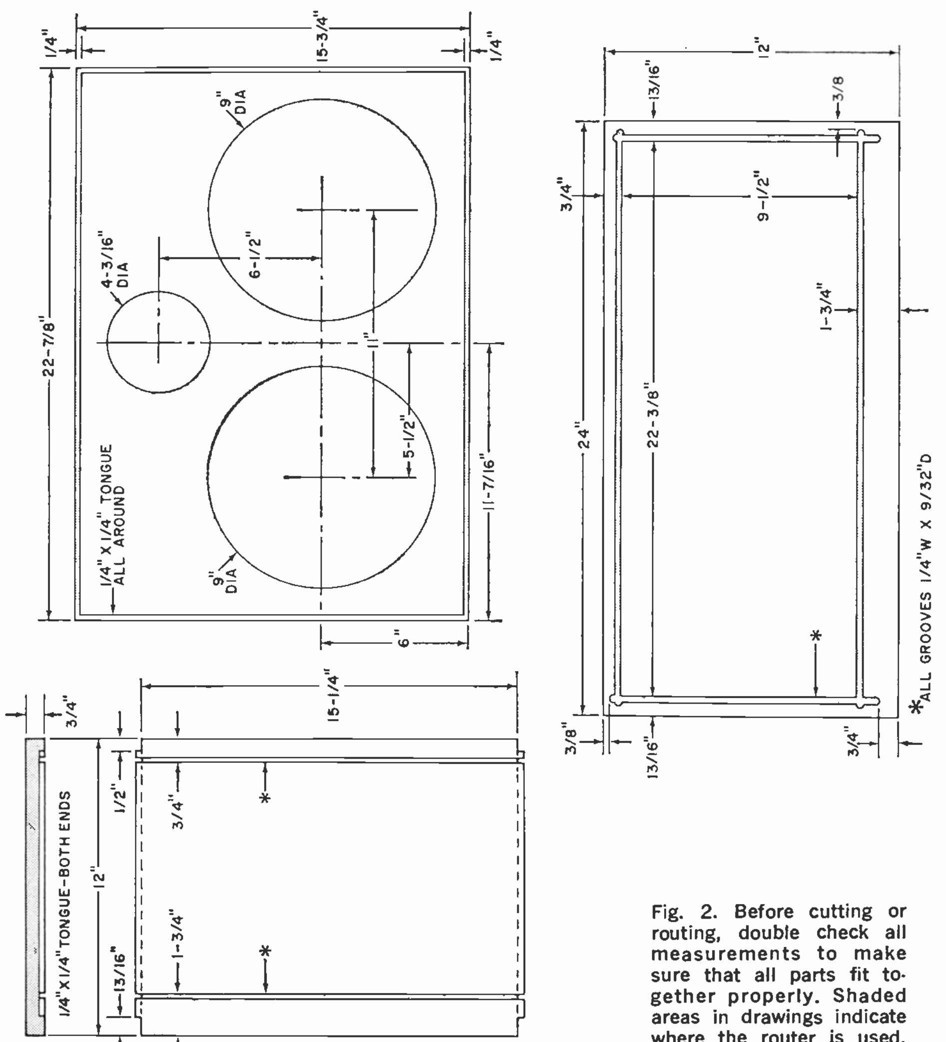


Fig. 2. Before cutting or routing, double check all measurements to make sure that all parts fit together properly. Shaded areas in drawings indicate where the router is used.

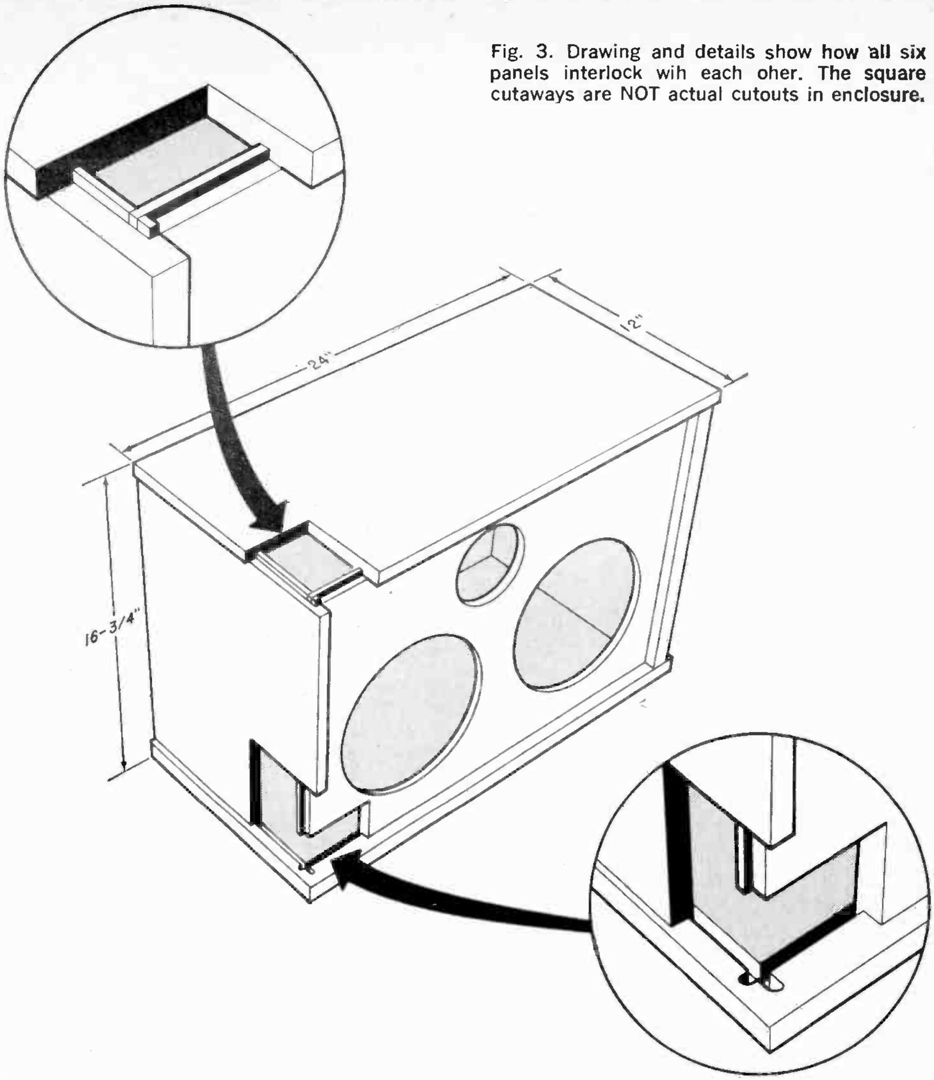


Fig. 3. Drawing and details show how all six panels interlock wih each oher. The square cutaways are NOT actual cutouts in enclosure.

Following is a description of a flexible speaker enclosure that, when built, is the equal of any professionally made enclosure now on the market. In keeping with this flexibility, three different speaker systems—one for every budget—are suggested.

Building the Enclosure. To make the job of finishing the enclosure easier, use prefinished 12″-wide by ¾″-thick particle board shelving for the top, bottom, and sides of the enclosure. The shelving is available with a variety of woodgrain finishes, in both dark and blond shades; so choose a combination that best suits your tastes and room decor.

Two 24″-long prefinished shelves (they come in standard lengths) will be used for the top and bottom of the enclosure. Another 36″-long shelf will be cut to size to make the sides of the enclosure with a few inches left over. Finally, two 22⅞″ × 15¾″ × ¾″ unfinished particle board plates will be used for the speaker mounting board and the rear of the enclosure. Make certain when selecting your shelving that all shelves are the same width, that the ends are square with the sides, and that the two 24″

shelves are within 1/16" of each other in length.

Check each shelf to determine which sides will be used as the exterior surfaces of the enclosure; mark your choices with pieces of masking tape. Now, carefully cut two 15¾"-long pieces from the 36" shelf, referencing your measurements from opposite ends of the shelf. This leaves the scrap material in the middle of the shelf and provides you with at least one neatly finished edge per side.

Now, carefully following the directions supplied with your router, chuck a ¼" straight bit (Stanley No. 1108 or Black & Decker No. U-2501) into place. Again referring to the instruction manual, practice a few dado (groove) and rabbet (tongue) cuts on a piece of scrap lumber to familiarize yourself with the handling of the tool and how to adjust for depth and width of cut.

When you are reasonably confident of producing straight, constant-depth cuts with the router, prepare the four sides and rear of the enclosure and the speaker mounting board according to the dimensions shown in Fig. 2. Note that the shaded areas of each plate indicate where the router is to be used. Make two identical plates for each drawing, but for the rear of the enclosure do not make the circular speaker cutouts.

The recommended procedure for using the router is as follows: First, draw in the groove outlines on the top and bottom panels, marking the start and stop positions with pieces of masking tape. Then, with the router adjusted for the proper width, set the tool down over the stop position of the groove with the bit just touching the masking tape, and strike a pencil line along the router base on the back side (opposite the stop position of the cut).

For uniform groove depth, it is best to cut all grooves that are the same distance from the sides down to ¼" in all four panels. Then reset the router for 9/32" depth and complete these cuts before changing over to the next width setting.

Now, with the router set for a ¼"-wide rabbet cut, rout away the material from the outside top and bottom of the side panels to just slightly more than ½" depth. (Clamp a ¾"-thick piece of

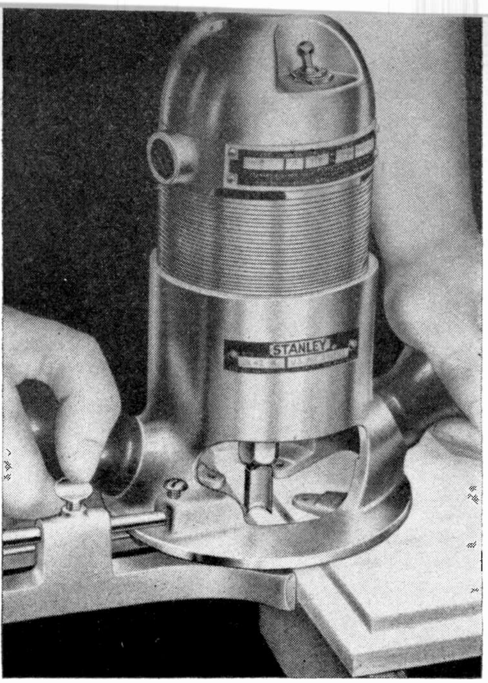


Photo shows the router guide set up for rabbeting to make the tongues. (Photo courtesy of Stanley Works)

scrap lumber to the end-of-the-cut edge to prevent splitting and flaking the finished edge). Then, with a fine-tooth hacksaw, cut off the ends of the tongues for a distance of ½" at the rear and 13/16" at the front edges.

Finally, rout away a ¼"-wide by slightly more than ½"-deep rabbet on all four sides of the speaker mounting board and rear panel. Locate the centers of the hole cutouts on the speaker mounting board and, with the circle guide attachment in place, use the router to make the cutouts.

This completes fabrication of the six enclosure panels. However, it is suggested that you round off the outside corner edges of all tongues with a sanding block to facilitate assembly. Also, apply a coat of resin sealer to all exposed raw edges to prevent flaking.

Temporarily assemble the enclosure to check for proper fit of all members. The tongues should fit snugly in their respective grooves and should not rock back and forth along their lengths (an indication of non-uniform groove depth). All interlocking joints should be perfectly square. If you are satisfied, disassemble the enclosure.

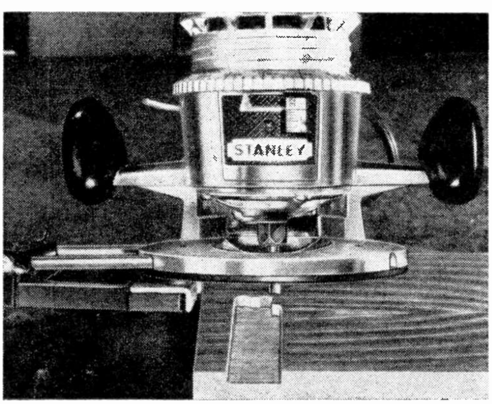
Place the bottom and two side panels

on a level, flat surface. Apply a bead of epoxy cement to the bottom and along the *inside* top edge of each *groove*. Be just liberal enough with the cement to prevent "bleeding" to the outside surfaces when the panels are assembled. Allow the cement to set for about fifteen minutes. Then set the speaker mounting board and rear panel firmly into place, followed by the side panels.

Apply cement to the grooves in the top panel as described above. Then fit the top panel in place, pressing down to seat all plates firmly, and weight the top of the enclosure or clamp the enclosure together to insure that it is perfectly square as the cement sets. Figure 3 illustrates how all six panels of the basic enclosure lock together. The cutaways in the drawing are provided only to illustrate tongue-and-groove jointing details (not actual cutouts in the enclosure itself). Note also in this illustration that both side panel exterior surfaces are recessed 1/16" from the edges of the top and bottom plates.

Speaker System Choices. The three speaker systems described here were selected to provide maximum flexibility and the best possible sound reproduction in the basic enclosure just described. In addition, all systems are of two-way design, and all speakers are front mounted to preclude any necessity for disassembling the enclosure as you go from one system to another.

For the top-of-the-line, the James B. Lansing (hereafter referred to as JBL) "S11" system (plus an optional



To cut grooves, the router guide is adjusted away from the cutting bit. (Photo courtesy of Stanley Works)

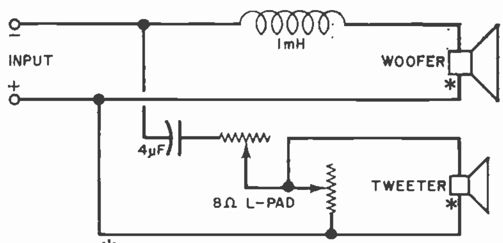


Fig. 4. All speaker systems suggested for basic enclosure are two-way, to be wired together as shown.

radiator) was selected. This system includes the JBL Models LE20 high-frequency transducer; LE10A low-frequency driver; and LX11 crossover network with high-frequency control. The optional passive radiator is designated the Model PR10, also by JBL.

When installing the system, start off by mounting the crossover network and high-frequency control on the rear panel of the enclosure. Mount the LX11 on the outside of the enclosure, over a 4¼" × 5½" cutout. Then mount the LE20 in the 4 3/16" hole and the LE10A in one of the 9" holes in the speaker mounting board. Wiring instructions are furnished with the network.

If you decide to use the passive radiator, mount it in the remaining hole. However, if you choose the ported system, you will have to make an adapter flange for the 4"-inner-diameter by 7½"-long cardboard mailing tube as shown in Fig. 5. Use ⅜"-thick plywood, white pine, or particle board for the flange, and fix the tube in place with epoxy cement. (The diameter of the tube hole will depend on the outer diameter of the tube selected.)

This system evenly distributes the high-frequencies through a wide angle so that the listeners hear a balanced blend of direct and reflected sound. For the low and midrange frequencies, the bass is robust, there is a wide dynamic range, and response on the whole is smooth and clean well up into the midrange. And although the passive radiator makes for a better system, substituting the port does not detectably degrade sound reproduction.

The *intermediate* system retains the superior JBL Model LE20 high-frequency transducer, and is complemented by the JBL Models D208 8" full-range

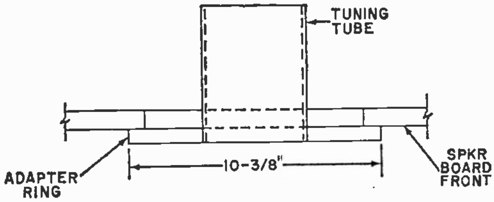


Fig. 5. If a ported enclosure is desired, an adapter ring is required for mounting port in 9" hole.

speaker and LX2 crossover network. This is a ported system requiring the use of a 4"-inner-diameter by 5"-long tube. The tube is mounted to the enclosure's speaker mounting board in the identical manner as above. Similarly, the crossover network has the same requirements as the LX11.

To mount the D208 full-range speaker in place, it is necessary to prepare an adapter ring as illustrated in Fig. 6. The ring serves two purposes: the speaker can be essentially front mounted and you can use the original 9" speaker cutout.

BILL OF MATERIALS
SPEAKERS

Top-Of-The-Line System ($123; $138 with PR10)*

1—JBL Model LE10A 10" woofer
1—JBL Model LE20 tweeter
1—JBL Model LX11 crossover network
1—JBL Model PR10 10" passive radiator (optional, see text)

Intermediate System ($100)*

1—JBL Model D208 8" full-range speaker (and adapter ring—see text)
1—JBL Model LE20 tweeter
1—JBL Model LX2 crossover network
1—4"-inner-diameter x 5"-long cardboard mailing tube and adapter ring (see text)

Economy System (about $15)*

1—5" woofer (Lafayette Radio Electronics No. 99-0154).
1—Jensen Mfg. Co. Model TP35V 3½" tweeter
1—4"-inner-diameter x 8"-long cardboard mailing tube and adapter ring (see text)
1—8-ohm L-pad

LUMBER & MISCELLANEOUS

2—24" x 12" pieces of ¾" prefinished particle board shelving for enclosure top and bottom
1—36" x 12" piece of ¾" prefinished particle board shelving for enclosure sides (see text)
2—22⅞" x 15¾" pieces of ¾" unfinished particle board for enclosure rear panel and speaker mounting board
Misc.—Zip cord; epoxy cement; ⅜"-thick lumber for adapter rings (if required); hardware; 7'-long x ¾" square pine for grille frame; grille cloth; damping material; etc.
**Prices listed include speakers and crossover networks only; lumber and miscellaneous extra.*

The *economy* system also employs a ported enclosure to complement its two-way speaker system arrangement. The speakers used in this system are a Jensen Manufacturing Company Model TP35V high-frequency radiator and a Lafayette Radio Electronics No. 99-0155 imported 5" low-frequency driver. A 4"-inner-diameter by 8"-long tube, mounted as in Fig. 5, rounds out the system.

It is also necessary to mount the Lafayette Radio speaker on an adapter ring (see Fig. 6, but this time substitute 4¾" for the 7" dimension of the cutout). Mount the TP35V on an adapter ring with the following dimensions: 5¼" outer diameter × 3⅛" cutout diameter. Then mount the assembly over the 4³⁄₁₆" hole in the speaker mounting board.

Refer to Fig. 4 for wiring the economy system. However, be sure you wire a 4-μF capacitor in *series* with the TP-35V to isolate it from low-frequency power. Then finish the system off with a suitable L-pad.

Whichever system you build, at least 50% of the interior surfaces of the enclosure should be covered with a 1" or more layer of acoustical fiberglass or other sound absorbent material. The actual thickness and location of the damping material have definite effects on the sound reproduction. As a result, no hard and fast rules are presented here. Just experiment with different thicknesses and locations until your system has the characteristics that most

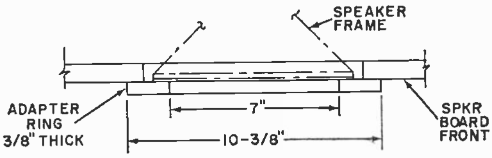


Fig. 6. Another adapter ring permits D208 speaker to be front mounted in one of 9"-diameter cutouts.

suit your tastes. However, if you experience "boomy" bass reproduction, try hanging a curtain of damping material behind the speakers.

When you have everything to your tastes, build a frame (about 22¼" × 15⅛") of ¾"-square pine. Cut your choice of grille cloth to size, stretch it over the frame, and staple or tack it down. Then press-fit the grille assembly in place. That's it! —30—

BY JAMES BONGIORNO

ULD Sine Wave Generator

5 TO 60,000 Hz WITH ULTRA LOW DISTORTION

THERE IS a certain aura of "rightness" about test equipment. Whether we buy a piece of commercial test equipment or assemble a kit, we always assume that the instrument is relatively absolute, that it does what it is supposed to do, and that the readings it provides are correct. We take it for granted that any detectable errors are in the device being tested. It is also customary to assume that a test instrument is more accurate than the device being tested.

Everyone (who has thought about it) knows, of course, that a perfect test instrument doesn't exist and that even very accurate instruments are expensive. However, there is no reason why the electronics experimenter should not use the very best equipment that he can find or build.

In the past, the EXPERIMENTER'S HANDBOOK has presented some remarkably accurate digital test instruments, which, in spite of their relatively low cost, had accuracies that rival those of commercial gear. Described in this article is a low-cost, top-quality ultra-low-distortion audio generator for the serious audio hobbyist and electronics technician. The specifications shown in the table compare favorably with some of the best available audio generators. (See box on Residual Distortion)

The circuit for the generator is shown in Fig. 1. Like any test instrument, the quality of performance depends on the accuracy of the bridge components (in the lower half of Fig. 1). To provide for ease of dial reading a dual log-taper potentiometer is specified. The bridge capacitors are relatively expensive. The two capacitors with the smaller values (*C10* and *C11*) are polystyrene having tolerances of ±1%, while the two larger units are metalized Mylar also with tolerances of ±1%.

The Author

After many years as a professional musician, Jim Bongiorno's interest in basic electronics led him into the field of servicing electronic organs and hi-fi equipment. After working his way up the technical ladder, he is now Chief Engineer, engaged in research and development at Lambert Laboratories, Westfield, N.Y.

The dual log-taper potentiometer (*R-26*) must track within 1 dB to produce the frequency response and amplitude stability given in the specifications table. Conventional, over-the-counter dual pots do not track this closely. However, one

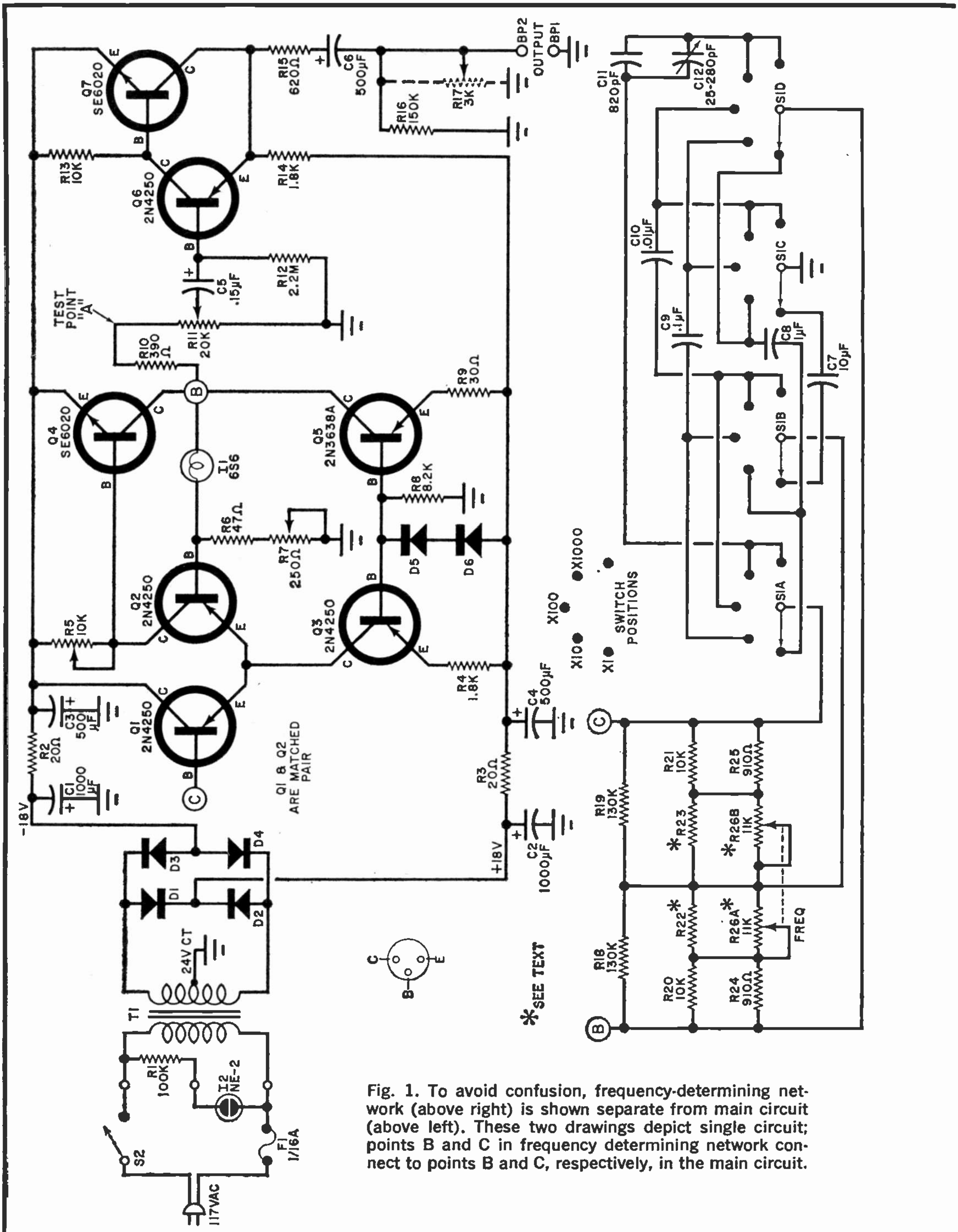


Fig. 1. To avoid confusion, frequency-determining network (above right) is shown separate from main circuit (above left). These two drawings depict single circuit; points B and C in frequency determining network connect to points B and C, respectively, in the main circuit.

is available through the source given in the Parts List. Special close-tolerance capacitors are also available from the same source.

Obviously, if you do not want your generator to have the accuracy shown in the table you can use conventional components with broader tolerances.

PARTS LIST

BP1, BP2—Five-way binding post, one red, one black
C1, C2—1000-µF, 25-volt electrolytic capacitor
C3, C4—500-µF, 25-volt electrolytic capacitor
C5—0.15-µF, 60-volt, 1% polystyrene capacitor
C6—500-µF, 15-volt electrolytic capacitor
*C7—10-µF, 200-volt, 1% Mylar capacitor**
*C8—1-µF, 200-volt, 1% Mylar capacitor**
*C9—0-1-µF, 60-volt, 1% polystyrene capacitor**
*C10—0.01-µF, 60-volt, 1% polystyrene capacitor**
C11—820-pF, 60-volt, 5% polystyrene capacitor
C12—25-280-pF trimmer capacitor
D1-D6—100-mA silicon diode (any type)
F1—1/16-ampere fuse and holder
I1—115-volt, 6-watt lamp (GE6S6 or similar)
I2—NE-2 neon lamp
Q1, Q2, Q3, Q6—Transistor (Fairchild 2N4250 or 2N5087)*
Q4, Q7—Transistor (Fairchild SE6020A or RCA 40459)
Q5—Transistor (Fairchild 2N3638A or 2N4354 or RCA 2N4037)
R1—100,000-ohm
R2, R3—20-ohm
R4, R14—1800-ohm
R6—47-ohm
R8—8200-ohm
R9—30-ohm
R10—390-ohm
R12—2.2-megohm
R13—10,000-ohm
R15—620-ohm
R16—150,000-ohm
R18, R19—130,000-ohm, 1%
R20, R21—10,000-ohm, 1%
R22, R23—see text
R24, R25—910-ohm, 1%
(All resistors ½-watt, 5% unless noted)
R5—10,000-ohm trimmer potentiometer
R7—250-ohm trimmer potentiometer
R11—20,000-ohm linear taper potentiometer
R17—3000-ohm linear taper potentiometer (optional)
*R26—Dual log potentiometer, 10% (nominally slightly greater than 10,000 ohms)**
S1—4-pole, 5-position rotary switch (Centralab PA1012 or similar)
S2—S.p.s.t. switch
T1—Power transformer; secondary, 24 volts, 0.085 amperes (Stancor P-8394 or similar)

Misc.—Heat sink for Q4 and Q5 (Wakefield NF207 or similar); 4" x 5" x 6" steel cabinet; line cord; knobs; frequency dial*; press-on lettering; mounting hardware; etc.
*Etched PC board @ $4.00, dual potentiometer (R26) @ $6.25, set of four bridge capacitors @$12.00, matched differential pair of 2N4250 @ $1.25, calibrated dial @ $6.00, and selected SE6021 @ $0.75 are available from Lambert Laboratories, 48 Washington St., Westfield, N.Y. 14787. A complete kit of parts is available for $48.50 from the same source, postage paid.

Construction. The audio generator, including the power supply, is built on a printed circuit board whose actual-size foil pattern is shown in Fig. 2. You can make your own board or buy one as listed in the Parts List. Assemble the components on the board as shown in Fig. 3. Be sure to observe the correct polarities of the electrolytic capacitors and the semiconductors. The arrangement shown in Fig. 3 must be followed to reduce hum to a low level. Place heat sinks on transistors *Q4* and *Q5*.

The prototype generator was constructed in a 6" × 5" × 4" metal enclosure. The front panel was laid out as shown in the photographs. Mount the frequency control potentiometer (dual *R26*), range switch (*S1*), level control (*R7*), output binding posts, power on-off switch (*S2*), and power-on indicator (*I2*) on the detachable front panel. Mount the capacitors on the range switch (*S1*), then wire in the various frequency determining resistors. Make sure that these are wired correctly or *Q5* will burn out.

Set *R5* (on the PC board) to its approximate center of rotation and temporarily wire the circuit as shown in Fig. 1. Connect a scope to test point "A" and turn the generator on. You should observe a sine wave on the scope. There is a possibility that *R7* (on the PC board) may be set for too low a resistance. In this case, adjust *R7* through its complete range observing on the scope that the output goes from zero to a clipped sine wave. Set *R7* so that a clean sine wave of exactly 5 volts r.m.s. is obtained.

Bridge Component Calibration. As previously stated, the frequency and amplitude accuracies of the generator are only as good as the components. This is particularly true of the decade capacitors associated with *S1*. You can select these from random capacitors using an accurate RLC bridge to measure the absolute values and, if necessary, paralleling small value capacitors to arrive at a desired value.

The frequency control dual potentiometer (*R26*) must be calibrated (see below), but first using a very accurate ohmmeter determine its total end-to-end resistance. It should be a little over

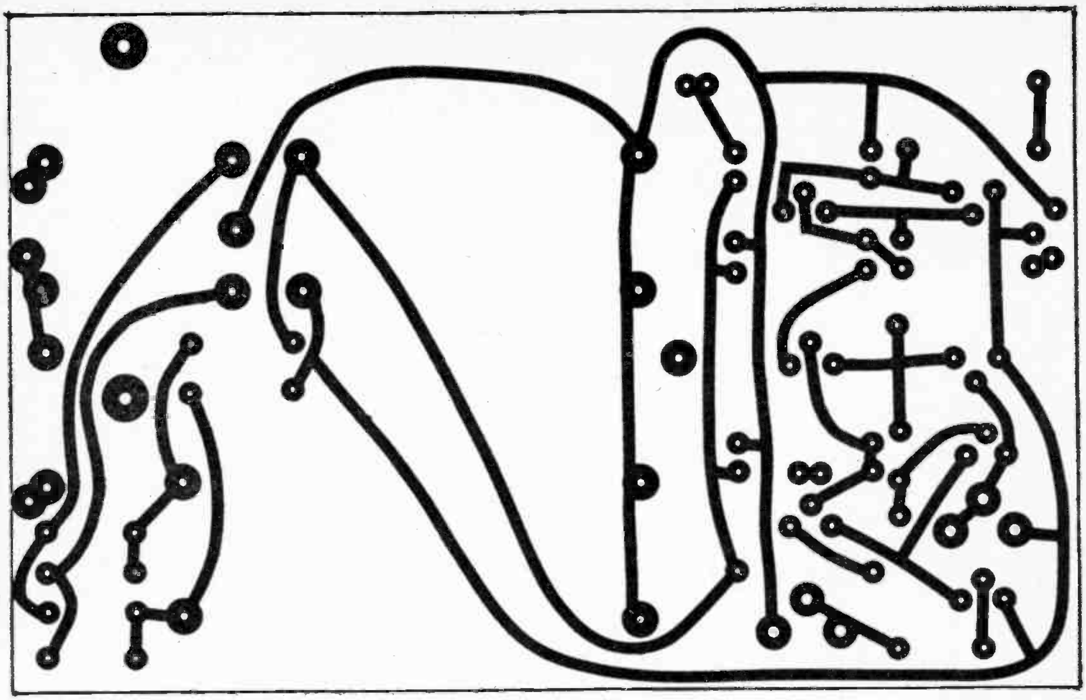


Fig. 2. Printed circuit board speeds assembly. To make your own board, copy actual-size foil pattern.

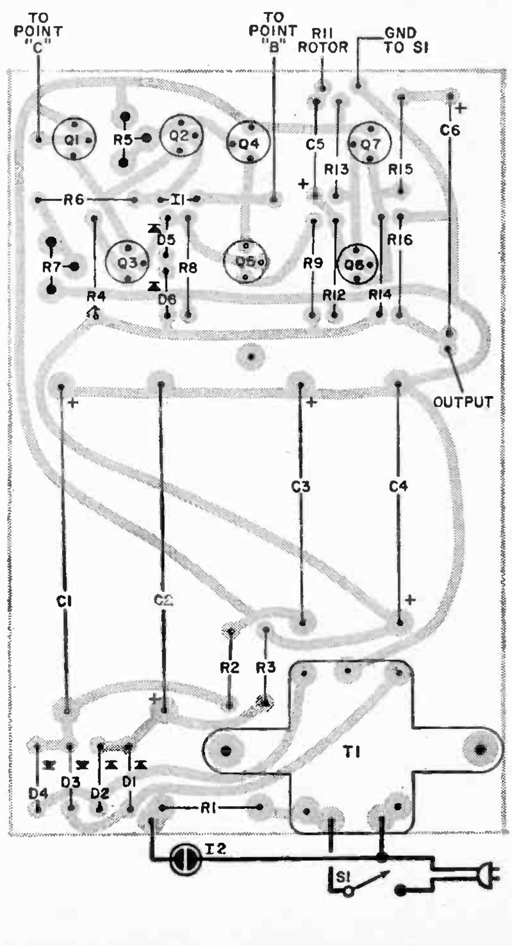
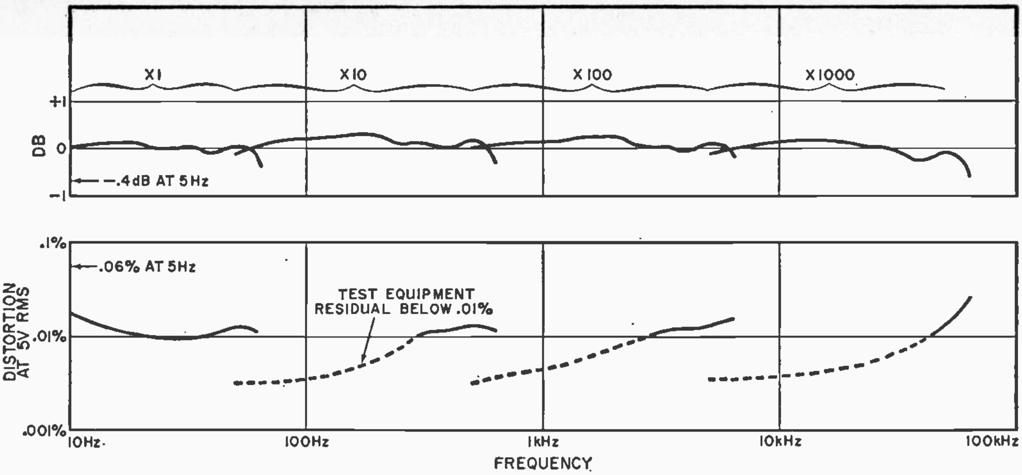


Fig. 3. Be particularly careful to observe the correct transistor, diode, and capacitor polarities when mounting the parts on the printed circuit board.

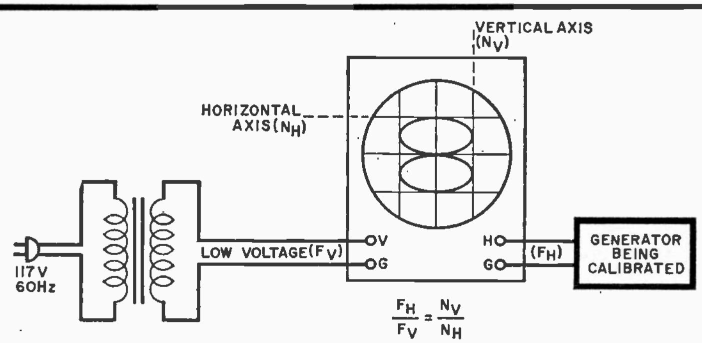
10,000 ohms. Connect a larger-value resistor across the potentiometer to bring the total resistance down to exactly 10,000 ohms.

After the potentiometer value has been adjusted, wire it into the circuit and set the range switch (*S1*) to the ×1000 position. Center the rotor of the frequency potentiometer. Adjust output level control *R11* to give a 5-volt r.m.s. output.

If you have access to a distortion analyzer, set the audio generator to the ×1000 position and the frequency potentiometer about one third of the way up (approximately 20 kHz). Connect the generator to the distortion analyzer and allow both to warm up and stabilize. Null the analyzer for a minimum meter indication. Slowly adjust *R5* for a meter minimum. It should be about 0.01%, which is about the residual distortion in most commercial analyzers.



Frequency response (upper) and distortion (lower) curves are typical when close-tolerance components are used in frequency-determining network.



LISSAJOUS PATTERNS

One of the easiest and most accurate methods of determining the frequency of an unknown audio generator is to use an oscilloscope to compare its frequency with that of a known source. The circuit arrangement is shown in the diagram.

The vertical input is taken from the low-voltage secondary of a filament transformer connected to the power line, while the horizontal input is from the audio generator output. This discussion assumes a 60-Hz power line; however, the theory can be used with any other line frequency.

The scope horizontal input should be switched to external input. With the scope and both frequency sources on, adjust the scope controls for an equal vertical and horizontal display. Adjust the controls so that the top of the display just touches one horizontal graticule of the scope screen while the vertical portion of the display just touches a vertical graticule.

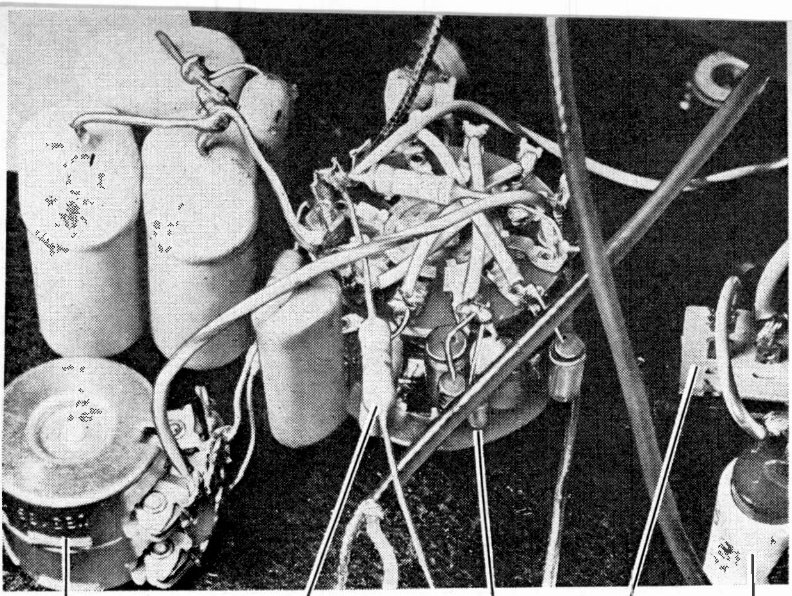
Adjust the audio generator frequency control until a circle is formed on the screen. At this point, the audio generator frequency is equal to the reference frequency. Note that the circle makes one contact with each vertical and horizontal graticule—resulting in a 1:1 ratio.

As the audio generator frequency is reduced, the displayed pattern makes many changes, and at certain points, the pattern becomes stationary. These stationary patterns occur at various reference-to-unknown frequency relationships. By counting the number of horizontal and vertical points of contact during stable pattern intervals the unknown frequency can be determined. Thus, if F_H is the reference frequency, F_V the unknown frequency, N_V the number of contacts on the vertical axis, and N_H the number of contacts on the horizontal axis, then

$$F_H/F_V = N_V/N_H$$

Thus the dial of the generator can be calibrated.

For example, assume one contact on the horizontal axis and three contacts on the vertical. Then, $60/x = 3/1$. So $3x = 60$ and $x = 20$ Hz. Again, assume two contacts on the horizontal axis and three on the vertical. Then $60/x = 3/2$; $3x = 120$; and $x = 40$ Hz.



Take your time when wiring range selector switch S1 (shown at center) to avoid making costly error. If the frequency determining components are not wired in just right, transistor Q5 might burn up.

RESIDUAL DISTORTION

The expression "less than 0.1% distortion" is quite popular with hi-fi manufacturers in describing their products. Sometimes it is desirable to know how much less than 0.1% and what type of distortion is referred to. The residual distortion of this audio generator is less than 0.02% across the audio range; and if you take the time and trouble to trim up certain components, the distortion factor can be reduced to about 0.005% and it will be mostly second and third harmonics.

HOW IT WORKS

The system can be considered to be an operational d.c. amplifier with very high open-loop gain. Transistors *Q1* and *Q2* form a differential input pair using *Q3* as a constant-current source. Transistor *Q4* is the output driver, while *Q5* acts as a constant current load for *Q4*. This approach was used instead of a resistor to reduce the distortion and produce a higher output swing. Bias for the two constant-current stages (*Q3* and *Q5*) is provided by diodes *D5* and *D6*. The use of a differential amplifier eliminates the need for a highly regulated power supply since the amplifier requires only a simple positive and negative supply to ground.

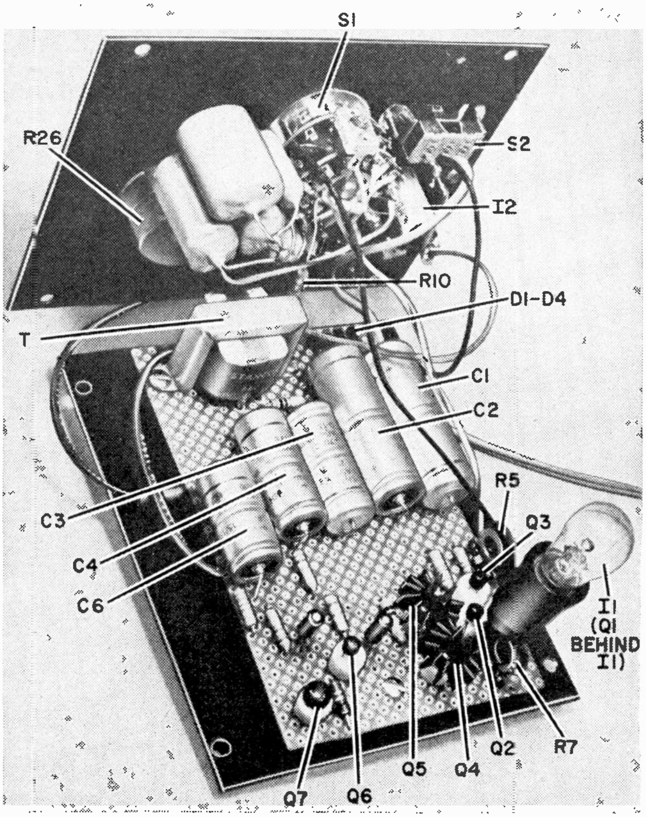
The bridged-T network (dashed line box in schematic) is connected in the negative feedback loop while a conventional low-watt incandescent lamp (*I1*) is used in the positive feedback loop. This makes the range switching arrangement a little unusual, but it saves the cost of three expensive 1% capacitors. However, each range capacitor must be an exact decade multiple for greatest dial accuracy and amplitude linearity.

The bridged-T configuration was selected because it gives better overall performance when compared to the commonly used Wein bridge. Both noise and distortion are reduced. Because this bridge has zero phase shift at only one frequency, the oscillator has an output only at this frequency. Since the bridged-T is a minimum-transmission network, it must be inserted in the negative feedback loop of the amplifier. The Wein bridge, on the other hand, is a maximum-transmission network and must be used in the positive feedback loop. Since there is a loss of ⅔ in a Wein bridge, the negative feedback loop would have to have a gain of three to make up for the loss. Because the negative feedback loop (in this case) is not frequency sensitive, the amplifier gain at all frequencies can never be less than three. In the bridged-T approach, however, the negative feedback loop contains the frequency-selective network which has a loss of ⅔ at one frequency and no loss at other frequencies. This means that an amplifier with unity gain can be used with more feedback.

A conventional low-power incandescent lamp (*I1*) is used to control the positive feedback. When such a lamp is operated at low power levels. it has a very nonlinear response—a necessity in this circuit.

Since the oscillator portion is d.c. coupled, there are no low-frequency time constants or roll-offs other than the lamp characteristic. This assures a positive start when power is applied.

The output of the oscillator is coupled to a super emitter follower (*Q6* and *Q7*) that is used to isolate the oscillator from loading. The output can drive loads down to 100 ohms with very little increase in distortion.



Interconnections between components mounted on front panel and rear panel mounted circuit board should be long enough to permit either panel to be lifted clear of case mounting lip by at least 2" when other panel is in place. Perf board is in prototype rather than PC type.

Calibration markings on sweep-frequency control dial (left in above photo) are obtained by interpreting Lissajous patterns produced by 60-Hz line and oscillator output frequencies fed into an oscilloscope.

AUDIO GENERATOR SPECIFICATIONS

Frequency range: 5 Hz to 60 kHz in four decade ranges.

Frequency response: ±0.5 dB, 7.5 Hz to 60 kHz; −0.4 dB at 5 Hz.

Distortion: Less than 0.02% maximum between 15 Hz and 50 kHz rising to 0.035% at 60 kHz and 0.06% at 5 Hz.

Amplitude stability: Practically unmeasurable over short term.

Frequency stability: Better than 0.05% (short term).

Output level: 5 volts r.m.s. open circuit; 2.5 volts r.m.s. into 600 ohms.

Total hum and noise: Better than −100 dB below 5 volts r.m.s.; better than −100 dB at any setting when using optional 3000-ohm output control.

Frequency Dial Calibration. Once the dial has been mounted on the frequency potentiometer, mark the two extremes of rotation. With the audio generator coupled to the vertical input of an oscilloscope, connect a low-voltage, 60-Hz source to the horizontal input. (This voltage can be obtained from any low-voltage filament transformer). Place the generator range switch on the ×1 position and use Lissajous patterns to calibrate the dial at 60, 30, 20, 15, 12, 10, 7.5, 6, and 5. (see Box on Lissajous Patterns)

If you have a power supply that has 120-Hz ripple, use this ripple as the horizontal input and you can get the 40 indicator. Of course, if you have a first class audio generator at hand, calibration is much easier—simply tune for circles on the CRT. Any type of press-on lettering can be used for both the frequency dial and the other front-panel identification.

—30—

TIGERS THAT ROAR

(Continued from page 72)

Follow construction instructions for the Tiger with regard to inputs, outputs, etc.

Testing. Before turning on the power, examine each board, the power supply, and the interconnections for proper component installation (including polarities on capacitors and diodes), solder bridges between foil sections, and wiring errors.

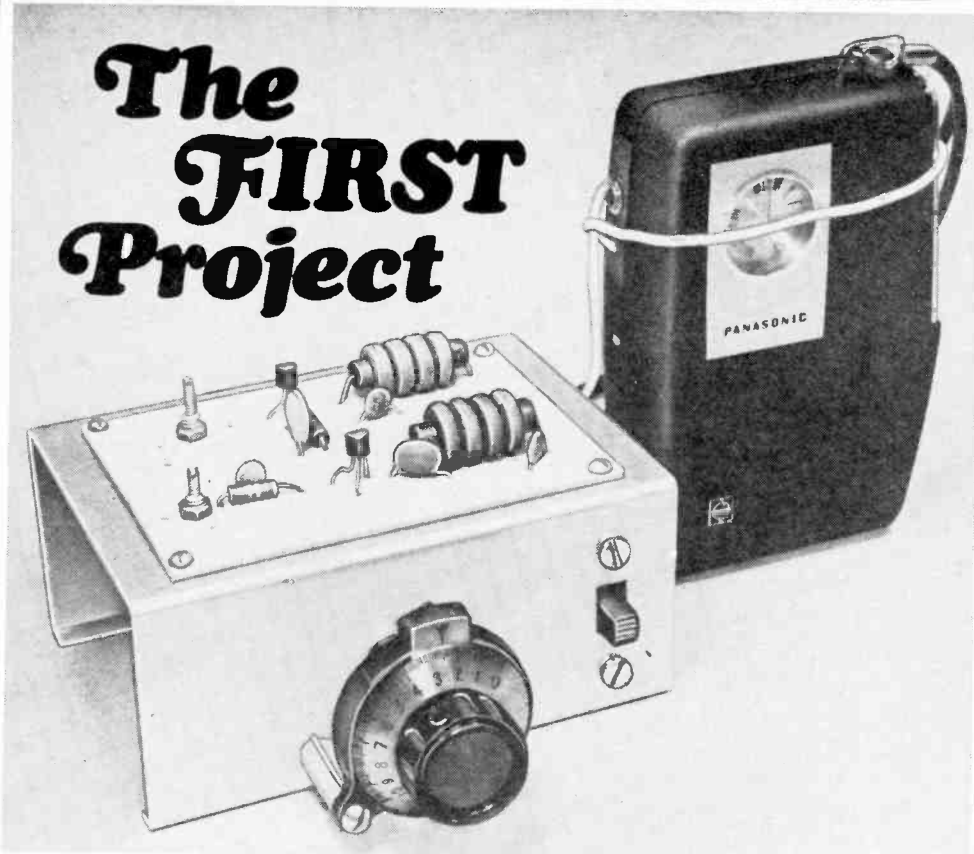
Disconnect the d.c. supply to the amplifier—60 volts for the Tiger, 80 volts for the Super Tiger. Connect a d.c. voltmeter to the power supply output and turn on the power. The measured voltages should be about 5 volts above nominal—65 and 85, respectively. Turn off the power and allow the power supply to discharge through the bleeder resistor.

Temporarily connect a 1000-ohm, 1-watt resistor between the positive output of the power supply and the voltage input terminal on the amplifier board (either one in a stereo system). Connect a d.c. voltmeter across the resistor, observing the proper polarities. When the power is turned on, the voltmeter should indicate about 20 volts. If it is more than 25 volts, you have a problem in that channel. Once one channel is found to be OK, perform the same test on the other channel. If you find trouble, one quick check you can make is to measure the voltage at the output transistor emitters. It should be about half the supply voltage.

Once you are satisfied that all is correct, shut down the power, wait a moment for the power supply to discharge, and then connect a 4- or 8-ohm speaker to each output terminal.

Since the input impedance to either amplifier is about 20,000 ohms, the power amplifier can be driven from either a transistor or vacuum-tube preamp. It will work particularly well with the FET Preamp described on page 85 of this issue. —30—

Editor's Note: A more powerful version of "Tiger" series of audio amplifiers appears in the October 1970 edition of POPULAR ELECTRONICS, on sale after Sept. 17.



SHORTWAVE CONVERTER MAKES IDEAL BEGINNER'S CONSTRUCTION EFFORT

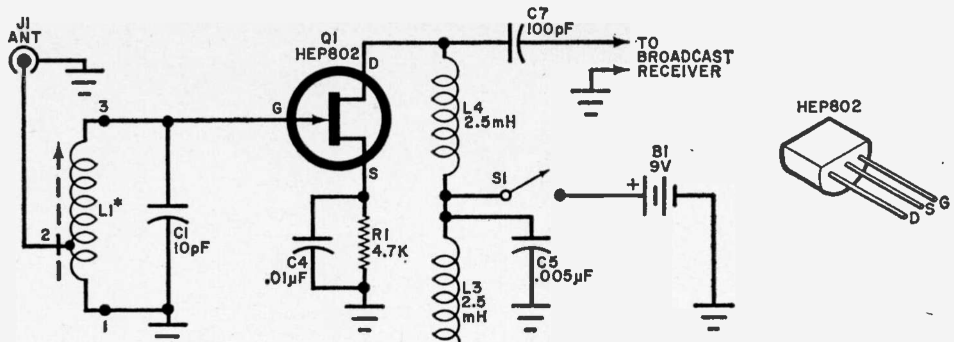
BY JIM WHITE, W5LET

THE HOBBYIST beginner in electronics generally favors a first project that is practical, foolproof in design, and easy to operate. He also wants his first project investment to be small; after all, he is venturing into an area about which he knows very little and does not want to be stuck the first time out.

Few beginner projects qualify on all these points as well as this short-wave converter for AM broadcast receivers. The converter is practical since it more than doubles the versatility of virtually any AM receiver (it allows you to listen in on radio amateurs, Citizens Banders, and anything else on AM between 14 and 31 MHz). It is foolproof; only a handful of components are needed to provide a maximum efficiency. Only two controls—main tuning and power on/off—make it easy to operate. And it is inexpensive (about $7 for all new parts, circuit board, and chassis).

About The Circuit. The short-wave converter is designed to use to good advantage two field-effect transistors (FET's) that sell for less than a dollar apiece. Referring to Fig. 1, FET *Q1* is the mixer and FET *Q2* is the local oscillator for the converter.

The local oscillator in this case is designed to be tunable, departing from the usual crystal oscillators found in most commercially made converters. By making the oscillator tunable, you can set your receiver to a quiet spot on the dial so that the output of the converter does



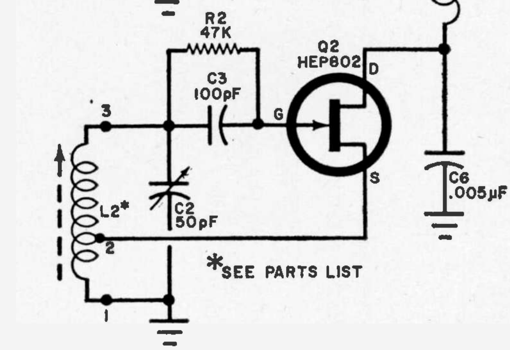


Fig. 1. Local oscillator (Q2) signal is induced into mixer circuit Q1 through mutual inductance existing between coils L1 and L2.

PARTS LIST

B1—9-volt transistor battery
C1—10-pF disc capacitor (see text)
C2—50-pF tuning capacitor (Hammarlund HF-50)
C3,C7—100-pF disc capacitor
C4—0.01-µF disc capacitor
C5,C6—0.005-µF disc capacitor
J1—Phono jack
L1—17 turns #28 enameled wire, tapped 3½ turns from bottom and wound on Miller Type 20A000 coilform
L2—15 turns #28 enameled wire, tapped 5 turns from bottom and wound on Miller Type 20A000 coilform
Q1, Q2—Motorola HEP 802 field effect transistor
R1—4700-ohm, ½-watt resistor
R2—47,000-ohm, ½-watt resistor
S1—S.p.s.t. side switch
Misc.—Battery connector; 4½"x3¼"x2" aluminum utility box; printed circuit board; vernier dial; shielded wire; hardware; hookup wire; solder; etc.

not have to compete with strong broadcast signals. Also, this uncommon design helps to keep component cost down.

Closing switch *S1* applies power from battery *B1* to the converter circuit. With an antenna connected to the circuit through jack *J1*, short-wave signals will be picked up by the converter. Simultaneously, the incoming frequency and the output frequency of the local oscillator will be mixed due to the mutual coupling between *L1* and *L2*. The incoming short-wave signal and the oscillator signal frequencies are mixed in *Q1*, producing, at the output, a difference frequency within the tuning limits of the AM broadcast band. This new signal frequency is coupled through capacitor *C7* to your receiver where it is handled as though it were any other broadcast-band signal.

Construction. For convenience, and to avoid unwanted interaction between components, it is recommended that you use printed-circuit wiring when assembling the converter. The drawing at the left in Fig. 2 provides all the details needed for etching and drilling your own circuit board.

Mount and solder in place on the circuit board all resistors, capacitors, and the two radio-frequency chokes (*L3* and *L4*) as shown in the drawing at the right in Fig. 2. Then wind coils *L1* and *L2* on their slug-tuned forms (see Parts List for instructions); carefully identify each coil according to its part designation. Mount and solder into place *L1* and *L2*, securing them with the nuts provided with the coil forms.

Next, bend the two outer leads (*emitter* and *drain*) of each transistor slightly toward the flat surface of the case but away from each other. Then bend the center or *source* lead slightly toward the rounded part of the case. N - -, all you have to do is pass the leads through the holes in the circuit board (see drawing for location of case flat), and very carefully solder into place. (Don't use too much heat.)

Prepare the top section of the aluminum utility box as follows. Measure in ½" from each side edge, ⅜" in from the front edge, and ½" in from the rear edge to find the limits of the cutout for the circuit board. Strike four pencil lines to guide you during machining. Then, with a nibbling tool, or a fine-tooth hacksaw, make the cutout. Use a file to deburr the exposed cut edges. Drill the mounting holes for the board and bolt the board down with #6 machine hardware.

Now mount *C2* and *S1* on the front and *B1* and *J1* on the rear of the utility box: for the battery, form a clamp from the material previously removed to make the circuit board cutout. Finally, interconnect the parts and board. Do not forget to connect *C1* between lugs 1 and 3 of *L1*.

One more thing; direct tuning of *C2* is touchy. It is suggested that you invest

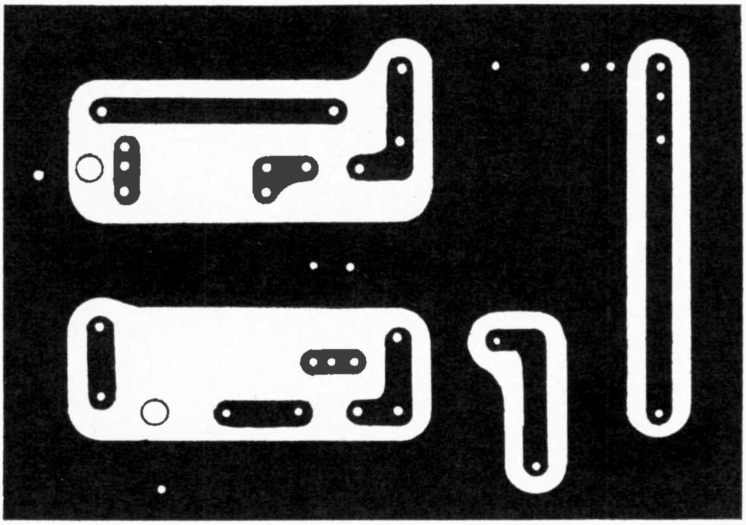
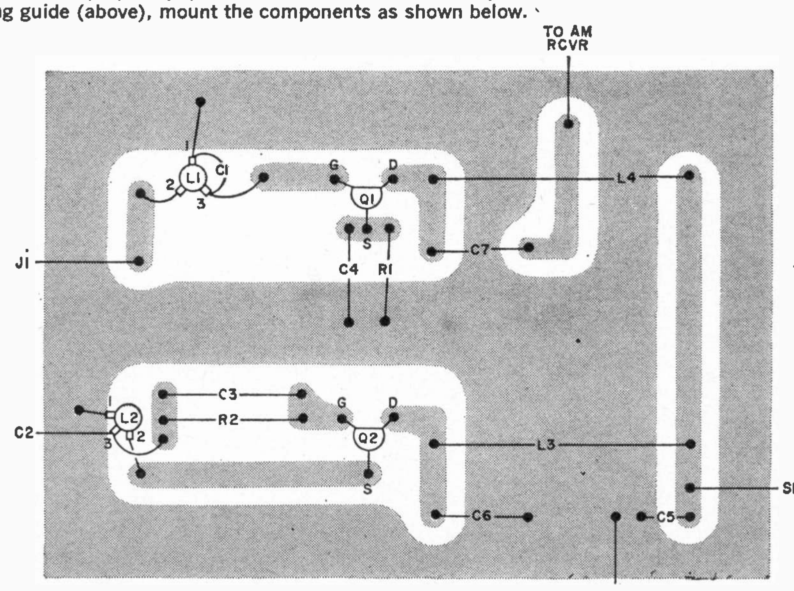
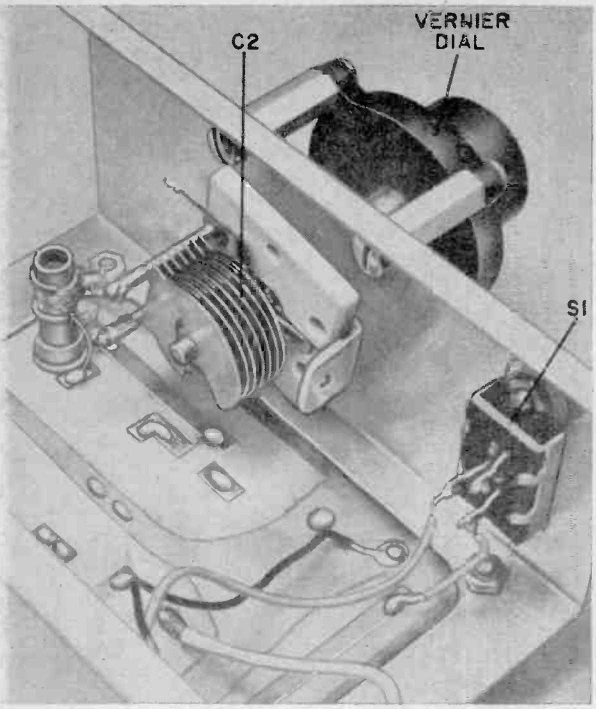


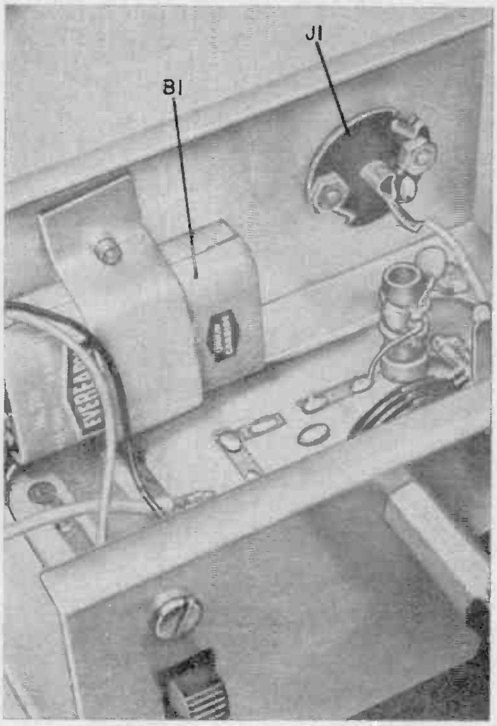
Fig. 2. After preparing printed circuit board according to etching guide (above), mount the components as shown below.

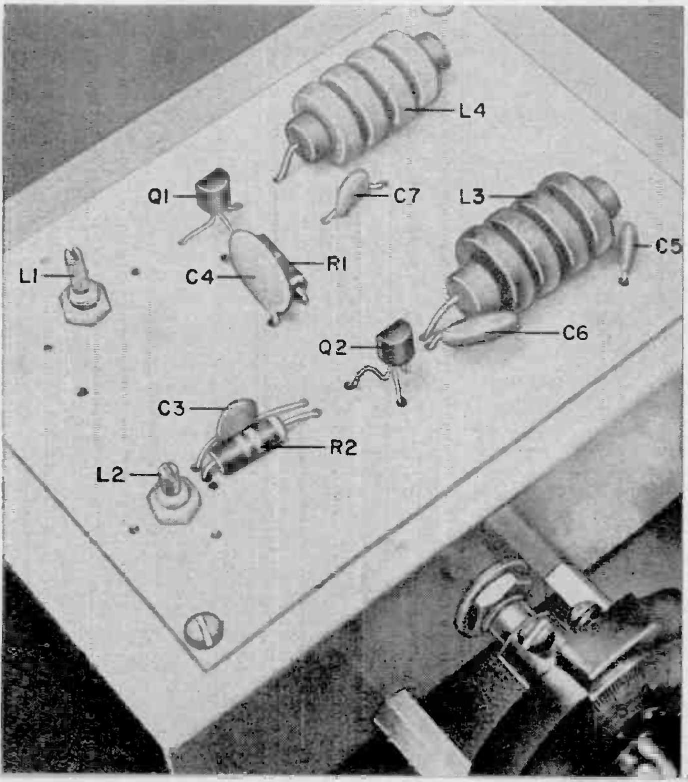




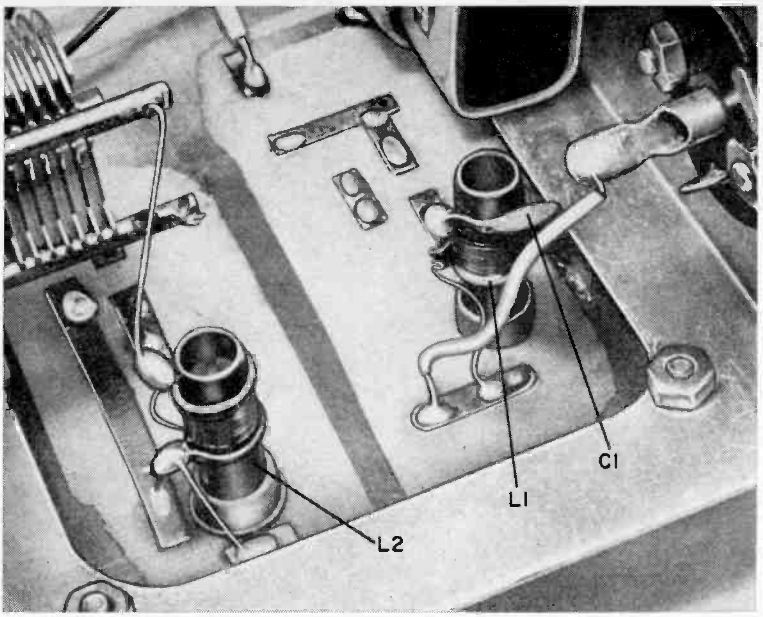
Before mounting vernier dial, rotate shaft of C2 until capacitor plates are fully meshed and knob on vernier dial is on zero position so that C2 and vernier dial rotate stop-to-stop in unison.

Battery clamp should be fashioned from material removed from cutout. Bolt battery and clamp in place as shown below.





All components in converter circuit (except B1, C2, S1, and J1) mount directly on circuit board. Note orientation of case flats and leads on both transistors.



Capacitor C1 should be soldered directly to appropriate lugs of L1. Make capacitor leads as short as possible. Also note that lead from lug 1 of L2 goes to upper terminal post of C2 when C2 is oriented as shown opposite.

an additional 89 cents for a vernier dial that will eliminate this problem. (The vernier dial shown in the photos is a Lafayette Radio Electronics No. 99 T 6031.)

Tuning and Using the Converter. The short-wave converter can be used with any AM receiver tuned to about 1600 kHz. However, the more sensitive and selective the receiver, the more you can expect from the converter. If you use a small portable receiver, a short length of wire from *C7* brought into proximity with the receiver's antenna will provide fair results. Reception, however, will be much better if you make a slight modification to the receiver; a modification that will in no way affect the performance of the receiver.

First, wind several turns of insulated solid hookup wire around the receiver's internal ferrite-core antenna. Then solder one end of this wire to the receiver chassis and make the other end available externally—perhaps through a pin jack. Now, run a small shielded wire from *C7* in the converter to the hookup wire coil just installed in the receiver, grounding the braid at both ends to the chassis.

Connect an antenna to the converter via *J1*. Switch on power to the converter and receiver, and set the receiver dial to about 1600 kHz. With tuning capacitor *C2* in the converter set fully counterclockwise, adjust the slug of *L2* until you hear ham stations at the high end of the 10-meter band. Now peak *L1* for maximum signal strength while listening to the receiver.

You should now be able to tune in the 27-MHz CB'ers, as well as the 13-, 16-, and 19-meter overseas broadcasters. Some increase in signal strength can be had by adjusting *L1* to the part of the tuning range in which you are most interested. *C1* can be increased to about 25 pF in value if 15 meters is your main interest.

The Beginner's Short-Wave Converter may not be the ultimate in sensitivity or selectivity but, connected to a good receiver, it does a surprisingly good job. The first tryout after construction had the converter pulling in stations from Havana, Mexico City, Paris, London, Moscow, Johannesburg, etc.—all in about a half hour! —30—

VARIABLE TRANSFORMER

(Continued from page 94)

coded screws of *SO1* and *P1*; the meter should indicate zero resistance—even on the lowest range setting. The resistance registered between the two silver-coded screws should be zero ohms.

HOW IT WORKS

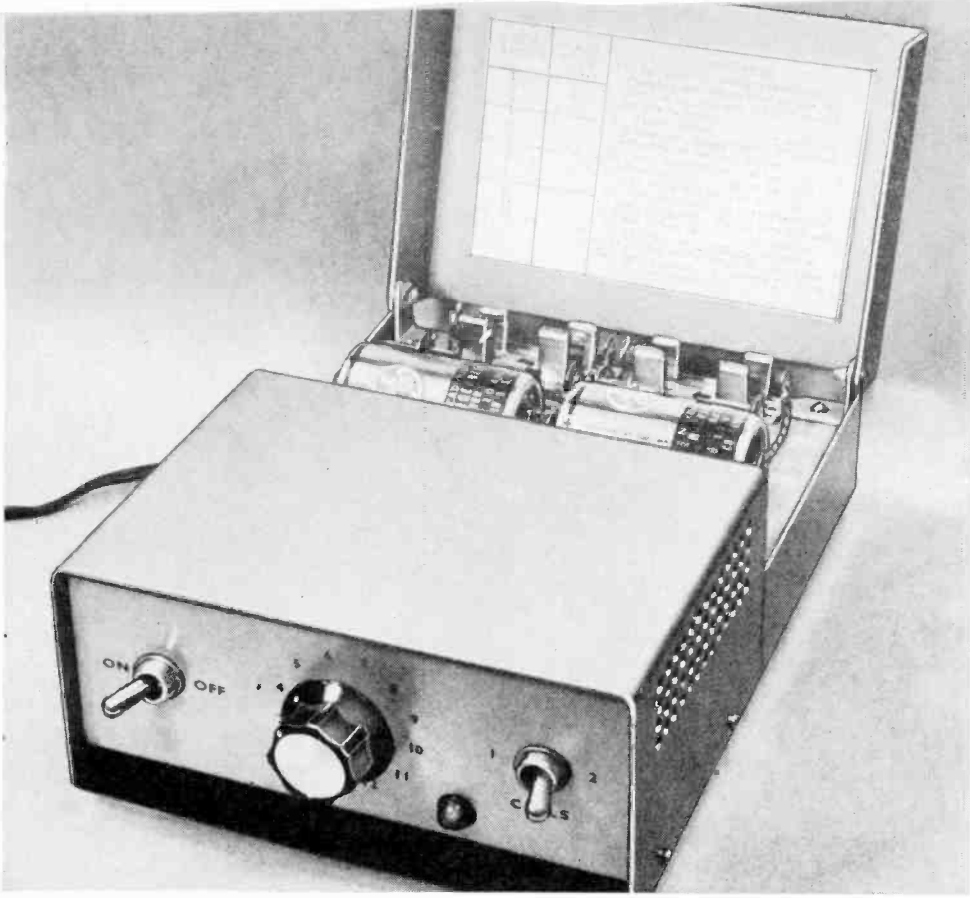
Referring to Fig. 1, with *R1* set for maximum resistance, the charge across *C2* is not sufficient to cause the integral trigger diode (at terminal *G* of *Q1)* to conduct. Therefore, no pulse is available to trigger the triac (between terminals 1 and 2 of *Q1)* into conduction. Consequently, no voltage can be dropped across a load connected to *SO1* because *Q1* is essentially an open switch.

Now, as the resistance of *R1* is decreased, a point will be reached at which the amplitude of the voltage across *C2* will be sufficient to cause the trigger diode to conduct and fire the triac for a portion of each a.c. cycle. The amplitude of the voltage dropped across the load is thus controlled by the point in each half cycle at which *Q1* triggers on. Decrease the resistance setting of *R1* even further, and you increase the average load voltage amplitude.

To improve circuit performance, *R2* allows *C1* to charge to a higher voltage than does *C1*. This allows the charge on *C2* to be partially restored once during each half cycle of the a.c. power by the charge on *C1*. The RC network consisting of *R3* and *C2* provides stability to the circuit when an inductive load is connected to *SO1*.

To use the Solid-State Variable Transformer, assemble the utility box. (It's also a good idea to anchor the two sections of the box together with sheet-metal screws to prevent the box from coming apart while you're removing it from a wall outlet.) Plug *P1* into a convenient a.c. outlet. Almost any electrical device that consumes less than 360 watts of power (3 amperes) can be operated via the Solid-State Variable Transformer. The only exceptions to the general rule are fluorescent lamps and devices that require a large starting current.

The markings on the control dial plate can be used only as a rough guide because *R1* is not linear at its low-resistance end. The best approach to using the control is to remember the settings most often used by different appliances. Or you can mark your favorite settings right on the dial plate. —30—



AA-C-D Battery Charger

BUILD A CONSTANT-CURRENT CHARGER FOR NICKEL-CADMIUM CELLS

BY A. A. MANGIERI

EVERY DAY another new piece of battery powered equipment is introduced on the market. There are radios, tape recorders, instruments, flashlights, toys—you name it—and you probably have several of them in your home. You have also been struck by the amount of money spent on replacing worn-out batteries. Did you ever consider buying rechargeable batteries and doing the "revitalizing" yourself?

Although the purchase price of rechargeable batteries is higher than that of conventional zinc-carbon flashlight batteries, the fact that they can be recharged and used so many times makes their end cost substantially lower.

To recharge a rechargeable battery, you can build the constant-current battery charger described here for a very modest price. It has fixed charge rates, covering nearly all types and ranges of cells—with capacities from 45 to slightly over 500 mA.

This charger has built-in clips for holding AA, C, and D cells or a simple connector and cable arrangement can be used to recharge groups of cells (up to six) without removing them from the equipment in which they are installed. Besides the larger cells, the "button" type found in subminiature equipment can be recharged. Metering and a variable charge-rate control can be included.

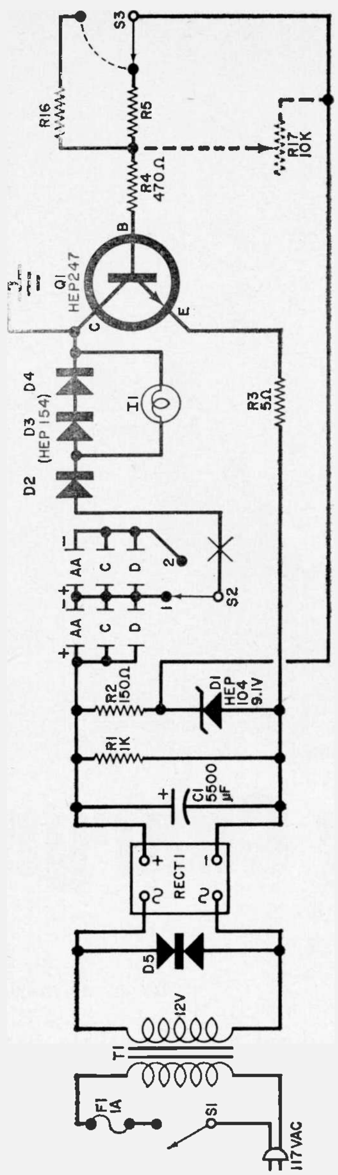


Fig. 1. Basic charger does not contain metering or variable charging facilities. If desired, 500-mA meter can be inserted at X; broken line potentiometer shows where rate control is to be connected.

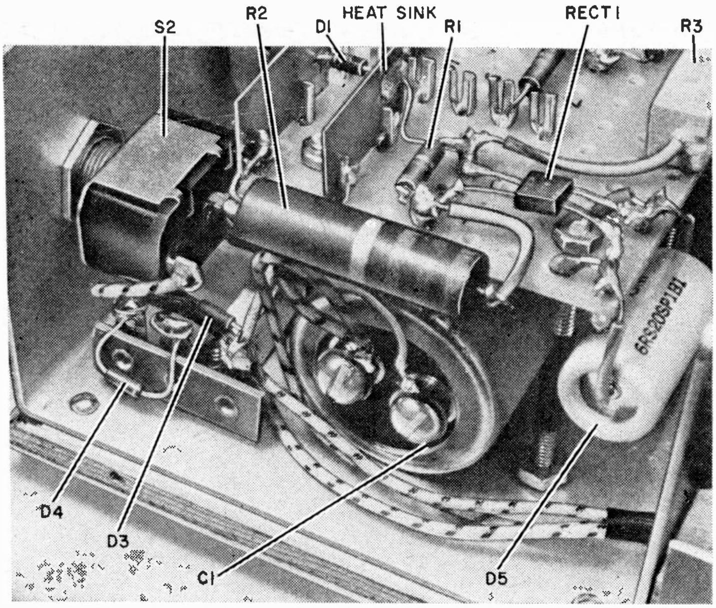
PARTS LIST

C1—5500-µF, 25-volt electrolytic capacitor (Sprague 552G025AB or similar)
D1—9.1-volt, 1-watt zener diode (Motorola HEP104 or similar)
D2-D4—1-ampere, 50-PIV silicon diode (Motorola HEP154 or similar)
D5—Thyrector diode (GE 6RS20SP1B1 or similar, optional, may be omitted)
F1—1-ampere fuse with holder
I1—#49 panel lamp with holder (preferably red)
M1—0-500-mA d.c. meter, 250-mV meter drop or less (optional)
Q1—10-ampere, 70-volt npn power transistor (Motorola HEP247 or similar)
R1—1000-ohm, ½-watt resistor
R2—150-ohm, 5-watt resistor
R3—5-ohm, 5-watt resistor
R4—470-ohm, ½-watt resistor
R5-R16—½-watt resistor (see text)
R17—10,000-ohm potentiometer (optional, see text)
RECT1—1-ampere, 200-PIV bridge rectifier (Motorola HEP176 or similar)
S1—S.p.s.t. switch
S2—S.p.d.t. switch
S3—1-pole, 12-position rotary switch (Mallory 32112J or similar)
T1—Filament transformer, secondary 12 volts at 2 amperes
Misc.—Perf board; push-in terminals; aluminum sheet for Q1 heat sink; copper sheet for D1 heat sink; AA, C, and D cell holders (2 each); knob for S3; mounting hardware; chassis as desired; terminal strips; etc.

About Rechargeable Batteries. There are two principal types of rechargeable batteries on the market—nickel-cadmium and alkaline. Of the batteries listed in the table, those made by Burgess, Eveready and General Electric are nickel-cadmium; the Mallory units are alkaline. (Note that the latter are *rechargeable* alkaline batteries—there are other alkaline batteries that are not rechargeable.)

Rechargeable nickel-cadmium and alkaline batteries are not interchangeable in most applications—particularly not in those containing built-in rechargers (electric toothbrushes, knives, etc.).

Mallory recommends that their rechargeable alkaline batteries be recharged on specially designed voltage-limited chargers; however, by following the precautions given at the end of the article, you can use this charger on alkaline batteries.



A clamp must be used when mounting C1 to the chassis. When tightening clamp hardware, be careful to avoid puncturing plastic jacket that encloses this capacitor.

Construction. Almost any type of mechanical assembly can be used for the charger. The photos show the commercial looking design built by the author. Use was made of a wood base and metal wrap-around and chassis. Transistor *Q1* is mounted on the chassis to provide adequate heat-sinking and reduce H_{fe} drift. If you use a closed container, make sure that enough ventilating holes are provided to prevent heat damage during prolonged operation.

The schematic of the charger is shown in Fig. 1. Most of the components are mounted on a small piece of perf board using clips to hold them in place. Note that zener diode *D1* is placed between a pair of thin copper plates ½" × 1" to provide a heat sink. Capacitor *C1* has an insulated jacket and should be mounted with a clamp to avoid puncturing the jacket.

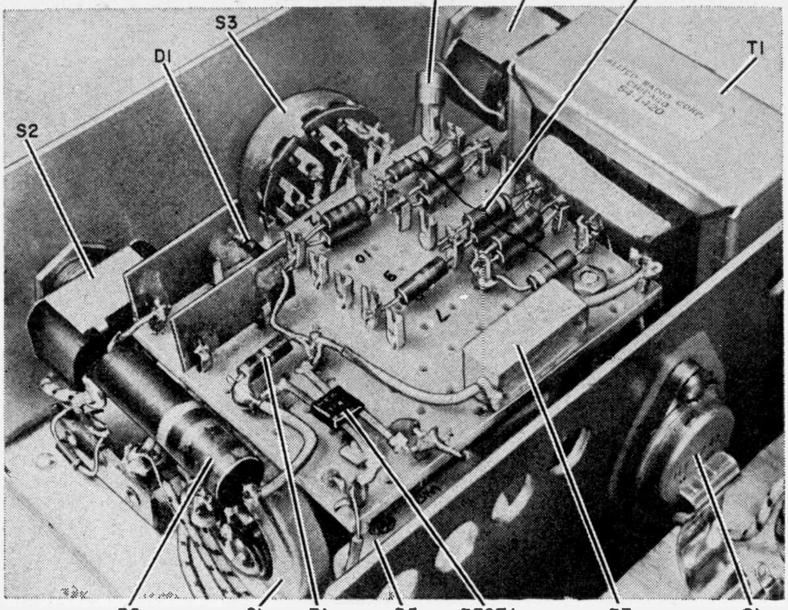
Mount the battery holders on a nonmetallic surface (preferably wood) so that they do not touch and are sufficiently separated so that batteries can be installed and removed with a minimum of effort. Note that the author used a symmetrical arrangement in mounting the battery holders—with a D, C, and AA holder on each side. When wiring cell selector switch *S2*, be sure that, with the switch to the left, the left row of holders is selected and vice versa.

CHARGING TIMES AND CURRENTS

Manufacturer	Type	Capacity (mA-Hr)	Charge current (mA)	Charge time (Hr)
Burgess	CD6-AA	450	45	14-16
	CD7-D	2500	250	14-16
	CD11-D	3000	300	14-16
	CD10-D	4000	400	14-16
Eveready	CH450-AA	450	45	14
	CH400-AA	500	50	14
	CH1.5-C	1500	150	14
	CH4-D	4000	400	14
General Electric	GC-1-AA	500	50	15
	GC-2-C	1000	100	15
	GC-3-D	1000	100	15
Mallory	SA-15-AA	300	13.5	30-36
	SA-14-C	1000	40	30-36
	SA-13-D	2000	80	30-36

MAGIC FIGURES

Nickel-cadmium batteries are usually sold with a rating clearly printed on the side of the battery. This rating is either in terms of a 10-hour discharge at "X" mA or in a "total" battery charge of "Y" mA-Hr. To recharge, you use the same discharge rate (if the 10-hour figure is given) or divide the mA-Hr by 10 to obtain the idealized recharging rate. To this you add the magic figure of 40%. Thus a 200 mA-Hr nickel-cadmium battery would be recharged at 20 mA for 14 hours (or 15 if specified by the manufacturer as shown in table).



All components not on the chassis can be mounted on a piece of perforated phenolic board. Flea clips facilitate the connections.

The author used a 12-position switch for *S3*. This provides enough of a variety of charging currents for most applications. Resistors *R5* through *R16* provide base bias for the transistor and thus determine the charging rates. Their resistances must be chosen to account for variations in the characteristics of the transistor. If desired, you can use only a few rates to suit your immediate needs (or if you are using only one type of battery) and add others as your needs change. The Table gives a number of charging rates for the common AA, C, and D cells. The charging rate and time for a cell are usually marked on its jacket. Note that physical size is not an indication of the required charging rate.

To select resistors *R5* through *R16* (if you are going to use this many intervals) allow the equipment to warm up for about 20 minutes at normal room temperature (75 to 78 degrees F). Insert a fresh carbon-zinc D cell in one of the D-cell holders and clip a milliammeter across the other D-cell holder. When *S2* is in the 2 CELL position, the meter and the battery will be in series with the rest of the circuit. First use a 5000- or 10,000-ohm potentiometer for the base bias resistors and set it to its highest resistance. Slowly rotate the potentiometer until the milliammeter indicates the desired charging rate. Turn off the power and remove the potentiometer. Measure the resistance of the potentiometer to determine the fixed resistor to be used for that charging rate. Since you may wind up with non-standard resistance values, it is best to use a resistor with a slightly larger value and put a second resistor of higher value in parallel to get the required value. You should be able to set the desired charging current to within five percent of the target value.

If you use the optional meter circuit, then potentiometer *R17* is the base bias resistor and the charging current is read

RECHARGING ZINC-CARBON BATTERIES

A fully discharged zinc-carbon battery will be unable to accept a recharge. To put anything back into a zinc-carbon battery you must interrupt its service life before it has dropped below the level of 1.0 volt. This is tricky since the battery may not have displayed any indication that its useful life was ending.

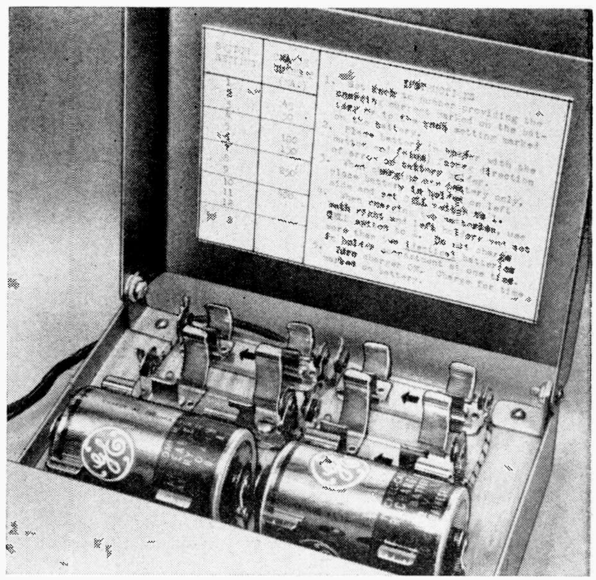
Recharge zinc-carbon batteries immediately after removal from service. The rate of recharging should be about 120% the average rate of discharge and the charge period should be 12 to 16 hours. Put recharged batteries back into service immediately and don't expect to recharge zinc-carbon batteries more than 4 times—if that.

HOW IT WORKS

The battery charger is basically a d.c. power supply (*T1*, *RECT1*, and *C1*) which is placed in series with the battery to be charged. A power transistor (*Q1*) maintains the series current flow at a predetermined level. The transistor chosen for this application has little change in collector current for moderately large changes in both collector voltage and load current, once its base bias has been set. This bias (and hence the collector current) is set by the relatively stable d.c. voltage determined by zener diode *D1* and the series base resistors.

Switch *S2* selects either one bank of cell holders or both banks in series. Charge indicator *I1* and diodes *D3* and *D4* provide visual indication of charge over the range of 45 to 500 mA. Diode *D2* prevents slow discharge of cells left in the charger for storage. Thyrector diode *D5* suppresses any voltage transients that might enter the circuit from the power line.

Two optional components may be added to the charger. A 0-500-mA meter can be inserted at point X in Fig. 1 to measure current flow, and a 10,000-ohm potentiometer can be inserted as shown by the dotted lines for variable control of recharging current.



Three time-saving ideas are shown in the photo at right: Battery holders are arranged symmetrically; large black arrows indicate directions of positive poles; and chart gives directions for use of charger.

directly off the meter for each application. In this case, increase the value of *R4* to limit the highest charging current to 650 mA.

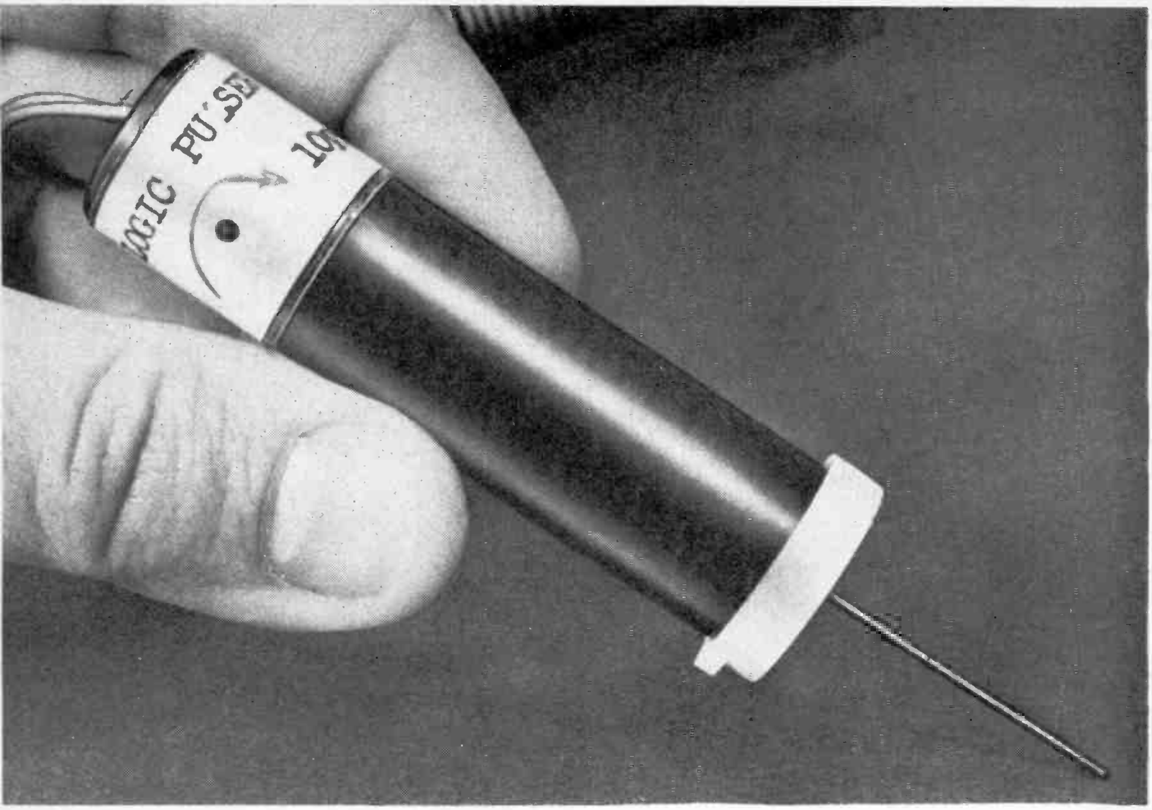
Applications. Make up a chart showing the correct setting of *S3* for each type of rechargeable cell you have, including the recommended charging time. This information is usually indicated on the package or the battery itself. Paste this chart on the charger so that you can refer to it when necessary. To charge one cell, set *S2* in the 1 CELL position and use the appropriate battery holder. To charge two *identical* cells, set *S2* to the 2 CELL position and insert both cells in their holders, one on each side. Do not attempt to charge cells in parallel since the current will not divide equally.

The charger can handle up to six identical cells connected in series. For this, make up a charging jack and cable to go between the charger and the batteries.

Recharge cells as soon as they appear to be weak in service. This avoids excessive discharging which tends to reduce the cycle life of the cell. Normally, a cell should be recharged when its voltage drops to about 1.1 volts at a load current equal to one-tenth the cell's rated mA-hour capacity at the normal 10-hour discharge rate.

Rechargeable alkaline cells may be recharged (at the recommended rate) with a few precautions: Be sure to turn off the charger at the end of the charge period to avoid cell damage. Recharge cells when cell voltage drops to 1.1 volts. Never discharge a cell below 0.9 volt or cell damage will result.

Alkaline cells are supplied fully charged. If it is necessary to recharge a partially discharged cell, clip a voltmeter across the cell and recharge it until the voltage reaches 1.65 to 1.75 volts. Or, discharge the cell to 1.1 volts and recharge for the full recommended time. —30—



POLA-Testers

SURPLUS CONTAINERS MAKE HANDY PROBES

BY E. B. BEACH

ONE OF the more vexing problems facing the electronics experimenter is finding a way to house small, odd-sized projects. The author, for example, designed a series of very useful, low-cost test instruments that occupy very little space and must be held in the hand during use. The novel packaging scheme he devised can be seen in the photographs. All three of the devices shown are packaged in discarded Polaroid® print coat containers. The containers are of generous proportions and fit well in the hand when used as probes. If you don't happen to have a Polaroid camera, you certainly know someone who would save you a couple of the containers since they are normally discarded. If that source is dry, you can use any small plastic container of the type used for pills.

If you are using the coater containers, remove and discard the used spreader and leave the cap off the container for a few days to allow the chemical to dry thoroughly. If this is not done, the chemicals in the coating compound will corrode soldered connections and leads, which may eventually lead to trouble.

After the container and cap have dried out, scrape the dried material from inside the container and the lip of the cap. Make sure that both are clean, inside and out.

The three test instruments which employ this unique packaging scheme are used with the many RTL digital IC projects recently published in this magazine. Several other, non-digital instruments are presently being designed and will appear in future issues. To use these instruments, connect the +3.6-volt lead to the power supply of the circuit being tested and the ground lead to the board ground.

Logic Probe

Connect the power leads to the respective terminals on the digital board being tested, then follow digital signal around the board, observing the lamp. Each time trace signal goes positive, the small lamp glows.

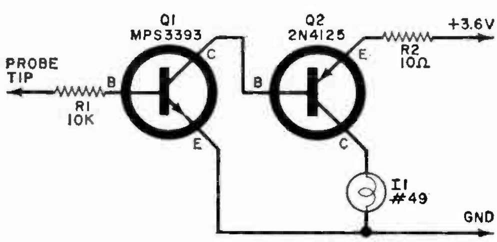
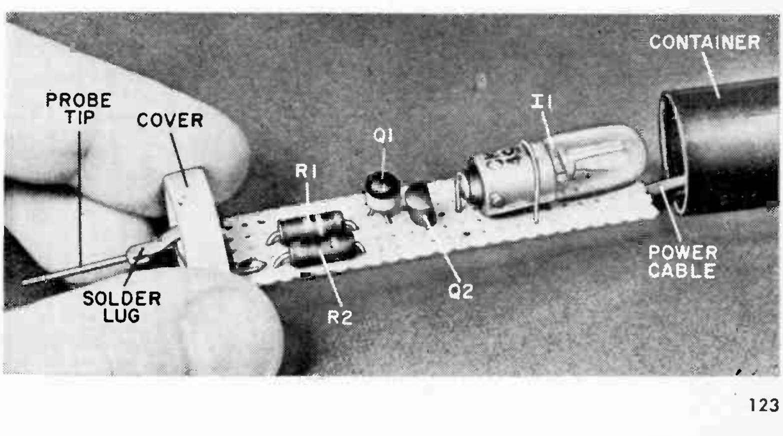


Fig. 1. In this simple electronic switch, resistor R1 isolates the probe from the circuit under test.

Fig. 2. Lamp is strapped down with a small piece of wire while other components are lead mounted.

Logic Probe. The purpose of a logic probe is to detect the presence of the discrete voltage outputs (1 and 0) in a digital circuit without having to disassemble the device. Place the tip of the logic probe on the proper point in the circuit and, when the voltage switches up and down according to the logic, a small lamp within the probe will blink on and off. A positive voltage lights the lamp.

The circuit for this simple probe is shown in Fig. 1. Any low-cost *npn* silicon transistor can be used for *Q1*, while any low-cost *pnp* transistor can be used for *Q2*. Using the specified value for *R1*



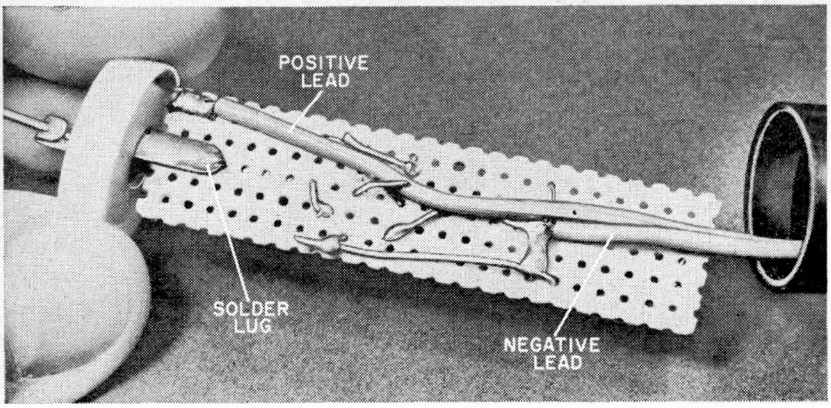


Fig. 3. The underside of the probe board showing the two power connections, and the solder lug that connects to the probe through cover mounted hardware.

gives an input sensitivity of about 0.8 volt. Resistor *R2* limits the current flow and gives degenerative stability to the circuit.

The circuit is assembled on a 2⅜" × 9/16" piece of perforated phenolic board having a 0.1" grid of 0.042" holes. The lamp is strapped down at one end using a small piece of bare wire. The other components are installed as shown in Fig. 2. Connections are made using component leads protruding through the board. The underside of the board is shown in Fig. 3. Two holes are made with a soldering iron tip in the closed end of the plastic case —one for the two power leads and one through which the lamp can be easily seen.

The probe tip is made from a piece of a paper clip soldered to a lug which is secured to the cap with a 4-40 screw and nut. A second solder lug on the inside of the cap is connected to *R1*. The board assembly is rotated and slipped into the plastic case so that the lamp is opposite its viewing hole. The cap then fits snugly on the container.

As a finishing touch, make up a typewritten label describing the device, identifying the color code on the power leads, and telling what the lamp does. Attach the label to the container with transparent tape.

Logic Pulser

Logic Pulser. This is an astable multivibrator made from a dual-buffer IC which is adjustable from about one pulse per second to about 10 pulses per second. It is capable of driving as many as 80 milliwatt RTL gates or 26 medium-power IC gates for testing purposes. It receives its primary power from the circuit being tested.

The circuit for the pulser is shown in Fig. 4. It is also built on a 2⅜" × 9/16" piece of perforated phenolic board having a 0.1" grid of 0.042" holes. The integrated circuit (*IC1*) fits directly into

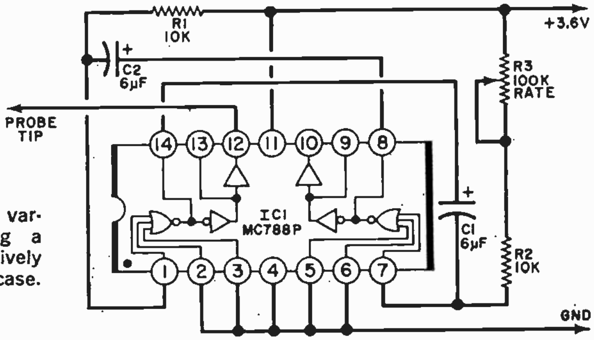


Fig. 4. IC1 is coupled up as a variable-frequency oscillator having a buffer output. Even this relatively complex circuit fits the small case.

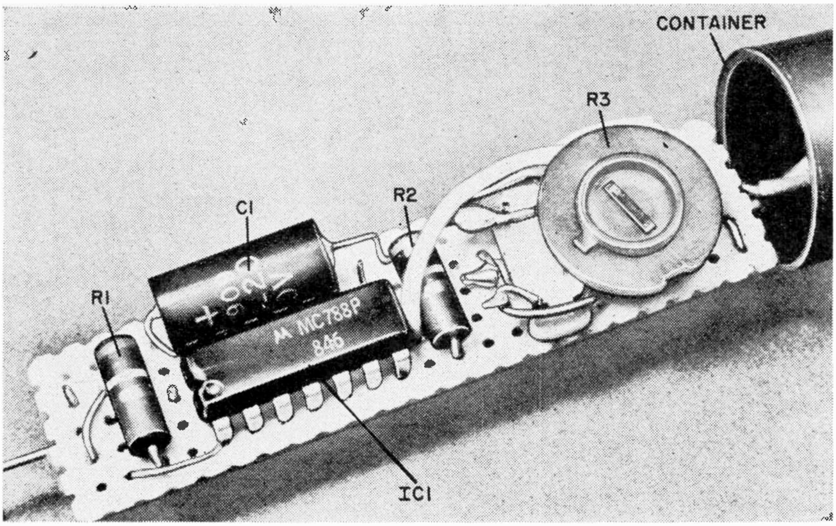
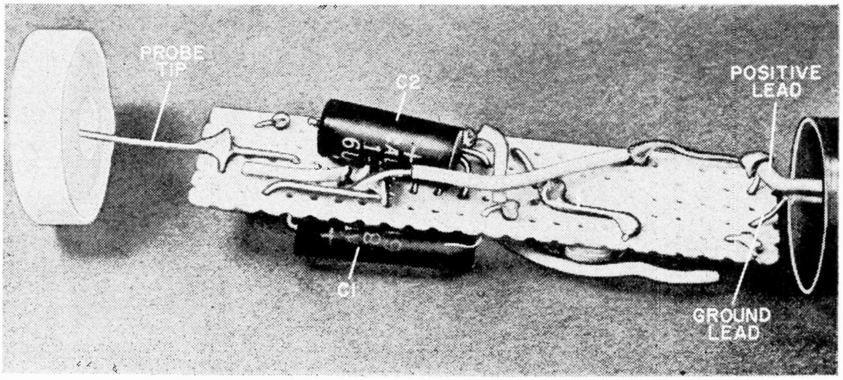


Fig. 5. The parts fit the small board easily if you follow the layout shown here. Make sure you have a small hole in the container to make screwdriver adjustments of R3 as required during operation.

the board holes and is positioned as shown in Fig. 5. Bend a couple of leads over to keep the IC in place while assembling the other components. Mount *C1* beside the IC and mount *C2* on the other side of the board as shown in Fig. 6. Be sure that these two capacitors are not larger than 5⁄16″ in diameter or the completed circuit will not fit into the container. Potentiometer *R3* is held on the board by the wiring to its three terminals.

The probe tip for this instrument is made from a length of paper clip. Make a hook in one end of the probe to fit through a hole in the board. A small piece of bare wire soldered to the hook of the paper clip will hold the probe in place while it is connected to pin 12 of *IC1*. Make a small hole in the center of the plastic cap for the probe tip to pass through. Make one small hole in the end of the container for the power leads and another small hole in such a position that *R3* can be adjusted with a screwdriver when the circuit is mounted.

Fig. 6. Underside view showing placement of C2. When selecting both C1 and C2, make sure that they are no larger than 5⁄16″ diameter so that they will fit the container. Note how the probe is supported.



Logic Switch

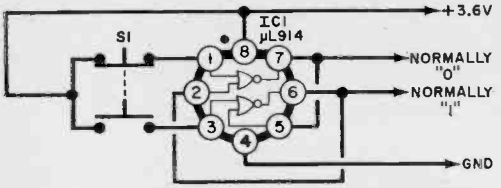


Fig. 7. The circuit is a basic "bounceless switch" made up of one small IC. It produces a clean pulse.

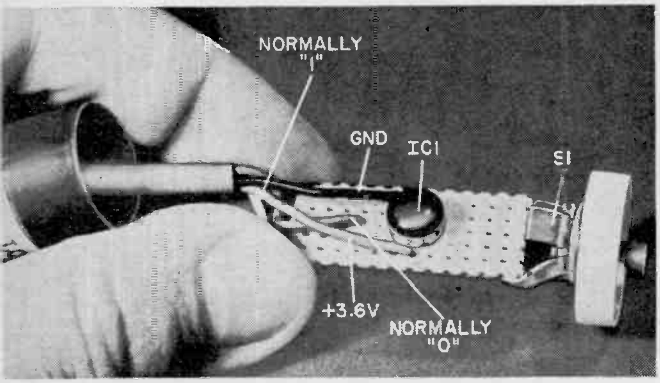
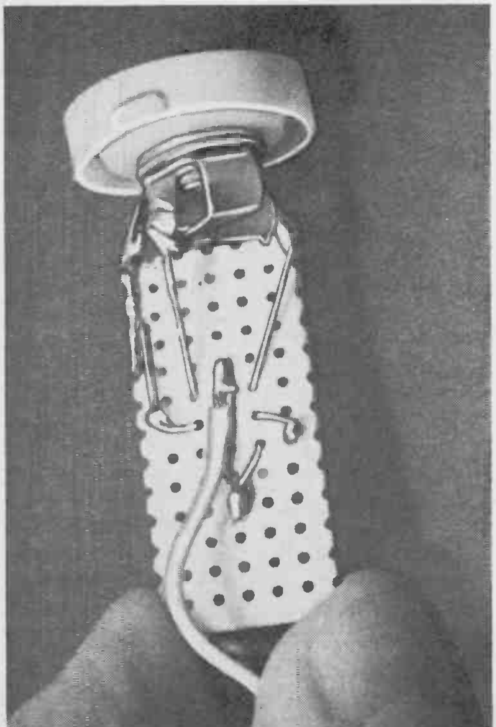


Fig. 8. All that's in the circuit is the IC and a switch. Four-lead flexible cable couples to board.

The pushbutton switch fits in a hole drilled in container cover. Like other testers, a typewritten label identifies leads and explains operation.

Fig. 9. Underside of the board showing method of mounting the switch using its circuit connections.



Logic Switch. One difficulty encountered in triggering an RTL circuit with low noise immunity is the erratic count that occurs when a conventional noisy mechanical switch generates the trigger. This noise can be eliminated by using a mechanical single-pole double-throw pushbutton switch to operate a set-reset flip-flop. This insures that a clean, noise-free, single pulse is generated each time the pushbutton is operated.

The circuit for the logic switch is shown in Fig. 7. It is built on a 1¼" × 9⁄16" piece of perforated phenolic board. Mount the s.p.d.t. pushbutton switch in a hole centered in the plastic cover. Drill a hole in the closed end of the container for a four-wire cable. The circuit is wired (Fig. 8) so that it holds the switch at the end of the board. Another view is shown in Fig. 9. –30–

Build a CAPACITANCE METER

CHECK YOUR JUNK-BOX CAPACITORS

BY STANLEY SULA

THE electronics experimenter is notorious for collecting parts from almost every source imaginable, including war surplus bargains and items cannibalized from defunct electronic gear. Among the odds and ends collected is usually a considerable number of capacitors of intermediate values and doubtful "goodness." Many reasonably accurate capacitance measuring instruments are available for checking these items, but most are too expensive for once-in-a-while use. However, for an investment of about $15 for parts, you can build a capacitance meter that measures capacitance values between a few picofarads and 0.1 microfarad. This range covers most small tubular and virtually all disc, mica, and variable capacitor values—the major types that are used in circuits.

The heart of the capacitance meter is a stepped-frequency multivibrator circuit. The output of the circuit is coupled through the capacitor under test to a sensitive metering circuit. The deflection of the meter pointer provides a direct readout of the capacitor value, interpreted according to the position of the range switch. Zener diode regulation insures stability throughout the entire life of the built-in battery supply.

Construction. Parts layout is not critical. However, for compactness and ease of assembly, it is suggested that you follow the layout illustrated in this article. The circuit was assembled on a 5″ × 2¾″ perforated board which was then mounted inside a standard 5¼″ × 3″ × 2″ aluminum chassis box. The cover of the box accommodates all of the components that are not directly mounted on the circuit board.

Begin construction by machining the top half of the box as shown in Fig. 2 to provide mounting holes for the meter, jacks, and power and range switches. Temporarily set the box aside.

Next, mount the individual components on the board, using "flea" clips where necessary, as shown in Fig. 3. You can begin by mounting the battery clip. Then mount the miniature potentiometers, bending the tabs to fit the holes in the board. Finish up by mounting the transistors and diodes, capacitors, and resistors in that order. When all components are mounted in place, double check your wiring, paying particular attention to diode and transistor polarity and to the absence of accidental short circuits where wires cross; then solder all connections.

Buy or fashion two L-brackets from ¾" × ¼" × 18-22 gauge aluminum or brass stock as follows: Bend the two strips at the center to form ⅜"-long legs at right angles to each other. Drill a hole through the center of each leg of each L-bracket. Now mount the brackets on alternate corners of the circuit board with #6 hardware.

Referring to Fig. 4, orient the top of the chassis box as shown. Mount the parts in their respective cutouts, and wire *D1* into place. Set the circuit board beside the box top, and connect and solder insulated hookup wire from the junctions indicated by two component numbers (C4/R6, etc.) to "flea" clips along the bottom edge of the board. Then, complete the wiring, checking your work frequently with Fig. 1.

Fold the circuit board into the top of the box (as shown in Fig. 3), and mark off the mounting holes for the L-brackets

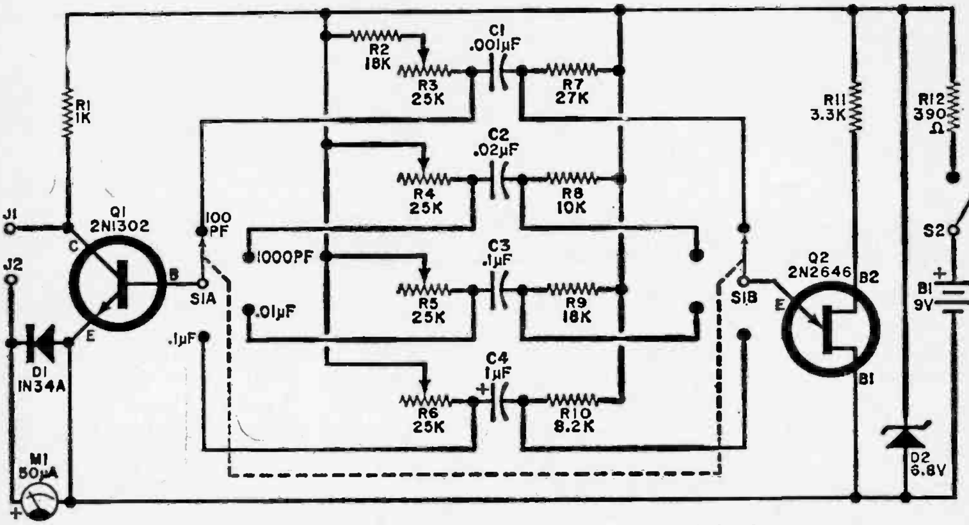


Fig. 1. Circuit consists of a basic multivibrator; for each of the four ranges, a different frequency-determining network can be switched in as required.

PARTS LIST

B1—9-volt transistor battery
C1—0.001-µF, 25-volt Mylar capacitor
C2—0.02-µF, 25-volt Mylar capacitor
C3—0.1-µF, 25-volt Mylar capacitor
C4—1-µF, 15-volt electrolytic capacitor
D1—1N34A diode
D2—6.8-volt, ½-watt zener diode
J1,J2—Banana jack (or substitute five-way binding post)
M1—0-50 µA microammeter
Q1—2N1302 transistor
Q2—2N2646 unijunction transistor
R1—1000-ohm
R2,R9—18,000-ohm
R7—27,000-ohm
R8—10,000-ohm
R10—8200-ohm
R11—3300-ohm
R12—390-ohm
(All resistors ½-watt, 10%)
R3,R4,R5,R6—25,000-ohm miniature potentiometer (Mallory No. MTC253L4 or similar)
S1—Four-position, two-pole rotary switch
S2—S.p.s.t. slide (or toggle) switch
1—5¼" x 3" x 2" aluminum utility box
Misc.—Perforated phenolic board; "flea" clips; battery holder; banana plugs (2); 1 brackets; control knob; calibration capacitors (see text); hookup wire; solder; hardware; etc.

on the sides of the box. Make sure that there is adequate clearance between the circuit board and box-mounted components and the circuit board and rear section of the box. When satisfied, drill the holes for and mount the circuit board L-brackets to the box with #6 hardware.

Calibration and Use. The simplest method of calibrating the capacitance meter is to use four high-tolerance, good-quality capacitors as "standards." The tighter the tolerance of these standard capacitors, the more accurate will be the calibration of the instrument. Select one capacitance value for each of the four ranges available with the meter. These capacitors should be 100-pF, 1000-pF, 0.01-μF, and 0.1-μF values to provide full-scale deflection of the meter pointer when each range is accurately calibrated.

Set the range switch to 100PF, and connect the 100-pF standard capacitor to *J1* and *J2*. Do not use test leads on this range; even the relatively small capacitance of the two leads can be enough to add as much as 20 pF to the true value of the capacitor. (This drawback can be put to good advantage in measuring the capacitance of coaxial cables, test leads, etc.). Switch on the power and adjust the setting of *R3* (see Fig. 3) for a full-scale deflection of the meter pointer.

Repeat the above calibration procedure for the remaining ranges and their appropriate standard capacitors. Adjust *R4* for the "1000 PF" range, *R5* for the ".01 MF" range, and *R6* for the ".1 MF" range.

ABOUT THE CIRCUIT

The operation of the Capacitance Meter (shown schematically in Fig. 1) is based on the principle that the maximum amount of a.c. current passed by a given capacitor is directly proportional to the capacitance value. In the case of the Capacitance Meter described in this article, the a.c. applied to the capacitor under test is in the form of a square wave provided by the *Q1-Q2* multivibrator circuit.

The output of the multivibrator is taken from the collector of *Q1*. From here it is passed through the capacitor under test (connected between *J1* and *J2*) and meter *M1* to the negative circuit buss. The meter, in turn, measures and indicates the maximum amount of a.c. current passed by the test capacitor, converting the current reading directly to a reading on its reworked scale.

Since the different ranges are all multiples of ten, range switching via *S1* is accomplished by changing the operating frequency of the multivibrator. Switch *S1* simply switches in and out of the circuit various combinations of resistors and capacitors.

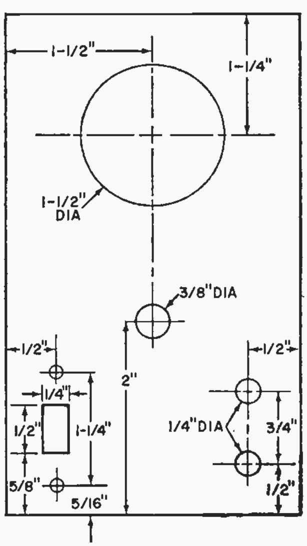
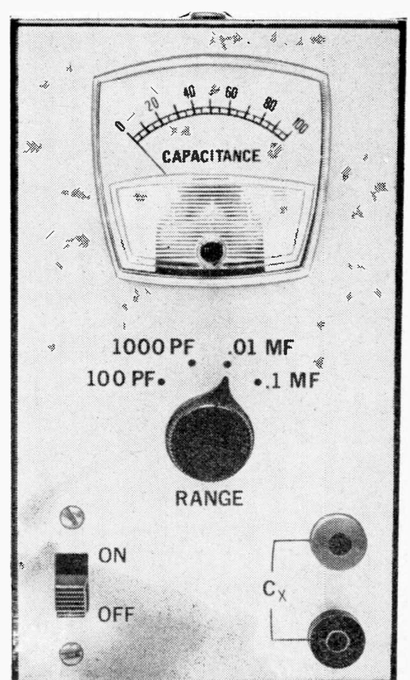


Fig. 2. To accommodate jacks, switches, and meter movement, machine top of box as shown.



Before mounting the meter movement, rework its scale to indicate a range of 0 to 100.

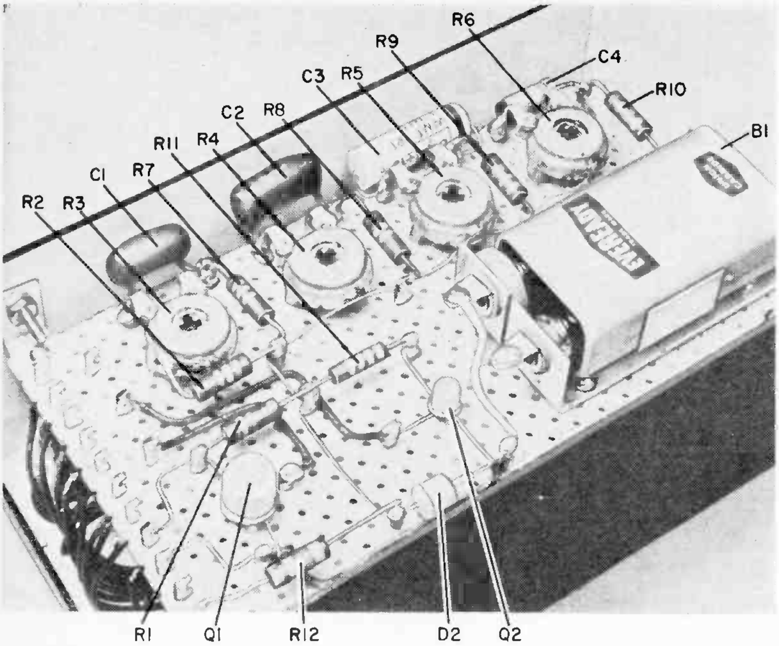


Fig. 3. To speed assembly time and keep project neat, use flea clips for component mounting. Note also common buss wire soldered to the cases of potentiometers.

In all cases, the calibration controls must be set to provide full-scale pointer deflection when the appropriate capacitor and range are used. Failure to obtain full-scale deflections means that you will have to experiment with the value of *R7*, *R8*, *R9*, or *R10*—depending on the range affected.

Avoid touching the exposed leads of the calibration capacitors and capacitors under test as your body capacitance is sure to produce a measuring error—especially noticeable on the lower ranges of the capacitance meter. Also, never attempt to check a capacitor while it is

(*Continued on page* 152)

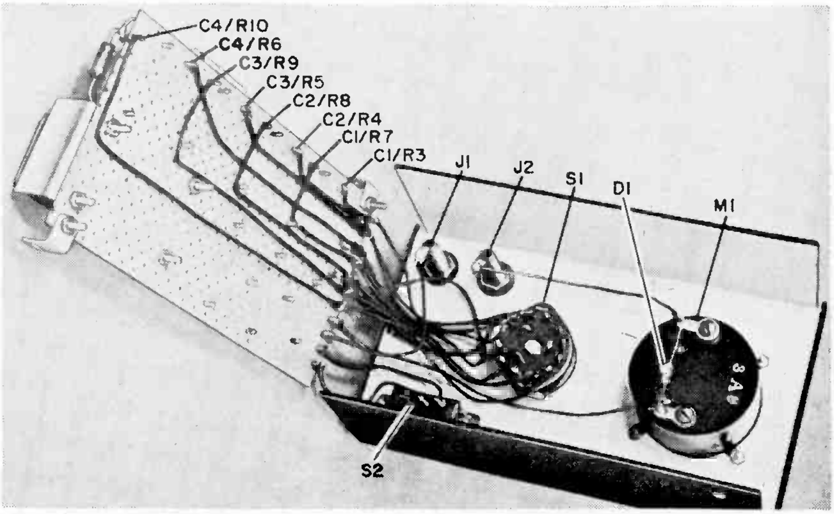


Fig. 4. To simplify wiring on bottom of board, connections labelled with two numbers designate component junctions to be located by observing the component side of board.

IC FREQUENCY SPOTTER/STANDARD

SELECT YOUR MARKER PIPS AT 1000, 500, 200, 100, 50, 20 OR 10 kHz

BY ADOLPH A. MANGIERI

UNLESS you have an expensive, highly sophisticated receiver, trying to locate a specific short-wave frequency is usually pretty much a gamble. The best you can do is tune your receiver to the approximate "ball park" and then painfully and slowly start searching.

Nowadays, most serious hams and SWL's use either built-in or added-on crystal-controlled frequency calibrators. However, in most cases, these permit you to tune only to 100-kHz pips on the dial and you still have to search between them. In fact, just trying to locate an ordinary marker in a maze of signals is often a problem. Usually you have to turn the calibrator on and off several times before you are sure you are tuned to it and not to some unmodulated carrier on the air.

Now, if you build the "IC Frequency Spotter," you can get switch-selectable, crystal-controlled marker pips at every 1000, 500, 200, 100, 50, 20, and 10 kHz clear out to 30 MHz (the limit of most commercial short-wave receivers). By flipping a switch, you can tone-modulate the marker so that it can be spotted easily in a crowd of carriers.

Using integrated circuit (IC) flip-flops as frequency dividers, one crystal can do the work of four. Thus, if you need 25-kHz markers for ham-band spotting, you can use a 125- or 250-kHz crystal. As an added feature, the audio tone, which is approximately 600 Hz, is available for audio testing. The various square waves of different frequencies that are present in the circuit can be used for checking scope sweeps, testing audio amplifiers for ringing, etc. The Frequency Spotter is self-powered (thus completely portable) and is easy to construct at modest cost.

PARTS LIST

B1—3.75-4.5-volt battery (see text)
BP1, BP2, BP3—5-way binding post (E.F. Johnson 111 or similar)
C1—0.01-µF disc capacitor
C2—200-pF capacitor
C3—100-pF capacitor
C4,C5,C6—0.02-µF disc capacitor
C7—0.033-µF capacitor
C8—22-pF capacitor
C9,C10—5-80-pF trimmer capacitor (Elmenco 462, Allied 43F3512, or similar)
D1—Silicon rectifier 1N2071
IC1—Quad two-input gate (Motorola MC724P or HEP 570)
IC2,IC3—Dual J-K flip-flop (Motorola MC790P)
Q1—Silicon npn transistor (Motorola HEP-55)
R1—15,000-ohm
R2—10,000-ohm
R3—270-ohm
R4,R5—4700-ohm
R6—2700-ohm
R7—470,000-ohm (see text)
R8—68,000-ohm (see text)
(All resistors ½-watt)
S1,S3—Two-pole, three-position, non-shorting switch (Mallory 3223J)
S2—Three-pole, four-position, non-shorting switch (Mallory 3234J)
S4,S5—S.p.s.t. slide switch
XTAL1—100.000-kHz crystal (James Knight H93 or similar)
XTAL2—1000-kHz crystal (James Knight H93 or similar)
Misc.—Crystal sockets (2); flea-clip board terminals (17, Vector T28); 3¼" x 4½" copper-clad board; 4" x 5" x 6" case (Budd AU1029HG); knobs (3); battery holders; IC sockets (3, optional, Elco 8358, Allied 47F-5701); hardware; solder; etc.
Note—Integrated circuit are available from Allied Radio Corp., 100 N. Western Ave., Chicago, Ill. 60680. For MC724P, order 50F26 MC724P MOT; for MC790P, order 50F26 MC790P MOT.

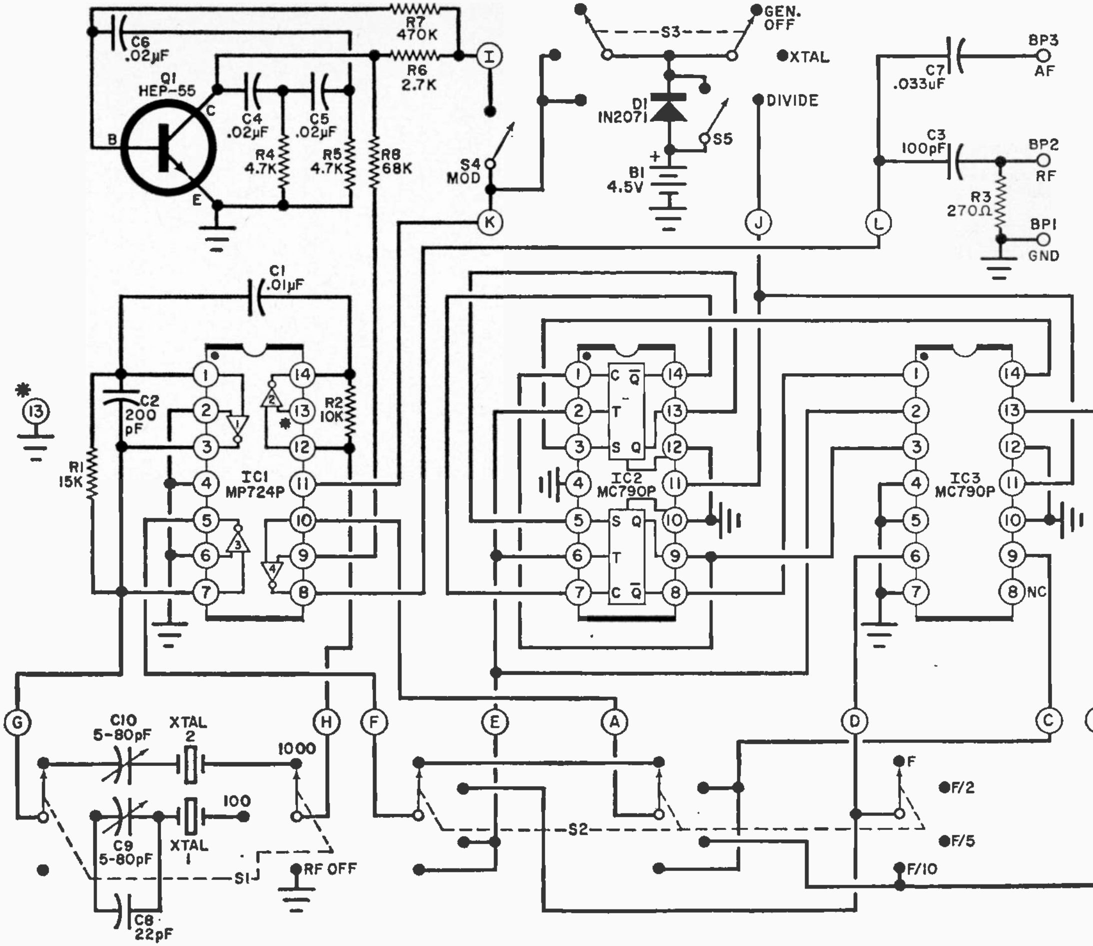


Fig. 1. The circuit consists of a switch-selectable crystal oscillator followed by a switch-selectable countdown made up of JK flip-flops. This enables a broad range of r.f. outputs. A built-in audio modulator helps identify r.f. signal.

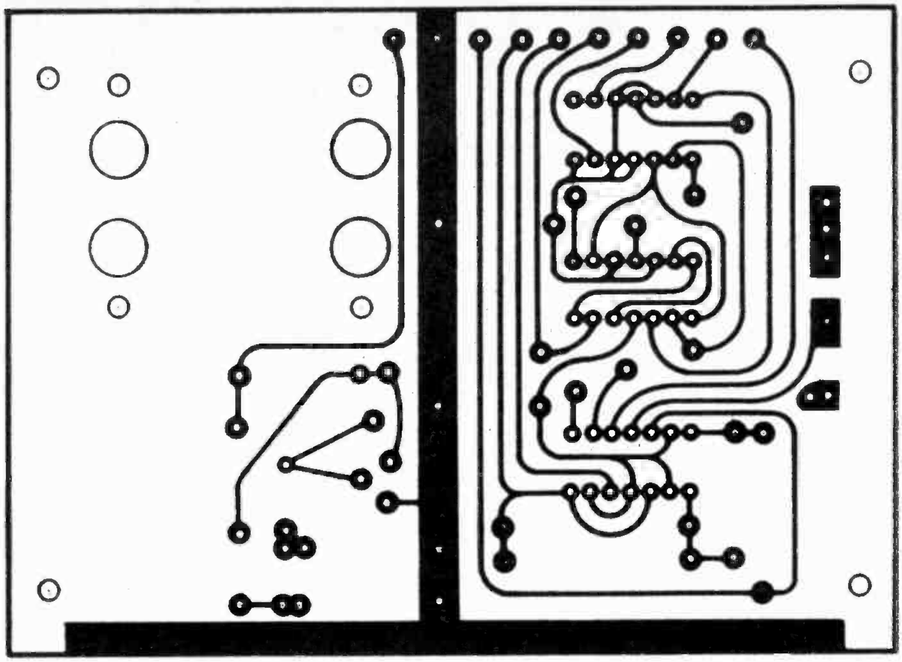


Fig. 2. Actual-size printed circuit foil pattern can be etched to build the Frequency Spotter. Two crystal sockets are shown, but only one may be used. Input/output connections are at top.

Construction. The circuit of the Spotter is shown in Fig. 1. Because of the complexity of the circuit, it is recommended that a printed circuit board be used. An actual-size foil pattern for such a board is shown in Fig. 2. Once the board has been fabricated and drilled, install flea clips for the connections to the board and for the mounting of resistors *R7* and *R8*. Install the components as shown in Fig. 3, being sure that the IC's are properly oriented as indicated by the notch and dot code at one end. The use of the optional 14-pin, in-line IC sockets will eliminate any chance of damaging the IC's during soldering. Include both crystal sockets, even if you plan to use only one crystal at first.

For complete shielding, use a metal enclosure for the Spotter. The author mounted all controls and output jacks on the metal front panel. The PC board is supported on two L-brackets so that it is about ⅝" from the panel and 1" from the bottom (see Fig. 4).

Frequency trimmer capacitors *C9* and *C10* are mounted on a piece of plastic attached to the front panel with a ½-inch spacer as shown in Fig. 5. Drill suitable holes in the front panel for insertion of a screwdriver to tune the two trimmers. Wire the rotary switches as shown in Fig. 6. Resistor *R3* is mounted directly between the r.f. output jack *BP2* and the ground jack *BP1*. Connect *C3* and *C7* from pin L on the board to their respective binding posts. Make sure that *BP1* is thoroughly grounded to the metal panel—scrape away the paint or finish under it, if necessary. Also be sure that the panel and the chassis are in good electrical contact when assembled. Mount the bat-

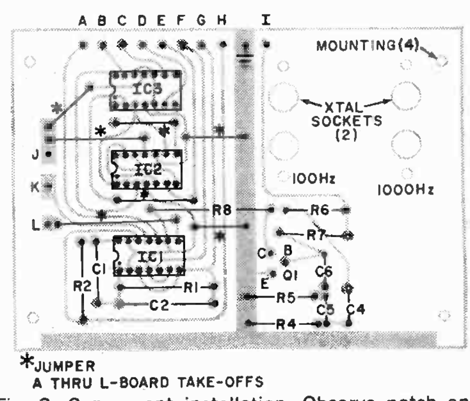
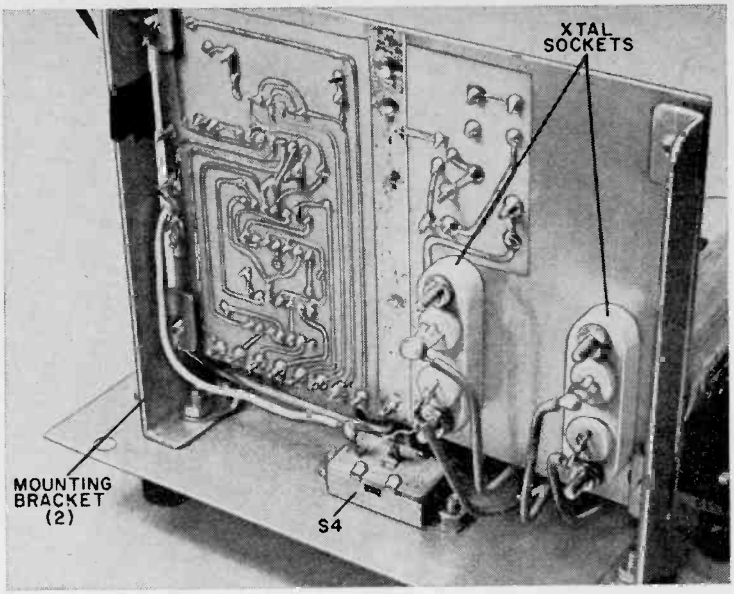


Fig. 3. Component installation. Observe notch and dot code on IC's to ensure proper installation. The values of R7 and R8 may have to be adjusted, so mount them on flea clips to facilitate changes.

Fig. 4. The PC board is secured to a pair of brackets which are mounted on the front panel. Other than the batteries, everything else is mounted on the removable front panel. Batteries are in mounting clip on the rear panel.



tery holders on the rear panel, making sure that enough clearance is left for the PC board. Connect the minus side of the battery to *BP1* and the plus side to the rotor of *S3*.

The battery you choose depends on how much you expect to use the Spotter. With a 4-volt battery, current drain is about 90 mA; with 4.5 volts, it is 115 mA. At this rate, conventional zinc D cells would provide about 30 hours of operation; alkaline cells, 70 to 90 hours.

Rechargeable nickel-cadmium cells can also be used if the Spotter is to be in operation frequently.

The IC's are rated for a maximum voltage of 4.0 volts. Since fresh zinc and alkaline cells supply about 4.5 volts, diode *D1* has been used to cut the voltage down. When the voltage (under load) across the cells drops to about 3.5 volts, *D1* can be removed from the circuit by closing *S5*. Mount *S5* and *D1* on the rear panel.

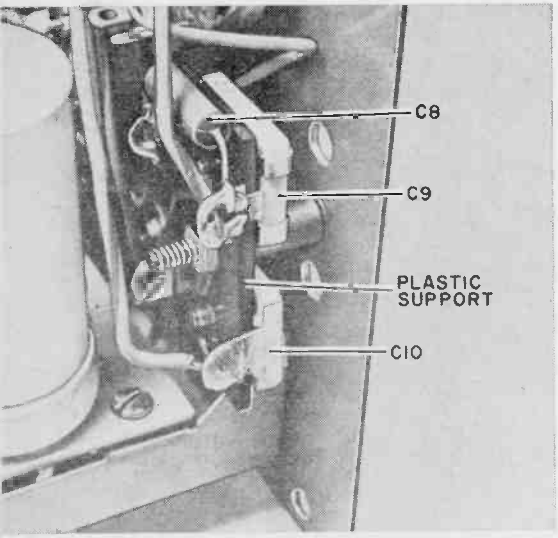


Fig. 5. Two frequency trimmer capacitors mount on a small piece of plastic attached to front panel. Appropriate holes provide for screwdriver trimming.

Circuit Adjustment. Set trimmer capacitors *C9* and *C10* to their maximum capacitance and set *S1* to the 100 kHz position, *S2* (FREQUENCY) to F, *S3* to XTAL, and *S4* (MOD) to OFF. Connect an insulated wire to the RF output jack *BP2* and wrap the loose end several times around the antenna lead of your receiver. Tune the receiver to WWV at any frequency except 2.5 MHz. Adjust *C9* to obtain a zero beat between the generator and WWV. Place *S1* in the 1000 kHz position and adjust *C10* for a zero beat. Try to zero beat during the WWV silent period (unmodulated) and adjust the coupling between the Spotter and the receiver so that the marker signal is about the same level as WWV. Close *S4* (MOD) and verify the presence of 600 Hz modulation on the carrier. If you have a scope handy, check for the presence of a 600-Hz audio signal at *BP3*.

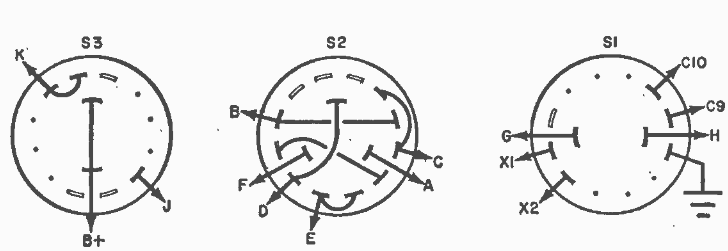
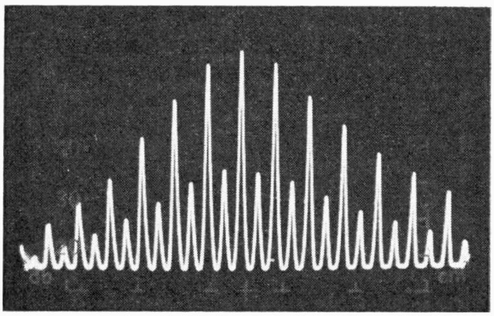
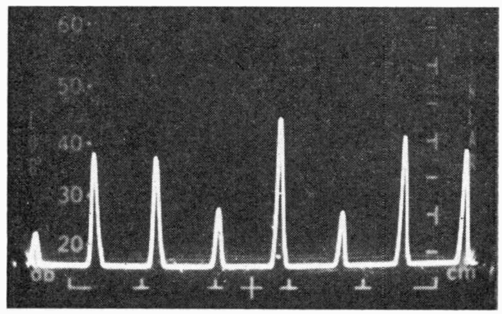
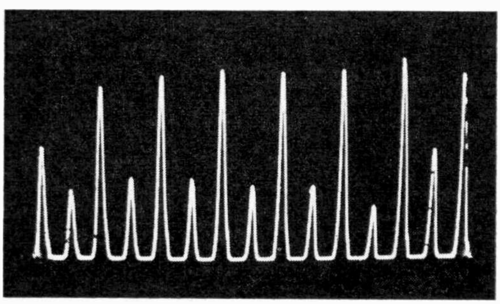


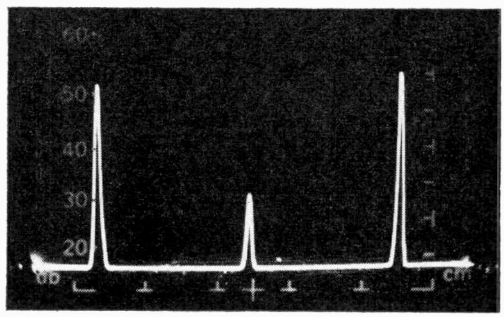
Fig. 6. If you use the specified switches, wire them as in these rear views.





These waveforms were taken from a Squires-Sanders "Bandscanner." Upper left shows spread of 10-kHz pips centered at 7250 kHz (hump due to receiver tuning). Upper right shows 20-kHz pips centered at 25,850 kHz. Lower left are 10-kHz pips centered at 25,850 kHz, and lower right are 50-kHz pips centered at 25,850 kHz. In all cases, the pips are clean and distinct, permitting accurate frequency calibration down to 10 kilohertz.





HOW IT WORKS

Gates 1 and 2 of *IC1* are cascaded to form a linear, high-gain amplifier biased by *R1* and *R2* and stabilized by *C2*. One of the quartz crystals is inserted in the amplifier positive feedback network through switch *S1* to sustain crystal-controlled oscillation. The crystal resonates in the series mode and acts as a very sharp feedback filter. Trimmer capacitors *C9* and *C10* provide for zeroing of the r.f. output for exact frequency calibration.

The oscillator output is applied to a buffer-driver stage (gate 3 of *IC1*) which drives dual JK flip-flops *IC2* and *IC3*. With *S2* in the F position, the flip-flops are bypassed and the marker interval at *J2* is equal to the crystal frequency. For the F/2 position of *S2*, flip-flop 4 of *IC3* divides the crystal frequency by two; for F/5, flip-flops 1 and 2 of *IC2* and flip-flop 3 of *IC3* (with their feedback networks) divide the frequency by five; and for F/10, the F/5 circuit drives the F/2 flip-flop to divide by ten.

The flip-flop outputs are square waves which feed into one input of the output stage (gate 4 of *IC1*). The output of gate 4 goes through a high-pass filter (*C3-R3*) which produces a sharply spiked r.f. output at *J2*.

High-gain transistor *Q1* is connected as an RC phase-shift audio oscillator with *R7* providing bias for a sine-wave output of about 600 Hz. Resistor *R8* couples the audio to the second input of gate 4 to tone modulate the r.f. marker signals.

Diode *D1* and switch *S5* provide a way to reduce the battery voltage when using new zinc or alkaline cells.

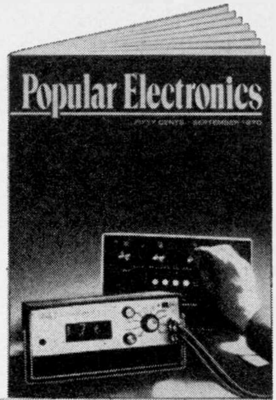
Get the most sophisticated electronics construction projects all year long...and much, much more!

with Popular Electronics

The world's most widely read electronics magazine

NOW AT HALF-PRICE!

One full year (12 issues) only $3.00!



Each month, PE's editors choose from a wide range of electronic components, equipment, devices, test gear and experimental projects. From lasers and computer components to audio-visual devices, stereo and hi-fi, electronic music, unusual electronic games and practical items for your home use and entertainment. Once selected, each project is laboratory-tested by one or more of the editors to make sure it performs as it is supposed to. You get 8, 10, or more valuable projects each issue—more than 100 per year... All with "how-to-build-it," "how-it-works" instructions, most with actual size PC foil patterns and all geared to increase your electronics know-how and add to your knowledge of the dynamic field of electronics...and besides, they're just plain fun.

Typical P.E. "Build-It-Yourself" Projects

Build an Audio Multicoupler
For recording more than one tape

Build the X10/X100 Instrument Sensitivity Booster
Extended range on scope or VTVM

Automatic Lightning Protection
Ground your antenna

Build Security 1
Speech scrambler for your telephone

One-Step Motion Detector
Ultrasonic intruder alarm

Numitron Readout
Seven-segment display in one tube

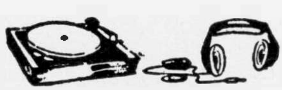
Build the Digital Logic Microlab
A super breadboard for learning logic

The Frisky Four Speaker System
Small speakers give top response

Popular Electronics Brings You Complete Coverage of Every Aspect of Electronics

ELECTRONICS FEATURES

Brilliantly illustrated articles and feature stories keep you on top of every new development every vital breakthrough—as they happen! You'll follow the latest advances (and build your own projects) in aviation and marine electronics, lasers, telemetry, computers, radio astronomy, nucleonics—every phase of the jet-paced world of electronics And you'll learn about rewarding and challenging career opportunities...for students and professionals alike.



HIGH FIDELITY & STEREO

In addition to complete coverage of every major hi-fi or stereo component and kit placed on the market, you'll get new and original plans for devices that convert and improve your present system—each one meticulously tested in advance by the prestigious Hirsch-Houck laboratory.

COMMUNICATIONS

Amateur radio, CB, SWL, TV and CATV are all covered regularly in the Communications section. You get all the latest news and developments including candid equipment reports, latest FCC regulations, satellite tracking and telemetry frequencies, DX contests, PLUS tips on how to get those tough QSL's from all over the world.

REGULAR DEPARTMENTS

Monthly features bring you fast-breaking industry news, photo-reports of the latest technological advances, reviews of new electronics books, valuable pro "Tips & Techniques," "The State of Solid State," helpful, detailed reports on new products and brain tickling quizzes.

Please enter my subscription to POPULAR ELECTRONICS at the special HALF-PRICE rate of:
One year for just $3.00

☐ Payment enclosed
☐ Bill me later

Mail this coupon today to:
POPULAR ELECTRONICS,
Dept. 0405, P.O. Box 1096
Flushing, N.Y. 11352

print name ______________________

address ______________________

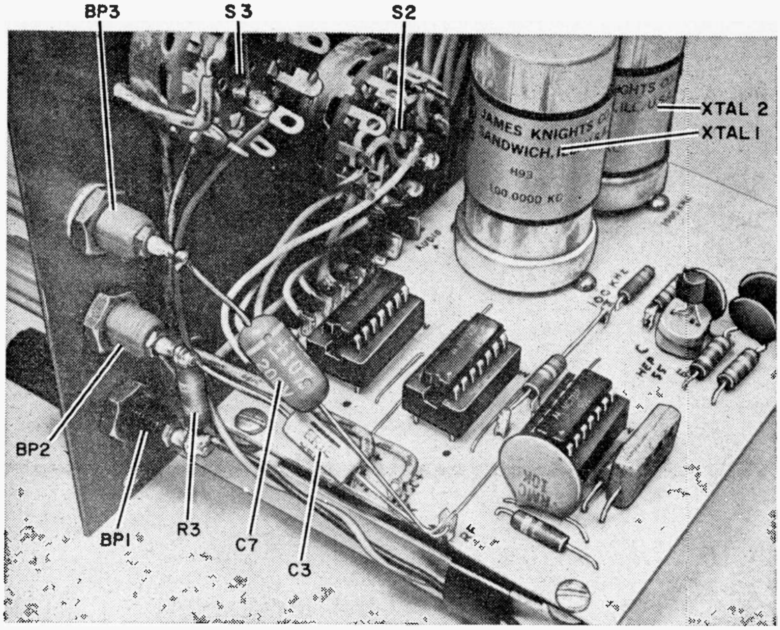
city ______________________

state ______________ zip-code ______________

POPULAR ELECTRONICS' regular subscription rate is $6 a year! But, as a reader of ELECTRONIC EXPERIMENTER'S HANDBOOK, you get the special HALF-PRICE rate of—

12 months for only $3.00

Use handy order card opposite this page or mail coupon at left—today!



Overall view of the frequency spotter. The use of IC and transistor sockets is optional. Note that resistor R3, and capacitors C3 and C7 are mounted off the board.

At this time, you can adjust *R7* and *R8* to produce 100% modulation while observing the RF output on the scope.

For final tests, assemble the generator within its metal case, making sure that the front panel is electrically bonded to the rest of the case. Couple the generator to the receiver antenna, and check all marker intervals generated.

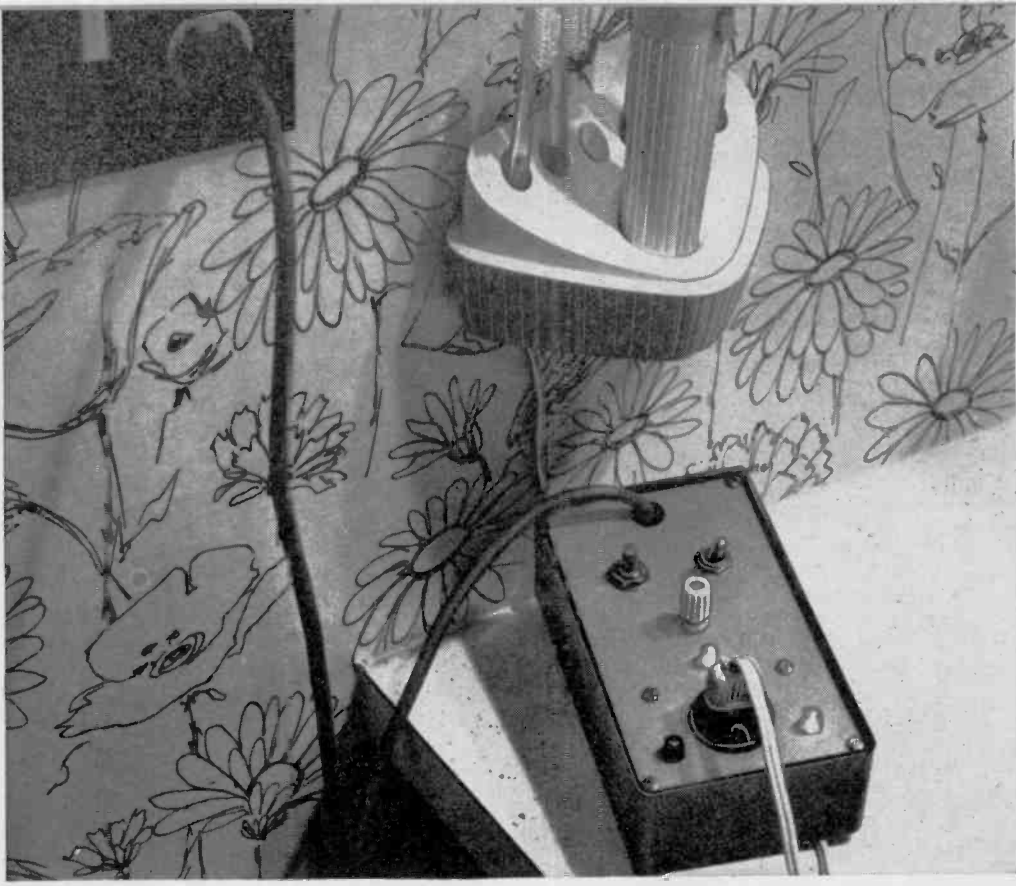
Although all IC's tested for *IC1* produced almost identical outputs, if you find that the 100-kHz markers are not clean and steady, it may be necessary to increase the value of *C2* by about 50 pF to correct for gain variations. On the other hand, it may be necessary to decrease *C2* by a small amount if *XTAL2* does not oscillate.

Application. Connect the ground (*BP1*) of the Spotter to the ground of the receiver and connect a short length of insulated wire to the RF output jack. Wrap a couple of turns of the other end of the wire around the antenna lead of your receiver. After performing the WWV zeroing on both crystals, the generator is ready to use.

Normally, marker signal strength will decrease as *S2* (FREQUENCY) is rotated from F to F/10. In the case of the shorter intervals, it may be necessary to make a direct contact to the receiver antenna terminals to pick up the markers. In all cases, avoid using excessive marker signal strength to avoid picking up images. Images are weak responses appearing at odd frequencies on the dial, depending on the receiver i.f. If you want to calibrate the receiver dial, remove its antenna completely to avoid picking up other signals. In calibrating, start with the larger intervals and work down to the smaller ones. You can use either the internal audio modulation or, if the receiver is equipped with a BFO, the zero beat method can be used.

Check the crystal zero beat with WWV everytime you use the calibrator, and touch up the frequency by adjusting the appropriate trimmer, if necessary.

Battery aging has little effect on the 100-kHz crystal and only a slight effect on the 1000-kHz crystal. In either case, any drift can be corrected by adjusting the appropriate trimmer. Battery minimum voltage is about 3.3 volts, checked under load, with *S3* on DIVIDE. -30-



Why Play Edison Roulette?

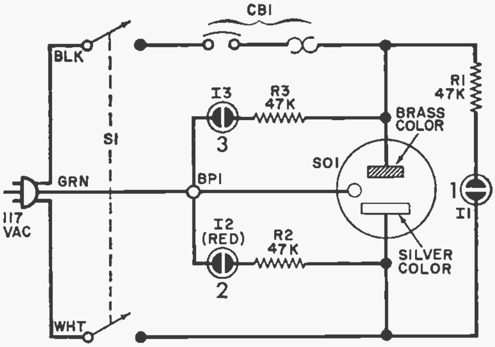
GROUND TESTER MINIMIZES ACCIDENTAL ELECTROCUTION

BY LYMAN E. GREENLEE

AS AN ELECTRONICS hobbyist, one of the most embarrassing (to say the least) ways you can die is through electrocution in your own home. It can ruin your whole day!

Quite seriously, it does happen. Unfortunately, many ordinary hand tools and appliances are wired so that, if a primary power lead should break due to vibration, improper handling, etc., the entire electrical resources of your local power plant can be literally at your fingertips. This happens if the hot lead of the power line comes into contact with the metal portions of the device while you are touching it and your body is making a reasonably good ground return path for the current.

To avoid accidental shock and even electrocution, most appliance manufacturers use a three-lead power cable. In this system, besides the two conventional power leads, there is a third, safety, lead. This lead, which is connected to a metal portion of the appliance, is brought out to a third terminal (usually a rod-like metal pin) on the plug. In the socket, the third terminal is con-



PARTS LIST

BP1—Insulated binding post
CB1—Circuit breaker to suit load
I1-I3—Neon lamp
R1-R3—47,000-ohm, ½-watt resistor
SO1—Three-wire power socket (Amphenol 160-10 or similar)
S1—D.p.s.t. switch, current rating to suit load
Misc.—Plastic utility box 7¼" x 3¾" x 1⅞" with metal cover; three-conductor power cord with plug (length as required); two-to-three-conductor adapter (optional); 4-lug terminal strip (2), plastic mounting for neon lamps (one red, two white); ⅜" grommet for power cord; mounting hardware, etc.

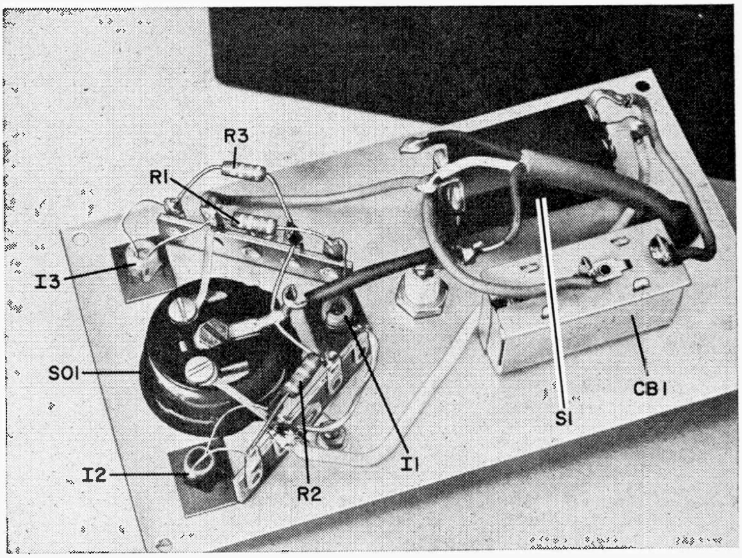
Fig. 1. The circuit is simple and foolproof if wired correctly. Under normal conditions, only lamps 1 and 3 should be lit. If lamp 2 comes on, the "cold" lead is 117-volts above ground.

nected to earth ground. If, for any reason, the electrical system within the appliance fails and contacts the metal part, a short circuit is made and a fuse is blown. This three-wire system is a must for any location where there is the slightest possibility that a person using a power tool or other appliance might make a ground while touching the device.

Even with this precaution, however, there is a way to keep tabs on the possibilities of inadvertent shocks—build the handy Ground Tester shown here. If you follow the instructions carefully and keep an eye on the three visual indicators, you may reach a ripe old age—without a sudden electrical termination.

Construction. For safety, the circuit (Fig. 1) should be built in a plastic utility box having a metal cover. Drill holes in the cover to fit the three-lead power socket (*SO1*), circuit breaker *CB1*, power on-off switch *S1*, three neon indicators, and a pair of four-lug (none grounded) terminal strips. You can use the layout shown in the photograph or make up your own as long as the three neon lamps are clearly visible.

In mounting the components make sure that lamp *I2* has a red lens to make it clearly distinctive. Wire the circuit



The entire circuit can be assembled on the metal panel. Make sure that this panel is grounded to the green lead of the cable.

WHAT A SHOCK!

Unlike a rattlesnake, electricity gives no warning before it strikes. When it does, the damage can range from a tingle, to a shock, to death by electrocution. However, like the woodsman who knows where the snake lies in wait, the electronics hobbyist also should be aware of where the electric shock can be encountered.

Look around you. In the kitchen, close to grounded sinks and other metal fixtures, there is probably an a.c.-d.c. radio. Although the manufacturer went to some trouble to make the radio electrically safe, did you repair it recently and substitute a knob with a set screw for the friction-fit one that was there originally? That set screw can be "hot" with 117 volts to the grounded metalwork; and if you have the radio plugged in the wrong way (how do you know you haven't?) and reach to tune the radio while leaning on the sink, this may be the last sentence you ever read. And if you're using a radio out of its protective case—forget it! What about the toaster? Would you want to take the chance of touching both the plugged-in toaster and the kitchen faucet, radiator, or other grounded metalwork? Try it. If you survive, keep reading.

Now let's go to the laundry room—site of many deaths by electrocution. Isn't your washer/dryer pretty close to the grounded sink? What about the moist floor? It makes a very good conductor of electricity, especially when either the washer or dryer has a loose wire that makes contact with the metal shell.

Now out to the yard or down to the boat dock. Do you get a comfortable feeling when using a power tool to do a hard job? You may not feel so good when you stop to think that only a few thousandths of an inch may stand between you and your Maker. If vibration loosens up a screw or if a piece of fishpaper changes position, bye-bye, dear reader.

Why this preoccupation with death? Because most of us live in an electrical environment and many of us are not aware of just how close to termination we are—even if it's just sitting at the breakfast table with the electric toaster or coffee pot near one elbow and the other elbow leaning on the radiator.

So what can you do about all of this? It's simple. Open both eyes and check everything in sight that has a 117-volt power cord attached. If you have the slightest doubt of the safety of any device, be sure that its metal sections are grounded to earth. In the case of large appliances such as washers and dryers, use a heavy-gauge wire between the metal frame and a cold-water pipe. For small, portable devices, read this article—and go three-wire!

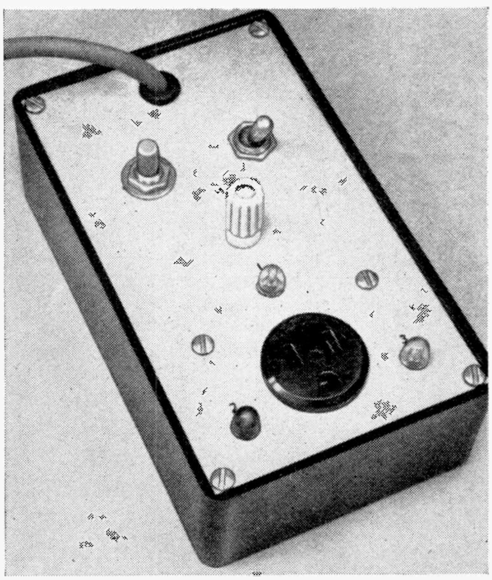
as shown in Fig. 1, taking care to observe the color code.

In the three-conductor power cable, the black wire is for the hot lead, white is for the neutral, or grounded, side of the power line, and green is for the actual ground. Socket *SO1* is also color coded: the copper-colored terminal is for the hot side and should be connected to the black lead; silver terminal to the white lead; and the narrow ground connector to the green lead. Make sure that the green lead is only connected to the insulated post on the metal panel.

Wire the three neon lamps (*I1*, *I2*, and *I3*) and their respective current-limiting resistors (*R1*, *R2*, and *R3*) so that the neon lamps are slipped into the plastic mounts through the metal cover with the leads and resistors on the terminal strips. Identify the lamps with the numbers 1, 2, and 3 on the front of the cover.

Choose the value of the circuit breaker to suit the largest load you will be using. A 7A breaker is adequate for most hand tools, but a larger capacity may be used for heavier applications. Do not, however, use a breaker rated over 15A since that is maximum for the #18 wire in the power cord.

Use. If you do not have a three-wire system in your home or on your bench,



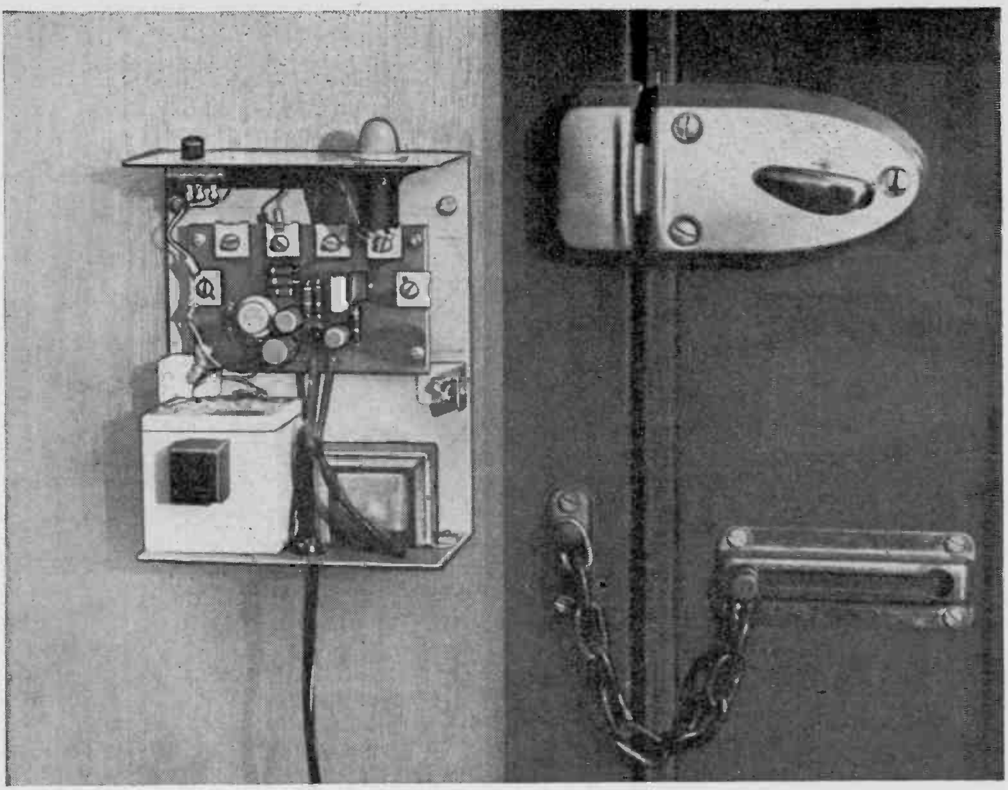
The front panel displays a neat, uncluttered look. The circuit breaker is the push-to-reset type. Keep an eye on red lamp number 2.

CHECKING INSTRUCTIONS	
Indicators Lit	**Condition**
1 and 3	Wiring correct. Only safe condition.
1 and 2	"Hot" and "neutral" wiring reversed. **DANGER**, must be corrected.
2 and 3	Ground is "hot." **DANGER**, must be corrected.
All	Should never happen. If it does, **DANGER**, must be corrected.
None	No power.

WARNING: Any time that light #2 (red) is lit, **DANGER TO LIFE AND LIMB** exists. Wiring should be checked immediately.

you can still use the ground tester by putting an adapter into the regular wall plug. The adapter has the conventional two prongs on the male side and three sockets on the female side with a short, usually green, ground lead coming from one side. Be sure that the adapter ground wire is adequately grounded. In many cases, particularly in large urban areas where the electrical code is strict and metal-armored cable is used, the outlet box itself is grounded. The adapter ground connection can then be made to one of the box mounting screws. If there is any doubt, or if your electrical system uses plastic-covered cable, run a separate wire from the adapter ground to an actual ground.

If you have followed the wiring diagram carefully and identified the three neon lamps (being sure that lamp 2 is red), operation of the ground tester is actually very simple. Plug the tester into a three-conductor wall outlet (or grounded adapter) and observe the condition of the three neon lamps. Under normal conditions, only lamps 1 and 3 should be lit. If all three lamps light, either there is no ground or it is not proper and the outlet should NOT be used until the trouble has been remedied. If lamp 1 is out and the other two are lit, the polarity is reversed. Again DO NOT use the outlet until it has been fixed. This is also true if lamps 1 and 2 are lit and 3 is out. In any case, if the red lamp (number 2) is lit at any time, YOU COULD GET KILLED. Have an electrician investigate the wiring. —30—



BUILD THE

HOMESTEADER

PROFESSIONAL BURGLAR ALARM PROTECTION AT LOW COST

BY DAN MEYER

THERE ARE many types of burglar (or intrusion) alarms that you can build—involving proximity switches, infrared beams, breakable wires, etc. They all have their points, but why not use the system that the professionals use? On the windows of most stores and commercial establishments, you will see strips of silvered tape around the edges and, on doors and windows, pressure- or magnetically operated switches.

In such a system, the conductive tape and switches are connected in series and a weak current is flowing through them. When any portion of the loop is either broken or grounded, an alarm sounds. This has been found to be a reliable, easy-to-set, easy-to-use system. The "Homesteader" described here is equivalent to most commercial alarms costing several hundred dollars if installed by a professional. Depending on how many places are to be protected, you can build this system for under $40.

Construction. The circuit for the Homesteader alarm is shown in Fig. 1. It can be assembled on the printed circuit board whose foil pattern is shown in Fig. 2. Once the board has been fabricated or purchased, install the components as shown in Fig. 3, taking care to observe the polarities of the electrolytic capacitors and semiconductors. Choose a suitable metal enclosure to house the alarm (about 4½" x 5½" x 2"). You should be able to mount it on a wall.

Mount *I1*, the a.c. power-on indicator and *S1*, the alarm switch, on the upper surface of the enclosure. Attach the transformer, *T1*, and the rechargeable battery to the bottom panel. The PC board is mounted on the enclosure using screws and small spacers as shown in the photographs. Note that the author used small metal plates and screws to make connections to the six contacts on the PC board. These are optional.

If you cannot locate the small rechargeable battery called for in the Parts List, you can substitute an automobile or motorcycle storage battery or an Edmund Scientific Co. (600 Edscorp Bldg., Barrington, NJ 08007) 6-volt, 4-ampere-hour rechargeable battery (#70942, $15.00). For short-term use, you can also connect in series an Edmund #60634 ($4.80) and #40986 ($1.50) rechargeable batteries (or similar units of other manufacturers). Batteries other

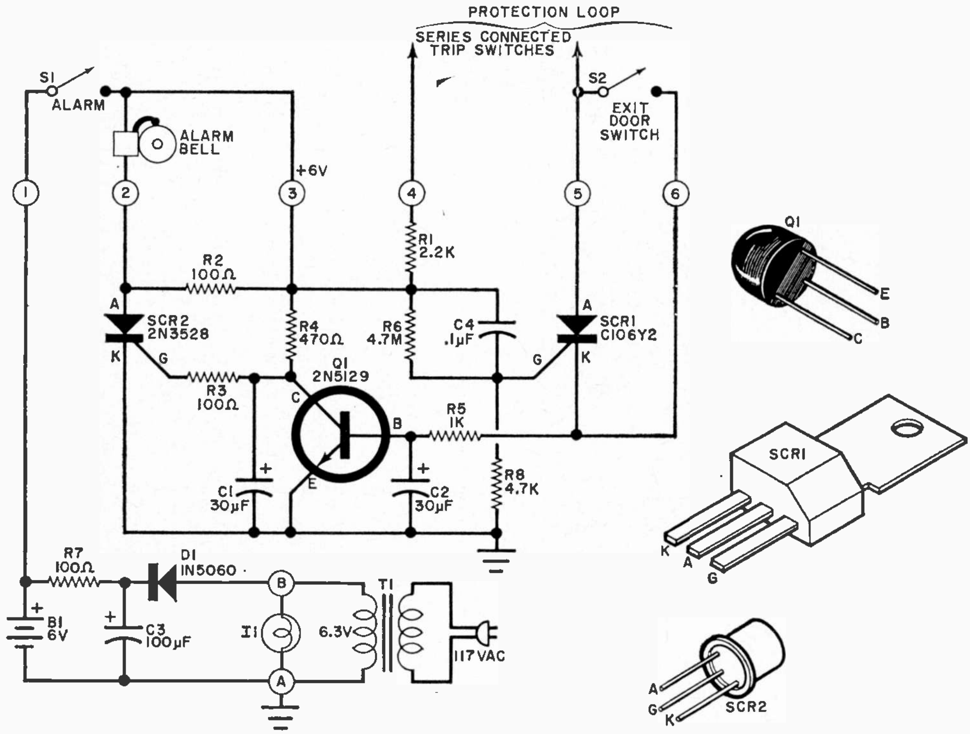


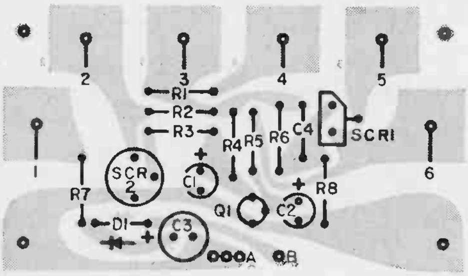
Fig. 1. Alarm system is equipped with fail-safe protection. You can eliminate battery B1 to allow a.c.-only operation. However, if line power fails, the alarm will not sound when an intruder trips an alarm switch.

PARTS LIST

B1—6-volt, 1-ampere rechargeable battery (Centralab RP-6101 or similar)
C1—30-μF, 16-volt electrolytic capacitor
C2—30-μF, 6-volt electrolytic capacitor
C3—100-μF, 16-volt electrolytic capacitor
C4—0.1-μF Mylar capacitor
D1—1-ampere silicon rectifier (1N5060 or similar)
I1—6-volt pilot lamp and holder
Q1—2N5129 transistor
R1—2200-ohm
R2,R3,R7—100-ohm
R4—470-ohm
R5—1000-ohm
R6—4.7-megohm
R8—4700-ohm
(All resistors ½-watt)
S1—S.p.s.t. switch
S2, etc.—Magnetic or other long-life switch
SCR1—Silicon controlled rectifier (GE C106Y2)
SCR2—2N3528 silicon controlled rectifier
T1—Power transformer; secondary 6.3 volts at 600 mA (Knight 54F1416 or similar)
Misc.—Frangible conductive tape, tape cement, interconnection wire, magnets for switches, a.c. line cord, 6-volt alarm bell (or similar warning device), suitable chassis, mounting hardware.
Note—An etched and drilled fiberglass PC board with connection clips (#163) is available for $2.85 from Southwest Technical Products Corp., 219 W. Rhapsody, San Antonio, Texas 78216. A complete kit of parts including battery, punched cabinet, and three magnetic switches (#163CP) is also available from the same source for $25.45.

Fig. 2. If you decide to make your own printed circuit board, follow actual-size etching guide shown.

Fig. 3. Mount components on circuit board as shown; then double check polarities of SCR's, transistor, and electrolytic capacitors.



than the one called for in the Parts List will require a different type of mounting. Of course, if you do not want to use a battery, which gives you protection in case your a.c. line is cut, the battery can be eliminated.

(*Continued on page* 147)

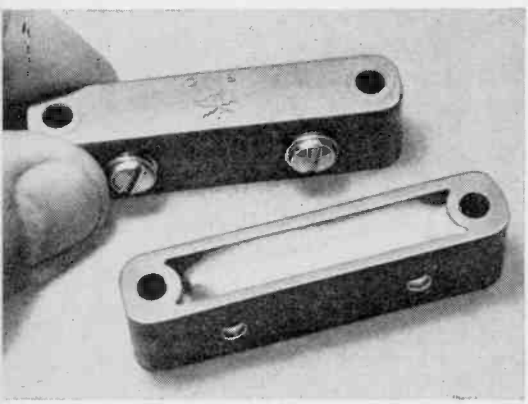
HOW IT WORKS

When switch *S1* is turned on and all external window and door switches in the protection loop are closed, transistor *Q1* is held in a saturated condition by the low current (approximately 2 mA) supplied to its base through the protection loop. The collector voltage of *Q1* is near zero in this condition. If the protection loop is opened, or grounded, base bias is removed from *Q1* and it cuts off. The voltage at the collector of *Q1* and the gate of *SCR2* then rises and the SCR turns on. The current flow through the SCR causes the alarm to sound off. The SCR does not turn off until *S1* is opened to remove the d.c. supply.

The exit door switch makes the system more convenient to use. With all of the protection loop closed except the exit door, *SCR1* fires when *S1* is turned on. This SCR, which is in parallel with the exit door switch keeps *Q1* saturated and the alarm off while the exit door is being closed. Thus you can turn on the alarm system before you leave the house and it remains quiet while you are leaving. When the exit door switch is finally closed, *SCR1* turns off, but *Q1* remains saturated.

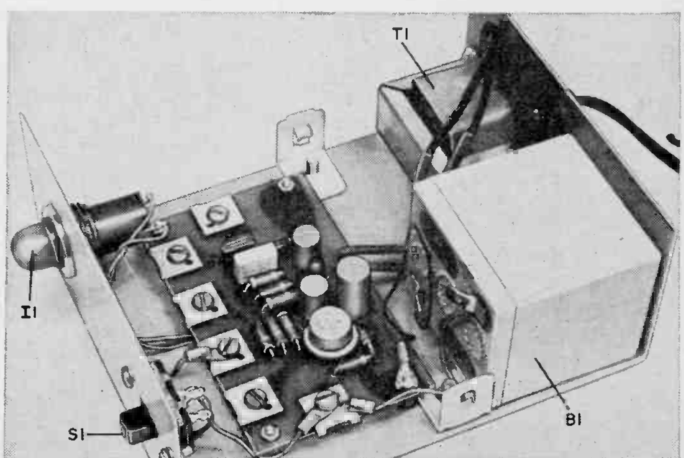
Note that although only three trip switches are shown in the schematic, many more can be used in the protection loop (which also includes any conductive tape on window panes) as long as they are all connected in series.

The 6-volt rechargeable battery is included to keep the system operative even if the a.c. power line is cut. The battery is kept trickle charged as long as the a.c. line is plugged in. No primary-power on-off switch is included so that only one switch has to be turned on to activate the system.



Place switch and magnet into separate plastic housings and seal in place with Silastic.

Metal contacts (Tinnerman nuts) and screws are optional. Connections can be soldered.



HOMESTEADER

(*Continued from page* 144)

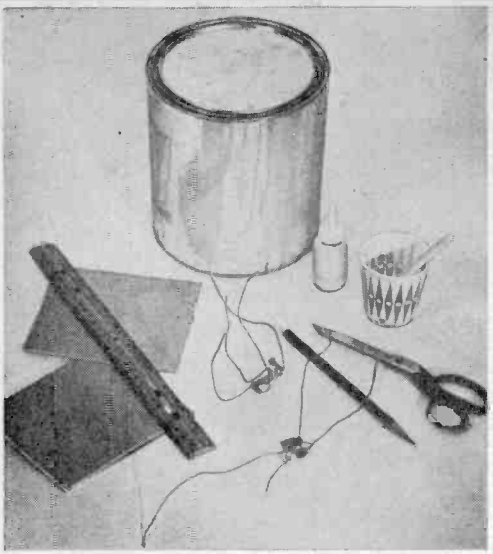
Protection Loop. The protection loop is a simple series circuit using switches and/or conductive window tape on the inside surface of the glass. Almost any type of switch can be used—including magnetic types in which the switch is mounted on either the window or window jamb and the operating magnet is mounted so that it operates (closes) the switch when the window is closed. (Magnetic switches are suggested because of their long life.)

The conductive window tape is cemented across or around the perimeter of the glass and terminated in contacts on the window frame. When the window is closed, the contacts are made. If the window is broken by an intruder, the tape shears very easily, opening the circuit and operating the alarm.

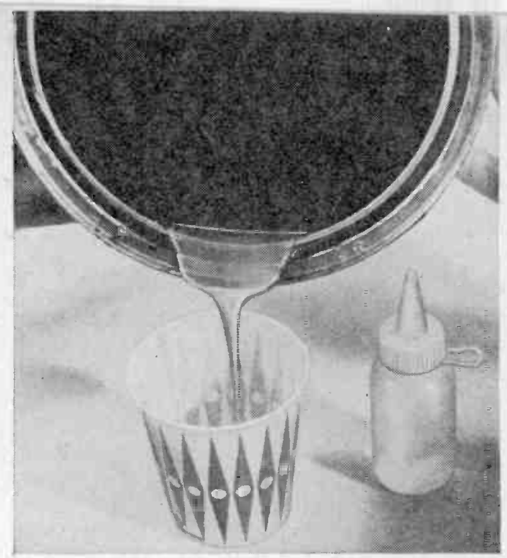
Wiring the protection loop may present a problem, depending on the type of construction of the building being protected. If the wires connecting switches, tape, or breakwire contacts cannot be run through the walls or ceiling, they can be routed up a seam in paneling or covered with tape and painted over. The interconnecting wiring can be fine-gauge wire since current flow through the loop is only about 2 mA.

The exit door can be protected with either a magnetic switch (as described above for the windows) or a mechanical, normally open switch that is closed when the door is closed. Besides switches, there are many other ways in which a contact can be made while a door is closed and broken when the door is open. Use your imagination. All you have to remember is that the circuit between terminals 4 and 5 on the PC board must be complete for the alarm to work and the exit door switch must make a complete circuit between terminals 5 and 6.

It is also possible to make a "silent alarm" by replacing the local alarm bell with a remote bell or light. In this way, the intruder will not know that you are aware of his presence, and you can take any action you deem neccessary. —30—



Except for epoxy resin compound and hardener (in can and small bottle at top), all materials used in circuit potting are common household items.



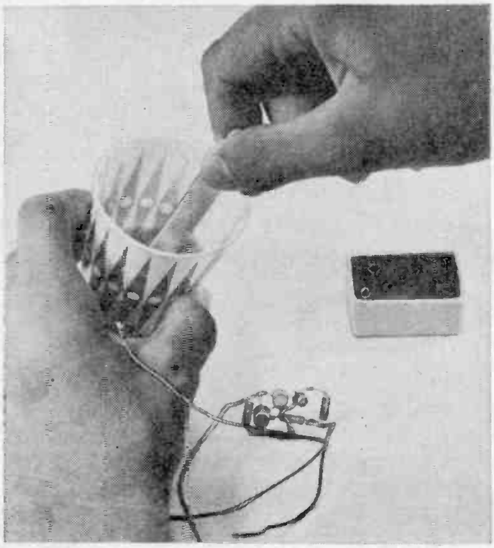
Using wood stirrer and paper cup, mix just enough resin compound and hardener to pot circuit adequately. (See mixing instructions on resin can.)

ENCAPSULATE YOUR CIRCUITS

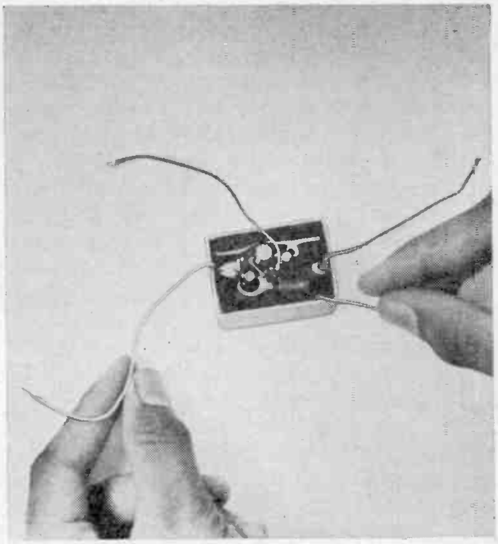
BY ALBERT H. COYA

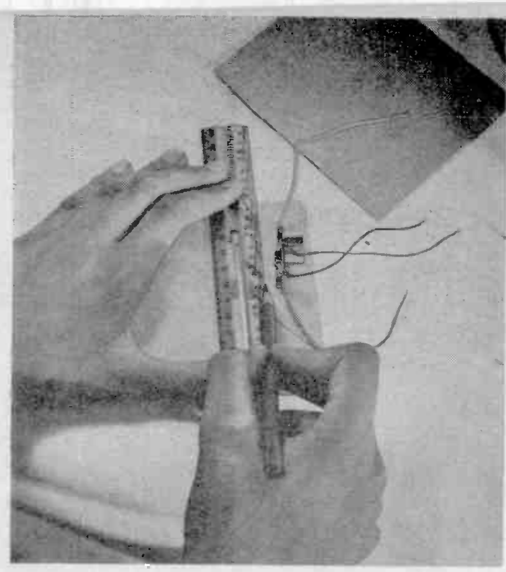
IF YOU'RE tired of making printed circuit boards for your simpler projects, why not borrow the casting technique some electronics manufacturers use for their experimenter modules? In addition to being inexpensive, the casting technique produces a finished circuit that is immune to moisture and foreign matter and is much more durable than either printed or chassis wired circuits.

After checking self-supporting circuit for shorts, being sure all components are in a single plane, stir the potting compound once more before pouring.



Set circuit into the form and pour in enough potting compound to cover half way. Orient leads as desired. Then pour in the rest of the compound.





Next, prepare your potting form from lightweight cardboard (allow 1/4" clearance on all sides of the circuit) and secure the edges with masking tape.

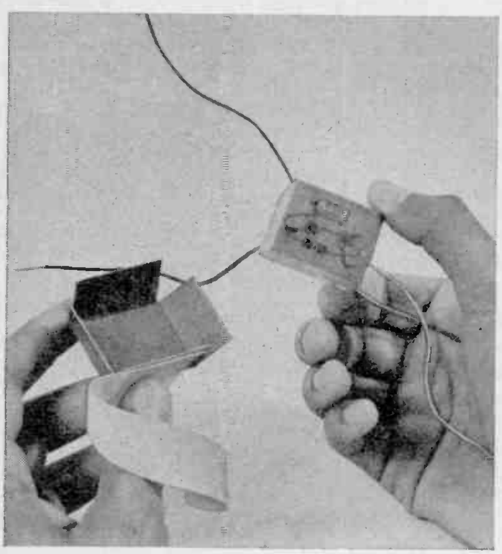
To prevent potting compound from adhering to form, liberally coat all interior surfaces of the form with Vaseline using a brush or a scrap stirrer.

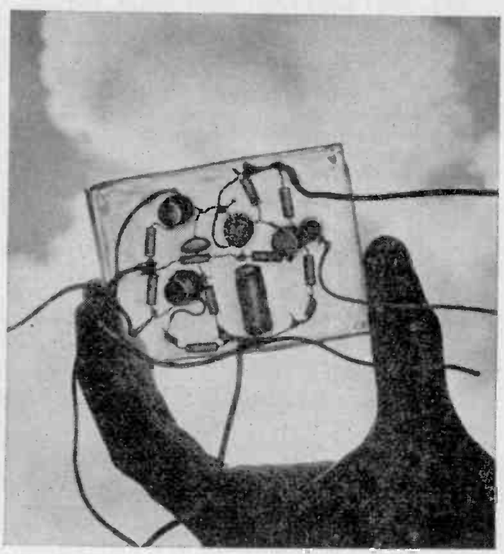
Commercially available modules are commonly cast in a black opaque epoxy resin. But for your purposes, Clear Cast resin (American Handicrafters Co.) available from plastic rod and panel supply stores is preferable. The clear resin allows you to read color codes and identifying numbers of components and to trace out the circuit.

Circuit construction inside the block of resin is simple. After assembling the circuit, making it self supporting and as compact as possible, check that the components are oriented so that their value coding and markings are unobstructed. Make sure that no unwanted short circuits exist and that all joints are properly soldered. Now you're ready to encapsulate the circuit following the instructions in the photos and captions.

Allow enough time for the compound to set. Remove the circuit from the form. Do not heat cure. Clean away Vaseline, and circuit is ready to use.

Crystal-clear block permits you to trace circuit, interpret color codes, and—if components are properly oriented—even read identification numbers.





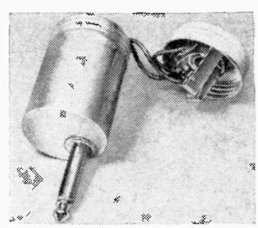
PARTS METHODS IDEAS GADGETS DEVICES TIPS & TECHNIQUES

DON'T BE CHEATED BY LEAKPROOF DRY CELLS

The leakproof "C" or "D" cell is a wonderful invention, but it has introduced a new problem. Some cells go dead unexpectedly when there should still be plenty of life left in the battery's electrolyte. This condition is generally due to an imperfect contact between the inner and outer shells of the leakproof container. If you suspect that there's life in your batteries, dent the bottom of the cell gently with a blunted nail (see photo). This will reestablish contact between the two shells. Be careful not to tap too hard. To be on the safe side, drill a ⅜" hole in a block of wood, and insert the positive terminal into the hole so that the wood supports the battery case.—*William S. Gohl*

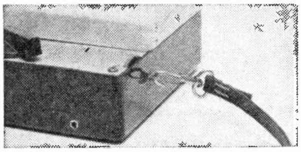
MONO ADAPTER FOR STEREO HEADPHONES

Chances are that you have comfortable headphones which you would like to use with your communications receiver without changing the plug on the headphones or the jack in the receiver. This can be accomplished by mounting a two-circuit jack and a one-circuit plug at opposite ends of a 35-mm color film cannister. The plug should be offset to one side of the cannister as shown in the photo so that, when the cannister is closed, the jack won't interfere with the plug. (Also, the offset phono plug allows the adapter to be used with receivers, such as the Drake SW-4A, that have a panel extension.) Wire the two "signal" contacts on the jack and the "signal" contact on the plug together. Do the same for the "common" contacts. Finally, screw on the cannister top, and the adapter is ready to use. —*A. A. Wicks*



TWIN-LEAD ANTENNA CABLE DOUBLES AS DURABLE SHOULDER STRAP

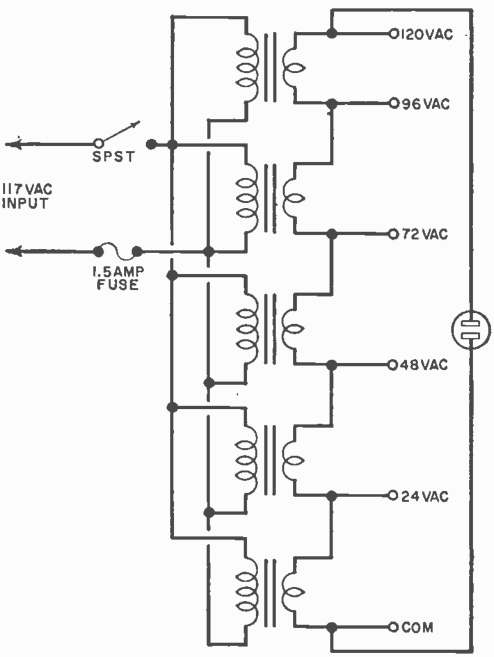
Ever need to replace broken shoulder straps on your portable tape recorder, CB transceiver, or camera case? If you have this problem, a length of flat 300-ohm twin-lead antenna cable can come to the rescue. Simply cut away the leather or plastic strap from the securing hardware, pass the ends of the twin-lead through the hardware, and staple each end securely. Good-quality twin-lead won't stiffen up and crack in cold weather, and chances are it will be a lot more durable than the original strap that came with the equipment.



—*James E. Arconati*

INEXPENSIVE ISOLATION TRANSFORMER

Many hobbyists and experimenters have hesitated to buy a line-isolation transformer because of the high price. Yet, for less than $9, you can assemble a 120-volt-ampere isolation transformer setup and have taps spotted at 24-volt intervals as a bonus. What you need are five 117-volt primary/24-volt, 1-ampere secondary transformers—available for as low



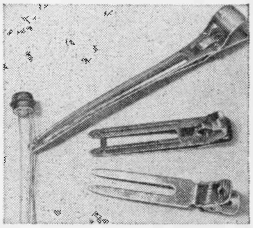
as $1.79 each from Lafayette Radio Electronics (catalog number 99 E 62663). Wire all primary windings in parallel with each other; wire the secondaries in series in the proper phase as shown in the schematic drawing.

Then, protect the setup by inserting a 1.5-ampere fuse in one of the lines of the primary circuit. Attach a line cord across the primary and an a.c. receptacle across the entire string formed by the secondaries.

—*Frank H. Tooker*

NEED A HEATSINK? CHECK YOUR WIFE'S CURLER BOX

You may not have given much thought to it, but your wife probably has a wide variety of custom-made heatsinks tucked away in her curler box. Those clips make dandy heatsinks—if you can wrest them away from your wife. They come in various shapes and sizes—probably more shapes and sizes than you'll ever find uses for. Some have wide gripping jaws to handle high heat radiation requirements, while others have very narrow—and sometimes bent—jaws to fit into even the tightest of spots inside a chassis. Three or four different sizes and shapes will cover most heatsinking jobs.—*Henry R. Rosenblatt*



CAPACITANCE METER

(*Continued from page* 130)

still in a circuit; any resistance, voltage, or other capacitance in the circuit will result in a false reading, and any external voltage might damage the meter movement.

You use the capacitance meter in much the same manner as you would use an ohmmeter to measure resistance. Simply set the range switch to the position desired, connect the capacitor to be tested, and interpret the value from the position of the meter pointer and the range multiplier.

Don't be surprised if many of your capacitors seem way off from their rated values. Many capacitors have much greater tolerances than other electronic components, and some of the less expensive ones may even be rated at +80%, −20% tolerance. This would mean that a 0.01-μF capacitor could have a value anywhere between 0.008 μF and 0.018 μF and still be considered good. Of course, if a different tolerance is stamped on the capacitor case, the final reading should be within those limits. -30-

ELECTRONIC EXPERIMENTER'S HANDBOOK WINTER 1971

Be creative–and thrifty too!

Save up to 50% with EICO Kits and Wired Equipment.

NEW "TREASURE HUNTER" KIT

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

Battery operated. **$29.95.**

NEW "BULLHORN" KIT

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

NEW EICOCRAFT

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

FM Wireless Mike $9.95.

8 NEW EICOCRAFT KITS

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

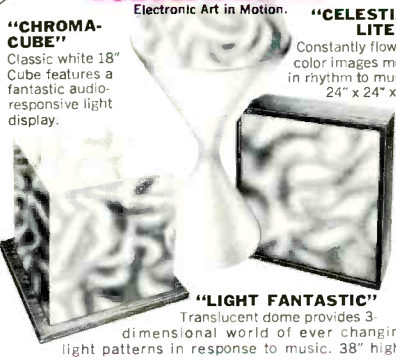
NEW "FLEXI-CAB"

Build your own custom designed cabinet in minutes!

Give your EICOCRAFT and other projects that finished professional look with decor-styled FLEXI-CAB vinyl clad steel cabinets. Fast, easy, push-together assembly. 3-sizes from $3.49.

COLOR IMAGES

Electronic Art in Motion.



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

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

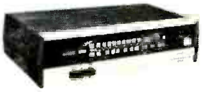
"LIGHT FANTASTIC"
Translucent dome provides 3-dimensional world of ever changing light patterns in response to music. 38" high.

NEW cortina2 STEREO KITS

The lowest-priced component quality high fidelity!

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

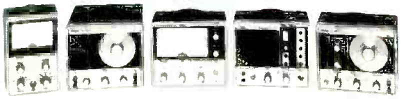
EICO 3080 50-Watt Silicon Solid State Stereo Amplifier. Kit $69.95, Wired $109.95



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

NEW SOLID STATE TEST INSTRUMENTS

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



EICO 240 Solid State FET-TVM. Kit $59.95, Wired $79.95.
EICO 379 Solid State Sine/Square Wave Generator. Kit $69.95, Wired $94.50.
EICO 242 Solid State FET-TVOM. Kit $69.95, Wired $94.50.
EICO 150 Solid State Signal Tracer. Kit $49.95, Wired $69.95.
EICO 330 Solid State RF Signal Generator. Kit $59.95, Wired $84.50.

FREE 1970 EICO CATALOG

EHW

☐ Send me **FREE** catalog describing the full EICO line of 200 best buys, and name of nearest dealer.

Name ____________

Address ____________

City ________ State ________ Zip ________

EICO Electronic Instrument Co., Inc.
283 Malta Street, Brooklyn, N.Y. 11207

EICO®

NOW YOU CAN SEE THE MUSIC YOU HEAR.

Sound n' Color

Color Organs, Translators, Strobes

COLOR ORGANS

The now dimension to music pleasure.

EICO all electronic solid-state Audio-Color Organs transform sound waves into moving synchronized color images.

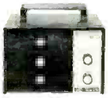
MODEL 3450 Giant (30" x 12" x 10") 4-Channels. Kit $79.95, Wired $109.95.

MODEL 3445 (24" x 12" x 10") 4-Channels. Kit $64.95, Wired $99.95.

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

TRANSLATORS

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

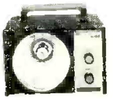


MODEL 3460 1 Channel. Kit $24.95, Wired $39.95.

MODEL 3465 3 Channel. Kit $39.95, Wired $69.95.

STROBE LITES

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

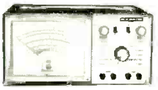


Model 3470 Adjustable Rate. Kit $29.95, Wired $39.95.
Model 3475 Audio Actuated. Kit $39.95, Wired $59.95.

AUTOMOTIVE

EICO 889 Solid State Capacitive Ignition System.

Boost gas mileage up to 25%, life of points, plugs to 100,000 miles; Kit $29.95, Wired, $39.95.



EICO 888 Solid State Universal Engine Analyzer. Tunes and troubleshoots your car/boat engine, the totally professional way. Kit $49.95, Wired $69.95.

CIRCLE NO. 4 ON READER SERVICE CARD